Designing Effective Interfaces for Older Users

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Abstract

The thesis examines the factors that need to be considered in order to undertake successful design of user interfaces for older users. The literature on aging is surveyed for age related changes that are of relevance to interface design. The findings from the literature review are extended and placed in a human context using observational studies of older people and their supporters as these older people attempted to learn about and use computers. These findings are then applied in three case studies of interface design and product development for older users. These case studies are reported and examined in depth. For each case study results are presented on the acceptance of the final product by older people. These results show that, for each case study, the interfaces used led to products that the older people evaluating them rated as unusually suitable to their needs as older users. The relationship between the case studies and the overall research aims is then examined in a discussion of the research methodology. In the case studies there is an evolving approach used in developing the interface designs. This approach includes intensive contribution by older people to the shaping of the interface design. This approach is analyzed and is presented as an approach to designing user interfaces for older people. It was found that a number of non-standard techniques were useful in order to maximize the benefit from the involvement of the older contributors and to ensure their ethical treatment. These techniques and the rationale behind them are described. Finally the interface design approach that emerged has strong links to the approach used by the UTOPIA team based at the university of Dundee. The extent to which the thesis provides support for the UTOPIA approach is discussed.

Dedication

I would like to dedicate this thesis to the individual aging of each and every one of us.

“I am entering a foreign country, one that will change me and eventually kill me. While I can still talk with you I would like to report back and tell you something of what I have found”

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Chapter 1 Introduction

1.1 Designing software for older users

This thesis looks at the issues involved in designing software that older people can use effectively. This is an atypical thesis with a much broader scope and broader research aims than most PhD theses. In the period in which the thesis was done (1999-2002) there was virtually no extant literature on designing interfaces for older users. It was obvious that there would be a rapid shift to a much older population with a need to engage with computing. Further it was apparent that older people, particularly older people exposed to computer use for the first time, were finding computer use challenging to say the least. However the HCI community did not appear to be involving itself with this problem. On this basis it was decided that my research should take the form of crisis research where the aim was to open up the area over a broad scope rather than to provide exacting support for a single narrowly defined proposition. This implied using a greenfields approach to the issue of how to design user interfaces for older people rather than the more typical approach in PhD theses of deriving a relatively narrow research question from extant literature. The research aim (rather than research question) was to examine relevant issues for those who intend to design effective user interfaces for older people. The intention behind the aim is to provide a research based enquiry that opens up a new field and at the same time makes computer use more accessible for older people.

In another sense the thesis is an extended case study of the process of acquiring the skills and resources to carry out the design of software that older people can use effectively. The thesis examines the aspects of aging that make older people a distinctive group of users and reports on three studies of creating effective designs for older users that were carried out in the course of the research. This is followed by reflection on the research methodology that was developed in the course of these design studies and further reflection on the design approach itself.

Interface design for a distinct group follows the general directions set out in approaches such as User Centered Design and Task Centered Design. One acquires knowledge of what makes the group distinctive. One acquires knowledge of the tasks that need to be supported by the design and the context within which the design will be used. One then involves members of the group in prototyping and testing at various stages through the creation of the design and its implementation. However the details of the approach may need to be adapted if the group being designed for differs markedly from traditional users. This thesis will provide an examination of adaptations of the approach to interface design that assist in successful interface design for older people.

Design for older people certainly involves adapting designs to the limitations that age imposes. However the study suggests that there are considerable subtleties that are overlooked in a design mantra for older people of “big fonts, big targets and simple layout”. There are a wide variety of ways in which age may affect older users in their interaction with an application. In addition there are difficulties within designers’ likely assumptions about older users. Older users are both likely to be considerably less able than most designers expect while at the same time older users are likely to be able to carry out more computer based tasks than might be expected from a first acquaintance with their difficulties with computer use. The achievement of effectiveness in older people’s computer usage depends on effective support from the interface design, but also on effective training.

The term “older users” represents a degree of lazy thinking. The reason for special approaches to design for some of the older population is that they are age affected, the aging process has reduced some of the abilities we assume in younger users. Some older users can be assumed to have few age reduced abilities well into their lives, the design issues described in this thesis are less relevant to these people. Although the thesis generally uses the less precise term “older users” the point that what is really meant is age affected users should be born in mind. The distinction is somewhat blurred however if, as seems likely, most older people have some age related effects even though they can compensate for a number of them in normal circumstances and so appear less affected by age.

One of the keys to designing for a distinctive group lies in acquiring a wide ranging knowledge of the characteristics of the group. The thesis makes a case that the literature on physical and cognitive aging contains a large body of information that is relevant to interface design for older people. Within the literature study the thesis will set out a summation of the implications of aging for those designing interfaces for older people and this is regarded as a useful resource. However the thesis will suggest that there is considerable value in extensive interaction with older people so as to force designers to confront the realities behind written descriptions of age related effects. Recent research by Newell et al. (2006) makes it clear that being told about the issues of aging does not prepare designers to make the paradigm shift needed in designing for older people. In that study Newell and co-workers found that experienced interface designers persistently discounted information they were given about older people's needs and issues. When these designers finally met with and observed older people working with computers they could fairly be described as stunned by the extent to which they would need to adapt their usual design practices to meet the older people's capabilities. Yet all the points that surprised the designers had been conveyed to them previously by people with extensive experience in design for older people. Thus design for older users requires a decided shift from design for users who are more like the designer. Interaction with older people is a way of achieving such a shift but as will be seen working with older people has its own special skills and sensitivities.

1.2 Relevance

Why is a study of interface design for older people relevant? There are two parts to an answer. The first is that with the demographic shift to an older population there are a considerable number of older people in the population and many of these people find computer use difficult. If interface designs that specifically address aspects of aging allow these people to use computers more effectively, then this clearly falls with in the aims of HCI in terms of studying and improving human-computer interaction. However the current older generation are largely people who have had no previous experience with computers and their struggles with computing are intertwined with the issues of learning computer skills as an older person.

The second aspect of relevance is to address the question of whether there is long term relevance for the study, given that future cohorts of older people will bring considerable experience of computing to their interaction with computers in their old age. We will now proceed to look in more detail at each of these concerns.

1.2.1 The demographic shift

It is now a commonplace that there is a higher proportion of older people in the population. This is due to a lowered death rate among the older section of the population and in many (but not all) western countries, reduced fertility among the younger section that is not fully compensated for by immigration rates. What may be less appreciated is that the scale and speed of this demographic shift is unprecedented.

The data presented here is for the United States, U.S. Census Bureau (2004). US data may in fact show a less rapid move to an aging population than Europe or Japan. This is both because of the high level of immigration from south of the US border and the high birth rate of the US Hispanic population. These factors mean that there is more replacement of younger population groups in the US than in Europe or Japan. None the less the trend is stark. The data can be seen in summary in the following figure 1.1. Supporting detail is supplied in Appendix A.

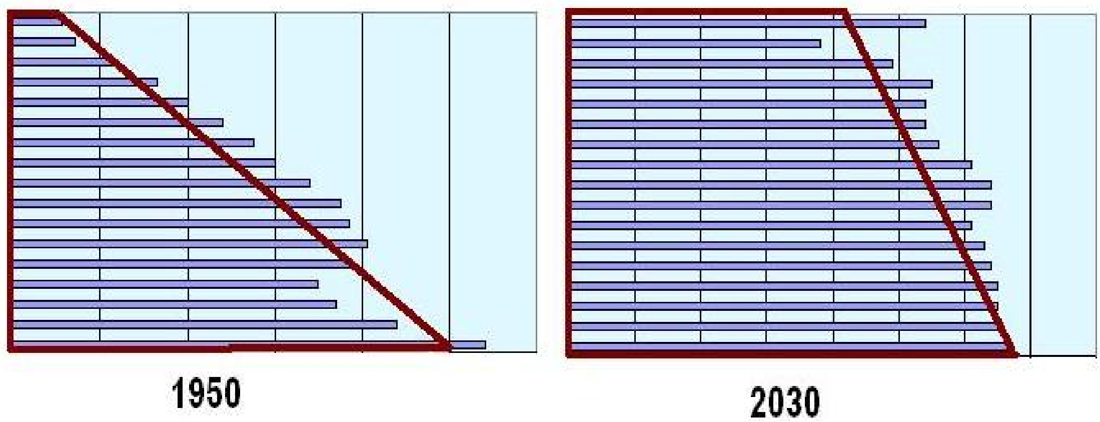

Figure 1.1 Contrast in US population structure from 1950 to 2030. Y axis gives 5 year age bands with 80+ grouped in the top band. X axis gives percentage contribution to the overall population.

In Figure 1.1 the top band represents the 80+ age group, the bands then descend in 5 year age groupings to age 0 to 4 at the bottom. The X axis gives the percentage that each band contributes to the overall population. What is made very obvious in this figure is that there is a very rapid shift occurring from a triangular population structure with a relatively small proportion of the population over 60 (12.1% in 1950), to a population structure that is more nearly rectangular and having a substantial proportion of the population over 60 (a forecast 25% in 2030). In fact a full 30% of the population is predicted to be over 55 years of age in 2030 so the number of people who may benefit from software that includes adaptations to the effects of aging can be expected to be substantial.

This in turn leads to problems with schemes for supporting older people in retirement caused by the increased number of older people combined with the reduced number of working age tax-payers available to support them. This is predicated to mean that there will be a need for older people to stay in some form of employment for longer, both in order to support themselves and because there are going to be fewer younger workers to replace them. In addition having fewer younger workers means that older people are likely to need to find ways of being less reliant on care givers and younger supporters.

1.2.2 The shift in the role of computing

The demographic shift has come at a time of major technological change, one aspect of which is the increased role of computers in work, communication and access to services. Some extent of computer fluency is becoming a requirement for full access to society. Already computer access can be a cheaper and faster way of accessing services such as banking. It is possible that the price and ease differential may increase to the point where not being able to use computer based services may leave people marginalized. It is also likely that if older people will need to have computer skills if they need to maintain themselves in employment within an increasingly computerized workforce.

1.2.3 Aging for a computer experienced population

The argument is sometimes made that this problem only exists for the current cohort of older people who entered old age without prior computer skills, further it is argued even this group is now on-line and so the issue of older people and computing is vanishing. There is limited direct evidence here but what is available is not reassuring. Firstly there is some evidence that after a very high rate of initial uptake, the rate at which older people are taking up computer use has leveled off and is now doing no more than keep up with new recruits to the older population and those older people who cease using computers, leaving around 80% of the older population as non-computer users, the figures are based on reports from the Pew institute, see Fox (2004). Again, examining the data provided in the Pew reports, in most categories of computer use older users remain the most infrequent and least sophisticated users as well as being the slowest group to adopt new trends.

In addition to this, computer use in the next cohort to become old, current 50 – 65 year olds has not been universal. There will be substantial groups of non computer users within this next older generation. Further there is some evidence that those in the 50 – 80 plus group who have learnt computing skills are on average more able than those who remain non-users. From this it could be argued that the problems facing older beginners may in fact be more severe in the next years than for the older people who adopted computing earlier. Again, where older people delay learning computer skills, the continuing effects of aging mean that the act of delay can make skill acquisition harder. On this basis there will remain a significant section of the older population who have the potential to benefit from gaining computer skills (and from software designed for their needs) but who will not find gaining such skills easy, who may indeed find the required learning harder than did those who went before them. The position of such people will not be helped by the assumption that the issue of computing for older people has been solved.

There is another strand to the counter argument, this suggests that the above is merely about timing. At some relatively near point in the future virtually all new recruits to the older population will have extensive computer experience and then surely the issue of special needs for computing for older people will vanish. Again I suggest that what little is known is not reassuring. One should firstly note that the Pew reports do not suggest that any current adult age group is completely computer literate. Findings on retention of expert behavior into old age from studies by Charness (1988) and Salthouse (1990) indicate that while skilled behavior is preserved into old age, particularly if practice in the behavior continues, there is virtually no generalization of the preserved abilities to presumably closely related abilities. Thus people may continue to practice as respected architects into their seventies but when tested on general problems involving spatial perception they do not perform better than the general older population. The implication is that we (the computer literate) will go into old age with a fairly specific set of computer concepts and skills but we will not find it easy to generalize those skills when the nature of computing undergoes a paradigm shift. It is worth noting that changes in the form of computing are a significant economic driver of the industry and that there is no indication that current changes such as the emergence of the web or the shift to portable and eventually ubiquitous computing represent any cessation of change in the industry. If, as we age, we find it increasingly difficult to adapt to changes, it may well be that in old age we will be most comfortable with the computing skills, concepts and tools we learnt in our mid 50s. Where these are no longer available we will perhaps be more similar to today's bewildered older novices than we might like to imagine. In this case the sections of the thesis on older people's issues in learning computer skills can be expected to retain an uncomfortable relevance.

There is also the point that overwhelmingly software and its interfaces come from designs that are produced by younger designers. The reality is that, unless forcibly restrained, designers will tend to design for people somewhat like themselves. This means that as we age we will be likely to meet software that assumes we can read 8 point fonts on colored backgrounds while dealing with fine manipulation and coping with memory demands that do not accommodate our likely reduction in short term memory capacity. Less rhetorically some of the difficulties that face older computer users come from normal aging. Although there may be some technical progress in alleviating some aspects of aging it is perhaps wise to assume that as those currently computer literate age they will be affected by much the same effects of aging as the current older generation in terms of things such as vision, manipulative skills and declines in aspects of cognitive capacity. Where such effects of aging conflict with the assumptions about ability that designers build into their interfaces, the new computer literate old will still face problems in coping with software. From this perspective those parts of the thesis that examine the ways in which software can be designed so as to make allowances for the effects of aging will also retain their relevance.

1.3 The history of the current research

My study of aging and its implications for interface design began in 1998 with a survey of the literature on physical and cognitive aging. This gave a view of the way in which the consequences of normal aging might be seen as indicators of characteristics of an older population that interface designers should be aware of and build into their designs. This led to two conference papers and a journal article, see Hawthorn (1998a, 1998b and 2000a). At this stage two strands of enquiry were pursued, I decided that the pure research perspective of the majority of the findings in the literature I had surveyed meant that there would be benefits from open ended observation of, and involvement with, older people who were using computers or trying to learn computing skills. This resulted in me observing as older people were taught computing in a variety of settings and also involved me in discussions with older computer users. At the same time I began a study that sought to explain the observed problems that older people had with software in terms of a dual task model where using cognitive resources for managing the interface of an application reduced the cognitive resources available for the older person to work with the substantive task that they were using the software as a tool to achieve. I designed a pilot study to test an experimental approach to studying the dual task hypothesis.

Thus at this stage I was involved in two simultaneous studies, one a fairly open ended observation-based study of older people and computing, the other a pilot for a traditional experimentally based test of a hypothesis. The results were striking. The observational study expanded to involve the construction of an interactive tutorial for introducing older people to very basic computer skills. Here the implications for design of the literature review of the effects of aging and my ongoing interaction with older people came together in a very successful design that is still in use today. Further the identification of the sorts of gaps in computing knowledge that affected older people and the extent to which such gaps seemed likely to persist provided valuable information for interface designers intending to work in this area. On the other hand the pilot study ended with no support for the dual task hypothesis in its simple form and with the recognition that treating the older volunteers in the study as experimental subjects had both distorted the level of realism and motivation obtained from them and had also exposed them to stresses that could be seen as unethical. The contrasting outcomes from the two studies led to a major change in the intended direction of the thesis.

The experimental approach was dropped for a variety of reasons. It was felt that the level of understanding of the effect of aging on computer use was too limited for the sort of hypothesis testing used in more mature areas of knowledge. It was also observed that a wealth of relevant knowledge came from working with older people during the process of interface design. In the process of working with older people to design interfaces that they could use, the older people expressed themselves to be well rewarded with their participation. This contrasted with the distress, disengagement and boredom shown in parts of the dual task study. The clinching argument came from considering the utility of hypotheses at the level of the dual task hypothesis if in fact the hypothesis had been sustained. What was found in constructing the interactive tutorial for older beginners was that a knowledge of the effects of aging (from the literature review) combined with frequent feedback from older people with an ongoing relationship to the design project gave a good basis for a designer to proceed with creating a successful product. In contrast a hypothesis such as the dual task hypothesis might be publishable if sustained, but was of less value in providing a designer with well targeted guidance. It was a reminder that the thesis was intended as an applied study and that the research techniques and outcomes should reflect this.

This change of direction saw the focus of the research shifting to case studies of design for older people based on both knowledge of the effects of aging and on encouraging considerable involvement from older people in developing the interface designs. A further interactive tutorial was constructed dealing with training older people in file management as a way of both checking the lessons learnt in the design of the interactive tutorial for beginners and of expanding the area of training to investigate the way in which training might be designed to allow older people to deal with software that was more complex and not specifically designed for older people. This file management tutorial was relevant to the thesis aims in several ways. For a start it considered the utility of an interface designer incorporating interactive training into their designs when the task involved areas of unavoidable complexity. It also looked at the possibility of designing training instead of redesigning a complex package thus giving an alternative strategy for allowing more effective software use by older people. Finally it provided another example of designing an application (the interactive tutorial itself) that older people could use easily. The completed tutorial was then tested with further groups of older volunteers and found to be highly effective both as usable software and as an effective training strategy.

This use of case studies in effective design was continued in the final study for the thesis. Here a reasonably full featured email system was constructed using the design approach that had been used for the two interactive tutorials. It was desired to retain the emphasis of the thesis on providing useful information for designers who were going to produce interfaces to be used by older people so the design focus was shifted to what was clearly application development without a training/tutorial focus. The system was evaluated with further older volunteers and was also put into long term use with a smaller group of older people. The results again support the idea that designing from a knowledge of the effects of aging coupled with the ongoing involvement of older people in the design process is a basis for a design process that results in products that are considerably better suited to older users than standard software.

There was then a nearly two year gap where illness resulted in very little progress with the thesis and writing up was not resumed until mid 2005. What has emerged from the writing up process is an examination of the research methodology and the design approach that evolved in the course of the research for the thesis and the positioning of these methodologies as important results of the overall research. The work on an appropriate design approach for working with older people in particular is seen as being important for designers intending to work with this target group. The thesis is less specific on specific design points such as, "use Arial 14 point font on a plain strongly contrasting background" since it was apparent that the sort of advice that was appropriate would vary strongly with different applications, consider for example Zaijchek's (2003) work on telephone information systems for older people. Recommendations for specific aspects of design are given in each of the chapters discussing an interface design development case, other work on specific design recommendations is identified in the literature review and the general recommendations from all the design cases are collected in an appendix to the thesis. However the role of these recommendations is seen as illustrative of the way that the designer can proceed from knowledge of aging to techniques appropriate for a particular development rather than a prescription for designing for older people.

1.4 What is meant by "older" people

Throughout the thesis there is reference to older people and older computer users. This is a convenience but should not be taken as implying a uniform "older" group. Because of the diversity of their life experiences coupled with the highly variable way that individuals are affected by the onset and progression of aging, the "older" group is the least uniform of the developmental stages. From the point of view of an interface designer it is not age itself that is the problem but some of the effects of aging such as reduced vision, reduced manipulative ability and a variety of cognitive effects that lead to declines in memory, reasoning ability and speed of learning. Typically in this research the older people involved were aged between 65 and 85 but numerical age is relatively insignificant. What matters is the extent to which one or more effects of aging such as reduced vision, reduced manipulative ability and a variety of cognitive effects are present. Again this research is aimed at older people who have moderate levels of functioning, this is not an attempt to make computer use available for people suffering from extreme effects of aging. Age itself can be seen as a surrogate variable that is only loosely correlated with the effects of aging. We use “age” and “older” as terms for our own intellectual convenience but it is the (individually varied) effects of aging that are actually of importance.

For this reason the thesis has focused on a group of people within the older population, those older people who have difficulties in using standard software and standard forms of instruction in computer skills. The thesis takes it as a given that a large number of today’s older people have difficulty using the available software, see Czaja and Lee (2003). The thesis does not attempt to identify the prevalence of this group in the overall older population or to examine the frequency of the various forms of age related decline. The assumption is made that by selecting volunteers from people who self identify as having problems with software use due to the effects of their own aging, we have a group of people whose problems are relevant to the age related problems with computer use present in the wider older population.

Later chapters will look at the design implications of the diversity in the older population. Here it suffices to say that the design aim is not to make software that is usable for all older people, nor is the aim to cope with a clearly defined sub-group of older people who have a particular set of age related concerns. The aim of the thesis is to provide designers with resources and guidelines that will increase the number of older people who can make use of the interfaces they design. As part of this approach the designs developed and examined in the thesis take the stance that a particular form of age related disability may or may not be present in an individual who uses the software. What becomes important in designing for older people is that the software contains features that make it more usable for different individuals with a number of different expressions of age related decline. Such design needs to be done in such a way that design for any particular age related issue does not disadvantage those older users who do not suffer markedly from that particular aspect of aging.

1.5 Overview of the thesis

The structure of the thesis at a chapter level is given in this section and then the more detailed argument set out in the thesis chapters is examined in the following section. This first introductory chapter is followed by a second chapter containing a literature review, that looks at work on physical and cognitive aging where this has relevance to interface design as well as looking at work on interface design for older people. The third chapter reports on the pilot study for the intended experimental examination of the Dual task hypothesis. The fourth chapter reports on the experiences with older learners that led to constructing an interactive tutorial for older beginners and goes on to describe that tutorial. After this chapter five reports on the development, design and evaluation of a second interactive tutorial constructed to help older people learn file management skills. The sixth chapter reports on the development, design and evaluation of an email system for older people. The next chapters describe the research methodology (chapter 7) and the design approach (chapter 8) that emerged from the study. There are considerable parallels in the research and design approaches developed in this thesis with those developed in the UTOPIA project based at the University of Dundee and so chapter nine compares the two approaches. Finally conclusions from the overall research are presented in chapter 10.

1.6 The detailed structure of the thesis

This section will provide an introduction to the detailed argument laid out in the thesis. The aim is to provide the reader with sufficient information about the material covered in each chapter to allow the reader to form a picture of the way in which each chapter contributes to the overall argument of the thesis.

1.6.1 Chapter 2 - The literature review

The initial form of the literature review was driven by the relative lack of studies on interface design for older people that were available in 1997. This meant that the topic of design for older users was a relatively new topic and the usual approach of reviewing an existing body of relevant literature was not available. There was not only a lack of literature that was specifically linked to my chosen topic but I was also aware of my limited technical knowledge of the effects of aging. As I read in order to increase my knowledge of aging and how it could relate to interface design for older people it became apparent that this offered a useful and appropriate approach to a literature review. As the review itself makes clear, there are a very large number of effects due to aging that could cause problems when an older person interacts with software designed (by) and for younger people. The literature on cognitive and cognitive aging is largely based on studies that contrast the behavior of older groups with younger control groups on a wide variety of experimental tasks. Studies typically seek to establish differences in behavior on the experimental tasks and then infer, support for, and, counter arguments to, various theoretical explanations of the difference. This is a body of literature that is strongly concerned with the theoretical mechanisms of aging and much less concerned with applied research or with supporting application of any findings. However it also represents a potential treasure trove for the interface designer. Firstly there is the emphasis on establishing differences in ability and behavior between younger people and older groups. This is clearly one of the areas of knowledge that an interface designer should acquire when designing for any group that is significantly different from the designer and the sort of user that a designer might assume. A second feature of the literature on physical and cognitive aging is the breadth of aging effects that have been (and continue to be) studied. Thus work on vision and aging looks at far more than simply the size of recognizable targets. Some of the sub-topics cover changes to color perception with age, the effect of age on the width of the useful visual field, effects of low lighting and of off center location of targets, ways in which ability in visual search decreases with age and many others. A third benefit of using this literature as a resource is that there is experimental rigor in proving the existence of this wide variety of differences between young and old.

However there is a note of caution needed here as the findings in this literature are not specifically intended to support application of the findings or use by interface designers in particular. Not all findings are in agreement and it is possible that particular findings may be artifacts of the experimental conditions under which they were obtained and might be less apparent in older people's behavior in real life situations. In addition the experimental conditions are created to examine and challenge specific theoretical issues, they provide tight control on variability, they are not designed to recreate the conditions faced by an elderly computer user in their home. It is usually sufficient for the hypotheses being tested in the original research to show that a difference exists between the young and old groups of subjects in the particular study, this does not translate into information about how widely an effect of aging is distributed in the population that an interface designer may be interested in, nor does the theoretical literature provide much guidance on the strength of various effects in the general older population.

There is a further problem in that the literature is not a source of guidance on how the findings should be translated into aspects of interface design for older people. If, for example, peripheral visual stimuli need to be stronger for older people to be aware of them, does the designer make them stronger, or design so as to place less reliance on peripheral vision? In taking either choice what trade-offs does the designer make that may impact on how the design affects some other aspect of aging? Again there are literally hundreds of old-young differences, which one's are likely to impact a particular design? Further if there is a requirement that interface design recommendations for older people be subject to rigorous experimental verification, then the number of possible design implications from the literature on physical and cognitive aging, the number of possible interactions of such implications and the number of ways in which adaptations to the implications could be implemented lead rapidly into paralysis by analysis.

What I suggest is that providing consideration of the possible implications for interface designers in the findings of the literature on physical and cognitive aging provides designers with a useful resource but not a rulebook. The role of the literature review in this thesis is to assist in the understanding of the process of developing designs with the participation of older people. It is not intended to provide background for some hypothesis to be tested in the course of the thesis.

As time has gone by there are an increasing number of studies of specific aspects of useful design for older people. The literature review has expanded to include these studies but the material from the literature on physical and cognitive aging has not been correspondingly shrunk. It is my contention that awareness of this literature and a continuing process of updating one's knowledge in this area is a valuable resource for any designer involved with older people.

1.6.2 A pilot study – Chapter 3 and the Dual Task pilot study

Chapter 3 "The Dual Task pilot study" describes an attempt to operationalize a hypothesis that, if supported, would assist designers in incorporating the findings of the literature review into their designs. One of the concerns that occupied me after completing the first version of the literature review was how to test the effectiveness of the implications that I had drawn from it. As pointed out in the preceding section, there is such a richness of implications that an experimental study at the level of verifying individual recommendations or even many such studies would be beyond the resources of even a well funded research institute, let alone a single PhD student. None the less I was strongly influenced by the almost exclusively experimental format of the literature on physical and cognitive aging. How then could one proceed with an experimental study that supported designers using the design implications of the literature on physical and cognitive aging as a framework for better design? After some consideration it appeared possible that a way of linking the individual implications to an overall framework for assisting older users might lie in the studies looking at how older people performed in dual task situations. It had been established that as people became older they showed poorer performance on dual task performance than younger subjects. This was usually explained in terms of older people having a more limited cognitive capacity than younger people and hence if they performed two tasks simultaneously the cognitive resources needed for performing one task would reduce the cognitive resources required for performing the other task. Under this formulation one could suggest that handling the demands of the interface became one of two tasks the older user was engaged in, referred to in Chapter 3 as the interface task. The other task was whatever job had led the older user to use the software in the first place, for example, writing and sending an email, this latter task was designated the substantive task. The dual task hypothesis then stated that the demands of the interface task had the potential to compete for cognitive resources with the substantive task. Hence a designer should reduce the cognitive demands of the interface task by plugging in design features that reduced demands on the older users in accord with the suggestions from the literature review. This, it was argued, would allow the older user to devote more resources to the substantive task and promote more effective computer use by older people.

A basic experimental design was developed in which older subjects would perform a task under differing levels of both interface difficulty and task difficulty. Two variations of the experiment were designed so that the test of the hypothesis could be replicated under two different types of task and interface. A pilot study was organized using 12 older volunteers. The bulk of Chapter 3 is devoted to describing the method and the results. However the core contribution of chapter 3 is in its last few pages where the results and the rethinking of the thesis that they prompted are discussed. This is addressed in the next sub-section (1.6.3).

What emerged was a complete lack of support for the dual task hypothesis. This was unexpected and daunting. I had already established that a finite set of resources would not allow experimental verification of the individual usefulness of the recommendations from the literature survey. I found the dual task hypothesis appealing and hard to disbelieve. It appeared though that if it were true it did not operate on a simple level over long periods of software use but it still might operate at a second by second level within the loadings that interface and substantive tasks simultaneously placed on various subsystems such as memory, vision and manipulation. This was potentially interesting if substantiated but it did not offer ready guidance to designers unless they were willing to engage in a level of task analysis that would be unusual and demanding.

1.6.3 Changes to the research direction from the Dual Task study

In the discussion and conclusions at the end of Chapter 3 the groundwork is laid for a complete change in direction for the research underlying the thesis. The resulting new directions resulted in useful and productive research. The issues raised by rethinking my approach in the light of the failure of the pilot study to support the dual task hypothesis included a question of whether designers would be helped by the level of abstraction that is represented by overall hypotheses or would they be better served by a background understanding of the effects of aging at the level of concrete issues that could be countered by appropriate design features? The older subjects in the Dual Task pilot had also shown unexpected distress when the experimental tasks led to them failing to achieve, thus placing older participants in such situations was ethically questionable.

Again the focus groups' discussions of the subjects' experiences during the experiment and in their day to day efforts in computer use provided a wealth of relevant information that was not tapped by the experiment and its results. It seemed apparent that a wider and more human understanding of older users would yield useful information that was not available in the literature that had been reviewed. (In fact there is information in the literature on psychological and social aspects of aging that would be relevant and related to the stories told by the Dual Task subjects in the focus groups but extending the literature survey to this extent was impractical.) At the same time as the Dual Task study was occurring I was involved in observation of older people in a variety of contexts and the relevance of the material gained here reinforced my decision not to rely solely on an experimental approach and its implied distancing from the subjects so as to obtain objectivity.

It was apparent that the older people who volunteered as subjects in the Dual Task study were considerably better educated and had greater levels of career success than the general population. Thus another concern raised by the Dual Task study was the need for finding ways of recruiting older people that reduced the strength of the selection bias effect.

Another striking observation from the dual task study was the extent to which I failed to anticipate the level of task simplicity appropriate for the older subjects. This was in spite of having a sample of older people obviously skewed towards indications of previous high performance. I was unusually informed (for an interface designer) about the effects of aging and was, I considered, aware of the need of older users for cognitive simplicity. I had pre-tested the substantive tasks with middle aged people and was unprepared for the older subjects being uniformly unable to cope with the two harder levels of task complexity that had been only mildly difficult for my middle aged testers. This suggested that design for older users was not possible without the active involvement of older users in actively and frequently informing the designer of the way in which the performance of older users would differ from the designer's assumptions.

Other indications of the need for a change in approach included the problems found with obtaining realistic motivation from older subjects in carrying out the experimental tasks where these tasks were a) not particularly relevant or interesting to the older people involved and b) led to painful reflections by the older subjects on their conception of their own competence. In an early part of the Dual task study the older subjects were involved in finding preferred font styles and sizes. This was a task that they saw as relevant and potentially helpful to older computer users, it was also non-threatening, it did not involve failure in the sense that the later tasks in the study did, the older subjects participated enthusiastically in the font preference task. It seemed that older people needed to be studied working on tasks that they saw as relevant to themselves and to people like them if realistic levels of motivation were to be obtained.

As part of my concern with gaining a wide knowledge of older people and their involvement with computing I looked for opportunities to observe older people working with computers as well as discussing computer use with a variety of older people. One particular opportunity came when Unitec, a local polytechnic, started running training courses for older people. The intention was to generate revenue and to do this by recycling courses that were already in use for providing adults lacking computer experience with basic computer skills and word processing. There was no expectation that older people would need any special treatment, the designation of the courses as being “for older people” was simply to extend the range of potential customers. I found out about the first course after a tutor had been assigned and students had enrolled. The tutor had no special training in working with older people and their teaching experience included presentations to computer professionals. After discussion with the organizers and the tutor I attached myself to the class in a combined roll as an observer and as an assistant.

The experience was unpleasant for me and distressing for the older students. On the other hand it gave me a very valuable understanding of the difference between older novices and the younger students the course was designed for. It also highlighted the consequences of treating older people as if they were simply younger people to whom one spoke a bit more loudly and repeated things slightly more often. Little learning was achieved, the older students blamed themselves for this and the tutor, while polite and patient with the students in class, wondered privately if they were wasting their (the tutor’s) time as the older people were obviously incapable of learning. My self assigned role gave me a possibly more objective view of the specific problems that the older people faced and allowed me to spend time with the older students individually at their computers rather than being limited to a “front of the class” perspective of the situation. A range of issues related to aging emerged, none of which was effectively addressed. The class struggled to see material at the front of the room, they did not pick up idioms and simple skills at the speed expected by the tutor, they had difficulty finding features on the screens in front of them, they suffered navigation problems when using the software provided and did not learn quickly from their errors. They failed to understand concepts that the tutor felt would be self evident. The course was typing intensive, many in the class were extreme “hunt and peck” typists, often undergoing their first attempt at typing. They learnt at different speeds and they forgot much of the material taught on previous days. They showed total incomprehension of the technical information (such as binary storage) that the tutor believed needed to be included in the course in order to give people a “respectable” understanding of computers. The conclusion of the individuals in the first class was that they were “too old to learn computing” rather than that the class was not designed for older learners. It would have been highly unethical to have set this situation up deliberately. I remained in a role of assisting individual students and observing the class and did not make suggestions for changes to the tutor on the grounds that I would be more objective about suggesting better approaches if I did not intervene until the five sessions of the first course had been completed. (The exception was reconfiguring the tutor’s machine so that it displayed more legibly on the screen at the front of the class and doing similar reconfiguration so that the older students could see the fonts on their own screens.) Early intervention with limited information, while tempting, would have added a partisan flavor to my analysis of what was occurring.

Following the first course I did intervene and provided the course with a simple tutorial program that let the students practice the most obviously lacking skills separately from the MS Works program that was the software the course was intended to teach. This was useful but the course content remained much too wide for the student’s needs. Older people who are struggling with using a scroll bar or finding and clicking an [OK] button are not likely to benefit from attempts to teach them introductions to spreadsheets and desktop publishing. These courses thankfully died a natural death but I was struck by the range of difficulties that older people found with apparently elementary (to me) computing skills. I was also impressed at how much difference the crude intervention tutorial made to the ease with which the older students acquired these skills.

Practical experience in working with this new set of concerns and directions began to emerge in the WinTutor study described in Chapter 4 and outlined below.

1.6.4 Older beginners – Chapter 4 and the WinTutor study

Chapter 4 documents the development of a much fuller interactive tutorial for older beginners. I was interested in whether the approach used in the intervention tutorial for the older students in the Unitec classes could be used more widely in training older novices. I also wanted to continue to extend my experience of older people as they worked with computers. A possible way of combining these aims was to work with an organization that already specialized in training older people in computing use and see if an extended tutorial could be developed that would be adopted in courses that already had material designed for older beginners. I started discussions with SeniorNet (NZ) tutors and this ended in the design of WinTutor. This design is discussed in Chapter 4 and it has in fact proved very successful, becoming widely adopted by SeniorNet simply through word of mouth advertising.

There are some points that are worth noting here. Chapters 3 and 4 both discuss case studies of the development of interactive tutorials for older users. However it was not the intention to divert the thesis direction towards gerontological education. There are a number of advantages that come from working with interactive tutorial design for older users in an overall project aimed at effective interface design for older people. Firstly it appears that learning in many older people is slow and fragmentary. What the work on WinTutor (as an interactive tutorial for older novices) provided was understanding of which skills older people initially struggled to master and an indication of the gaps in knowledge that were likely to mean that older users broke the assumptions about pre-existing computing skills likely to be made by younger designers. Secondly an interactive tutorial is in fact an excellent exercise in appropriate design for older people. To an extent one theme of the thesis is the presentation of an ongoing case study of the process of one interface designer (the author) acquiring skills as an interface designer for older users. Creating WinTutor involved me in designing some 57 interactive screens that were each expected to be functional for older novices. So creating the WinTutor tutorial provided extensive practice and grounds for reflecting on what worked, and what did not, for older users, while drawing on the implications of aging as explored in the literature review. Thirdly there is a place for some understanding of appropriate training for older people in the armory of interface designers. One of the ways in which an application can be made more accessible to an intended older audience is to provide carefully designed training (suited to older users) as part of the application package. The analysis of the design features of WinTutor reported in Chapter 4 is useful material to that end.

One of the other features of the WinTutor design was the incorporation of two older novices into the design stages of the project. These people were consulted on a day by day basis as the design was developed and very obviously contributed strongly to the eventual success of the project. Older people in this role are referred to from here on as the “in-house testers”. In-house testers were used in the next two design studies and one of the outcomes of the overall research was refinement of the way that the role of in-house testers could be handled. This is considered in more detail in section 1.6.8 describing Chapter 8 which deals with the skills needed in working with older people.

A weakness in the WinTutor project is that it was not originally intended as work to be written up. It was undertaken partly out of desire to make life easier for older people who were trying to learn computing skills, prompted by anger at what I had observed at Unitec. It was also motivated by a belief that it was desirable for a designer to get a more rounded and more human picture of older people than that which emerged from the descriptions of experimental work in the literature review. I had not intended to write this work up and was caught unprepared when it emerged as both a useful source of important information and as a highly successful case study in designing for older people. What was missing was a process for formally evaluating its usability with older people. The tutorial was released to the SeniorNet community and adopted by many branches to replace their previous teaching materials but in place of a description of success based on results from usability trials the WinTutor chapter has testimonials and continued sales figures. It was decided to rectify this lack in the next study.

1.6.5 Learning more complex applications – Chapter 5 and the FileTutor study

The next study in the research for this thesis was again based on the design of an interactive tutorial for older people. As noted above there was a desire to recapture the design success of the WinTutor project in a way that allowed more analysis of the factors leading to a successful design and more formal demonstration of the success of the design, if in fact it was successful. I had some concern that including a second interactive tutorial in the thesis would lead to the core design message behind my work being missed by readers who might see the work as just being about teaching older beginners, rather than maintaining a focus on appropriate design for older users. There were several responses to this incorporated in the research. It was decided that the thesis would include a third design project that was clearly an application design for older users after the second interactive tutorial was completed. It was also decided to shift the nature of the second interactive tutorial so as to extend the range of useful information (for interface designers) that could be extracted from the study. The previous arguments for viewing the construction of an interactive tutorial as excellent practice in designing multiple screens that needed to be workable for older users still applied.

The extended target for the new interactive tutorial project was to look at how somewhat experienced older computer users could be assisted with learning more complex computing skills and assisted in learning an application that challenged their ability as older users. The topic eventually chosen was Windows file management and the related application was Windows Explorer. The interactive tutorial product that came out of the design process was nicknamed FileTutor.

Although finding a way of training older people in file management under Windows was itself a useful achievement the reader is asked to bear in mind that this was a secondary aim in this project. The relevance of the FileTutor project to an interface designer for older users comes from the following argument. If older people are to use computer applications that are part of the computing mainstream and therefore accommodate younger users, older users will be asked to work with situations and information presentations that are not extremely simplified. One weapon in the interface designer's set of tools is to design training programs for older people that allow them to develop the skills needed for working with software that they otherwise would be defeated by. What was examined in the FileTutor project was how to tackle training older people in levels of skill that were regarded by experienced teachers of older people as difficult to acquire. The result is an example of how to extend the range of software that older people can use and understand.

In designing the FileTutor interactive tutorial the same design process used with WinTutor was followed. As before I consulted widely with experienced SeniorNet tutors before starting the project in order to choose an appropriate topic. As before I worked with in-house testers who contributed to the day to day development of the design. Two differences in the process were that firstly I was consciously aiming for inclusion of the project in the thesis writeup and so I was more analytical about the successes and failures as individual screens were designed. The second difference was that an evaluation of the usability of the tutorial was undertaken at the end of the development. The form of this evaluation was quasi-experimental in that the older people recruited for the evaluation were recruited from people who had tried and failed to learn Windows file management by a variety of means. They used FileTutor to learn Windows file management and then, a day after training, completed an exercise outside the tutorial environment to see if they had in fact achieved useful skill levels.

There was also a change in the content of the tutorial. The WinTutor tutorial was aimed at simple skills that were general throughout computer use under the Windows operating system. The FileTutor tutorial also covered general skills and concepts, this time related to file management. However the FileTutor tutorial was also intended to be an example of training older people in the use of a moderately complex application, as stated above this would potentially extend the ability of designers to make widely used software available to older people.

To return to the issue of finding a way of training older people to use a complex application there had been interesting work done by John Carroll looking at how to improve the training of younger people so as to improve their eventual competence in mastering a complex application. Carroll et al.(1990) showed in a series of studies that ruthlessly simplifying the information initially presented to trainees so that they learnt a very restricted but core sub-set of application skills meant that over time their eventual performance was significantly better than the performance of students who were initially taught a wider set of application skills. In arguing for such restricted training approaches as “the minimal manual” and the “training wheels” version of an application (where many options were deliberately unavailable) Carroll made a case that initially restricting instruction to simple core information meant that the learner emerged with a more robust conceptual model of the application which then provided better support as the learner later proceeded to investigate further options on their own. This work had been done with young people as the subjects of the studies. It appeared to be of interest to see if the same effects would hold for older trainees.

Thus in order to see if Carroll's findings could be extended to older people the tutorial included a training wheels version of Windows Explorer specifically designed for older users and the evaluation of the usability of the tutorial included a section where the participants were asked to apply the skills they had learnt within the tutorial and the training wheels version of Windows Explorer to an exercise done with the real life version of Windows Explorer. The results supported the argument that an initial reduced instruction set as suggested by Carroll was appropriate for older trainees.

1.6.6 Application design for older users – Chapter 6 and the SeniorMail study

The last stage of the research for the thesis was aimed at clearly establishing the utility of the design approach that had emerged in the previous two design studies, to a relevant application for older users. An email application was chosen as the design target since this offered the chance to design a reasonably fully featured application that older people would see as relevant to their needs and interests. The system that eventuated was called SeniorMail. As in the previous two design studies, research was carried out to examine the context in which older people would be likely to use email and the likely needs of older users. Focus groups and discussions were carried out with older users and potential users of email in a variety of settings. Some older people were observed using standard email software, this gave useful insight into current difficulties. Focus groups were also used to get information from the supporters of older email users, this gave valuable additional information relevant to the design aims for an email application for older people.

In-house testers were again used as a core part of the development and they again gave rapid feedback, virtually on an as-required basis, influencing much of the design. There was, however, a worry that the in-house testers would become too familiar with the overall gestalt of the application as it emerged and so loose their quality as naïve users. Therefore the concept of in-house testing was extended to include groups of people who wanted to become users of the new email system as soon as the very early versions became functional. This gave the designer a further set of motivated testers who could be relied on to show an involved interest in how changes and developments would affect the usability of what would become “their” system. A number of observations were made as to what techniques led to useful prototyping and useful gathering of usability information. These observations and the implications for a design approach to be used when developing with older people are examined in Chapter 8.

At one level the aim of this design study was simply to provide an email system that older people found easier to use than standard email systems, in particular MS Outlook Express which was the system that I found older people attempting to use. At another level the design study was intended to support the case that usable design for older people could result from a design approach that combined sensitive use of older people in the development process with knowledge of many of the relevant effects of aging. To show success on either level there needs to be some form of evaluation of how well the system lets older people carry out emailing tasks. This evaluation was carried out with a group of 25 older users who were volunteers at a local Citizen’s Advice Bureau and found conventional email difficult to use. The results supported the argument that the SeniorMail design study had succeeded and these results are reported in Chapter 6. As this evaluation was carried out in a short time frame, under an hour per person, the chapter also notes the experience of a small group of long-term older users of the system who retained enthusiasm for it. However the chapter also reports the response of a group of middle aged users who, while they found the SeniorMail system easy to understand and use, did not want to adopt the system as it failed to provide sufficient features. This disparity between the feature sets likely to be used by older and younger users is seen as an important issue in the whole area of designing for older users.

Chapter 6 proceeds to describe the features of the SeniorMail system at some length and to examine how they have been derived from a consideration of the information from the literature review in combination with the feedback from the extended team of older testers. It is noted that the system makes use of the ideas developed in the previous study on training older people to use complex applications and in fact contains its own training wheels version within the application. This was used to train volunteers in how the system should be used when evaluating the usability of the system.

1.6.7 The research methodology – Chapter 7

Note that the research methodology emerges from reflection on what worked as a greenfields investigation was carried out, hence the unusual positioning of the research methodology chapter after the chapters describing the research. The research methodology is a product of the investigation, not a primary driver of it.

The opening sentence of this introductory chapter describes the aims of the thesis in the following terms, “This thesis looks at the issues involved in designing software that older people can use effectively”. As initially conceived this implied a framework of relatively traditional design guidelines; use big fonts, use simple layouts etc. As my research proceeded and as I reflected more on what was happening in the design studies this concept broadened. It became clear that the inclusion of older people in the design process was central to the success I was achieving. Slightly less obvious, but equally important, was the way in which the older participants were included and the relationship between the older people contributing to a design and the designer.

This process of reflection on what I was achieving led to two sets of understandings about the process I was engaged in and about the outcomes of the research. In the first place I had developed a structure for addressing the research aims of the thesis, this is described in the methodology chapter and will be outlined here. In the second place I had developed a useful body of experience in working enjoyably, ethically and productively with older people on interface designs. This is addressed in Chapter 8.

The methodology chapter opens by examining the lessons to be learnt from the Dual Task pilot study. As previously mentioned the failure of the Dual Task pilot study to support the dual task hypothesis and the distress and low motivation of the older subjects led to me rethinking the direction of my research. The arguments for this change of direction are examined here. The question then became if an experimental approach was not going to meet the aims of the research what methodology was in fact suitable? The chapter starts the process of addressing this question by restating the aims of the overall research as a way of focusing on the question of what methodology would be appropriate to meeting those aims.

Having spelt out the research aims, the chapter proceeds to look at a variety of candidate methodologies; quasi-experimental research, case studies, ethnographic approaches and action research. It is concluded that while elements of each of these approaches are useful in supporting the research aims, none in their basic form meets the specific needs of the research aims of the thesis. The research methodology that was eventually used is then described showing how it draws from the candidate methodologies that have been described.

The chapter next looks at the way in which the research incorporates the information from the literature on the effects of aging together with the observations made in the design studies and the supporting activity surrounding those studies. Finally the rationale of the format used within the design studies is examined in terms of the research methodology. It is argued that the development of a methodology for addressing the research questions of the thesis is one of the valuable outcomes of my research.

1.6.8 Working and designing with older users – Chapter 8

A further valuable outcome from the overall research is the experience in working productively with older people in creating designs for older users. This is reported in Chapter 8. The position taken is that while interaction with older people is a vital part of the design of artifacts for older people, constructive interaction with older people around technology issues is not obvious, simple or likely to be undertaken successfully on the basis of a designer's or supporter's usual patterns of interaction.

There was a further benefit for the overall research that arose from the WinTutor design. I had two close friends who were not computer literate, had tried to become so and had failed. They were in jobs that now required them to use computers in the near future. They knew of my interest in training older people and half jokingly suggested I train them. I blithely went to see them, expecting that a half hour clearing up misconceptions would have them on track and self supporting. What I discovered was a puzzling inability to learn that closely paralleled the problems I had been observing in the Unitec courses for older beginners. These people were intelligent, articulate, self aware, in their mid fifties and worked from home close to where I worked and could easily take short breaks during the day. They badly needed computer skills. After discussion we came to an agreement that they would help me field test the screens I was developing for WinTutor on a daily basis and that as they did so I would assist in their learning of computer skills. In effect they became in-house testers for the project and surrogate older users. The concern that they might not really represent older users was reduced in so far as they showed some of the same behaviors predicted from the literature survey and seen in the Unitec classes. In addition the eventual product, WinTutor, which obviously owed a great deal to the in-house testers, was found to be very effective with much older people.

This in-house testing agreement became a very useful and mutually rewarding arrangement. The in-house testers ended up with the skills they needed. I ended up with an insight into how transformative it was for me to have immediate responses to my design ideas from older learners. As a computer experienced designer I could not shake enough of my preconceptions about what should be obvious. I repeatedly produced initial designs that met with incomprehension and frustration from my in-house testers. This could arise from either my way of presenting computer concepts or from my interface designs. There was another benefit in the relationship. These were old friends, they did not treat me as an unapproachable authority figure, they were volubly cheerful in pointing out my and my program's failings. This was a vital contrast to the deference shown the tutor in the Unitec classes. As we built up experience in working together I came to increasingly value their insights into what was lacking in a prototype screen, they on their part came to see that their suggestions were resulting in useful changes and that some of the problems they found with gaining computing skills were not ingrained (and blameworthy) aspects of who they were but were amenable to well designed training. This experience became the prototype of the format of including older people as participants in the design process that was used and refined in the FileTutor and SeniorMail studies. This design process is discussed in Chapter 8. It also became an independently developed way of working with older people that strongly matches the UTOPIA model and hence adds some support to that model, especially given the success in developing useful applications for older people that has come from the use of my approach. This is discussed in Chapter 9.

Chapter 8 starts by giving a bulleted outline of the approach to doing interface design with older people and then moves to considering typical problems in working with older people. It looks at the gap created by the differing experience of (younger) designer and older person. It looks at the issues related to the lack of respect accorded to older people in our society. One of the problems here is that older people may well “buy into” a view of age as implying that they are insufficiently competent to tackle modern technology such as computing. In a related issue older people are likely to defer to those they see as more authoritative and this is likely to include the interface designer or developer. The problem here is that this undermines the communication of problems the older person experiences with a design and communication of ideas the older person may have for improving a design. The chapter notes that there are stereotypical and unproductive patterns that younger people fall into when trying to communicate with older people, the use of so called “elder speak”.

In the light of these concerns the chapter considers how a researcher or designer should care for the older people who are part of the designer’s team and design resources. After summarizing the set of issues to be dealt with the chapter provides extended coverage of each issue in turn. The chapter looks at issues such as older people’s need to avoid being subjected to time restricted tasks if realistic optimum behavior is to be obtained. Variations on standard information gathering techniques are considered so that interviews and questionnaires are less likely to create miscommunication due to the older people’s lack of familiarity with apparently common technical terms and potentially due to power imbalance between researcher/designer and the older person. The problem of selective sampling is also addressed.

The chapter then turns to specific techniques that were found to be useful in my experience of developing designs with older people. Variations on needs analysis when addressing an older target group are considered. Initial concerns in creating the basic designs are discussed. This includes discussion of the argument that low fidelity prototypes are less appropriate for older users. It also examines the creation and maintenance of a good working relationship with in-house older testers. Usability test cycles involving older people are considered and the value of establishing a pool of long term testers is looked at.

One of the problems in working with older people is that the potential power imbalance between researcher/designer, as well as older people’s tendency towards deference and politeness can mean that older people are not well protected from unethical treatment. Nor is it always immediately apparent what constitutes unethical treatment of older people. Therefore the chapter concludes by devoting a section to considerations of how to achieve ethical treatment of older volunteers.

1.6.9 Parallels with the UTOPIA approach – Chapter 9

The approach to research design and to productive and ethical work with older people has strong parallels with the important approach to research on the design of technical assistance for older people that has been developed by the UTOPIA team centered on the University of Dundee and headed by Alan Newell. This is interesting and important since my own work was done without my being aware of the UTOPIA research. The network of citations I pursued in largely American journals did not reach widely into English and European work. In an ideal world I should have been aware of Newell's team and their work in considering dynamic diversity and inclusive design at the beginnings of my own research. I would then have been in a position to build my work within the framework of the considerable insights that they provided on working for and with older people. However by proceeding independently of Newell's team and yet coming to very similar positions on research and design approach it can be claimed that I have contributed to strengthening the case for both positions.

In this light Chapter 9 provides a detailed examination of the stance involved in Newell and his co-workers' position statements on dynamic diversity, inclusive design and appropriate ways of working with older people and makes a point by point examination of the similarities and differences with the approach I have developed. A very high degree of agreement between the two approaches is demonstrated and the chapter concludes that my own work can justifiably be seen as an independent verification of the UTOPIA approach all the more so in that both approaches have led to successful product development for older people.

1.6.10 Conclusions – Chapter 10

The thesis concludes with an examination of how the various studies have built towards the development of a design approach for working closely with older people as part of designing products for older people. In the course of this review of what the thesis has achieved the twin themes are the way in which insights during the research have contributed to the design approach and the way in which the results of testing the design cases with older users has provided support for the design approach. Inevitably a wide ranging thesis of this nature raises numerous questions and so the conclusions chapter also considers areas for further research that appear relevant in the light of the current work.

1.6.11 The appendices

There are five appendices that either provide further information related to the study or are intended to provide useful summaries of information contained in the study as resources for designers intending to work in this area.

Appendix A gives further information on the demographic shifts as developed countries move to a population with a higher percentage of older people.

Appendix B provides the test protocol used for evaluating the FileTutor Study.

Appendix C provides the test protocol used for evaluating the SeniorMail Study.

Appendix D provides a summary of the changes that occur during aging and appear relevant to the concerns of an interface designer. In effect this is intended to give a reader easy access to the main findings of Chapter 2 but shorn of the discussion and citation of the research studies on which Chapter 2 is based.

Appendix E also provides a summary, this time of the age related interface features that were implemented in the three designs used in the case studies. The aim here is not primarily to provide a designer with a set of firm guidelines for dealing with interface design for older people, in different designs different approaches may be appropriate. The concern here is to gather together the design features from the three successful design studies as a set of examples that may help future designers to consider how to proceed from a knowledge of the effects of aging and a design problem so as to work with older people towards a successful design.

1.7 The Contributions of the Thesis

The thesis has taken a significant problem on a world scale and has applied a greenfields approach to it resulting in a wide ranging body of useful work and resources for approaching the area of interface design for older people. At the time the thesis was done (1998-2002) the HCI community did not appear to be involving itself with a vital problem. See Czaja (1998), Hawthorn (1998a) and Czaja and Lee (2003) for backing for this contention. There was limited published research on the issue but it was obvious that there would be a rapid shift to a much older population with a need to engage with computing. Hence the thesis was conceived in terms of crisis research where the aim was to open up the area over a broad scope rather than to provide exacting support for a single narrowly defined proposition.

Accordingly the contributions of the thesis cover a broader scope than would normally be expected for a PhD thesis. The contributions can be considered under several headings; opening up a new area of interface design, providing resources for designers for older users, providing an approach to be used when designing for older users, findings on training for older users that are relevant to designing for older users, support and extension of other worker's findings and finally a contribution to research methodology.

Opening up a new area

1. The thesis research has helped open up a new and important area in which there was little extant work at the time of the research. (This contribution was achieved by publishing the work as it was done at the times when it was relevant so the contribution is ascribed to the research rather than to the thesis.)

Providing resources for designers for older users

2. The thesis provides a useful resource sumarizing the potential impact of aging effects on the interface design needs of older users. This has been done by an extended examination of, and reflection on, the interface design implications of the literature on physical and cognitive aging.
3. The thesis provides a picture of the elderly novice that should assist designers in this area.

4. The thesis provides three exemplars of designing effective interfaces for older users, giving information on the design considerations involved, the design approach and the level of effectiveness achieved. This is important because there are few, if any, examples of application design for older users that have progressed beyond the prototype stage. It is also important in that Newell's team found that designers appeared to be at a loss as to how to proceed when they were exposed to the actuality of older users.

Providing an approach to be used when designing for older users

5. The thesis suggests an extension of traditional user centered interface design that can be adopted when working with older people. The value of this extended approach is supported by the success of the designs described in the case studies.
6. Based on reflections on what worked and what did not in the author's own experience as an interface designer for older users, the thesis gives a set of strategies for managing the relationship between younger designers/researchers and older participants.
7. The thesis explores the role of the designer as an outsider to the culture of the elderly and ways of working that accommodate to this. In effect the thesis contributes to an understanding of the needs of applied ethnography when working with an older target group.
8. The thesis demonstrates the usefulness of high levels of participation by older people in interface design for this group and relates this to the differences between (young) designers and the target older population.
9. The thesis develops a picture of just how broad is the range of issues that can usefully be considered in designing for older users.

Findings on training for older users

10. The thesis demonstrates the value of appropriately designed interactive tutorials in assisting older people to learn computer skills and applications. Further the thesis provides guidance on features that contribute to appropriate design of interactive tutorials. I see this as a finding of considerable importance to people who are trying to integrate older people into a workforce. It also breaks new

ground in that it suggests an alternative approach to the current favorite of accessible design.

Support and extension of other workers' findings

11. The thesis extends Carol's findings on the use of "minimal manuals" and "training wheels" versions of an application to the teaching of older users. (This is relevant to designers for older users since the complexity allowable in an age appropriate design can be increased by providing inbuilt, age appropriate interactive tutorials.)
12. The thesis has provided independent support for the UTOPIA approach.

Contribution to research methodology

13. The thesis has developed an eclectic and wide ranging research approach that allowed the range of contributions given above from a greenfields beginning.

The thesis provides a comprehensive survey of the research literature on aging covering the abilities of older people that are relevant to interface design. This picture of aging is extended and enriched by reporting experience with older people in a variety of computer related contexts. By reporting observation of, and interaction with, older people, the thesis establishes a picture of the current target group for those wishing to design for older computer users. The thesis then provides the reader with three case studies of design for older people carried out as part of the research. These designs are shown to be successful in terms of older users being able to use them where they have not been able to use standard forms of training and applications in the same areas. The designs are described in some detail and the rationale behind the designs is examined so that a designer is provided with examples of converting from academic knowledge of aging to workable designs for older people.

In the course of selecting areas for the interface design cases used, the thesis looks at two examples of interactive tutorials aimed at training older users. Not only did these tutorials provide the author with extensive experience in design for older people that strengthens the basis from which the information in the thesis is presented, but the work on interactive tutorials opens up two areas of older people's learning of computer skills that are of importance for a designer. Firstly the WinTutor tutorial looks at the sorts of gaps that are likely to occur in older novices' skill sets and makes the point that some older users are likely to remain at novice status, a fact that designers need to allow for if they are going to target a wide range of older users. Secondly the FileTutor case study makes the point that with appropriate training older people may be able to work with some software that is not only poorly designed for older users, but that they have previously failed to learn while using standard approaches to learning designed for the younger population. This is important given the tendency of both managers and older people themselves to write off their ability to master computing skills. The two case studies on interactive tutorials also contribute useful ideas and working demonstrations both on overall design for older people and on the suitable design of interactive tutorials for older people.

The third case study covers developing an email application that older people have been shown to find highly useable. This study showed that the techniques used in the tutorial development could be extended to developing a more typical application with a moderately complex feature set and system structure. It also provided a third replication of the general design approach so that the reader is provided with more than one example in which this approach has been found to work.

In the course of designing the interactive tutorials the importance of working with older people in an appropriate manner became increasingly obvious. Use of contributions from older people became central to the design approach. It is argued that designers inevitably design from a perspective of users somewhat like themselves, but that this assumption is invalid in the case of older people because of the extent of the difference that aging creates between designer and target audience. This difference and the resulting gap between designer and target audience is extended in the case of the current older generation with their generally minimal computer skills. What the thesis has argued strongly is that bridging this gap demands working with older people as part of the design team, rather than the designer working in isolation merely using guidelines about the needs of older users. What the thesis also argues is that for a younger technically knowledgeable person to work on interface design with representative older users is not a simple undertaking. It requires a new set of skills in working with older people. Since considerations of how to work with older people as distinct from what to provide for them, may not be central to the thinking of a designer new to this area the thesis provides a careful analysis of the issues to consider in working with older people and enabling them to make useful contributions to the ongoing design process.

Overall one of the key contributions of the thesis is to show that the knowledge required for successful interface design for older people is multifaceted and covers fields that may not be initially thought of as part of a designer's brief and skill set.

Chapter 2 Design Implications of Physical and Cognitive Aging

2.1 INTRODUCTION

This chapter of the thesis provides a survey of the literature on physical and cognitive aspects of aging and considers the implications of these effects of aging on interface design. In the original versions of this chapter, published in 1998 and 2000, there was almost no extant literature that specifically addressed interface design for older computer users see Czaja (1998), Hawthorn (1998a) and Czaja and Lee (2003). In the absence of an extant literature the decision was made to ground the thesis in the existing (and wide) literature on the effects of aging. The situation has now changed and there are now a number of publications in the area of interface design for older computer users. However since details of interface design are dependant on the particular computing environment the users face, any particular recommendation about such things as mouse use can become less relevant as the technology changes. What is less subject to change is the nature of human aging, although here too better understanding of the aging process is leading to lessening of the severity of the effects of aging. It still seems that there is a case for maintaining the original focus and considering the most obviously relevant effects of aging, discussing the possible implications of these effects for interface design and incorporating the newer findings on suitable design for older people within this discussion. One of the other points that will be brought home by maintaining a focus on the effects of aging rather than research specifically on interface design for older people is the sheer breadth of the changes that aging involves and hence the range of aging effects that may prove of relevance to a designer.

Another way of looking at this is to see each of the differences that aging makes between younger and older people as a break in the in-built assumptions of (younger) designers that they are designing for someone who is generally similar to themselves. Hence these age related differences are areas that require deliberate consideration by designers if they are to design effectively for a group so unlike themselves.

The chapter will use the structure outlined in Table 2.1 below.

Table 2.1 Organization of the literature survey chapter

1. Introduction
2. Methodological issues in aging research
3. Problems with interpretation of Research on Aging
4. General aspects of aging, slowing and recruitment
5. Vision and Aging
6. Speech, Hearing and Aging
7. Motor control and Aging
8. Memory and Aging
9. Attention and Aging
10. Cognitive ability and Aging
11. Learning, Training and Aging
12. Conclusions

The next sections of this chapter (2.2 through to 2.4) look at some of the methodological issues and some of the problems with interpretation and application of the studies in the remaining sections. The aim is to make it easier for a reader without a background in this area to be aware of the limitations in interpreting and applying this research.

The chapter then looks at the main areas in which relevant effects occur, giving a brief survey of findings and then considering the possible implications and relevant findings from research on interface design for older people. In these sections that describe specific effects of aging (sections 2.5 through to 2.11), the sections will each be split into a general discussion of the findings within this area of aging, followed by a bullet point summary of the main findings, followed in turn by a discussion of the way in which these findings may have implications for interface design for older users. Thus in each of these sections the material will be structured in the following manner:

2.5 Vision and Aging

2.5.1 Studies of vision and aging

Review of findings on vision and aging

Summary of age related changes in vision

2.5.2 Possible effects of age related changes in vision on interface design

Vision and Text - relevant changes

Vision and Text - design suggestions

Vision and glare - relevant changes

Vision and glare - design suggestions

…etc

Reviews of the changes that aging makes to the human factors impacting design can be found in Scheiber (2003), Klein (2003), Morrell et al. (2001), Hawthorn (2000) and Carmichael (1999). Well written guides to general design for older people including interface design can be found in Charness and Schaie (2003) and Fisk et al. (2004).

2.2 Methodological issues in aging research

As Rybash et al. (1995) point out studies on aging are particularly subject to confounding effects. This section of the chapter looks at methodological issues in aging research which mean that it is difficult to make authoritative research based statements about aging. The studies which will be cited in later sections of this chapter are part of a lively debate as to what exactly does happen to human abilities with age. The points in this section on cohort versus longitudinal studies and on controls needed in experimental studies on aging, as well as the points made in Section 2.3 on factors to consider in interpreting research findings on aging are useful in interpreting the sections surveying the general research on aging.

2.2.1 Cohorts vs. longitudinal studies

Most studies of ability and aging are cross-sectional, comparing two or more age groups at one point in time. As well as age, each group reflects the shared history of the group and hence the changing patterns of the society. What appears to be an effect due to aging may, on closer examination, be due to the increased years of education for each generation this century, due to changing patterns of mental and physical activity in work or leisure, due to changes in nutrition or to some other factor. A cross-sectional study showing decreasing performance with age on some cognitive task may show no such effect when the level of education of the subjects is controlled for. Rybash et al. (1995) and Permutter and Hall (1985) argue that for studies of aging and memory or cognitive performance, control for educational level is virtually mandatory.

Longitudinal studies attempt to counter the problems of cross sectional studies by following the performance of the same set of individuals over time. There are fewer longitudinal studies due to the extent of time and commitment required. Longitudinal studies of ability and aging tend to show smaller effects due to aging than cross sectional studies, Rybash et al. (1995). However part of this tendency may come from methodological problems in the longitudinal approach. Following the same set of individuals over time has two effects, the subjects are being trained in test taking and the study deals with those subjects who remain in the study. A problem is that elderly individuals with impaired cognition may be more likely to drop out.

Rybash et al. (1995) state that the problems of longitudinal research tend to overstate the ability of the older groups while cross-sectional studies are more likely to exaggerate the decline in function with age. However, even this may be questionable since the typical control for cross sectional studies is in terms of number of years of education and over this century prolonged education has changed from an elite pursuit to a mass movement. Groups of widely differing ages with the same years of education may have had quite different initial abilities. Rabbitt et al. (2004) looked at the effects of correcting longitudinal results for practice effects and for dropout effects. They conclude that interpretations of longitudinal studies of cognitive aging are misleading unless effects of practice and selective drop-out are considered. When results were adjusted for practice and drop-out effects they revealed accelerating declines in fluid intelligence and cumulative learning, linear declines in verbal free recall, and no substantial change in vocabulary. Socioeconomic status and basal levels of general fluid ability did not affect rates of decline. After further adjustment for demographics, variability between individuals was seen to increase as the sample aged.

As Charness (1988) points out, the methodological problems which beset the field occur because chronological age is a surrogate variable for a number of poorly understood determining variables which form the biological basis of aging. The manifestations of biological aging are further modified by the nature of individual adaptation to these changes. Individual adaptation in turn reflects the individual's history, part of which is common to a cohort. With cross-sectional groups selected for participation in some activity, such as computer users or marathon runners, one is looking at a selection effect where those who remain in the older group are those who are able to, or chose to do so. The older group is in effect a group of survivors, therefore examining their performance understates the problems of aging individuals who fail to remain within the group. If we wish to understand the impact of age on interface design it may be worthwhile to design studies which examine the reasons for which individuals avoid, reduce or move away from computer use.

2.2.2 Controls needed in experimental studies of aging and computer use

We next look at some of the controls required if we are to design studies of computer use and aging. There are some controls that are standard in studies on aging such as controlling for health, medication and eyesight. Salthouse (1996) states that controlling for the general slowing of response time found in older people is required in any study that wishes to make findings on response times for specific abilities. Otherwise as Salthouse (p40-41) points out the apparent link between age and an ability using response time as the measure is open to the interpretation that any effect shown is simply due to the general slowing of processing speed found in older people. Work by Gilbert and Rogers' (1996) makes it clear that training effects persist for longer in old people, older people take considerably longer to reach asymptotic performance indicating that training has been completed. Studies seeking to eliminate training effects should be designed to allow for this.

When we look for controls more specifically related to computing rather than aging we meet the question of levels of expertise. People who have areas of expertise seem to maintain performance in these areas as they age but to show declines typical of the general population in areas unrelated to their expertise. See for example Charness (1988) on aging and chess playing. Computer users cover a wide range from novice to intermittent user to expert and it is worth considering if the level of skill and experience affects performance as users age. While length of experience with computers is relevant it seems probable that several other factors will affect results. In particular controls should be established for the type and variety of experience and for frequency of computing use. It seems reasonable that any proposed study of computer use and aging should consider the subjects' depth of computing background which provides the basis for abstraction and expertise. Researchers should also consider how closely the subject's computing background matches any test environment. Are subjects experienced for example with a command line or a WIMP/GUI environment?

Charness (1998) points out that in their unpublished studies of older adults performing word processing tasks, that breadth of computer experience was an important mediator of age effects on performance. Because of this Charness suggests cohort effects are probably the most relevant issue for understanding future age effects for computing. Future cohorts of old adults will surely have had a great deal of experience with computers (though they may have even greater problems with obsolescence of knowledge if they don't stay engaged). So current research may lie within a relatively narrow window in time where older adults are particularly disadvantaged in using computers. However full breadth of experience with computers lies in the realms of computer expertise and expert users will probably be a small subset of all users even decades from now.

In common with other studies of the effects of aging on skilled performance, the older groups actively involved in computing are likely to be unrepresentative of the general population due to self selection, those who meet significant age-related problems are more likely to withdraw from the pool of computer users. It might be worthwhile to select subjects on a basis unrelated to computing such as membership of service clubs so that the study can sample responses from non computer users. Such studies could then, as suggested above, examine the reasons for which individuals avoid, reduce or move away from computer use.

2.3 Problems with interpretation of Research on Aging

2.3.1 Individual Variability

Results on aging tend to be expressed in terms of average declines for the age group and variances. This is misleading where older populations consist of sub-groups with disabilities on different abilities rather than distributions showing a strong central tendency about the mean. It is worth remembering a comment by Oldaker (1992) that old people are among the most stereotyped groups in our society and yet in fact show the greatest internal variation of almost any group. In any aging population many of the individuals will show declines on a few specific abilities, but on different sets of abilities in each case. Spirduso and MacRae (1990) point out that descriptions of average behavior become less accurate as the age of the group being described increases. Heart conditions, poor eyesight, reduced memory, stiffness and all the other manifestations of aging do not advance uniformly throughout the population but apply apparently at random to individuals who retain good functioning over many of their other abilities. Statistics of central tendencies do a poor job of reporting this. See for example the study by Schaie (1990) reported later in this chapter which shows this pattern for individual differences over different types of mental ability. The effects of age are highly idiosyncratic and the average picture may in some cases be false for many of an aged sample.

Decline in finger-tapping speed (Dixon et al. 1993) is an example of such an average finding. To establish the relevance of slowed finger-tapping for interface design it may be important to know whether this is a widespread moderate decline among the aged group or whether the average decline for the group represents near normal performance for most and seriously impaired performance for a few. As the aged are likely to have more health problems we can also find mixtures of performance patterns for health reasons. For our finger-tapping example this might be a general slowing of neurological function overlaid by a significant subgroup suffering from the onset of arthritis and possibly other groups in which finger-tapping is slowed for other causes. Our final concern is for interface design that makes reasonable performance possible for a wide cross section of the population despite the uneven distribution of problems such as finger-tapping speed.

2.3.2 Plasticity

Plasticity is a term used to refer to changes in performance in the face of practice, training or disuse. This is another potential problem in interpreting apparently authoritative statements of decline in specific abilities with age. The impaired performance of older people can show marked improvement with practice or decline with disuse. A general statement about decline in finger-tapping ability based on apparently competent research results has an air of authority but it does not in fact tell us the extent to which older adults can expect to retain or regain finger-tapping ability if this action is important to them, as in for example double clicking or typing.

Krampe and Ericsson (1996) emphasize the importance of recent practice in maintaining skills for older pianists. Also see Salthouse (1984) for work on the retention of expert typing skills. Presentation of results in the face of plasticity is something of a balancing act. The bald statement that an ability declines by x percent between the years of 30 and 60 can cement a self fulfilling expectation of such a decline into the minds of doctors, employers and the aging themselves. On the other hand in a wide-ranging review qualifying every observation with cautions about plasticity becomes repetitive and distracting. It should also be borne in mind that the underlying causes of decline in performance with aging can potentially be compensated for with new discoveries in drug treatments, training methods or general care of ourselves. Normal aging is a dubious concept. We tend to accept it for intellectual and statistical convenience.

2.3.3 Ecological validity

Much of the research knowledge on the psychological effects of aging is based on extending standard psychological tests to aged groups, see Rybash (1995), Birren and Birren(1990). Though these tests are traditional in psychometric literature they present subjects with atypical, simplified, stand-alone tasks in an unfamiliar environment. It is not certain how far one can generalize findings based on tasks such as figure rotation or list memorization to performance on real life tasks where the task is familiar, done repeatedly and done within a supporting and meaningful context in which the person may well have a different level of motivation. If we accept that there are changes in ability with age the questions become; how strongly such changes are manifest within the work and home environment, how well individuals are able to adapt their behavior to compensate for such changes and how the environment might be made more supportive of such adaptation. However see Diehl et al. (1995) for studies showing good correlation between lab tests and some everyday tasks.

2.3.4 Interconnection of effects

Considerable work is done in pure research on aging to separate the effects due to different aspects of aging. One of the issues in theoretical aging research is to tease apart the separate contributions of physical and neural aspects of aging. Thus in studying aging and vision there is an effort to understand the contributions of deteriorations of physical structures in the eye and to distinguish this from possible impairment in the brain's ascending visual pathway, which in turn should be distinguished from visual effects due to declines in higher cognitive function involved in interpretation and ascribing meaning to visual stimuli. However when we consider the application of findings on aging and vision we return to a situation where all the interconnections between the various levels at which aging can apply to vision are present concurrently. There needs to be some caution in applying findings that arise in the course of pure research aimed at clarifying a hypothesis about aging to the much less controlled situation of an older person in front of their computer where many effects can come into play at once.

2.4 General aspects of aging: cognitive processing and recruitment

2.4.1 Reductions in cognitive speed and cognitive capacity

Reductions in processing speed are the most widely established finding in research on aging. Salthouse (1996, 2004) has shown that the cognitive factor of processing speed accounts for a significant amount of the variance in almost all measures of aged performance. There has been debate as to the cause, with discussion of reduced efficiency in neural transmission and consideration of the costs of re-routing neural signals through an age damaged network.

What is important from the perspective of an interface designer is that older people can be expected to take longer in actions that require cognitive processing. The extension to this is that most human activities of interest to a designer do require cognitive processing so that cognitive slowing effects can be expected to show up in areas of activity that may initially appear to be physical such as vision, hearing and motor control. Note, though, that recent work challenges the idea that cognitive slowing is global and offers instead that view that cognitive slowing is task dependant, see Ratcliff et al. (2003) and Thapar et al. (2003).

It is also argued that aging is associated with declines in cognitive capacity, see Salthouse (2004). However it should be noted that it can be hard to give precise definitions of an overall concept of cognitive capacity as distinct from capacity in specific functions such as short term memory span, see Wenger and Gibson (2004).

2.4.2 Recruitment

Increases in the areas of the brain activated while undertaking a particular task are typically seen in brain imaging studies comparing older people with younger people. This is assumed to indicate compensation for diffuse neuron loss in aging. One view, the recruitment hypothesis, posits that diffuse neuron loss in aging is associated with transient (i.e., task demand associated) use of additional circuits to aid performance. Another view, reorganization, posits that neural decline in aging prompts the consistent use of alternative brain circuitry as a means of compensation for failing circuitry. Nielson et al. (2002) suggest that recruitment and reorganization may be better seen as aspects of the same thing and in this chapter evidence of greater brain activation by older people will be referred to as recruitment. Wu et al. (2005) point out that since recruitment means integrating the activity of larger areas of the brain, task performance that relies on recruitment is less effective. Hence recruitment may be an aspect of the general finding of cognitive slowing noted above. Recruitment is not universal in older people, Cabeza et al. (2002) carried out a brain imaging study that compared young adults with low performing and high performing older adults. Interestingly the low performing older adults showed similar activation patterns to the young adults with no evidence of recruitment. The high performing older adults activated extra areas of the brain in addition to the areas activated by the younger adults. There are possible implications from this. If as seems increasingly likely, recruitment is not organized on the fly but requires reorganization of brain function over time, then older adults maintaining intellectual activities are more likely to accompany this by recruiting additional areas to assist them in their pursuits in spite of generalized neuronal decline. This offers the possibility of a mechanism underlying the “use it or lose it” maxim for successful aging.

2.5 Vision and Aging

2.5.1 Studies of Vision and Aging

Progressive visual impairment is one of the more clear-cut areas of decline in performance with aging. See Kline and Scialfa (1996) for a recent review. Fozard et al. (1977) suggest that aging affects vision at two levels. One level of changes becomes apparent between 35 and 45 though actual decline may have started much earlier. This level is largely the result of reductions in the eye's ability to accommodate to near focus and reductions in the amount of light transmitted to the retina. Effects from this level of changes include the need for reading glasses in one’s forties, increased sensitivity to glare, reduced sensitivity to color and the emergence of problems with depth perception. These problems continue and worsen in later years but a second level of changes becomes noticeable between 55 and 65. These changes reflect changes in the retina and the nervous system and include reduced visual field, problems with dim lighting and reduced ability to detect flicker.

Somewhat more than 10% of elderly suffer from seriously impaired sight due to one of three degenerative diseases; glaucoma, cataracts and macular degeneration. The presence of these diseases increases sharply in extreme old age. Desai et al. (2001) report that half of those over 65 have sufficient opacity of the lens to meet the formal definition of a cateract condition. At the other end of visual ability about 10% of elderly above 80 retain 20-20 vision, Rybash et al. (1995). The remainder of elderly adults show various levels of non pathological decline both in the ability to perceive visual sensation and in the way in which these sensations are processed. However not only does vision generally decline with increasing age but the visual defects of advanced age are less likely to be able to be satisfactorily corrected with prescription lenses. The level of such intractable visual defect is reported to be around 14 percent of people in the 70-79 age group but increases to over 30% of those over 85.

Near vision

The most widely noticed problem is the reduced ability to adapt the lens of the eye sufficiently to allow focus at short distances, a problem which emerges in the early forties and is compensated for with reading glasses. The eye also becomes slower to adjust to shifts in focal depth. These problems arise because of increased stiffness of the lens and some atrophy of the muscles responsible for adjusting lens curvature, see Kuwabara (1975).

Visual acuity

Visual acuity declines, this is the ability to detect fine detail as measured by letter recognition on the familiar optician's or Snellen chart. The pupil becomes smaller with age (this increases focusing power but decreases the use of available light.) In addition the lens yellows letting less light through to the retina, the effect of these changes on visual acuity can be partly compensated for by increasing the available light. Pollack and Atkeson (1978) point out that the decline in visual acuity after age 50 is much greater than would be predicted purely from the changes to pupil size and lens yellowing. However other retinal changes occur, Fozard et al. (1977) report on metabolic changes in the retina with age and Schieber (1992) reports that there is a substantial decrease with age in the number of cone’s in the fovea at the center of the retina and suggests that this contributes to loss of visual acuity. Weale (1975) provides an extended exploration of possible reasons. There is a peak of visual acuity between 15 and 20 years followed by a steady decline to age 60 with a slight acceleration in decline after age 60, Richards (1977). Gittings and Fozard (1986) report that with corrective lenses a majority of individuals retain 20/40 vision into their 80s. However Salthouse et al. (1996) show that there is still a decline in corrected visual acuity with age. Rybash et al. (1995) point out that measures of visual acuity are taken under fixed conditions providing strongly illuminated stimuli and hence may overestimate subject's ability to make visual discrimination under more usual conditions. Kline and Scialfa (1996) p32 cite findings indicating that the reduction in acuity with age significantly worsens in dim light even among older subjects who were visually equivalent to younger subjects in well-lit conditions. See also Haegerstrom-Portnoy et al. (1999) who confirm this and note that this can be extended to low contrast visual stimuli. From this report high contrast acuity is reasonably well maintained on average, even into very old ages High contrast acuity is reasonably well maintained on average, even into very old ages. Standard visual acuity testing, Haegerstrom-Portnoy et al. found, underestimates the degree of vision function loss suffered by many older individuals under the non-optimal viewing conditions encountered in daily life. All spatial vision functions show a similar rate of decline with age of the population, but the age at which decline begins varies among different measures. West et al. (2002) report that the failure rate for all vision functions and physical performance measures increased exponentially with age. Standard high-contrast visual acuity and standard visual field tests showed the lowest failure rates. Nonstandard vision tests that could be more representative of actual living situations showed much higher failure rates. Poor performance on many individual vision functions was significantly associated with particular individual measures of physical performance in activities of everyday living. Kline and Scialfa (1996) cite numerous recent studies which indicate that some of the decline in vision associated with aging is due to decline in functioning of both neural pathways and cortical functioning. Salthouse et al. (1996) support this by showing in three studies that the relation of impairment in corrected vision to age occurs via a factor related to cognitive functioning rather than directly with age.

Contrast sensitivity

Contrast sensitivity is measured by the ability of individuals to detect differences in illumination levels usually in lines forming gratings of differing fineness. This has been argued to provide a more sensitive and realistic measure of visual ability. Owsley et al. (1983) reported a significant decline in contrast sensitivity comparing 50 year olds to 20 year olds and the decline increases again by age 80. Kline and Scialfa (1996) provide references to a number of later findings confirming and extending this. Age-related losses are not as great for wide gratings which Kline and Scialfa suggest test real life abilities similar to detecting a truck in fog.

Glare sensitivity and dark adaptation

There is also increased sensitivity to glare with age. Glare results in the older lens scattering significant amounts of light onto areas of the retina that are away from the line of the incoming light, resulting in a “veiling luminance” over the back of the eye decreasing the contrast available for images, reported in Shieber (2003). This means that where strong lighting is used because of its generally beneficial effect on older people’s visual acuity, the lighting needs to be arranged with care so as to minimize glare. Schieber (1994) found that after exposure to 10 seconds glare older subjects took around 2 seconds to detect a low contrast stimulus that they could comfortably detect under normal conditions. Middle aged subjects took about 1.2 seconds to recover while young subjects took around .98 seconds. Schieber's concern is with loss of contact with oncoming vehicles at night but there could be interface implications for older users in both increased sensitivity to environmental glare and difficulty with marked contrasts in screen lighting levels between successive screens.

Glare problems are distinct from the problems older people experience with dark adaptation. The overall reduction of light to the retina and possibly changes in retinal metabolism reported by Fozard et al. (1977) mean that the eye is slower to adapt to dim conditions and the level of dark adaptation achieved decreases, Domey et al. (1960). Older people are slower to recover losses in visual sensitivity after being exposed to glare from sources such as oncoming car headlights.

Color discrimination and detection

There is a decline in color recognition under normal lighting starting at age 20 and becoming marked by age 70. The loss of ability to distinguish colors is particularly concentrated in the shorter blue green wave lengths. Helve and Krause. (1972), Lakowski (1973). Color recognition in dim light is worse for older people and particularly so for short wavelength light partly because of the differential filtering on blue/green hues of the yellowing older lens.

Critical flicker frequency

There is a decline in the frequency at which subjects can detect flickering as opposed to reporting a steady light, known as the Critical Flicker Frequency declines, see McFarland et al. (1958). A related phenomenon also reported by Mcfarland et al. is persistence, the sensation of continued presence of the stimulus after presentation of the stimulus has ceased.

Motion detection and estimation

Older people appear to be less able to detect minimal motion by objects they are observing and may give more cautious estimates of speed of real life objects Kline and Scialfa (1996).

Depth perception

The ability of older people to make accurate estimates of depth declines. According to Bell et al. (1972) there is only a slight decline up to 40 years but after this there is rapid decline in depth perception through to age 70 which corresponds to the oldest subjects in the group studied. Gittings and Fozard (1986) found little evidence of decline with age in the threshold at which people can detect depth differences. However this is not inconsistent with reports such as that of Wright and Wormald (1992) showing an increasing frequency for older people of failing to notice depth differences.

Useful-field-of-view

The effective visual field becomes smaller with age. This means that peripheral stimuli must be stronger and/or closer to the center of the visual field to be detected, Cerella (1985). Ball et al. (1993) found that a composite measure that they term Useful-field-of-view (UFOV) had a strong relationship to driver history of crashes in the previous five years. UFOV measures the percentage reduction in the useful visual field. It depends on at least three measures; duration of target presentation, competing levels of task demand from a peripheral target location task and a central target identification task, and the salience of the peripheral target. The UFOV declines with age. However linear modeling showed that other measures including chronological age, cognitive status and visual sensory function had minimal predictive ability on crash history. Visual acuity shows greater declines with age in the peripheral visual field. Critical flicker frequency also appears to decline more sharply in the peripheral visual field, Casson et al. (1993).

Pattern recognition and identification of differences

The overall processing of visual information and the recognition of patterns appear to be slower with age Kline and Szafran (1975), Fozard et al. (1977). There are declines in several of a person's abilities to make sense of what is seen. The ability to recognize figures that are embedded within other figures is reduced, Capitani (1988). There is a decline in the ability to recognize objects that are fragmented or incomplete, Salthouse and Prill (1988), Frazier and Hoyer (1992).

Older adults are slower to identify whether two objects are the same or are different. While younger subjects were faster on a comparison task if there was a match (the two stimuli were the same), older people were equally slow on match and mismatch decisions and slower overall. Older subjects showed a greater benefit from redundant information. Gottlob (in press). However findings by Ratcliff et al. (2003) and Thapar et al. (2003) indicate that speed differences in identifying differences may be task dependant. Over two sessions older people remained slower than younger people and less accurate in identifying whether two letters were the same or different. However when the task was switched to identifying whether two patches were of the same or different brightness older people became as fast and as accurate as younger subjects by their second session.

Visual Search

Older people do not perform as well on location tasks when trying to locate a target figure in a field of distractors Plude and Hoyer (1986) or on visual search tasks when trying to check if a figure is present amidst distractors, Madden and Plude (1993). Hommel et al. (2004) found that older people had worse performance on visual search tasks involving search for a feature or for a conjunction of features. The performance of the older group was particularly impaired on target-absent trials and with increasing numbers of distractors.

However on filtering tasks where the subject must identify a figure that is always in the same location with or without distractors there is little or no difference due to age, Farkas and Hoyer (1980). This is extended by Carlson et al. (1995) who showed that in visual search of text, consistent target location not only eliminated age-related effects due to neutral distractors (shown as xxxx) but also nearly eliminated effects for meaningful distractors. Without consistent target location there were effects from both the presence of distractors and from the meaningfulness of the distractors. Age differences in visual search are also dependent on how visually distinct the target is from its background, Plude and Doussard-Roosevelt (1989). Older people appear to benefit more than younger people when presented with advance cues indicating the future location of a visual search target, Kline and Scialfa (1996). However older people appear to learn visual searches at the level of the specific targets presented and unlike young people they do not show transfer of learning to new searches where the specific examples have changed but the catagories have not, Fisk et al. (1997). This is consistent with Underwood et al. (2005) who found little evidence of an age-related decline in the search of a simulated traffic scene when detecting traffic hazards. Traffic hazards are presumably well learnt categories of targets.

Effective visual search requires that saccades (eye movements) be accompanied by remapping of the visual environment such that previously visited positions are not revisited (inhibition of return) and items classified as irrelevant get less visual attention (inhibitory tagging). Langley et al. (2005) suggest that age deficits in inhibition are selective, for example when they looked at visual search in older adults they found no deficit in inhibition of return to positions previously visited but inhibitory tagging of objects that had been previously searched was found to be absent in older people but not in the younger subjects.

In consistent mapping the categories of the target and distractor sets do not overlap while in varied mapping the target and the distractor items are randomly chosen from the same category of items over successive trials. Search through a menu of fonts is an example of a varied mapping visual search. Fisk et al. (1990) confirmed other studies reporting that older people perform worse on both types of visual search, corresponding to a higher intercept for older groups on a plot of response time against number of items searched. Fisk et al. then looked at the slope of response time against number of items. In the consistent mapping condition they found that for older people, the time to respond increased moderately with the number of items being searched, for younger people response time did not change with the size of the search item set. The interpretation was that younger people unitize the display, treating it as a single perceptual item whereas older people do not. For varied mapping the slope of response time against number of search items was large and similar for both groups. Fisk et al. further reported that over both types of search, subjects instructed to respond only if a target item was missing took longer than subjects instructed to respond only if a target item was present. Positive search has clearer end points. Anandam (1994) confirmed that younger subjects after visual search training did not show a display size effect (unitization) whereas older subjects did show a display size effect. However when Anandam restricted the area of visual search to the central 2 degrees of the display older subjects also showed evidence of unitization.

Ho et al. (2001) observed older and younger subjects searching for traffic signs embedded in road scenes previously classed as cluttered or uncluttered. Both groups were less efficient at searching the cluttered scenes. Although the older group made more errors and took longer there was no interaction between age and clutter. Ho et al. found that clutter as such did not appear to specifically worsen visual search for the older group. However later studies have found that older people perform more poorly when searching cluttered scenes. Grahame et al. (2004) performed a study in which eye movements, reaction time and errors were used to analyze performance in a search of web pages for links. It was found that older adults showed additional benefits from increased link size, while they were disproportionately affected by increased numbers of non target links and by the degree of clutter on the page. McPhee et al. (2004) looked at older and younger adults searching for traffic signs in digitally altered traffic scenes in which the level of clutter was varied. Searching was carried out under either single-task or dual-task conditions. The older adults were less accurate overall. This age effect was worsened by high-clutter scenes. The older adults were slower to decide that a target sign was not present. In the divided-attention condition, older adults exhibited longer eye fixations as well as showing a reduction in recognition memory for the content of the secondary task.

Vision in everyday living

Kosnik et al. (1988) found in a large survey of adults from 18 to 100 years of age that older participants reported five areas of concern where visual ability affected everyday functioning; Visual processing speed - the speed needed to read a passage or recognize an object. Lighting - trouble seeing at dusk or sorting dim colors. Near vision - trouble reading small print. Dynamic vision - ability to read moving type. Visual search - eg. difficulty locating products on supermarket shelves.

Summary of findings about vision and aging

Size and contrast

- Harder to focus at short distances
- Less ability to detect fine detail such as small print. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer color discrimination and detection especially in short wave lengths (blue-green)

Searching

- Visual search becomes harder
- Useful-field-of-view declines

- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Older people are less able to filter out irrelevant items
- Less ability to tell if similar objects are the same or different
- Visual search is improved by consistent positioning
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space

Speed of perception

- Reading is slower
- Slower to recognize items but this effect is reduced for familiar items
- Ability to detect small movements declines
- Poorer estimates of speed and time of arrival
- It becomes difficult to read moving text
- Ability to detect flicker declines

Lighting and illumination

- More disrupted by glare
- Slower to adapt to changes in illumination

Perception of 3 dimensional information

- Poorer depth perception and estimation
- Poorer perception of 3 dimensional information

2.5.2 Possible effects of age-related changes in vision on interface design

The possible effects of changes to vision are extensive and suitable adaptations will vary for individuals. Note that the finding by Salthouse et al. (1996) on decline in visual acuity with age <u>after</u> allowing for individuals' use of corrective lenses means that we can expect some level of visual problem to be widespread. In addition tri-focals or graduated lenses are expensive, not all older users will be able to afford them or will be able to learn to use them satisfactorily. We can thus expect that some older users will be perpetually squinting at fuzzy screens, which is tiring and may increase the cognitive effort needed to follow text.

The high level of variability of vision in older people as well as in other indicators of performance means that applications should probably give users greater control over the appearance of the application. Klein (2003) notes that in any interface aimed at older users care should be taken to allow for the variability shown by older people, rather than a “one size fits all” approach Klein suggests that older people need to be able to adjust fonts and other visual aspects of displays to suit their individual needs. This however can run into a catch 22 situation for users with very poor sight where the task of customizing the application is also dependent on the persons' visual abilities. There is however a problem in whether older users will have sufficient knowledge to make such adjustments.

Vision and Text – relevant changes

- Harder to focus at short distances
- Less ability to detect fine detail such as small print. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer color discrimination and detection especially in short wave lengths (blue-green)
- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Reading is slower
- It becomes difficult to read moving text

Vision and Text – design suggestions

The obvious starting point is to use large fonts. Schieber (2003) and Fisk et al. (2004) suggest fonts of at least 12 point. Morrell and Echt (1997) suggested that older adults will benefit from san-serif fonts (with a specific recommendation for Helvetica) that are in the 12 - 14 point range and of medium to bold weight.

The choice of font should be one that is simple, easily recognized and does not rely on fine detail. When saying easily recognized I am arguing for a font that gets full benefit from peoples life-time exposure to text and so lies within the reader’s learnt expectations of what letters “should” look like. Older people with imperfect vision should find it easier to recognize highly familiar lettering. This reasoning is consistent with the recommendations of other authors that fancy fonts, italic text and ALL CAPS should be avoided. My preference is to use sans-serif fonts in particular Arial for screen displays. I argue that given the lower resolution of screen displays compared to paper, serifs (the small lines at the bottoms of letters) are not well displayed and become distracting detail. However for printed text there is an argument that serifs help the reader scan along lines of text.

Such text should be displayed so that it contrasts strongly with the background. Remember that Charness (1988) found reading slowed for older adults if the text was colored indicating increased cognitive load. Strictly this should translate into a recommendation for using black text on a white background. It is not clear from the literature how far a designer can go from this standard while maintaining older people’s performance. White backgrounds may accentuate glare problems so the possibility of pale off-white shades should be considered. Plain backgrounds are essential, older people struggle to make sense of text on any patterned background.

Focusing is improved when pupil size reduces and this can be achieved by a well lit, but glare free, environment and reasonably bright displays. In addition the focusing problems of older people are for short distances, or, when using corrective lenses, for distances between reading distance and long sight. One set of solutions to these focusing distance problems lies in altering the size and position of the screen. Larger screens can be used and placed further away and high enough to be in the long distance field of bifocals (with an appropriate increase in font size). Alternatively smaller screens such as laptops can be placed closer and lower down so that they are in the range of the short distance field of bi-focals.

Morrell and Echt also recommend short line lengths and left justified text. These recommendations were for printed text but it appears that they hold for on-screen displays. In general older people should not be asked to read large blocks of text on-screen.

As vision declines the obvious strategy of increasing font size for captions and general text runs into two problems; limited screen size prevents unlimited font size increases, while the presumed difficulty of older people in integrating complex information from multiple sources limits the extent to which an application can be split into simpler, large font, sub-screens. In addition narrowing of the visual field with age reduces peripheral vision and may make it more difficult for older people to integrate widely spaced parts of a screen. This could possibly affect the ability of older users to benefit from status bar information. This may also affect older people's use of multiple or very large screens as these become more common. An additional effect may hold with large fonts for screen displays of text where the reduced amount of text entering peripheral vision is likely to interfere with an individual's pre-processing of text and will therefore interfere with the flow of comprehension in reading. This effect can be observed when normally sighted adults attempt to use large print books for the poorly sighted.

Problems with recognition of embedded and overlapping figures may translate into a need to provide slightly greater separation between lines of text and to make greater use of white space in the areas surrounding text such as framing and margins.

Text in itself provides a complex background and it may be useful to ask if older users are likely to have target acquisition problems when locating the typical carats currently used in word processing applications. This could be made more difficult if the blink rate for a carat gets close to the lowered critical flicker frequency for older adults. If so, how should the insertion point carat be customized? A slow blinking red carat for example?

Older users should not be asked to work with displays that show moving text. Because of issues with focusing and slowness of adapting to working at differing focal lengths older people will find difficulty in working with a combination of on-screen and printed materials.

Vision and glare, brightness adaptation and environment – relevant changes

- More disrupted by glare
- Slower to adapt to changes in illumination

Vision and glare, brightness adaptation and environment – design suggestions

Screens should not produce rapid sequences of bright followed by dim displays since accommodation to brightness is slower as people age. Fisk et al. (2004) suggest older users will be better served by LCD screens because of the increased display brightness and hence contrast that they offer over CRT screens.

Reduction in the ability of one's eyes to accommodate quickly to changes in focal distance can be expected to make it harder for older users to work from a mix of paper and screen documents. This may already be reflected in the development of tri-focal and multi-focal glasses. Designers of work environments might usefully consider allowing greater choice in distance from the screen to allow for poorer near sight adaptation and the provision of diffuse back lighting which increases visual acuity by reducing pupil size. Klein (2003) suggests that the majority of older people will have difficulty in focusing on objects at an intermediate distance (60 – 100cm) such as automobile dashboards or computer monitors. Klein suggests that particular care should be given to the visual design of such objects.

Older people may have more difficulty with viewing LCD screens at an angle since the visual display quality declines, however Charness (1998) points out that this is less true now that active matrix screens have become more common. As sharing screens is relevant to sharing of information and training it is worth asking if this might also apply to CRT displays where, as the viewing angle changes, standard cues such as letter proportions and spacing are distorted. It is possible that older people are, on average, less comfortable with prolonged use of VDU displays and should incorporate more breaks from screen use in their work schedules.

Vision and graphics – relevant changes

- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Poorer color discrimination and detection especially in short wave lengths (blue-green)
- Useful-field-of-view declines
- Less ability to tell if similar objects are the same or different
- Harder to focus at short distances

- Less ability to detect fine detail. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer depth perception and estimation
- Poorer perception of 3 dimensional information
- Slower to recognize items but this effect is reduced for familiar items
- Ability to detect small movements declines

Vision and graphics – design suggestions

The basic response to the changes above is to design graphics for older people that are simple, do not involve subtle shading or detail and are reasonably compact so that all the important elements can be encompassed in the older adult's reduced useful-field-of-view. Older adults should not be asked to make sense of details using blue-green shadings and should not be asked to detect small differences. The reported problems with depth perception in older people may affect the suitability of 3D graphical information. Kline and Scialfa (1996) recommend that 3D displays provide additional cues such as grid lines that reduce the dependence on pure depth perception but a simpler approach is to ask if 3D graphics are needed or simply regarded by the designer as decorative.

When it comes to animated graphics for older people the changes above imply that older people will be better able to make sense of animated material if the animation is relatively slow and the elements involved are familiar. Again making sense of an animation should not depend on distinguishing small differences or details or movements.

Older users are going to be less able to detect color and contrast differences that are taken for granted by younger users (and designers) as suitable cues for indicating important differences. Becker and Nowak (2003) describe various tools for adapting web site design to suit older users and one of the tools described - The Aging Vision Simulator tool available at http://cob.fit.edu/facultysites/abecker/Accessibility/OlderVision/ColorandAging/OlderVision.html) allows a designer to simulate the effects of the older person's less vivid rendering of color.

Another way that designers can simulate some of the effects of older users' visual problems is to simulate loss of fine detail. Graphics can be subjected to the Gaussian blur test used by Schieber (1998) to examine the legibility of road signs. Those graphics that remain distinguishable when tested under severe blurring are presumably going to remain distinctive and therefore learnable when used by older users with poor sight.

Vision and screen layout – relevant changes

- Useful-field-of-view declines
- Visual search becomes harder
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space
- Visual search is improved by consistent positioning and advance cues
- Older people are less able to filter out irrelevant items
- Ability to detect small movements declines

Vision and screen layout – design suggestions

In general the aim should be for simplicity of layout, Aula and Käki (2005) showed that a simpler visual layout improved older people's performance in a redesign of the Google display of search results. The changes they made emphasized using fewer elements, better grouping of elements and the removal of irrelevant items. Older users may be expected to be more dependent on consistency and simplicity of layout for locating target areas of a form and less able to cope with complex and overlapping or embedded designs. In particular young users appear to appreciate visually complex, if irrelevant, backgrounds while older users are distracted by them.

Since older people in Western cultures still follow the top-down and left right pattern of eye movement typical of Western reading this should decide the basic flow of attention that a screen layout is designed for. The decline in the useful-field-of-view implies that items that follow each other in terms of task flow should be kept closer together than one might need to do for younger users. If a related item is too far away from an older user's current focus it simply may not be seen, or alternatively the search to find it may be disruptive of the older user's overall task focus.

Older users' lack of awareness of visual items that younger users will notice and use, applies particularly to designs that require older users to scroll. Older people are less likely to scroll and more likely to have problems with scrolling. Designing screens and web pages to eliminate scrolling is an ideal but if this is not done then older people appear to have more problems with horizontal scrolling than with vertical scrolling.

The vulnerability of older people to clutter means that screens designed for older people should be drastically simper than screens for younger users. This together with the need to use larger fonts is one of several reasons why effective design for older users will restrict the number of options that can be made available and the amount of material that can be presented on a single screen. Older people's problems with filtering out irrelevant items may be particularly acute when animation or flashing or moving text is present. Animation should be presented so it does not compete with other activities and flashing and moving text should not be used.

The fact that search for items is faster when older people are provided with advance cues may translate into support for the standard practice of a layout that has clear conceptual groupings for task elements. The use made of consistent positioning by older users in achieving faster search results supports consistent positioning of similar elements over all the screens in an application. This is likely to be aided by consistent task flow through the various screens.

Screen changes which indicate completion of a task will need to be both obvious enough to attract notice but not such as to affect the consistency of the older person's model of what is being presented. The reduced ability of older people to detect minimal movement implies that small changes should not be indicated purely by analog indicators such as gauges or sliders. The need for more time to absorb information and slower processing in general may impact on any designs where the time of display is under program rather than user control, the old are unlikely candidates for space invader games or rapidly flashed information.

One of the implicit recommendations in the preceding material is to greatly reduce the need for older users to search for items on any screen. However some searching is always going to be required so it should be made as easy as possible.

Vision and searching – relevant changes

- Visual search becomes harder
- Useful-field-of-view declines
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space
- Visual search is improved by consistent positioning

Vision and searching – design suggestions

The first option is to eliminate visual searches or substitute simpler searches for more complex one's. Where search is required it should take place in limited area or if it is over a large area there should be organizing principles that effectively make the search area a set of several small areas. Search fields should be static and consistent. There should be as few items as possible within a search field and there should not be any irrelevant graphics. Where graphic items are used as search items they should be clearly distinguishable. It seems likely that searching a line of search items is going to be easier than searching a two dimensional array of search items. Searches should preferably be designed so that they have obvious end points, If I am searching for C then A B C D E and A B D E both assist with the search but S W A G B does not. Older users should not be asked to perform searches under limited time conditions.

The findings on visual search support current design practices for simple consistent screen layouts with clearly defined features. They may also offer support for full screen designs rather than designs involving overlapping or tiled forms. However in some situations, such as searching for information on the Web, the user is faced with a wide variety of layouts, this may reduce efficiency for older users. Note a review by Kelley and Charness (1995) which finds that, in several studies, older people's success in learning a new application is correlated with their scores on spatial ability, again this seems an argument for keeping the layouts to be learnt, very simple.

The findings on visual search indicate that while younger users learn to treat the search list as a unit thus reducing cognitive load this “unitization” does not happen for older users and so we can expect visual searches to remain sources of cognitive effort for older users Fisk et al.’s 1997 finding that older people learn visual searches at a specific word level rather than a semantic category level appears to indicate that older people will be more disrupted by version changes which make minor, semantically consistent changes to such things as menu contents. Menus with typically small type and large numbers of competing choices and large collections of icons with the need to search over a wider area than the effective visual field of older people both seem likely to challenge the ability of older people to perform effective visual searches. As noted later menus also lead to motor control issues.

The findings cited by Kline and Scialfa on the involvement of higher cognitive processes in visual processing and its decline with age could indicate that older people may be more sensitive to cognitive load due to poorly designed visual displays. Hence a poor visual design could lead to greater reductions for older users in their ability to cope with the underlying task. This is interesting but remains to be researched. However note that Chadwick-Dias et al. (2003) did not find that text size affected older people’s performance on a simulated web site, while Fukuda and Bubb (2003) found that older people showed significant slowing as measured by eye fixations when font or search target shrank below a size corresponding to fonts below 10 point, (these are below the sizes tested by Chadwick-Dias et al.)

2.6 Speech, Hearing and Aging

2.6.1 Studies of Speech, Hearing and Aging

Speech

Speech becomes less distinct with age, possibly due to reduced motor control of tongue and lips, possibly due to impaired ability to hear and correct one’self or to compare one’self to others. In addition a proportion of the elderly have speech impairment due to strokes. Speech slows with age both from the insertion of more and longer pauses into spoken material and due to word lengthening, Balota and Duchek (1988). The ability to produce words which correspond precisely to experimenter defined constraints declines and the time taken to produce words to precise requirements increases with age, Mackay and Abrams (1996). Older adults speak less fluently with more evidence of language planning deficits such as false starts, hesitations and filled pauses such as um and er or word repetitions, Kemper(1992). They are also more subject to tip of the tongue episodes where a familiar, but infrequently used, word eludes the speaker, Burke et al. (1991), Burke and Shafto (2003).

Hearing

Overall hearing declines with age, about 20% of those between 45 to 54 have some hearing impairment, this rises to 75% for those between 75 and 79 years of age, Fozard (1990). Rybash et al. (1995) quote estimates that 15% of the US population over 65 is legally deaf. About 9% of middle aged adults and 11% of adults between 65 and 74 suffer from tinnitus or ringing in the ears, Rockstein and Sussman (1979). Hearing loss due to aging appears to be from both physical changes to the inner ear such as the loss of hair cells within the inner ear but there is also evidence for neurological changes, this distinction is important in that physical changes in the ear could be compensated for by interventions that improve the available signal, while neurological effects suggest interventions based on training, Shieber (2003). Given that prolonged exposure to noise at 75 decibels (vacuum cleaner) can cause damage to the hair cells within the ear and consequent hearing loss and that workplace regulations have at least until recently allowed levels up to 90 decibels (lawn mower), a significant proportion of hearing loss in Western societies must be considered as due to environmental noise damage rather than due to normal aging. Recent concerns about localized noise levels in headphone's for young music listeners suggests that hearing problems are likely to persist in society even with reform of industrial legislation.

There is usually a loss in the ability to detect tone's over all frequencies but particularly for high pitched sounds. The selective loss of high pitched tone's is termed presbycusis. This is detectable in laboratory tests from age 25 but significant loss is fairly common by age 50 particularly in men, Rockstein and Sussman (1979), Schieber (1992). It has also been reported that older people are less able to discriminate between similar sounds that differ in intensity and /or frequency, He et al. (1998). Older people are also poorer at judging time intervals of sounds and this is worse if the sounds are part of a more complex aural sequence.

Since some consonants in English are high pitched (such as f, s, t, z,), selective loss of high frequencies (presbycusis) means that parts of speech are not heard and the impaired listener needs to guess at meanings. Older individuals may find female voices harder to follow than male voices because of the overall higher pitch. Feldman and Reger (1967) reported that by age 80 people may miss 25% of the words in a conversation.

Older adults also show reduced ability to localize sound and this is more pronounced in individuals with presbycusis or poor speech discrimination, Kline and Scialfa (1996), Shieber (2003). There are problems for older people when dealing with background noise as evidenced by the typical complaint about being unable to follow conversations in noisy groups of people. This may be partly due to physical changes which reduce the ability to attribute direction to sound, see Corso (1977) but is also consistent with many reports of difficulties with selective attention in older subjects. Tun et al. (2002) found that older adults were more impaired than young adults in extracting information from speech given the presence of competing spoken material in the background. Since the younger subjects were more able to recognize words from the distracting stream of speech this implies that the older adults' difficulties can be interpreted in terms of reduced ability to direct attention and inhibit attention to competing material.

Corso also reports that sentences which are meaningful under test conditions are lost when words within the sentences overlap or are interrupted and that, for older people, the ability to obtain meaning from spoken information declines under conditions of stress. Kline and Scialfa (1996) report that older people make more use of contextual clues to identify speech than do younger groups.

Another contributing factor is thought to be the general slowing of processing experienced with age. Calearo and Lazzaroni (1957) found that young adults could understand virtually all of conversation speeded up to 350 words per minute especially if the speeded conversation was somewhat louder. In contrast older people managed to pick up only 45% of the content of such speeded conversation no matter how loudly it was spoken. (Normal speech runs at about 150 words per minute.) Looking at mild speech compression, DeGroot and Schwab (1993) found that older users on an audio menu and instruction system took more time, made more errors on the subsequent tasks that the system had given them instructions for and were less satisfied. Gordon-Salant and Fitzgibbons (2001) confirm that time compressed speech is generally difficult for older listeners. By examining different forms of time compression Gordon-Salant and Fitzgibbons found evidence that the problems of older listeners in recognizing time-compressed speech are associated with difficulty in processing the brief, limited acoustic cues for consonants that are inherent in rapid speech.

Older adults appear to react more slowly to pure tone’s, even when their ability to detect the tone is similar to that of younger adults. Rees and Botinwinick (1971) suggest that this is due to a general caution on the part of older adults which affects reporting of signal detection, as one gets older one is more likely to report a maybe as a no rather than as a yes.

Summary of findings about aging and speech and hearing

Changes in speech for older people

- Less distinct pronunciation with age
- More pauses and fillers such as “um”, “err”
- Harder to produce the exact word for precise requirements
- More tip of the tongue episodes where a familiar word cannot be found

Changes in hearing for older people

- High pitched sounds harder to hear
- Some words are lost when listening to speech
- High pitched voices can be harder to understand
- Harder to work out the location of a sound
- Harder to make sense of speech when there is background noise or competing speech
- Less able to deal with fast speech
- May depend on extra information from lip movements to make sense of speech

- Slower to respond to sound cues

2.6.2 Possible Effects of Age-related Changes in Speech and Hearing on Interface Design

Speech

At first glance speech offers an attractive alternative to forms of input that some older people have problems with such as typing and mouse input.

Speech and using spoken input – relevant changes

- Less distinct pronunciation with age
- More pauses and fillers such as “um”, “err”
- Harder to produce the exact word for precise requirements
- More tip of the tongue episodes where a familiar word cannot be found

Speech and using spoken input – design suggestions

Many older people face major problems with learning to type so the use of voice recognition as an alternative form of input is appealing. However it is not certain that speech recognition software will be easier for older people, see Kalasky (1999) . In part speech recognition relies on the user observing errors and correcting them which will bring into play difficulties older people face in visual search, sustained attention and motor control. Speech recognition software may also need to cope with slower speech from older users, more hesitations, interruptions and filled pauses as well as more audible breathing. There is the problem with reduced articulation among some elderly as well as the disrupted speech of stroke victims. Czaja and co-workers are currently starting work on this problem. It can be expected that some older people will have less control over their speech production, see Morris and Brown (1994), Ryan and Burk (1974), and so may be less able to adapt to the sensitivities of speech recognition software. It seems reasonable that elderly people are more subject to respiratory infection and so have more periods during which their voice is significantly different from the voice the interface is adapted to. It may also be that extended periods of more precise speech are difficult for some elderly people. Finally the willingness of older people to take the time needed for training speech recognition systems is not known, nor is it known whether training times will be longer for older people.

Speech as a control mode for interfaces may meet problems when used by the elderly. In the light of the material on difficulty in speech planning, word retrieval and conforming to a precise vocabulary, use of a verbal command language is likely to be more difficult. On the other hand, Vercruyssen (1996) notes that where single word responses are used to replace manual responses, the age difference in response time found with manual responses disappears.

If elderly people use computers in the same environment as users who use a speech interface there may be problems for the older users because of their lower capacity to filter out distracting noise so that the problem of shared work spaces with a speech interface becomes more acute when older users are involved.

Hearing

Hearing is less relevant to current interfaces but problems with hearing among the older population may affect attempts to design speech based interfaces that compensate for problems with sight or with lack of keyboard skills.

Hearing and detecting sound alerts – relevant changes

- High pitched sounds harder to hear
- Harder to work out the location of a sound
- Slower to respond to sound cues

Hearing and detecting sound alerts – design suggestions

Older adults miss attention getting sounds with peaks over 2500Hz. Commercially available telephone bells and smoke alarms tend to have intensity peaks around 4000Hz which is effective for younger users but these sounds are missed by older users, Berkowitz and Casali (1990), Huey et al. (1994). To design ringers and alarms which are suitable for older users these authors found that the sounds need an intensity peak in the 500-1000Hz range. This means that computer interfaces that use sound to get the users attention will need to use lower frequency sounds for older users. Huey et al. found that a beep that swept a range of frequencies including the 500-1000 range was reasonably effective. This could be transferred into applications that use sound cues to alert users to events so that the sweeping of a frequency range could be used to replace standard sounds. It would be useful to know how well sounds provided by current operating systems fit within these recommendations

If at some later stage binaural sound is used to indicate to users where sound is coming from on a display designers should be prepared for this to be less effective for older people. Although reports presented in Shieber (2003) suggest that older people's problems with localizing sound are worse for low pitched sounds there are problems with using high pitched sounds to aid in localization given the reduced ability to hear high pitched sounds particularly for older men. Older people may be less able to use binaural sound to locate where information is coming from if sound from computer speakers is used to indicate position or it is important to distinguish which of several people are speaking in a video clip. Kline and Sciafla (1997) suggest that performance on localization tasks can be improved by increasing the duration of the sounds involved. It might be useful here to combine sound information with redundant visual information confirming the area to which attention should be directed.

Hearing and understanding spoken output – relevant changes

- High pitched sounds harder to hear
- Some words are lost when listening to speech
- High pitched voices can be harder to understand
- Harder to make sense of speech when there is background noise or competing speech
- Less able to deal with fast speech
- May depend on extra information from lip movements to make sense of speech

Hearing and understanding spoken output – design suggestions

Recorded voice should make use of speakers with low pitched voices. Computer generated speech as output for older people needs to accommodate the likelihood of hearing loss affecting the ability to hear high pitched tone's and the ability to distinguish speech from background noises. Designs which allow for the use of headphone's may be useful.

Smither (1992, 1993) found poorer performance for older adults with remembering and understanding computer generated speech and attributed this to short term memory demands. He found older subjects showed poorer memory for numbers given via synthesized speech and that this effect did not diminish over 78 trials. It has also been claimed that part of the understanding of speech shown by elderly people may in fact be due to unconscious lip reading and hence designers could find that speech from a mechanical source was less intelligible for that reason. Czaja (1996) suggests that the meaning of verbal content may be better communicated to older people if the visual cues used in communication are also made available.

In general a note of caution may be needed in considering the utility of audible material for improving older people's performance. Shieber (2003) notes that while older people "can successfully employ higher order cognitive mechanisms to compensate for age related loss in sensory (hearing) function…what remains to be established is the attentional cost of such compensatory processes". Given that spoken input gives the recipient little control over the flow of new information and given older people's problems with short term memory it seems likely that unless spoken information is carefully designed, useful information in earlier parts of a message risks being "overwritten" by later parts of the message. Zajicek and Morrissey (2001), note that the performance of older people in using spoken information is improved by making certain that messages have a short and simple structure.

Archer, et al. (1996) found for young users that adding voice to text did not improve comprehension but slowed performance while adding text to voice did lead to improvement. However this applied to blocks of text for young adults with adequate eyesight. Older people might benefit more from the availability of a speech option. On the other hand the slowness of speech compared to reading and the lack of user control over the delivery may lead to problems in remembering content since older people are more likely to suffer from interference effects where a stream of facts makes it hard to remember earlier information. There is also the characteristic of spoken information that it does not remain physically present so that going back to refresh one's understanding of some point depends on working memory rather than eye movement.

One can speculate on interfaces where the current fly-over help could be optionally replaced by voice to give brief names or explanations of buttons and other features. Are older partially sighted users able to use spatial / iconic clues to organize and retain the memory of what a button is for provided a verbal explanation is available if needed? It is possible that interfaces of this sort could extend the number of years during which users were able to make use of applications.

2.7 Motor control and Aging

2.7.1 Studies of Motor control and Aging

Ketcham and Stelmach (2004) and Vercruyssen (1996) provide wide- ranging reviews of this area. Vercruyssen states that 70% of Americans over 65 have some degree of restriction of activities due to problems with general mobility ranging from mild arthritis to stroke damage. Reginster (2002) has found around 80% of adult Americans over 65 have some arthritic restriction of movement. With age comes slowing of response times on motor tasks as well as loss of muscle strength and endurance. Control of fine movement declines for older people. Older people show lower peak speeds within a movement, they have reduced ability to control the amount of force applied and the structure of sub-movements within an overall movement changes from that of younger people. Vercruyssen (1996) notes that a number of explanations have been advanced for loss of motor skill and for problems with control of fine movement with age, among them being loss of controlling muscle and neuron groups, reduced ability to inhibit interference from neural noise and a cautious approach to speed-accuracy trade-offs that develops with age, however Vercruyssen does not regard any one explanation as sufficient by itself.

Slowing of movement response

There is general agreement that slowing of response times is common over a range of activities among older people and that this is due to a common factor, presumably reflecting cortical function, see Salthouse (1996). Such overall slowing certainly applies to movement response times for older people with the slowing being more pronounced if the action is more complex and the number of possible choices increases, Goggin and Stelmach (1990), Light and Spirduso (1990), Fozard et al. (1994), Melis et al. (2002).

This slowing can be seen as a result of slowing in two aspects of movement with older people taking longer to pre-plan the movement and then taking longer to carry it out.

Training can provide some improvement in response times. There is little evidence for age-related decline on simple discrete actions which can be planned in advance, Welford(1977), or on real-life, well practiced non-laboratory tasks, Salthouse (1984). Bosman (1996) confirmed Salthouse's 1984 finding that older skilled typists maintained their speed by scanning further ahead than younger typists. However Bosman also found that response time contributed to the speed of older skilled typists. Bosman showed that skill may at times overcome age effects on finger speed but that this was dependant on the context within which finger speed was being measured. Skilled older typists appeared to have faster reaction times than unskilled older typists only on typical typing movements, not on non-standard finger + keyboard movements. Compared with skilled younger typists, skilled older typists appear to be slower in activating plans to translate input into keystokes but to be as fast in executing those keystrokes once the plan is activated. Low skilled older typists appear to be slower than similar younger typists in both planning and executing keystrokes. There is likely to be slowing as a task becomes more complex, Spirduso (1995), or as demands for repetitive speed increase. Dixon et al. (1993) report decline in finger-tapping speed but this is modified by the extent of recent practice, see Krampe and Ericsson (1996). The degree of choice required also affects response time and highly predictable responses may show little age differential.

Changes in movement structure

Older people are generally slower and more cautious when executing movements. They are widely found to be slower in point to point tasks Ketcham et al. (2002). Slowing is also found on a range of other movement tasks as reported by Ketcham and Stelmach (2004), with the extent of slowing increasing with task complexity. With respect to Fitt's law Ketcham et al. (2002) found that slowness of movement was more affected by distance traveled to the target and less so by alterations in the size of the target. For other work on aging and Fitt's law see Brogmas (1991).

A movement can be broken down into sub-components and it is now possible to track such sub-components. Typically one sees an initial first phase consisting of acceleration and then deceleration which takes the subject close to the target. This is followed by secondary correcting movements until the target is acquired. When older people's results from such studies are compared with results for younger people the major differences that stand out are that; 1) younger people produce higher peak speeds, 2) that younger people cover more of the distance between starting point and target in the first movement phase and 3) the acceleration and deceleration within the first movement phase are symmetrical for younger people while for older people acceleration is of relatively short duration followed by a longer deceleration phase, see Figure 2.1

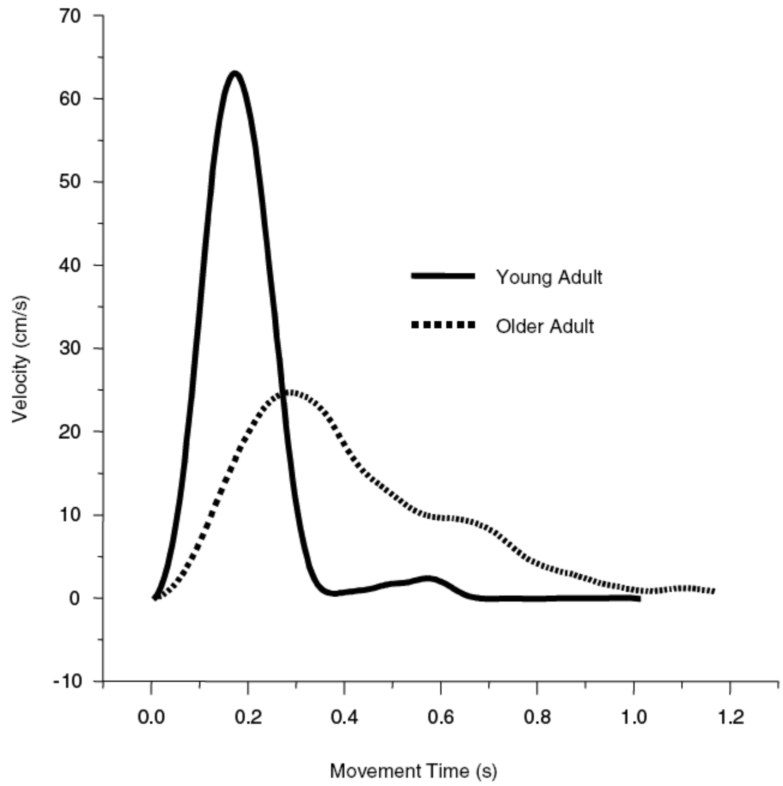

Figure 2.1 Example velocity profiles for an older and a young adult on a point-
to-point aiming task. adapted from Ketcham et al. (2002, p. 56).

From the point of view of an interface designer it is of interest to consider how these differences might change if the older adult is performing a well practiced task. The results from training studies using blocks of repeated trials showed that while older adults did improve overall times this improvement came from the secondary phase of the movement. Training did not help older adults increase the closeness to target achieved in the primary phase of the movement.

Changes in movement control

Walker et al. (1997) confirmed earlier studies showing that older people made more sub movements and were slower in capturing a target with a mouse. Both old and young made more sub-movements as distance increased and as width decreased but there was also a significant interaction between age and distance with the number of sub-movements increasing more strongly with distance for the older group. Vercruyssen's 1996 review also reports that older people may have difficulty in receiving new information during the execution of movements. It seems possible that this corresponds to a greater need for more involvement of higher cortical functions in responding to feedback from movement and planning and controlling subsequent movement.

In general, Ketcham and Stelmach (2004) report that older adults show less accuracy and fine control in executing movements. In point to point movement as discussed above the secondary phase of movement is likely to consist of a number of sub-movements as the older person makes several corrections to direction as they near the target. Not only is the primary movement likely to end further from the target for older people but in addition the trajectory of the primary movement, its peak speed, duration, acceleration to deceleration ratio and the location of the end point is likely to be more variable over repeated trials, Cooke et al. (1989). This has the result that the secondary sub-movements start from different places and so need more attention to result in ending at the target. This is compounded by older people’s slower perceptual speed so that the process of obtaining feedback as the secondary movement proceeds is itself slower. In other words given reduced perceptual speed it is possible for older people to outrun their ability to provide feedback on the progress of a movement.

Ketcham and Stelmach (2004) cite a number of studies that show that older adults have a bias for accuracy over speed. In the study by Walker et al. (1997) subjects were tested under a variety of rules that imposed either a penalty for error or no penalty for error. Older people were more cautious / error aversive in their movement strategies, younger people changed their movement strategy according to the penalty for error while the older group adopted a consistent error avoidance strategy independent of the penalty level. In trials where there was no penalty for error and subjects were asked to make a single movement towards a target as fast as possible younger people were able to move and accelerate the mouse faster than the older group. The inaccuracy (distance from target) of these fast movements climbed more sharply with peak acceleration for the older group which Walker et al. see as consistent with the theory that older people experience more noise in the signals they use for muscle control. Older people in the no-penalty-maximum-speed condition were in fact able to exceed the speeds used by young people in the penalty-for-error-speed-chosen-by-subject condition. However when there was a penalty for error the older group chose to use slower mouse movements. Walker et al. see older subjects producing a movement strategy that compensates to an extent for both their reduced ability to produce acceleration force without noise and their slower perceptual speed. This strategy is seen as successful in that the overall increase in response time is less than would be expected from a linear combination of the observed effects for maximum force, perceptual speed and increased sub-movement. Ketcham and Stelmach (2004) suggest that there is a common sense explanation for such findings. If an older adult has learnt by experience that the results of trying to close directly with a target are unpredictable, so that in reaching for a glass one may in fact knock it over in some attempts, a more workable strategy is to deliberately undershoot and then apply caution in the final approach. Part of what we may be seeing is older people's implementation of a compensatory strategy for having less control over movement.

Other changes in movement

Force production - Older adults are reported as having less ability to control and modulate the forces they apply, Siedler and Stelmach (1996). Older people have poorer control over force production with reduced maximum available force, more variability in the amount of force produced in repeated trials and are also slower to exert peak force. As control over force production contributes to arm and other body movement this carries part of the explanation for the overall reduction in precise and controlled movement described in the preceding section.

Coordination - Older people show reduced ability to coordinate multiple parts of movements such as the arm extension and finger opening and closing that make up a reach and grasp task, see Wishart et al. (2000) and Ketcham et al. (2001). If older adults attempt to increase the speed of tasks such as drawing, handwriting or tracking, performance starts breaking down at lowers speeds than is the case for younger people. Older adults show poorer performance when asked to track a target, Jagacinski et al. (1995). Charness and Bosman (1990) report that older adults have some problems with cursor positioning if the target is the size of letters or spaces in text and they note that this is in accord with a study by Welford (1977) which recommended adding an age correction factor to Fitts' law governing target acquisition. As the number of joint sections increases the difficulty older people find with smooth coordination increases. There is also difficulty in coordinating activities between both hands, particularly as the complexity of the activity increases, Wishart et al. (2000). Light and Spirduso (1990) looking at young, middle aged and older groups found that as well as general slowing of movement response time with age there was also an interaction with the complexity of the response with age. Single digit movement was faster than two-digit movement which in turn was faster than similar movement involving digits on both hands. Sensitivity to movement complexity increased with age. I have not found reports of unintended finger movements during arm movement being more common in older people. However I observe this in myself and in some of the older people I have worked with. This problem could be seen as either difficulty in inhibiting actions or as part of difficulty in coordination arm and finger movements. The consequences are unintended mouse actions; drags may be interrupted by unintended pressure on the right mouse button, clicks may be made while the mouse is being moved and drops may occur at unintended places.

Proprioception is the term for a person’s awareness of body position in relation to their surroundings. Ketcham and Stelmach (2004) have reported studies indicating that older people are less accurate in reporting body position in relation to surroundings and in relation to other parts of the body. This appears to be due to reductions in the effectiveness of sensors in the joints and limbs. Vercruyssen (1996) reports that older adults require more time to verify the accuracy of their movements and slow more following an error than do young subjects. In the study by Walker et al. (1997), both older and younger people took more time to verify that they had captured the target as target size decreased but this effect was stronger for the older group. Older people are less able to maintain balance and are more dependant for visual input in order to maintain balance, Woollacott (1993). Ketcham and Stelmach (2004) note P79 that “during quiet stance, disturbances in incoming information greatly affect postural stability in older adults whereas young adults can quickly and effectively recover from such disturbances”.

Touch sensitivity is an area where there is conflicting evidence but it appears that there is a degree of loss of sensitivity to light pressure on the palms evident in the sixties (Kenshalo 1977) and there is a loss of sensitivity to vibration in feet and hands but this is much more evident in the feet and seems to involve only response to high frequency vibrations, Skre (1972), Verillo (1980). Stuart et al. (2003) found that vibration sensitivity was preserved at the fingertips. Specifically they tested the palmar surface of the end of the middle finger and found that this site showed no significant decline in sensitivity to sine wave vibrations even for a group aged 70 – 90. However arm, shoulder and face sites did show sensitivity declines.

Summary of findings about aging and motor control

- Response times are slower
- Movement is slower
- There is less control of speed, direction and force
- There are more small movements in a larger movement
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets
- Older people are slower to recognize that they have captured a target
- Skilled movement such as typing by experts can be maintained but appears to require more plan ahead strategies
- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk
- Coordinated movement is harder
- There are more involuntary movements
- Less accuracy in knowing one’s own body position
- Poorer balance and more need for visual input to maintain balance
- Possibly less touch sensitivity

2.7.2 Possible Effects of Age-related Changes in Movement Control on Interface Design

Motor performance appears to decline with age and it seems relevant to ask what should be done to revise the interface standards for such things as minimum acceptable button size and timing or elimination of double clicks.

Movement Control and target size – relevant changes

- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets
- There are more involuntary movements
- Less accuracy in knowing one's own body position

Movement Control and target size – design suggestions

Users should be provided with larger targets. This covers a wide range of features including the following. Larger buttons allow older users to click buttons while diverting less attention to controlling the movement. Targets should be clearly separated so that the consequences of overshooting and clicking off target are reduced. Larger fonts in drop down menus will mean that each line becomes a more easily captured target. Older people are likely to experience small target problems at the level of inserting, selecting and correcting text in textboxes at typical fonts used for younger people. Aula and Käki (2005) showed that part of the improvement of older people's performance resulting from a redesign of the Google display of search results came from increasing the size of the text used in the textbox in which the search terms are entered.

Movement Control and mouse skills – relevant changes

- There are more involuntary movements
- Less accuracy in knowing one's own body position
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets

Movement Control and mouse skills – design suggestions

Many older users show sub-optimal mouse skills. Designers should not require older users to double click or to perform drag operations. As always this is not to imply that no older users can perform these operations but that the percentage of older users able to use an interface will increase if these recommendations are followed. The presence of involuntary finger movements in some older people means that clicks and drops may occur without the older person intending such action or at times being aware of doing so. One area in which this becomes apparent is in older users faced with multiple overlapping windows where clicks outside the window boundary can lead to the older user being perplexed as to why a window has vanished and unsure as to how to recover from this. Applications that use full screen designs avoid difficulties of this nature.

Because of problems with inhibition of motor noise older people may have more problems with basic mouse action such as holding the mouse still while clicking or controlling dragging on scrollbars. Fine control of movement is difficult for older users and should be avoided. Pointing devices such as button mice and touch pads which depend on fine control of movement may be difficult for older users to manage. Problems with tracking and with responding to new information presented during movements may cause problems for older people scrolling or using drawing tools in addition to problems related to drag and drop actions.

Movement Control and other aspects of design – relevant changes

- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk
- Coordinated movement is harder
- Response times are slower
- Movement is slower
- There is less control of speed, direction and force
- There are more small movements in a larger movement
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- Older people are slower to recognize that they have captured a target
- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk

- Coordinated movement is harder

Movement Control and other aspects of design – design suggestions

Menus and scrollbars

Menus are an area in which the mouse skills required can be difficult for older users to manage. Here the problems arise from the need for precision in capturing one of several closely positioned targets and, where sub-menus are involved, from the need to follow precise paths or to move quickly in order to move from the main menu item to the sub-menu, Rogers and Fisk (2000) suggest that menus are not suitable in designs for older people. Another problem related to older users' movement control arises with scrollbars which Morrell et al. (2003) notes are a frequent source of disadvantage for older users. The problems here are partly lack of knowledge by older users of the conceptual model of scrollbars but there are also problems in coordinating mouse movement with visual information from the text being scrolled as well as problems with unintended drops of the slider and clicks on the scrollbar.

Timing of motor tasks

It is worth considering the timing of complex physical tasks, do they occur in the midst of other cognitive activity such as composing a letter or do they occur after creative effort has paused? For example scrolling or control-S to save during work have more potential to disrupt cognition in older users, compared with clicking a minute exit button after work has ended despite the greater difficulty of capturing the small target.

Layout

It appears that layout should accommodate the finding of slower, more deliberate movement by older people but it is a matter for research as to how this can best be achieved. In general layout should limit the amount of movement required as well the amount of fine control needed. Thus buttons should be large enough and sufficiently separated that older users do not click unintended buttons. Problems with target size may arise in designs that use controls where the target area is particularly small such as radio and option buttons.

Where very large screens are used or multiple screens joined to make a large virtual screen this will either require more mouse movement to get to distant targets or higher gearing between mouse movement and screen movement, either may affect older users.

Providing redundant information

Given that older people are slower to acknowledge target capture, will they be assisted by redundant information such as a flat button becoming three dimensional when captured or by sound cues? Gottlob (in press) showed adults benefiting from simple redundancy, Jagacinski et al. (1992) showed that while older adults were not as good at a tracking task as younger adults both groups improved to the same extent when an audible tone was provided that gave (redundant) information about position or speed. Jagacinski et al.'s work is probably not support for general use of redundant cues as the effectiveness of the auditory information varied quite specifically with gender and the type of information carried. Female subjects benefited more from velocity information and male subjects benefited more from position information. Again when observing older people in the SeniorMail study there were specific problems with such things as flat buttons since the older people relied on the traditional appearance of a Windows button to assist their search. There may also be a resource competition effect when the redundant information is using the visual channel (showing a change in button appearance) while that channel is also engaged in mouse control. Finally there may be a problem in making use of redundant information about target capture as older people are slower to respond to new input while performing movement tasks.

Typing and Handwriting

Loss of strength and endurance may affect prolonged typing or indicate more care with keyboard design and work procedures designed to avoid occupational overuse syndrome. Typing will slow with age but the findings on retention of learning of sequences of body movements suggest that if previously learned the skill will remain usable, this is confirmed by work on older expert typists, Salthouse (1984), Bosman (1996). What is not certain is how much of a barrier a need to learn to type is for older novice users. It is important to consider how easily older people learn new motor sequences in general and how well they handle learning sequences that conflict with previously well-established sequences. It should also be noted that age has an effect on the speed, sustainability and legibility of handwriting and that this may make the use of a pen based interface more difficult.

New interfaces

These suggestions are supported by two small studies by Charness et al. (1995) in which a mouse was compared to firstly cursor keys and secondly a light pen. The light pen was significantly easier to use than the mouse, cursor keys were hardest to use. Older users showed less difference from young performance with the light pen. Greater difficulty with stimulus response incompatibility for older adults might suggest that a mouse, which maps a horizontal response to a vertical stimulus, may be more difficult for older adults than a touch screen. With a light pen one points directly at what one sees, with the other forms one points to an imagined map of the screen and confirms success by looking at the mouse cursor. Extra cognition seems to be required and the feedback is more indirect. Charness et al. (1995) suggest these points as the basis for the superiority they found for the light pen over the mouse as a pointing device for older users. The differences found are marked but Charness et al. note that the study numbers are small and it is not clear how the extra strain in holding a light pen to the screen would affect prolonged use.

The findings on reduced touch sensitivity and ability to modulate response force with age could have implications for feedback mechanisms such as data gloves. Again Buxton (1996) found that using a mouse in each hand for control of drawing sequences in a designer's drawing tool gave more appropriate ability to express the designer's intentions. However this may be difficult for older people. In general new interfaces and interface tools are more likely to exploit motor skills available to younger users.

2.8 Memory and Aging

2.8.1 Studies of Memory and Aging

Education is one of the few times in life where people actually engage in list learning, the favorite task of memory research, This poses some questions about the real life applicability of research findings on memory. There is general support for memory becoming less effective with age, but the extent of decline varies with the area of memory researched. Memory is a complex phenomenon and researchers have approached memory in a number of different ways over the last three decades. Smith (1996) distinguishes between resource theories, structural theories and stage theories of memory. Resource theories look at the amount of support the environment offers to a memory task and the amount of processing an individual must contribute to the task as well as reduction in processing quality due to age. Structural theories divide memory tasks by time over which memory is required and broad categories of remembering being undertaken. The understanding here is that differing brain mechanisms support each type of structural memory. Stage theories have looked for explanations of memory problems in aging within the presumed stages of encoding, storing and then retrieving memory. There are findings from all these approaches that are relevant to interface design for older people.

Resource theories

Resource theories of memory cover a number of apparently competing explanations for poorer memory performance with aging. Craik (1994) has used level of environmental support versus amount of deliberate processing required to explain the lack of age-related decline in recognition tasks compared with the marked age-related impairment on recall tasks. Implicit memory is involved in tasks where there is no conscious attempt to remember but it can be shown that prior exposure to items improves performance. An example might be filling in the blanks on the words res_u_ce and con_r_te . Here implicit memory leads to the first word being more readily filled in since it has been primed (that is, it was encountered earlier in the text) while the second word was not. Explicit memory on the other hand involves deliberate processing by the individual in an attempt to remember. Jacoby et al. (1993) suggest that most memory tasks are able to be influenced by both familiarity leading to priming and deliberate remembering. However Jacoby et al. found that the implicit component of remembering was not affected by age while deliberate remembering was poorer for older subjects. The context in which an item is encountered while being memorized is important as a cue to later remembering. Older adults appear to have problems in making use of contextual cues if either the context is only loosely related to the target item or there is competing cognitive load during the memory task, Craik and Jennings (1992), Park et al. (1990). Smith (1996) interprets these findings in terms of the older subjects being at a disadvantage to the extent that deliberate processing is required to integrate context and the information to be retrieved. Hasher and Zacks (1988) see the available resources for memory tasks in older people being affected by reduced ability of the elderly to inhibit thoughts which are irrelevant to the task. Resource theories overlap with structural theories in the areas of working memory and perceptual speed that are considered below.

Stage theories of memory

Stage theories of memory consider the stages of encoding, storing and then retrieving memory. There is no support for any difference between young adults and healthy older adults in the way that information is stored in memory or for actual losses of stored material, Light (1990). Rather the problems faced by older adults from the perspective of stage theories of memory lie in the strategies used for encoding and retrieval of memories. It has been shown that older adults tend not to adopt strategies for organizing material to be remembered unless prompted to do so, Ratner et. al. (1987). However if adults are provided with semantic categories to organize learning and are again provided with semantic categories to aid recall the differences between young, middle aged and elderly essentially vanish, Smith (1977), Craik et al. (1987). It was suggested by Perlmutter and Mitchell (1982) that the encoding abilities of young and old do not in fact differ, they claim that what does differ is the spontaneous use of complex encoding strategies by older groups. See also the work by Baltes et al. cited below in the section on training. It is argued that there is little if any decay in the storage of long term memory but that the age-related deficits found are due to problems with recall and to problems with older people using less than optional strategies for organizing or encoding new information so as to facilitate later recall. Springer et al. (2005) using brain imaging found that higher levels of education altered the areas that older people recruited to deal with memory encoding and retrieval and that this corresponded with better performance by these better educated older people.

Touron and Hertzog (2004) looked at older and younger adults performing a noun-pair task. Even when the noun-pair list was learnt in advance older adults were slower to switch to a catagory-based retrieval strategy despite comparable noun-pair knowledge. Young and older adults reported comparable confidence ratings for the accuracy of each memory probe response. However, older adults reported lower confidence in their overall ability to use the category based memory retrieval strategy, which correlated with avoidance of the category based retrieval strategy.

Structural theories

Research based on structural theories of memory tends to see memory as comprising a number of distinct abilities that are brought into play in different tasks. The main distinction is between short term memory, defined as a system for storing and using memory for very recent events (under 60 seconds), and long term memory which as its name suggests is involved in the storage of information over longer periods of time, up to and including the individual's lifetime.

Short term memory is a system for storing information of immediate concern. Within the short term memory system **primary memory** is used to hold the events of the immediate past as well as information just recently retrieved from long term memory. Primary memory is limited in capacity and information stored in primary memory is lost rapidly over time unless it is transferred to long term memory. **Working memory** combined with **executive** control provides a system for temporarily manipulating the information contained in primary memory, see Baddeley (1989).

Long term memory is involved in information storage for periods longer than 60 seconds. Long term memory involves several components, **episodic memory** for specific events, **procedural memory** for holding knowledge of the way in which tasks are carried out and **semantic memory** which holds information about meaning of the components of one's world. Normal aging (excluding pathological conditions such as Altzheimer's disease), produces differing degrees of impairment on the different forms of memory. Different brain sites appear to be involved in different memory tasks, Rybash (1994).

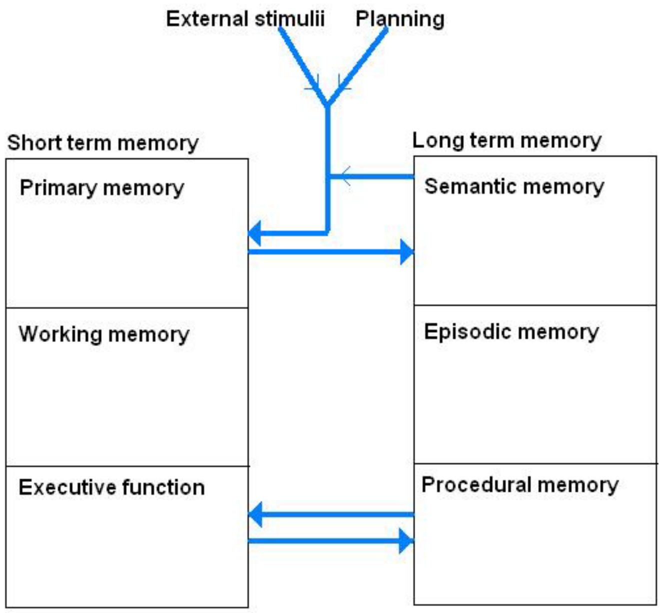

Figure 2.2 Short Term and Long Term Memory: adapted from Schieber (2003)

The short term memory system

Primary memory

Research on short term memory shows only a slight decline in the number of items which can be held in primary memory, an average of around 6.5 items can be held from the 20s through to the 50s but this then drops to around 5.5 for the 60s and 70s, Botwinick and Storandt (1974). Even this may be a cohort effect since Dobbs and Rule (1990) showed that primary memory span was correlated with education level rather than age and general education levels have increased over the last century . We can in general rule out extreme declines in primary memory with normal aging.

Working memory

Tests of working memory show that there is a decline in the ability to engage in processing of the content of short term memory as distinct from simple recall, Salthouse(1994). Dobbs and Rule in the study quoted above found that age significantly affected the ability of subjects who heard a new digit every 2 seconds to answer questions such as "What was the number two back from the one you just heard?". Haarmann et al. (2005) report that older adults have less success in maintaining context awareness on a short term memory task such as responding to the presentation of a target letter but only if it is preceded by a letter denoting a response context. Thus subjects might be asked to respond each time they heard an X in a series of letters but only if the X was preceded by an A. Bopp and Verhaeghen (2005) performed a meta-analysis of findings on different verbal span tasks related to primary and working memory. They found that there are age differences in all verbal span tasks with the size of the age related deficits being greater for working memory span than short-term memory storage span.

Older people are observed to have problems in text comprehension. Light (1990) reviewed and analyzed work in this area, looking at the interrelations between aging, working memory limits, memory for information and verbal ability. Light examines and then rejects claims that verbal ability at the single word level accounts for the observed results. She suggests that the key issue lies in working memory reduction in old age. Light states that this means that it is harder to place later passages in a text in the context of earlier one's where this is needed to understand the later passages. This effect according to Light, is self amplifying, since points that are not understood are harder to remember, both in working memory and in long term recall of the substance of a text.

Executive function and working memory

Salthouse and Babcock (1991) split the effects on working memory into processing and storage components and found that the declines in working memory with age were attributable to the processing component. Howard and Howard (1996) suggest that we will see few effects with age where tasks impose little load on working memory but that as tasks become demanding age-related problems will appear.

The general slowing of cognitive processing with age also shows up in search speed when scanning primary memory, Fisk and Rogers (1991), with both middle aged and older adults taking more time to process each item in primary memory. Studies requiring mental rotation of figures also indicate that processing of visual information in working memory slows with age, Hoyer and Rybash (1992). However slowing of search speeds for short term memory appears to be reversible with training, Salthouse and Somberg (1982) found that after 40 sessions the relation between response time and the size of the set of items held in short term memory had become comparable for young and elderly adults. However an age difference remained in the overall time needed to perform the task. Training can actually increase the gap between young and old in some memory tasks in spite of improving performance for the older group, as younger groups can show more benefit from training, see Baltes and Kliegl (1992).

Salthouse (1996) in a meta-analysis examines ten studies as part of a growing body of evidence pointing to the relation between memory and age being largely mediated by speed of processing. In these studies when the variance due to processing speed is controlled for, the relation between age and memory is markedly reduced. In this 1996 survey Salthouse found evidence for a general factor based on processing speed which contributes to the variance of a wide range of performance measures. This general speed of processing factor in turn is strongly related to age but after controlling for the general speed factor there is little relation between Salthouse's varied performance measures and age. Salthouse strongly recommends that future studies proposing a specific age effect on any timed aspect of behavior should control for processing speed.

Long term memory

Long term memory shows different results with age depending on the tasks involved. Recognition tasks are those where a mix of previously presented and new stimuli are presented and the subject identifies which stimuli have been seen previously. Recall memory tasks involve the subject remembering previously presented items without the environmental prompting provided in recognition memory. According to Howard and Howard (1996) findings of age-related deficits in recall of episodic and procedural information are common but there is generally little age-related decline in semantic or recognition memory until extreme old age.

While studies typically show little if any decline in the ability to perform on simple recognition tasks there are significant age related declines in the ability to recall information, Rybash et al. (1995). This is subject to the complexity of the memory tasks. When learning material contained in stories, interviews or text, age-related declines are also found in recognition tasks, Hultsch et al. (1991), Hertzog and Rogers (1989) and Stine and Wingfield (1987).

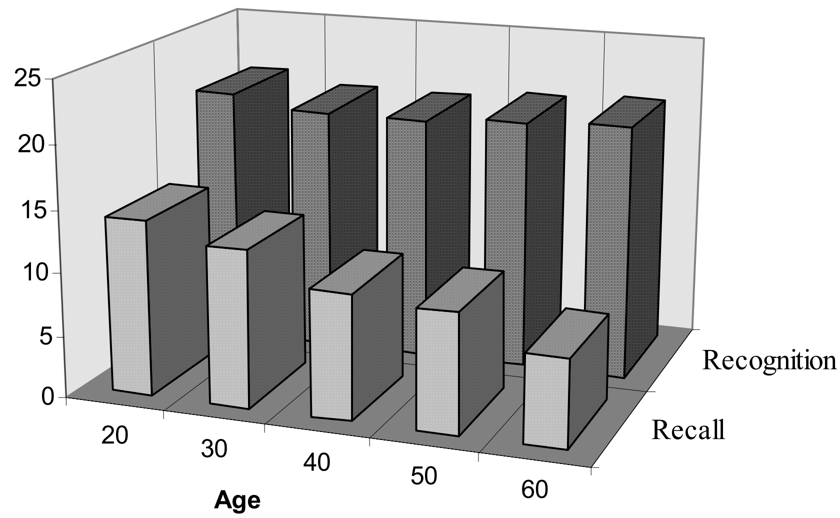

Figure 2.3 Items remembered on recall versus recognition tests with age. Adapted from Rybash et al. 1995. The lack of age-recognition effects may only hold for simple list learning.

An age related decline in the ability to spell words correctly has been shown by several studies, Stuart-Hamilton & Rabbitt (1997), MacKay and Abrams (1998), Burke and Shafto (2003). Typically the words that older people cease to spell effectively are those with a spelling that differs from their pronunciation. The misspellings of both young and older adults usually matched the correct pronunciation (e.g., calender instead of calendar, spontanious instead of spontaneous).

May et al. (2005) tested young and older adults for memory retrieval at the time of day that corresponded with their peak arousal as well as at an off peak time. Memory responses for explicit attempts at recall were better at the time of peak arousal in each group. Interestingly the effects of time of testing on implicit memory were opposite with best performance in implicit stem completion and category generation tasks occurring at the time of off-peak testing.

Procedural Memory - memory for actions

Nilsson (2003) in a review of memory and aging reports that procedural memory generally shows little change across the adult life span but that an age related deficit is revealed with some of the tasks used to assess procedural memory. The findings on skilled performance cited in the section on expertise indicate that procedural memory for motor control tasks requires continued practice if skill is to be maintained.

However, while established procedural memories are reasonably preserved, forming new procedural memories may be more difficult in old age. There is evidence for older people having greater difficulty in remembering which actions they have performed when the actions consist of a set of complex activities. Earles and Coon (1994) provide an example where the activities to be remembered were a set of psychometric tests performed earlier. However Smith (1996) suggests that there are mixed findings as to the ability of older adults to remember which actions they had performed from sets of simple physical actions. Kausler (1994) found that all the studies reporting non-significant differences gave results in the direction of increased difficulty for remembering actions by older adults. Kausler suggests that performing a physical action automatically encodes it and that this explains why there are smaller age differences when recalling which physical actions have taken place than when recalling verbal materials.

Spatial memory and non-verbal memory

Older adults appear to perform worse on tasks which require remembering spatial location, for example which quadrant a word appeared in, Denny et al. (1992) or replacing items in a model, Cherry et al. (1993). Smith and Park (1990) summarized the previous decade of spatial memory studies and found that 12 of 14 studies showed age differences. Gilbert and Rodgers (1999) found that older adults were slower to master a spatial mental model and fewer of the older adults achieved mastery (62% vs 91% for younger adults). Once the older adults had mastered the mental model they made equally effective use of it except for tasks that placed a load on working memory.

Older adults tend to have poorer memory for non verbal items such as faces Crooke and Larrabee (1992) or map routes, Lipman and Caplan (1992). However Park et al. (1990) confirmed her earlier work showing that memory for complex scenes was equivalent in young and old, it appears though that this depends on the consistency of the internal support provided by the interrelated elements of the scenes, Frieske and Park (1993).

Source memory

Source memory is the ability to remember where information was previously encountered as distinct from the remembered information itself. Shimamura and Squire (1991) argue that source memory is a separate system from memory for facts. According to Dywan and Jacoby (1990) source memory shows a decline in accuracy with age. This is confirmed by Simons et al. (2004) who found that age-related deficits were observed on both specific- and partial-source recollection but that there did not appear to be a difference between the age related effects on the two forms of source recognition. Cabeza et al. (2002) compared older adults who were rated as low performing on cognitive measures with high performing older adults and with young adults. Subjects were compared on tasks involving recall and source memory identification of recently studied words. Young adults showed a pattern of activating the right side of the pre-frontal cortex. Low performing older adults showed a similar limited pattern of brain activation to young adults. However high performing older adults engaged areas on both sides of the pre-frontal cortex. The authors suggest that the observed difference is consistent with the idea that high performing older adults recruit extra cognitive capacity to compensate for neural impairment while low performing older adults remain with the patterns of activation used when they were younger.

Anxiety and age stereotyping

Li et al. (2004) found that anxiety worsened performance on episodic and source memory for older subjects but not for younger subjects. In work by Hess et al. (2004) older but not younger people showed altered performance on memory tasks when exposed to implicit versus explicit priming with stereotypes related to aging. Implicit priming with positive stereotypes led to improved memory recall while implicit priming with negative stereotypes led to decreased recall. When explicit priming was used there was an effect due to the strength of the stereotypes. With exposure to subtle stereotypes older people showed little effect but blatant stereotype exposure led to decreased performance irrespective of whether the primes were positive or negative stereotypes. Chasteen et al. (2005) also found that being negatively stereotyped influenced older subjects in a way that increased age differences in memory performance. In addition it was found that that the effects on performance from negative stereotyping were not easily reduced by reframing the task instructions.

Prospective memory

Prospective memory is the ability to remember to remember, to remind one'self to keep appointments, take out the rubbish or take one's medicine. Prospective memory is reduced in elderly people. Einstein and McDaniel (1990) found no problems with older subjects' prospective memory on a simple task where they had to press a key each time they saw a target word during the performance of other tasks. When the prospective task was made more complex such as having several target words to respond to, Einstein et al. (1992) or seeing a beard while looking at pictures, Maylor (1993) then age differences appeared. Age differences are also seen with tasks which require subjects to perform an action every so many minutes without providing reminders, McDaniel and Einstein (1993). Salthouse et al. (2004) looked at performance on four prospective memory tasks and found age related declines for prospective memory. Salthouse et al. analyzed the relationship of prospective memory to other measures and found evidence that there was evidence for prospective memory existing as a valid independent construct after allowing for the fact that prospective memory was correlated with cognitive abilities, such as executive functioning, fluid intelligence, episodic memory, and perceptual speed. Prospective memory was only weakly related to self-ratings of memory and to personality traits.

Einstein et al. (1998) looked at prospective memory in a specifically computer based situation. Subjects did 11 tasks each 3 min long on a computer. They were told to press the F1 key at some stage at least 30 seconds after the start of each task. In one condition the subjects had a reminder note "Remember to press the key" taped to the keyboard. In addition half the tasks were presented under divided attention conditions. Subjects were young - ~20 vs old ~70. Errors could consist of repetition or omission. Subjects were questioned as to whether they had pressed F1 after each trial. Older subjects performed worse than younger subjects. This was most pronounced in the divided attention condition where repetition errors were higher in the older group in earlier trials while omission errors were higher in the older group in later trials. Einstein et al. suggest that older people in later trials may have difficulty in remembering whether a key press had been made in the current or a previous trial. In earlier trials the effect could be due to slower learning by the older adults. The presence of a cue had a paradoxical effect, it gave slightly worse performance overall, this was particularly so for omission errors in the older group in later trials.

McDaniel et al. (2003) confirmed earlier studies showing that when execution of retrieved intentions must be briefly delayed, older adults display deficits in performing those intentions. McDaniel et al. interpret their findings as suggesting that age compromises maintenance of information in awareness. Consequently, when forced to delay execution of retrieved intentions, older adults may rely more on plan reformulation and subsequent retrieval of the intention from long-term memory at the end of the delay.

Memory Training

It may be that, without intervention, older adults persist with encoding and recall strategies that they used and found adequate when young but which are no longer adequate given an aging brain. A study of learning practice effects by Gilbert and Rogers (1996) is of interest because it demonstrates training effects on response time persisting over a very large number of trials. Gilbert and Rogers found that older subjects in a group provided with 960 practice trials maintained an advantage over a control group of the same age which did not undertake practice trials. This advantage was maintained over the next 3600 trials in the study. In younger subjects practice did not provide a long lasting advantage, both younger groups rapidly reached asymptotic performance. This indicates the very long period during which older subjects' response times continue to fall with increased task experience.
Morrell and Echt (1997) suggest that for older but not younger groups learning of procedures given in text is poorer when the text is presented accompanied by superfluous graphic material. However Morrell and Echt also note that where including graphics reduces cognitive load there is a positive effect on accurate learning.

Baltes and Kliegel (1992) put groups of young and old adults through 35 training sessions over 16 months using a method of learning to associate items to be remembered with familiar images from the subject’s life. Both young and old groups in the Baltes and Kliegel study showed ability to improve their test scores with this method. However the young group showed much greater benefit from training and the separation between the groups increased over the training period. Kliegel et al. (2003) looked at inhibition efficiency, memory span and the way that participants structured the material learnt. All these factors contributed to the observed poorer performance of the older group. There was a notable contribution from the subjects’ quality of structuring the learnt material by categories. Kliegel et al. emphasize the importance of teaching strategies for organizing learning material in the context of cognitive training for the elderly.

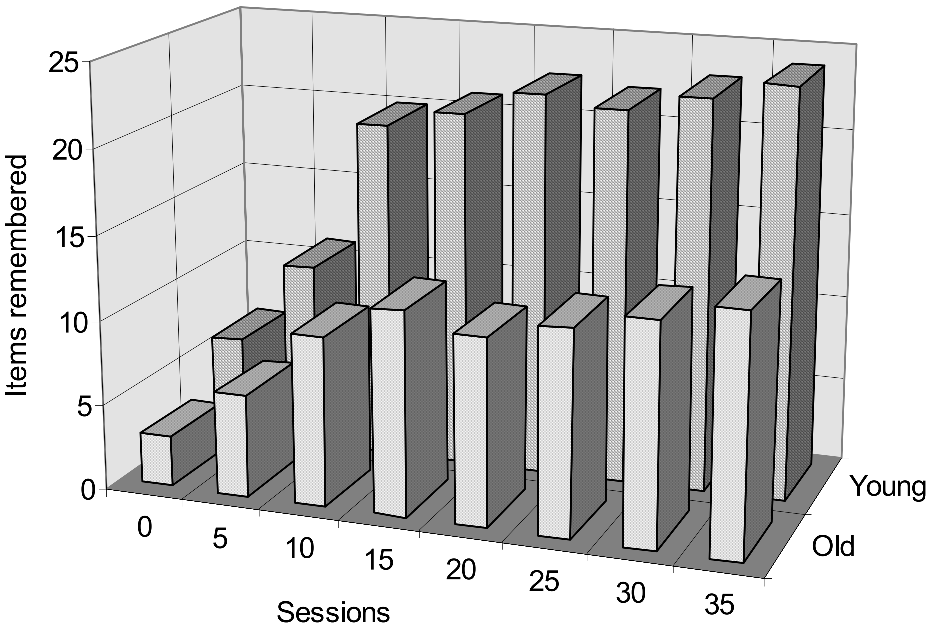

Figure 2.4 Younger subjects benefit more from memory training than older subjects. Adapted from Baltes and Kliegl (1992)

Summary of findings about aging and memory

Short term memory

- The ability to make use of information in short term memory declines
- Older people are slower to recall information from working memory
- One effect of reduced short term memory is in problems with text comprehension, especially for longer or more complex passages

Recognition and Recall from long term memory

- Deliberate recall of previously encountered material becomes harder with age
- Recognition of previously encountered items is not greatly affected if the items are simple
- Older people are likely to use inadequate strategies for learning new material so that it can be retrieved
- Structuring of memories may be worse in less educated older people
- Problems in using context to prompt recall memory as distinct from recognition
- Less ability to inhibit irrelevant memories
- Attempts to recall information are more affected by anxiety

Specialized forms of long term memory

- Spelling of unusually structured words becomes poorer
- Memory for how to do relatively simple things remains
- Skilled motor performance requires practice to retain
- There can be problems in remembering if a job has been done or is still to do
- There is poorer memory of spatial information and other non-verbal information
- There is poorer memory for where information was found (source memory)
- It becomes harder to remember to do jobs at some later point in time (remembering to remember or prospective memory)

2.8.2 Possible Effects of Age-related Changes in Memory on Interface Design

Memory is an essential tool for acting in the human world and for working with human artifacts. Older people will in general work within an application under the burden of reduced memory function. There are a variety of ways an application designer can attempt to assist older users to compensate for this but the core message is that if your users have poor memory then give them less to remember. Simplicity is the central design approach for coping with poorer memory.

Memory, Learning and Cognitive Ability have pervasive and interwoven effects on application use by older people. As such they are harder to discuss separately and harder to make specific design recommendations with respect to particular aspects of computer use.

Learning is covered later in this chapter but for now it is enough to say that partly because of issues with memory older people will be slower to learn, will require more repetitions to learn, will forget more details for a longer period. For this and other reasons a designer should expect some of their older users to attempt to use an application with a more partial knowledge of the application than would be expected of younger users. It is my impression that some older users will retain the status of "perpetual newbies" over a year or several years. One of the design challenges in designing for older people is to design applications for users who may not remember the basics, "Well I have done that, now what do I do?....Oh you want me to click that button with OK on it?"

In younger people cognitive function provides an alternative to memory, if one has forgotten how to do something then it is often possible to use a variety of models of the situation (a task model, an application model and an environment model) to work out what should be done. However because of a degree of decline in cognitive function older people are likely to be less able to construct new solutions in this manner.

One aspect of designing for people who forget, or do not learn, basic application details and interaction idioms is that a younger designer uses these details with little conscious thought. Older users with minimal knowledge and limited capacity to acquire it break a younger designer's fundamental assumptions about what can be assumed of the users they are designing for. Because of the younger designer's unconscious mastery of such detail (and similar easy mastery by the younger users that the designer may have experience with), the designer's assumptions about basic skills and basic knowledge are usually taken for granted. Meeting users who break these assumptions, and carefully designing within the limitations of such users rather than rejecting them, can be a rude shock.

Short term memory – relevant changes

- The ability to make use of information in short term memory declines
- Older people are slower to recall information from working memory

- One effect of reduced short term memory is in problems with text comprehension, especially for longer or more complex passages

Short term memory – design suggestions

If we look at the general roles of memory in computer use we can see that short term and working memory are crucial for detailed control of interaction and for placing action or interpretation of one part of an application into the context of actions or interpretations made in some other part of the application. We can speculate that since older people have more difficulty processing information in working memory this should affect computer use. The role of the application should be to minimize the load placed on working memory and to make it possible for a user to conveniently off load and later recover some of the contents of working memory.

This should also be important where physical slowness or perceptual difficulty means that it takes an older adult longer to complete a task with a consequently increased likelihood of information being lost from short term or working memory. The implication is that older people in particular will benefit from simplicity of interface design both where this reduces cognitive complexity and where the time and number of items that need to be remembered is reduced. We can ask if older Web users are more affected by delays in displaying web pages where they need to relate information obtained from several pages.

It is worth considering if older peoples' problems with text comprehension on paper documents become greater when text is available via a word processor on a VDU display. It seems likely that where scrolling is involved, requiring extra manipulation via a word processor to view the text will create task interference and hence extra cognitive load. Charness (1998) suggests that the visual unavailability of text that has scrolled out of view will mean more bridging is required in memory to relate sections of text when working with long documents in VDU displays. "You can't make return saccades to disambiguate text when its scrolls out of view."

Long term memory, Recognition and Recall – relevant changes

- Deliberate recall of previously encountered material becomes harder with age

- Recognition of previously encountered items is not greatly affected if the items are simple
- Older people are likely to use inadequate strategies for learning new material so that it can be retrieved
- Structuring of memories may be worse in less educated older people
- Problems in using context to prompt recall memory as distinct from recognition
- Less ability to inhibit irrelevant memories
- Attempts to recall information are more affected by anxiety

Long term memory, Recognition and Recall – design suggestions

Remembering how to use an application

Older users can be expected to remember fewer ways of activating features of an application. This means that older users are likely to have to search for the tools that they want to use instead of remembering where to find them. It is also likely that older users will have a less detailed knowledge of what a particular tool does. A design response to this is to have fewer tools (or features) and to provide very obvious visual cues that make it easy to find ways of activating the required tools. The tools themselves should be suitable for using with a limited knowledge of the tool's function.

Longer term memory has numerous roles; remembering actions or interpretations made in some other part of a complex document in the current or a previous session, remembering how to use the program, remembering external data or events which are relevant to the current session and remembering information acquired during the session after the session has ended. The research findings suggest that while long term memory itself is not impaired with age older adults may suffer from problems with strategies for organizing newly acquired material or for retrieval. Here the role of the application may be to indicate useful ways of organizing material and to provide suitable cues for retrieval.

The relevance of source memory here would seem to be in remembering how or where one previously obtained information about a complex and infrequently performed task. Source identification tasks with a computer interface would seem to be mixes of 1. motor tasks – what mouse targets or keystrokes combinations were needed in the past to get to application options, 2. purer source tasks - who told me that, which book, which chapter and 3. verbal memory tasks - what key word will get to this task in the Help system's search engine.

We can expect older users to remember fewer shortcuts, icons and idioms. The design response is to make less use of such items, trying to make an application whose ease of use does not depend on the user finding clever ways of doing things. Older users can be expected to have greater reliance on knowledge in the world so designs should provide clear visible affordances such that older users will both find and correctly interpret them. This may translate into well captioned links and buttons rather than icons and pictorial toolbar style buttons. It also would support a design approach where the information about what to do next appears close to the position at which an older user completes the previous action. It is likely that caution needs to be taken when adding graphic material to ensure its simplicity and relevance, both of which should enhance an older user's ability to remember the relevance of the graphic.

Kelley and Charness (1995) suggest that function keys may be too demanding for older users since they require recall rather than recognition. Menus which provide cues depending on recognition would appear to be appropriate for older users except for the problems noted earlier related to motor control and to visual search. Kelley and Charness see the status of icons as intermediate between menus and function keys. However older people may be more sensitive to proliferation of low quality icons. Common warning symbols had varying levels of recognition for both young (< 40) and old. For a few symbols such as Explosive, Hot, Moving rollers older adults were much less likely to recognise the symbol that younger adults. For other symbols older adults typically showed a slightly smaller (non-significant) recognition rate. (eg Flammable 91% vs 98%), Mayer and Laux (1989). In 1989 both groups had zero recognition of the biohazard symbol. The study was extended to see what actions subjects reported that they would take in response to encountering a warning symbol. Subjects chose from a check list of appropriate actions. Older users were much less likely to check behaviors such as not smoking near an object marked with a Flammable symbol, (17% to 95%) so the authors raise a concern about the ability of older adults to link appropriate behavior to graphic symbols.

As Fisk et al. (2004) point out, paradoxically in some parts of their computer use older people will be more dependant on “knowledge in the head” where they will expect conformance with those conventions that they do know. The examples provided by Fisk et al. include using an upward move or rotating to the right to increase a value, the point made by Fisk et al. is that where the conventions that older people do remember are broken by a design older people will have fewer resources available to discover the new behavior required, in addition older people tend to be more upset and disrupted by what they see as error or inconsistencies.

Obtaining and transferring information

Memory and in particular short term memory is relevant where users are involved in obtaining and transferring information. The situations vary; understanding parts of a document or sentence in relation to other passages or other documents, reading Help documentation, working between a paper source and the screen, cutting and pasting and remembering the content of the passage cut in the course of transferring to the place where pasting will occur, noting and remembering relevant information in a document, re-reading information, making sense of text and diagrams.

In following on-screen instructions a user is engaged in remembering position while making saccades to the area where the information will be applied and back to the information source. This may involve more returns to the source list for older users with their poorer working memory. Design choices to assist could involve making the list items short and clearly written but could also involve making the position in the list easier to remember by numbering the list or by having a position pointer that is moved when a part of a task is completed. Similarly when making estimates from an on-screen graph short term memory is involved in part of the control of saccades from the axes to intersections of values on the graph. As another example it can be shown that performance can be improved for younger users by providing grids and smart graphs that provide mouse over information as the mouse moves over the graph, see for example Hawthorn (1996), similar techniques could reduce the short term memory demands on older users.

It is not always clear how findings on memory should be applied. As an example Fozard (2003) takes issue with asking older people to enter long sequences from credit cards when entering security codes. What I have observed is that in fact older people seem to cope reasonably well given that the codes are usually broken into 4 or 5 digit blocks, at the bottom end of Millers limit of 7+-2 for primary memory. Where memory problems come into play in this example is that older people may not have learnt that the entered code should be devoid of spaces and the lack of spaces in the entered text may make checking harder as one has to remember the segment and relocate a position in a long string. What would help here in my view is that the application should deal with the spaces without generating an error. A possible further refinement is the approach taken when entering authorization codes for installing applications. In this scheme, not only are the numbers grouped but each group of numbers has its own box and the focus shifts automatically as a box is filled.

[1234]   [5678]   [   ]   is easier for people with limited short term memory than 12345678____

With some documents the designer has control over the content and the display. Thus a Help document might follow the recommendations for text understandability for older people given earlier and it might also be displayed within the application in a format where the user can still see the application screen the older user is obtaining help for, so that the older user does not have to remember details from either a paper manual or full screen Help while transferring their attention to the application screen where help is needed. Keeping documents short so that a user does not have to scroll is another design response, the aim being to avoid requiring the user to hold off screen information in short term memory. Another response could be to make it easy to print any text, including error messages. Automatic error message logging could again assist older people, provided that they understood that the message had in fact been stored.

For other documents however the designer provides the container within which they are displayed but does not control the content. It could be of interest to consider if improved tools can be constructed to assist older readers to find and or highlight passages of interest, but such tools themselves imply more tools to be found and skills to be remembered so may not lead to improvements over the wider group of older users.

Although healthy older adults appear to retain most semantic memory the designer should be aware of the possibility that some aspects of long term memory for rules and meaning will fail. An example is the increasing frequency of spelling difficulties with age. Spelling correctly is part of self presentation and hence part of maintaining an older person's self respect. Thus the provision of easily usable spell checking in applications such as email where an older person's writing will be seen by others is a useful step. Such spell checking needs to actively point out errors rather than expect the older person to remember to spell check. The wriggly red underline available in Microsoft Word is an example of this.

Specialized forms of long term memory – relevant changes

- Spelling of unusually structured words becomes poorer
- Memory for how to do relatively simple things remains
- Skilled motor performance requires practice to retain
- There can be problems in remembering if a job has been done or is still to do
- There is poorer memory of spatial information and other non-verbal information
- There is poorer memory for where information was found (source memory)
- It becomes harder to remember to do jobs at some later point in time (remembering to remember or prospective memory)

Specialized forms of long term memory – design suggestions

Remembering where one has been and where to go

In web sites older users have been shown to be poorer at navigating, see Mead et al. (1997). This seems likely to be general, applying to application navigation as well. Navigation skills include holding an overall model of the site or application, holding knowledge of specific locations for finding particular facts or tools, remembering where in the site or application one is currently located and understanding how to move to other parts of the structure.

Ways of reducing memory demands on older users as they navigate may include the following. Making the application structure as simple as possible. Holt (2000) has shown that older web site users are definitely helped by appropriately designed site maps. So application designers could consider providing the equivalent of a site map. One way of doing this may be to make the home base of an application into a set of command buttons that take a user to each of the other parts of an application, with a provision for a sort of sub-menuing where some buttons may take the user to a further screen of navigation buttons. In effect the main screen(s) of an application become a permanently open menu, this reduces the older user's need to remember what options are located in what parts of a menu and to combine searching with mouse manipulation. It may also assist by providing the older user with repeated views of what is effectively a site map (and hence repeated learning opportunities for absorbing the application model). In translating the site map concept to applications it may be useful to clearly identify the destinations available with the tasks to be achieved by going to each destination.

Another way of assisting navigation is to enforce a simple navigation model where progress is essentially linear, either proceeding away from the main menu to options or proceeding back to the main menu. This can be accompanied by consistent location of the buttons or links for achieving relevant navigation tasks, particularly the buttons or links for returning to the main menu. Pages and screens can be captioned in such a way as to make it clear how the page or screen fits into the overall site.

Remembering what has been done and remembering what needs to be done

Older user's problems with remembering if they have completed particular actions and with remembering to remember to carry out actions in the future should be considered by designers. To an extent existing designs already accommodate some aspects of remembering to remember such as asking users if they want to save changes before exiting. However other common prospective memory situations do not allow the application to understand a user's likely intention, for example in the matter of attaching a file to an email before sending it. It becomes a matter of interest in working with older users to identify tasks where users either repeat already completed sub-tasks or fail to carry out sub-tasks and to experiment to find if there are changes to structure or cuing within an application that make such lapses less likely.

2.9 Attention and Aging

2.9.1 Studies of Attention and Aging

Simplistically, attention is the ability to focus on elements needed for the performance of a task. Plude and Hoyer (1985) defined attention in terms of the capacity or energy to support cognitive processing. Shieber (2003) notes that a key characteristic of attention is that it represents a limited human capacity, our ability to coordinate tasks with our awareness of environmental input and stored information can be overloaded. Within the overall topic of attention there are five traditional research concerns; **sustained attention** – maintaining attention over time, **selective attention** – maintaining a focus on relevant aspects of incoming information, **divided attention** – maintaining attentional focus on more than one task simultaneously, the **span of attention** – the spread of information that can be attended to, and **automatic response** – where well learned behavior can proceed without attentional control. There are numerous findings of age-related decrements in performance on a variety of attention-related tasks, including sustained attention, selective attention, and inhibition tasks, Armstrong (1997), Chao and Knight (1997).

Attention, sustained performance and vigilance

Vercruyssen (1996) states that older adults have problems maintaining attention over long periods of time. This is indicated by the increased frequency of gaps in performance in older subjects who are asked to perform response time trials for periods over 10 minutes. Vercruyssen suggests (p66) that tasks requiring rapid or continuous scanning are particularly fatiguing for older adults. However note findings cited by Kline and Scialfa (1996), p37 in the same handbook, that reported no age difference in a vigilance task involving detecting infrequent double jumps on a chronometer display over very long time intervals. Berardi et al. (2001) also found no age related differences in sustained attention. But when Mani et al. (2005) used the continuous performance test to measure sustained attention, they found evidence for age-related differences in performance, particularly for deficits in selective response inhibition.

Deaton and Parasuraman (1988) found differing effects for cognitive versus sensory vigilance tasks. The tasks involved detecting episodes where a pair of numbers were odd and even (cognitive) or different in size (sensory). For young and old vigilance dropped more over time on sensory tasks. Old subjects showed poorer hit rates when cognitive events were presented rapidly (40/min) and had more false alarms on the sensory task. Deaton and Parasuraman found that older users were best at a slowly presented (15/min) cognitive vigilance task though they see older users as less suited for vigilance tasks overall. Interestingly older users gave the cognitive task a higher rating on a subjective workload scale than the sensory task. As the authors point out this means that subjective ratings could lead to a designer picking the type of vigilance task older people are worst at.

Selective attention

In selective attention tasks the subject must extract relevant information from distracting detail, here there is agreement in the literature that the ability to pay attention to relevant information in the presence of distracting information declines with age, Connelly and Hasher (1993), Kotary and Hoyer (1995). In a series of papers dating from 1988, Hasher, Zacks and co-workers have argued that this is because older adults are less able to inhibit response to the presence of distractor items, see Kane et al. (1995) for a summary.

The Stroop interference effect is found where incompatibility between stimulus and response slows response time, for example in identifying the color in which a target word is displayed where the word might be RED and the color in which it is displayed was in fact green. In such cases people have to inhibit the initial well learnt response to the meaning of the word before they can produce the desired response, “Green”. This demonstrates difficulty in inhibiting strongly learnt associations. Vercruyssen (1996) reports that the Stroop effect is accentuated with age. That the Stroop effect is more pronounced in older adults is possibly due to declines in inhibitory control with aging.

Nielson et al. (2002) showed that older adults activate additional brain areas to those activated by younger subjects when engaged in tasks that require inhibitory control. In spite of this older adults achieve poorer levels of success on tasks requiring inhibitory control. Langenecker et al. (2004) using functional magnetic resonance imaging found older adults were slower and made more errors during the interference condition of a Stroop test. The imaging results indicated that the older adults activated more parts of the frontal brain areas in performing the task, thus offering support for the recruitment hypothesis.

Top-down modulation is a cognitive control mechanism that supports both attention and memory by the suppression and enhancement of sensory processing in accordance with task goals. The distinction between bottom-up and top-down forms of attentional control is important in current theories of visual search performance. An example of bottom-up attention is the involuntary orienting to a target item distinguished from nontarget (distractor) items on the basis of local distinctiveness of its display properties (e.g., a red target letter among gray distractor letters). In top-down processing, in contrast, search is driven more by the observer's knowledge and goals than by the properties of the display. Most forms of visual search represent the combined influences of bottom-up and top-down attentional control.

Top-down modulation has been reported to be less efficient in older people. Gazzaley et al. (2005) used functional magnetic resonance imaging to investigate the effect of normal aging on top-down modulation. Their findings emphasize a defect in older people's ability to suppress irrelevant information. They found that older adults had much less brain activation when they needed to engage in the suppression of cortical activity associated with task-irrelevant material while activation for task-relevant activity was preserved. This supports the role of decrements in inhibition in older people's poorer performance with selective attention. A singleton is a search item that is the only distinctive item in a collection of search items by virtue of being the only colored item or by some other distinguishing feature. Madden et al. (2004) compared younger (19–27 years of age) and older (60–82 years of age) adults performing a letter search task in which a color singleton was either noninformative (baseline condition) or highly informative (guided condition) regarding target location. The guided condition provides an example of top-down modulation and under this condition both age groups exhibited a substantial decrease in response time (RT) to singleton targets, relative to the baseline condition, as well as an increase in RT to nonsingleton targets. Madden et al. conclude that under conditions that equate the physical structure of individual displays, top-down attentional guidance can be at least as effective for older adults as for younger adults.

Divided attention and dual task performance

There is agreement on the effect of age on the ability to maintain divided attention where the subject must pay attention to more than one task at the same time. Researchers such as Hartley (1992) and McDowd and Craik (1988) have reported declines in performance with age on divided attention tasks. However divided attention problems with age appear to occur only in complex tasks rather than simple or nearly automatic tasks. There is an argument that the apparent attention deficit may be a result of overall task complexity rather than due to divided attention as such, (McDowd and Craik 1988 , Salthouse and Somberg 1982). Holtzer et al. (2004) found that age increased the performance problems found where the degree of temporal overlap was increased between competing tasks in a dual task situation. This effect was reduced but still present when the dual tasks represented different modalities.

Hogan (2003) examined whether higher levels of anxiety are associated with poorer cognitive performance in older adults. Looking at selective and divided attention tasks it was found that higher anxiety was associated with poorer divided attention performance in older, but not younger, adults.

Korteling (1994), in an interesting paper, showed that old people initially performed as well as a younger group on familiar dual tasks in a driving simulator. The dual task involved was to keep to the center of the road while maintaining a set following distance from a vehicle ahead. However when gas pedal polarity was reversed so that faster became up, the older group had trouble, not with the following task involving the gas pedal but with the steering task. Kortelling interprets this to mean that while coping with the reversed gas pedal was possible, to do so markedly reduced the cognitive resources available for the second task.

Wikman and Summala (2005) had subjects perform a visual search task on a display unit within a car while driving. The older group spent longer looking at the in-car display, they traveled a longer distance with eyes away from the road and showed a larger lateral displacement of the car in relation to the road. The number of long (>2 sec) glances was larger among the elderly group. The difference between the older and younger subjects was larger when the subjects needed to press a key on the display (motor response) than when a verbal response was required. The authors conclude that even by the age of 65 to 70 years, older drivers have difficulties in time-sharing in highway driving.

Morrow and Leirer [77] reviewed studies of pilot performance. Older pilots were similar to younger pilots in response time on simulator tests except for "high workload conditions" such as a landing involving cross winds and turbulence. Older pilots made more mistakes in responding to and feeding back air traffic control communications in flight simulator tests and this effect worsened when the messages were made more complex. Age had more impact on communication tasks than on routine maneuvers. This is of potential interest to those looking at co-operative environments. It may be that older users have less ability to cope with the communication load and demands on working memory expected in a co-operative environment.

Automatic responses

While most activity requires attention to support it, some activities that are well learnt appear to shift to a different category of performance where the behavior is in essence automated, that is it does not require conscious control and attention for the behavior to be carried out. Activity of this sort is referred to as automated responses, automatic responses, automatic attention responses and similar terms. Testing for the presence of automatic responses can involve showing that the supposedly automated behavior does not contribute to extra load in dual task situations – thus demonstrating that the task does not make extra demands for attention and control. Alternately testing for automatic responses can involve putting a person in a situation where the stimulus that normally provokes the automated response is presented but the older person is required to produce a different response and inhibit the automatic response. An automatic response can be shown to be more difficult to inhibit than a non-automatic response that is under conscious control. Automatic responses are important in that they are seen as reducing the cognitive load associated with task performance.

While it seems that automatic responses that have been established while young persist into older individuals there is concern as to the ability of older individuals to establish new automated responses. Work by Plude and Hoyer (1981) and Fisk and Rogers (1991) supports the argument that there are reductions in the capacity of older individuals to direct attention to support complex tasks but that this does not apply to tasks, which, through training, have become automated. A group of studies done by Rogers, Fisk and co-workers concluded that most older adults may be unable to form an automated attention response (AAR), see Rogers, Fisk et al. (1994). Gilbert and Rogers (1996) report a study confirming this. In this study during extensive practice (3840 trials), words from some categories always served as targets in a visual search task while words from other categories always served as distractors. The test for the formation of an automated attention response occurred after the practice period in a new set of trials where the target categories now served as distractors and the distractor categories now served as targets. Under the new conditions, for the younger group, response times increased indicating that interference from an automated attention response to the previous target categories had formed during training. Most of the older group (16 out of 24) did not show this effect and this is seen as consistent with other reports that older adults do not form automated attention responses. The suggestion taken from this is that, while older adults may be more flexible in learning new sets of associations, what they do learn remains attention demanding.

However recent work by Wu et al. (2004, 2005) suggests that older people can in fact form automated responses, at least in sequences of motor actions. Using brain imaging Wu et al. found that older subjects took longer to achieve automatic responses and that they recruited greater areas of the brain to achieve these responses. These effects were increased by the complexity of the movement sequence being learnt. Wu et al. suggest that these extensively greater activated brain regions indicate that the strategy aged subjects use for execution of automatic movements is obviously less efficient. They appear to require more brain activity to compensate for the greater difficulty they have in performing automatically at the same level as young subjects. This appears to be the main reason why aged subjects have more difficulty in achieving automaticity.

Where older adults do possess automated responses a study by Rogers and Fisk (1991) found that these automated responses led to higher levels of disruption for an older group on tasks that made the automated response inappropriate. On the other hand Kelley (1996) showed that for subjects trained on an experimental word processor, young expert users (20 - 35) showed more disruption than older expert users (50 - 65) when learning a version which contained a non standard sequence of actions for selecting and changing an object. This is consistent with the older subjects not automating their learning over the course of Kelly's experiment and thus having a lower barrier to conscious control of the learnt behavior.

Summary of findings about aging and attention

Attention and vigilance

- There are some problems with maintaining focused performance over time but this appears to depend on the type of task

Selective attention

- Poorer ability to inhibit responses to irrelevant items
- Less ability to control an activity with a top-down plan of action

Dual task performance

- Less able to do multiple tasks at once if the tasks are complex
- Problems in dual task situations may paradoxically show on the task that takes less concentration
- Anxiety reduces dual task performance

Automated responses

- New automatic responses are hard to form for older people
- Existing automatic responses are harder to suppress if necessary due to changed circumstances

2.9.2 Possible Effects of Age-related Changes in Attention on Interface Design

Attention and vigilance – relevant changes

- There are some problems with maintaining focused performance over time but this appears to depend on the type of task

Attention and vigilance – design suggestions

If applications need to involve older people in vigilance or monitoring tasks this should raise a note of caution in the designer's mind. Obviously it is preferable if the application can perform the monitoring but if older humans must be involved the question becomes one of careful usability testing. From the findings so far we know that poorer performance on monitoring tasks by older people is possible but we do not know under what conditions, so it is left to the designer to see if the particular application that they are working on triggers vigilance difficulties for older users.

It also seems possible that older people, or at least some older people, may be more easily distracted while in the middle of long computer tasks. This might mean that older people would benefit from information that re-establishes where they were in a task. The challenge is to create such features without creating extra tools for older people to learn, the answer might lie in simple solutions such as re-finding one's position in a long text passage through an insertion point that becomes more distinctive over time if the screen is unattended.

Selective attention – relevant changes

- Poorer ability to inhibit responses to irrelevant items
- Less ability to control an activity with a top-down plan of action

Selective attention – design suggestions

Older people will be more easily distracted by features that are not relevant to the task they are engaged in. The design response is again to simplify and to remove irrelevant features. Obvious distractions such as graphics that are not required for the task, animation, flashing parts of a screen or moving text are easy to identify and remove if a designer is willing to think in terms of usability rather than appearance. A problem remains in that what older people find distracting may fall below the distraction thresholds of younger designers. What a younger designer may find comfortable to live with might reduce the ability of some older people to use the intended design. Once again there is a case for careful testing and discussion with older people as part of design. Another issue is with control over the on-screen environment. If an application for older people uses screens that are not full screen there is a potential for distracting displays to exist in the background that are from other applications of from a browser. Since some older people have limited understanding of windows management they will not be able to re-arrange the task window to hide the distraction, nor should they be required to do so. Designing applications for older people with full screen windows rather than overlapping windows gives a designer appropriate control over the environment in which the older users will work.

However even with carefully designed simplicity as a user works through the sequence of a task, at any point in time some of the elements of a screen will be immediately relevant, other elements will provide confirmation of completion of previous parts of a task and some elements will become relevant in later parts of the task. Older people's problems with selective attention, possibly combined with a narrower effective field of view and a poorer mental model of the application mean that the designer may need to give more care to providing interface elements for guiding older people through a task sequence than would be the case for younger people. This might be achieved by careful layout where the design elements to be used in the next sub-task are always close to the end point of the previous sub-task. More active solutions such as graying out areas of a screen that are not immediately relevant, may meet problems from older users' lack of knowledge of conventions such as graying out unavailable features and older users problems with reading greyed text given its lack of contrast with the background.

Attention and Dual task performance – relevant changes

- Less able to do multiple tasks at once if the tasks are complex
- Problems in dual task situations may paradoxically show on the task that takes less concentration
- Anxiety reduces dual task performance

Attention and Dual task performance – design suggestions

Divided attention in dual task situations seems applicable to many application tasks. Consider word processing where attention must be split between composing the document and manipulating the interface. It is convenient to refer to the composition task as the substantive task, this is what the user came to the computer to achieve. The other task is the interface task and this can be seen as potentially competing for the older user's attentional and cognitive resources with the substantive task. Interface designers can perhaps ignore the theoretical distinction between divided attention over multiple tasks and overall task complexity and concentrate on reducing the effort and attentional resources required by the interface.

A similar issue exists here as for the preceding section on selective attention. A young designer is not in a position to easily decide what makes an interface resource hungry for older users. Given poorer vision, less idiomatic computing knowledge, less motor control and a more limited application model, older users will devote resources to aspects of an interface that a younger designer is likely to find make minimal demands for attention. The solution is again to obtain the participation of older people in design so that the designer's perspective is modified.

The issue raised by Korteling (1994) is that under dual task situations the impaired performance that occurs when one task becomes harder may show on the concurrent task, not the task with increased difficulty, as the older person diverts resources to the more difficult task. This has serious implications for testing new interface features with older people, we should be concerned not simply that older people can use a new feature but that they can maintain task performance on the substantive task while using a new interface feature.

Attention and Automated responses – relevant changes

- New automatic responses are hard to form for older people
- Existing automatic responses are harder to suppress if necessary due to changed circumstances

Attention and Automated responses – design suggestions

The problems with forming automated responses are potentially very important. Automated responses are a key method by which users reduce the cognitive load of an application. From the work by Rogers, Fisk et al. (1994) and Wu et al. (2004, 2005) we can expect that older people will not form automated responses quickly and that comparatively simple actions for controlling the interface will remain attention demanding for much longer in older adults than in younger adults. It is not certain that automated responses are entirely an all or nothing aspect of brain function and the possibility still exists that older users may offload some of the attentional demand of interface features that they have first encountered in old age by a form of partially automated response.

For older experienced software users one might expect that previously acquired automated responses would seriously interfere with learning new applications which required conflicting responses. However Kelley's (1996) results cited above either conflict with this or suggest that we need to be cautious about assuming that older experts have in fact automated their responses simply because we have classified them as expert. Lassiter et al.'s 1996 paper also indicates that we may need to consider when skills were acquired if we want to interpret the effect of well learnt skills on aging and performance. Kortelling's (1994) findings also suggest that the problems emerging from alteration of established tasks may appear in concurrent or underlying tasks rather than the behavior directly affected by the new task. The implication is that older users may be observed to cope with a new interface feature but will in fact have a significant reduction in the cognitive capacity available for other tasks.

2.10 Cognitive ability and Aging

2.10.1 Studies of Intelligence and Aging

There are considerable problems with even the definition of intelligence. Some authorities argue for a single generalized factor while others argue for multiple mental abilities each involving some distinct areas of the brain. Measurement is also a matter of difficulty, the initial thrust of intelligence testing was to look at the rate of individual development relative to the average so as to identify individuals who could benefit from special assistance. Work with adults, aimed at studying intelligence changes with age, needs to work with raw scores on adult intelligence tests rather than with the traditional approach of adjusting scores for age group to obtain an intelligence quotient. Modern adult intelligence tests consist of batteries of subtests each covering different aspects of mental ability.

A large scale cross sectional study by Schaie and Willis (1993) provides detail of the sorts of declines in mental ability found with age. In this study four sets of abilities;

inductive reasoning, spatial orientation, perceptual speed and associative memory showed a similar pattern of a performance plateau extending to about 40 years of age followed by a steep and relatively steady decline of the order of about 30% by age 90. (Associative memory is the ability to recall relevant information through associations with information presented in a problem.)

Two other abilities; verbal ability and numeric ability showed a different pattern with age - a performance plateau or even slight gains over the period up to the mid 60s and then a decline of about 10 - 20% by age 90. To avoid confusing overlap these two patterns are illustrated by data only for inductive reasoning and numeric ability in the graph in Figure 2.5

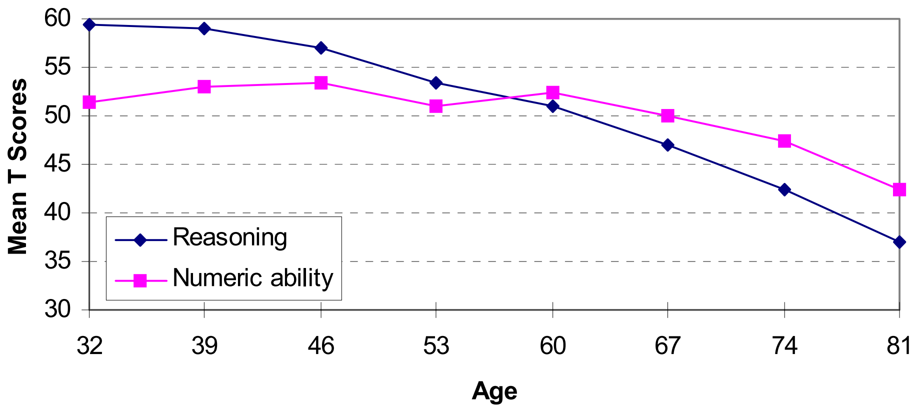

Figure 2.5 Decline in reasoning and numeric ability with age - cross sectional data adapted from Schaie and Willis (1993)

The cross sectional data are alarming, the onset of senility appears rapid and inevitable. It should be noted that the charts present the data with a cutoff value of 30 on the Y axis which accentuates the apparent decline. More importantly it has become clear from repeated comparisons of cross sectional and longitudinal data that cross sectional data do not give a valid picture of the progress of intellectual functioning in individuals over time. The key set of longitudinal studies is the Seattle Study started in 1956 by Schaie, see Schaie (1996) for a review. The reports arising from this and other longitudinal studies give a different picture in which performance on various mental abilities is maintained or even displays gains until around 55 and then shows some decline from this age. The data is displayed in the graphs below where composite longitudinal data based on combining the shifts in abilities within cohorts over 7 year periods is contrasted to the cross sectional data from the 1977 test period of the study

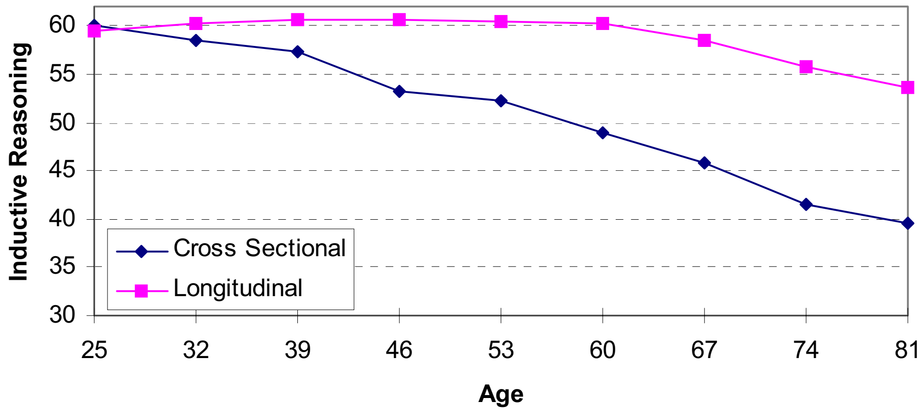

Figure 2.6 Reasoning - cross-sectional versus longitudinal scores. Adapted from Schaie (1985, 1996)

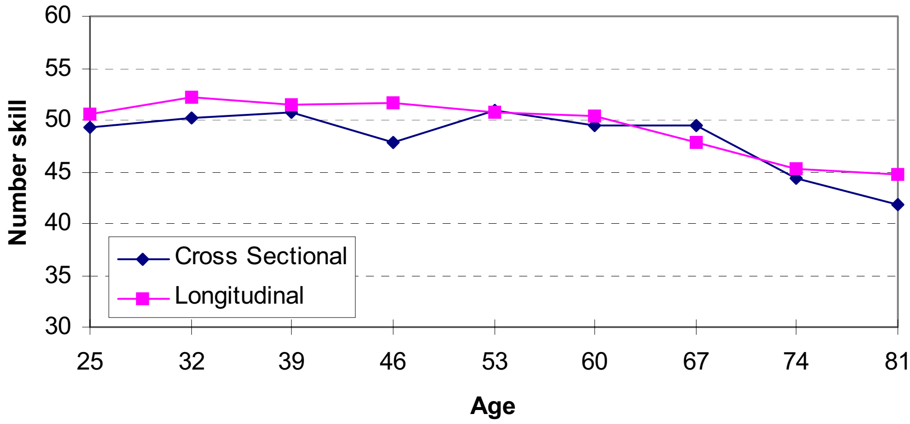

Figure 2.7 Number tests - cross-sectional versus longitudinal scores. Adapted from Schaie (1985, 1996)

Schaie (1996) confirmed his earlier findings when analyzing later results from the Seattle study. In essence longitudinal scores on verbal meaning, spatial orientation and inductive reasoning improve from a baseline figure at 25, peak sometime in the 40s and 50s and do not decline to baseline levels until the mid 60s or early 70s. A pattern of accelerating decline shows in the late 70s and 80s. A different pattern shows for longitudinal scores on measures of numeric ability and verbal fluency where decline starts in the 30s. Schaie suggests that longitudinal change over short periods is minimal in normal individuals and that major decline in intellectual abilities is limited to late old age and probably mainly in abilities which were not central to the individual's life experience.

The longitudinal decline, based on composite data, shows *individuals* maintaining the ability they had in their 20s until their mid 60s. However Charness (1998) notes that as Schaie adds more measurement occasions, decline is detected at earlier ages. Charness suggests this is probably due to the greater power to detect change as longitudinal age ranges approach cross-sectional study ranges. The cross-sectional data show that today's older age groups do not score as well as today's younger age groups and that the difference between them is significant and increases as the ages compared become more different. This demonstrates the Flynn effect, a well documented increase in the ability to score on intelligence tests for each generation this century, see Heylighen (2000).

Perceptual speed

Longitudinal scores on measures of perceptual speed taken in the more recent test periods of the Seattle study show a markedly different pattern to measures of intellectual function. Perceptual speed showed an almost linear drop in perceptual speed from age 25 leading to about 1/3 reduction by age 88. Lindenberger, Mayr and Kliegl (1993) found that there was little direct relationship between age and measures of intelligence. In an analysis using latent variables they found that age related to speed and speed in turn related to the measures of intelligence, *even though these measures of intelligence did not depend on speed of completion*. This extends the numerous studies by Salthouse showing that the relation between aging and a number of cognitive measures depends on the relation between aging and perceptual speed, see Salthouse (1996) for a review. Birren has maintained since 1951 that speed is an important factor in intellectual performance and that if a person is unable to think quickly then they are unable to think well, Birren and Fisher (1992).

Schaie reports in his 1996 review that age of peak performance and age of onset of decline appears to be occurring later in life when cross sectional figures for performance by each age group are contrasted between 1970 and 1991. Schaie found that each succeeding generation showed increased scores on measures of verbal meaning, inductive reasoning and spatial orientation. (In contrast there is a striking decline in numeric ability which appears for Seattle residents to have peaked for those born in 1924 and declined fairly steadily for those born in later years.) Rybash et al. (1995) suggest that to explain improved performance in successive birth cohorts we should look at increased years of formal education, a greater cognitive orientation in work tasks and improvements in treatment of disease.

Selective drop out of impaired individuals will boost results in longitudinal studies, see Rabbitt et al. (2004) but the difference between cross-sectional and longitudinal studies also reflects the point that social changes over this century have boosted the ability of succeeding cohorts to obtain results on IQ tests. The increase is of the order of three IQ points per decade, this increase has been found for virtually every type of intelligence test in a wide range of countries. The effect is actually stronger on non-verbal tests. This effect, known as the Flynn effect, is supported by a number of studies, see Heylighen (2000) for a review. One consequence of the Flynn effect is to strengthen the difference between younger people's view of average performance and older people's actual attainment. Heylighen notes that older people who were rated as high performing early in the 20th century (on the Raven progressive matrices test) would now be rated as below average in performance.

Schaie reported in a 1990 analysis that individuals exhibited very variable patterns of decline when he looked at longitudinal results over differing mental abilities.

Table 2.2. Percent of individuals showing decline over time on specific mental abilities

Mental Ability	Age 53 - 60	Age 60 - 67	Age 67 - 74	Age 74 - 81
Verbal meaning	15	25	27	36
Spatial orientation	21	27	30	33
Inductive reasoning	14	26	24	28
Number	17	26	26	32
Word fluency	24	28	27	37

Table 2.3. Percent of individuals showing decline over time by number of abilities impaired

No. of Abilities	Age 53 - 60	Age 60 - 67	Age 67 - 74	Age 74 - 81
0	41	27	24	15
1	35	35	38	37
2	17	22	22	25
3	5	10	11	14
4	1	5	4	6
5	< 1	< 1	1	2

The point made clearly in the two preceding tables is that decline for an individual is likely to be on two or fewer abilities. Which abilities are affected and which are unimpaired appears to be almost random, though which abilities are preserved may be affected by an individual's career choices, activities and interests. This is not a population for which concentrating on one or two specific problem areas will provide a widely applicable solution. Schaie (1996) and Baltes (1993) make the point that ability loss is likely to be shown only in situations which are complex and challenging enough to require activation of an individual's reserve capacities. Most normal and routine activity is likely to be largely unaffected by the losses of aging. However where individuals do show declines on intellectual functioning they may simultaneously be disadvantaged by declines in perception. As part of the Maastricht Aging Study, Valentijn et al. (2005) looked at the relationship between perception and cognitive functioning. Acuity measures in both visual and auditory perception were strongly correlated with a number of measures of cognitive functioning and this finding held for both cross-sectional and a longitudinal data.

Crystallized intelligence and fluid intelligence

A different approach first developed by Horn (1970) attempts to divide intelligence into crystallized intelligence and fluid intelligence. Crystallized intelligence corresponds to performance based on life experience and cultural knowledge held in long term memory. Fluid intelligence on the other hand, measures skills of perception and abstract reasoning that are not directly incorporated in experience but are more directly related to the integrity of the central nervous system. Fluid intelligence is thought to be more important in novel task performance while crystallized intelligence is related to achievement on well practiced and familiar tasks.

Studies by Horn (1970, 1982) and Horn and Donaldson (1976) show that there are gains on crystallized intelligence up to the sixties which tend to compensate for the losses shown on measures of fluid intelligence so that overall intellectual performance declines only slightly. This can be seen as compatible with views held by Dittman-Kohli and Baltes (1988) suggesting that practical and social intelligence increases with age and that these aspects of functioning are not well measured by traditional IQ tests. This gets some support from Cornelius and Caspi (1987) who found measures of practical problem solving and verbal meaning increased with age while a letter series test showed scores peaking at about 40 and then declining. Beier and Ackerman (2005) examined the role of prior knowledge, fluid intelligence, and crystallized intelligence in a task involving learning new information. It was found that all three factors contributed to learning. Beier and Ackerman argue that this provides a more optimistic perspective on the relationship between aging and learning than that offered by theories that focus only on the role of fluid abilities in learning.

Expertise

There is a general belief that once the current generation of older users who have to learn computing skills in old age are replaced by future generations of older people then the difficulties with older users will become unimportant. As part of examining this it is useful to examine other areas where skill is maintained into old age. Studies by Salthouse (1984) on typists and by Clancy and Hoyer (1994) on medical technologists showed that experts retained high levels of performance in skills specific to their area of expertise while showing normal declines in areas such as figure identification and reaction time which might be argued to underlie their specific skills. Salthouse's work also showed that, for expert older typists, the maintenance of typing skill depended on developing compensating strategies for reduced speed and reaction time. The older typists planned keystrokes further ahead than younger skilled typists. Szylk et al. (1995) looked at driving performance with age. They found that older adults drove more slowly and made more eye movements, compensatory actions which translated into a lower real world accident rate for the older drivers in spite of the younger groups' faster responses. It is of interest that the older adults showed poorer driving in a simulator in contrast to their real world performance. Does this suggest that older adults did not adapt as well to a generally familiar task (driving) in a new setting (the simulator)? If this interpretation is valid it reinforces concern for the adaptability of older adults.

Masunaga and Horn (2001) looked at Go players and found that expertise (in Go) related working memory and expertise (in Go) related deductive reasoning were independent of general fluid reasoning and general short-term working memory measures. While, overall, players showed a decline in the expertise related measures with age this did not show for the more expert players and decline appeared to be reduced by intensive practice.

Lindenberger et al. (1992) and Salthouse et al. (1990) found that older experts in architecture and graphic design showed significant declines on measures of general visual thinking and imagery. Bosman (1996) found that skilled typing in old age translated into faster responses only on finger movements that specifically matched standard typing keystrokes. On non practiced movements such as responding with a Z or a / when the fingers started at rest on either the Z or / keys older skilled typists did not have an advantage over older low skilled typists. It seems that expert performance is maintained only over narrowly specific areas as skilled people age.

Docampo Rama et al. (2001) have made the interesting suggestion that there is in fact another aspect to the ease with which people model the concepts underlying skilled performance. Docampo Rama et al. showed that it is possible to disentangle general effects of aging from and effect due to a generational shift. In Docampo Rama et al.'s work suggests that those who grew up before 1960 had a world view that was shaped by interacting with electro-mechanical devices (basically an off/on style of interaction) while the different forms of interfaces associated with electronic devices such as sliders led to a world view that was easier to adapt to graphical user interfaces for those who grew up after 1960. Thus major shifts in technology paradigms after a person matures may be more difficult for that person to adapt to, at least on initial exposure to examples of the new paradigm.

Decision making and information seeking

Ronnlund et al. (2005), note that there is a relative lack of studies addressing issues concerning decision making in older adults in general. We do know that older people have problems in understanding complex text, see Light (1990). They also appear to do less well in extracting information from complex data, for example see Chadwick-Dias et al. (2003) on older adults' ability to cope with large tables of data. Thus older adults may have poorer resources with which to begin decision making. There is also some evidence of generally poorer decision making in older people as the following research indicates.

Decision making can be slower in older adults. This may not simply be due to differences in processing speed or cognitive capacity. Ratcliff et al. (2001) identified two other comparisons between the decision making of older adults and young adults. First, the older adults set more conservative criteria than the young adults, accumulating more information before making a response. Second, the non-decisional components (encoding and response execution) of processing were slower for the older adults. Deakin et al. (2004) looked at a computerized gambling task and found that aging was associated with longer deliberation times, poorer decision making and reduced risk taking. Lemaire et al. (2004) had young and older adults estimate values for 2-by-2-digit multiplication problems under varying conditions of speed and accuracy emphasis. It was found that as well as being slower and less accurate, older adults chose estimation strategies less adaptively than young adults.

Mell et al. (2005), note that flexible learning of stimulus-reward associations, when required by situational context, is essential for everyday behavior but may be more difficult for older adults. The task studied required learning and reversing associations between actions and their outcomes as the context changed. Older participants had more difficulty with this than a younger group. They collected fewer points, needed more trials to reach the learning criterion, and completed less blocks successfully compared to young adults.

Mead et al. (1996) looked at on-line library catalog use by older and younger groups of roughly equal levels of education and found that the older users had a range of problems formulating command line queries. Problems included wrong search catagories, missing commands and errors when attempting use of logical AND or ALL. Notably older users not only made more initial errors but were significantly poorer in recovering from them. In a later study Mead et al. compared users by age and by degree of computer experience. Previous findings were generally confirmed. In addition computer experience made little difference for younger users (but the range of experience was from low to high). Older people with low computer experience showed somewhat poorer performance than young people with low computer experience but the most disadvantaged group were older people with no computer experience. Despite a prior training session on use of the library catalog older people with no computer experience had a much poorer success rate, completed fewer searches, often avoided the slightly more complex tasks, took up to 5 hours to attempt 10 searches and showed poorer understanding of the underlying basis of the search. This was in spite of the older subjects being more educated than the general older population. It was pointed out that older library users are in fact less likely to make use of computerized catalogs and the authors suggest that current library search designs significantly disadvantage older users.

Zaphiris et al. (2003) looked at various ways of linking pages into a tree. They examined different depths of link structure and they examined different ways of presenting the links. They found that both older and younger groups preferred broad shallow trees. While older adults were slower and more error prone, the rate at which difficulty increased as depth of structure increased was similar to the rate of increase for the younger group. However when the authors looked at different ways of presenting the tree structure they found striking contrasts between young and old. The two forms of presentation consisted of an expandable view of the tree structure and a non-expandable view of the tree structure. In the expandable sets of links the view was such that any set of branches could be expanded or compressed so that clicking on a link resulted in a new page showing the same tree but with a different section expanded. In the non-expandable links clicking on a link would show a new page displaying only the links that branched from the previous link. In the expandable condition shown on the left in Figure 2.8 the expanded tree always fitted onto the page without scrolling so that scrolling problems cannot be used to account for the age related differences.

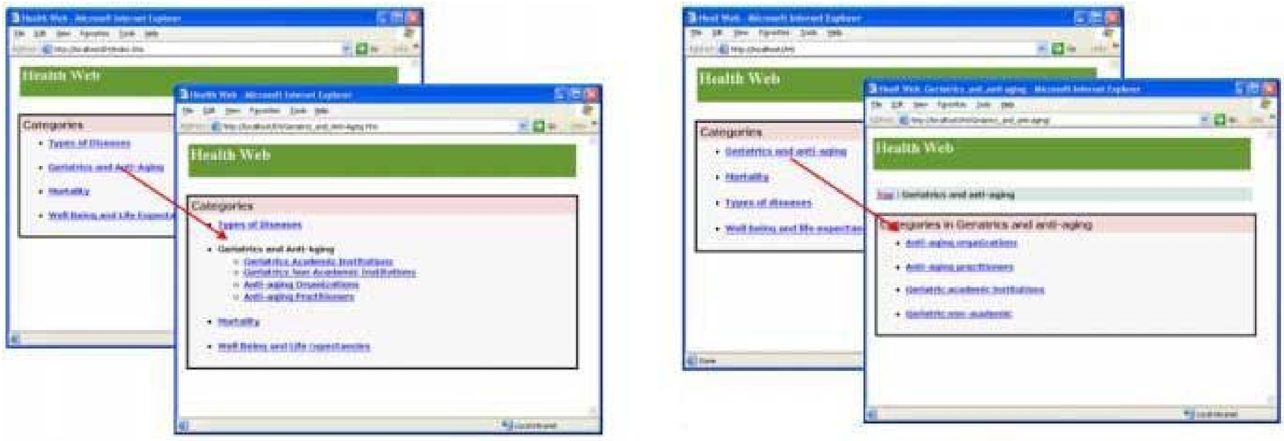

Figure 2.8 Examples of Expandable (on left) and Non-expandable views of a tree of links, adapted from Zaphiris et al. (2003).

Older adults showed greater loss of orientation when working with expandable sets of links than when working with non-expandable links in order to navigate a tree structure. The difference between young and old with depth of structure was markedly worse when using expandable links. Older participants preferred the non-expandable hierarchies, whereas their younger counterparts preferred the expandable hierarchies.

Training and plasticity

Baltes in a 1987 paper introduced the idea of plasticity of adult intellectual development where training or life experiences can enhance test performance. A number of papers have supported this concept but it is not clear to what extent this represents generalizeable enhancement of life skills beyond test taking. See Baltes (1993) for a review. There is however general consensus that adults are able to benefit from education and training well into old age. Studies on improving cognitive performance by training have showed that 5 hours of training can significantly improve test scores over a range of cognitive abilities; see Baltes and Willis (1982) and Schaie and Willis (1986). More impressively two follow-up studies have shown that the effects of such 5-hour training show up in significantly lower levels of decline over a seven-year period, Willis and Nesselroade (1990), Willis and Schaie (1994). Schaie sums up the findings with the statement “It seems likely that periodic reactivation of specific mental skills is likely to reduce the magnitude of intellectual decline in community dwelling persons" Schaie (1996, p280).

There is also a suggestion from explanations of cohort effects that longer periods of earlier education and training facilitate later ability to learn as well as general retention of cognitive ability. Schaie (1989) found that high levels of education predicted that individuals would show slower rates of intellectual decline. Dutta (1992) and others cited in Schaie (1996) provide evidence that high job status and work complexity indicate a likelihood of maintaining cognitive functioning into old age. However it appears to be education, not initial ability that is in effect here. Rabbitt et al. (2003) cast some doubt on the claim that people with higher intelligence in youth maintain better intellectual functioning in old age. Scores on a vocabulary test were found to be stable with aging while measures of fluid intelligence declined sharply over the period 42 - 92. Further, in younger people, the verbal scores were found to be closely correlated with scores on fluid intelligence. Rabbitt et al. therefore used the verbal scores in their older subjects to estimate the fluid intelligence that these older people had possessed when they were young. When the rate of decline in fluid intelligence was then calculated the rate of estimated decline did not vary according to initial levels of intelligence.

Summary of findings about aging and cognitive performance

- Reasoning ability declines
- Speed of mental processing slows
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- Older people are slower and less able at decision making
- When faced with problems older people rely more on existing knowledge and are less able to work out new solutions, (crystallized versus fluid intelligence).
- The performance of older experts is maintained at levels similar to younger experts but this depends on high levels of practice and does not translate into general ability in areas that relate to the expertise
- While intellectual decline is relatively slow if one follows the same individuals over time, the gap between today's younger people and older people is wider than the gap between today's older people as they were when young and as they

are now. This is due to a well established but not fully explained improvement by each generation in test performance, (the Flynn effect).

- Losses of types of mental functioning are not uniform, they vary widely between older individuals
- Older people adopt a more conservative strategy with regard to risk taking
- Ability to work with spatial problems declines

2.10.2 Possible Effects of Age-related Changes in Intelligence on Interface Design

Simpler conceptual modeling – relevant changes

- Reasoning ability declines, older people are poorer at making inferences
- Older people have poorer comprehension of complex information
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- Older people are slower and less able at decision making
- When faced with problems older people rely more on existing knowledge and are less able to work out new solutions, (crystallized versus fluid intelligence).

Simpler conceptual modeling – design suggestions

Older people will create and use simpler system models so systems for older people should be such that they fit simple modeling. Remembering that older people find it harder to ignore irrelevant information, this will normally mean simpler versions of applications for older people with either less features or with some features suppressed. Instructions for older people will benefit from being short and simply expressed. As an extension to this, interaction design for older users should be such that it suits short, simple explanation. Fisk et al. (2004) suggest that one of the things that contributes to simplicity when trying to understand text (or applications) is the use of familiar terms and concepts. Because older people have problems with inference and do not benefit as much from associative memory, Fisk et al. (2004) suggest that designs for older people should explicitly spell out connections between features and actions that younger people might be expected to infer. We do not know if this means applications that display simple procedural instructions at the level of "Step 5 press the [OK] button" but the level of "knowledge in the world" and the presentation format of such information needed to extend the range of older people who can use applications would appear to be a useful area of investigation.

Older people will also have simpler models of the graphical user interface environment, the operating system and the machine. Since older people have problems with inference, applications should not depend on older people reasoning from knowledge that might be assumed to be standard (or even elementary) in these areas. In older users the knowledge may well be missing or incomplete but even if the knowledge is there it will be more difficult for older users to form correct inferences from such knowledge.

Older people may benefit from training on considerably simplified versions of applications where the initial system model learnt is correspondingly simple. The issues here are firstly, can an older person benefit from a training version of an application to form an adequate if simple model of the situation that the full application addresses, and secondly, can they apply such a model to guiding their interaction with the full application. This also raises the possibility of older people benefiting from multi layered application designs that allow users with limited needs to work with a simplified and reduced feature set, only adding additional features as required and making it easy to drop features that are difficult to use or understand.

By depending on experience (crystallized intelligence) rather than on new reasoning about situations (fluid intelligence) older people may maintain performance on applications or parts of applications that are the same as past applications they have used. However they may be unable to proceed where there are apparently small differences in the way of proceeding towards the same aim. Designers may need to be much more careful about maintaining interface consistency between versions of applications when designing for older people.

Older people may be less able to adapt to modal responses to commands where the response to a command varies with context. Hence design for older people should avoid results from responses that are situation dependant. If older people become stuck they will have less ability to work out what has gone wrong and how to recover from this. Older users will benefit from applications that protect them from errors and have error messages that clearly and simply explain how to correct a problem. Applications for older users should provide very simple procedures for undoing, trying again or for working out what should be done. Older people will need longer to respond to information. For older people all aspects of response to information presented by applications need to be user paced.

Older people are more likely to learn associations at a specific rather than general level. This means that aims such as saving, scrolling and so forth will be associated with the specific appearance of the controls used to make the action happen, similar aims but visually different controls are likely to require that they are learnt separately. Younger people may reduce cognitive load by seeing that a new control with a couple of arrowhead icons for moving through a set of pictures uses the general scrolling model. Older people fail to make such a generalization, will learn such a control separately and experience increased cognitive load. Where standard patterns of interaction exist, using the standard appearance for controls, not simply the concept behind the pattern, will assist those older users who know the pattern.

Decision making, Information gathering, Problem and information presentation – relevant changes

- Older people's declines in cognitive function are likely to show under novel situations and conditions of increased cognitive load, although older people's performance may be well preserved in familiar activities.
- Older people adopt a more conservative strategy with regard to risk taking
- Ability to work with spatial problems declines
- Speed of mental processing slows
- Reasoning ability declines, older people are poorer at making inferences
- Older people have poorer comprehension of complex information
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- Older people are slower and less able at decision making

Decision making, Information gathering, Problem and information presentation – design suggestions

Tufte (1983) made the point that differences in the way that information is presented can make large differences in problem solving and interpretation of data, conversely poor presentation of information can create difficulties in achieving accurate understanding. It seems reasonable that older users will both benefit more by simple presentation of information and be more affected by information presentation that departs from simplicity. For example Chadwick-Dias et al. (2003) found that where web pages had large data tables, older users had significant difficulty accessing information and often could not move beyond that page while attempting to complete a task. However the actual form of information presentation that older people will find best in simplifying modeling of information is uncertain. Consider for example Zaphiris et al.'s work on extensible versus non-extensible views of tree data where showing the tree structure more fully, via the extensible view, led to poorer orientation by the older users, Zaphiris et al. (2003). We need to be aware that there may be a disproportionate pay-off from giving simple representation of data to older people but we should be very cautious about what such simple representations will consist of.

It is not clear how the findings that older people show declines on spatial ability should be interpreted by interface designers. The findings come mainly from experiments involving mental rotation of figures, not a common feature of interface designs. However it has also been found that spatial ability as measured by figure rotation tests correlates with the ability of older people to learn new applications. On the other hand it has been shown that older people can benefit from site maps which incorporate a form of spatial information. Fisk et al. (2004) suggest that spatial ability indicates the ability to infer extra information from the visual presentation. The implication for interface designers might then be to make the transition from visual representation to system model as simple as possible and to be particularly cautious in testing whether older users can benefit from spatial presentation and layout information. It may be that providing support in the area of spatial inference could provide assistance with the large table problems identified by Chadwick-Dias et al.

Cognitive performance gaps between young and old – relevant changes

- Older people's declines in cognitive function are likely to show under novel situations and conditions of increased cognitive load while older people's performance may be well preserved in familiar activities.
- While intellectual decline is relatively slow if one follows the same individuals over time, the gap between today's younger people and older people is wider than the gap between today's older people as they were when young and as they are now. This is due to a well established but not fully explained improvement by each generation in test performance, (the Flynn effect).
- The performance of older experts is maintained at levels similar to younger experts but this depends on high levels of practice and does not translate into general ability in areas that relate to the expertise
- Losses of types of mental functioning are not uniform, they vary widely between older individuals

Cognitive performance gaps between young and old – design suggestions

Examination of the longitudinal data on various aspects of intelligence implies that most individuals should maintain reasonable intellectual functioning until their mid sixties. Further only a small minority are likely to show impairment in multiple areas of mental functioning. Again impaired functioning should only be apparent in tasks whose difficulty challenges individual's cognitive reserves, routine tasks, including well-learned computing tasks, should be carried out with little decline in performance.

What is of concern is that younger designers may either attempt to model the likely performance of older users on their own performance or they may take evidence of older people functioning normally in familiar settings as evidence that the older people will be competent in the new circumstances into which the designers are about to thrust them. Neither assumption is likely to be helpful. The Flynn effect seems likely to increase the gap between younger designers and older users when it comes to intuition about what constitutes an easily solvable problem. What younger designers assume to be simple may be see as too difficult by older people. There is more need to check with actual older users when designing for older people than is the case when designing for younger people.

Older people may be seen as having a degree of expertise in everyday living. However it would be mistaken to take this as evidence of ability to cope in new areas or even areas seemingly related to existing skills. The performance of older experts is maintained at levels similar to younger experts but this does not translate into general ability in areas that might be expected to relate to the skill set, visual thinking for example is not disproportionately preserved in older architects. Maintaining expertise in old age depends on high levels of practice. Masunaga and Horn’s (2001) findings on Go players suggest that as well as needing practice, expertise is better maintained in those who enter old age with a very high level of expertise, moderate players show declines in skill with aging. It also seems that expertise in old age is best produced in a relatively narrow and highly familiar context, Szylk et al. (1995). This raises questions as to how well computing skills acquired by future generations of older computer users before they age, will assist their computing use in old age.

A variety of issues mean that the disadvantaged status of older computer users may ease but is unlikely to disappear. Masunaga and Horn’s findings may indicate a reason for concern in that few older people will enter old age as highly expert computer users and with full or partial retirement the level of practice of their skills can be expected to reduce. Szylk et al.’s work and the lack of general preservation of ability in skill related areas suggests that skills are maintained with a very narrow focus indeed and that the paradigm shifts and feature changes that are an economic driver of the computing industry will erode the relevance of the computing skills that older people bring into old age. We know that driving skills decline with age, we would expect this to be much more pronounced if cars changed paradigms rapidly, the same seems likely for computing skills. It appears probable that future generations of older people will not have generalizable computing skills that will allow them to work well in new computing environments.

2.11 Learning, Training and Aging

2.11.1 Studies of learning and older people

Baldi (1997) has reviewed the literature on training older adults to use applications. The papers reviewed indicate that while older adults can learn applications it may take them twice as long to reach the same level as younger users. Older adults also needed more assistance during learning. Baldi also noted reports that prior experience with computers improved learning for older adults. What is not clear from the papers Baldi reviews is what happens to older learning as program complexity increases, some of the negative findings on successful learning involved Lotus 1-2-3. Bosman and Charness (1996) suggest that declining cognitive resources may hamper acquisition of new skills in older adults. It seems reasonable that this will depend on the complexity of the skill being learned. Kelley and Charness (1995) reviewed twelve studies in which older users were trained to use computer applications and found that in ten of the studies the older users had significantly greater difficulty in learning. It should be noted that these were older pre-Windows applications, the duration of training was short – less than a week and the subjects were computer novices. Czaja and Sharit (1993) found that the level of prior computer experience outweighed the effects of age when considering performance on training to use an application. It is also worth considering that older people have been shown to have a more negative bias in self evaluation and that they may further see learning computer skills as more challenging for the old in particular. Stresses caused by such expectations could impede learning, Baldi (1997).

Where learning is seen or experienced as difficult or unrewarding it would seem probable that learning is minimized so that a person learns a bare minimum for surviving in a particular computing environment. It may also be that minimizing learning is a strategy for reducing the complexity of the material older adults face when meeting new computer tasks. Once a method has been learned there may be resistance to abandoning it to learn a more efficient alternative. Given richly featured and evolving applications and operating systems this has potential implications for the efficiency of older users. Perlmutter and Mitchell (1982) suggested that some of older peoples' memory problems are due to differences in applying strategies for organizing material. It is worth asking if there are differences in the way older people organize information about richly featured applications and whether more effective patterns of organization can be offered. However Touron and Hertzog (2004) found that older people's belief that they would not be able to learn a system for improving memory by using categories meant that they avoided such learning when in fact they were able to benefit from it. We can ask if older people have less effective application models and is this subject to training effects? It may be worthwhile to consider if older users are more averse to making mistakes while learning applications, show less one-shot or incidental learning and possibly tend to learn on tasks which are important to them rather than tasks which are artificial. There is also a concern that, particularly for older adults, poor techniques included in early learning of an application are resistant to later changes.

Rogers et al. (1996) found that the best form of training out of a brief description, a text manual, a pictorial manual and an online tutorial was the on-line tutorial. Rogers et al. concluded that this was because the older adults benefited from repeated hands on experience with the component tasks of ATM use. Note however that Charness and Bosman (1990) looking at earlier studies of training mode and learning success with older computer users report that there is no clear indication of what training mode is best. However Charness and Kelley (1995) recommend self-paced learning using a minimal manual approach for older adults. They note that the studies they review on on-line tutorials found that this represented the least satisfactory form of training, possibly because of the lack of self pacing and the lack of opportunity to learn from mistakes. They also cite findings by Caplan and Schooler (1990) which indicate that while younger users may benefit from emphasizing the metaphor underlying an application older adults performed worse on training when the desktop metaphor was explained prior to training. In Baldi's 1997 review of training a number of studies report that the method of training affects the success of older learners of computer programs. However a rather wide variety of methods are reported as being better.

There is a tradition of research using contrasting tutorial designs for teaching older users to use computer applications, see Morrell and Echt (1996, 1997) and Kelley and Charness (1995) for reviews. Morrell and Echt (1996) point out the dominant research method is to contrast two different approaches for delivering the same content. There are at least two problems here. There is a question of the fit between the content of the tutorial and its delivery medium, would the same medium have performed differently in delivering different content specifically designed for the medium? There is also the question as to how representative the tutorial studied is in relation to best practice among tutorials of the same type. Debate about the best method for teaching older people may well be unproductive, a demonstration of older people succeeding well with one approach to acquiring complex computer skills does not rule out other approaches. Note that Morrell and Echt's reviews endeavor to extract underlying principles that could be generally useful in producing instructional material for older people, rather than arguing for a particular type of instructional approach.

It may also be that, as the supporting technology improves, different approaches may become more valuable. For example earlier studies of on-line tutorials such as Gist et al. (1988) found them to be a poor form of instruction for older people but later studies are more likely to support on-line tutorials, emphasizing the advantages of active performance of procedural steps by the learners, see Mead & Fisk (1998), Morrell, et al. (2000), Rogers, et al. (1996), Czaja & Lee (2001). Morrell et al. (2000) found that providing older learners with background conceptual information in addition to step by step instructions led to poorer performance both immediately after training and on retesting one week later. Morrell as well as Czaja and Lee (2001) and Rogers (2000) argue for providing the older user with active hands on learning. These studies used limited tutorials constructed purely for use in their experiments. However they give overall support for computer based training as a method of training older people in computer skills.

We can summarize the guidelines for instructional material and delivery for older people offered by Morrell and Echt (1996, 1997), Morrow and Leirer (1999), Morrell et al. (2000), Rogers (2000) and Willis (2004) as follows.

- Text formatting: Use a typeface with rounded distinctive sans-serif letters (e.g. Helvetica), use 12 to 14 point with strong contrast between letters and background, use short, left justified lines with a maximum of 65 characters per line, use white space to increase clarity.
- Instruction structure: Use lists in a standardized format, language structure and vocabulary should be kept simple, avoid the use of negatives, use an active rather than a passive voice.
- Provide an active learning situation and provide sufficient practice with task components. Ensure that the training environment is free from distractions.

- Content: Emphasize procedural steps and leave out background conceptual information, use concrete examples, some instructions should be accompanied by relevant simple illustrations since some information is not well conveyed in text, slowed animation may be useful. Training material should be well organized and important information should be highlighted.
- Ensure that help is available and easy to access
- Delivery: Allow extra time for training. Training should be self-paced and may work better in small groups
- Instructional materials for older learners should be designed so that attention can be focused on single areas, being mindful of older adult’s issues with maintaining divided attention.
- General: Be aware of older peoples' problems with: reductions in working memory capacity, reductions in ability to deal with complexity, reduced color discrimination particularly in the blue green range.

What can be seen from this list is that the recommendations come from a wide range of areas related to the effects of aging on older people and techniques for addressing those effects. In fact training older people is another example of the general area of interaction design for older people. In particular training older people on computer skills and applications is going to involve computer based materials if not a full fledged interactive tutorial. From this it follows that the whole of the literature review thus far can be seen as having implications for the design of any computer based training material for older users and this includes the design of interactive tutorials. This considerably extends the number of considerations that are relevant to training older people in computer skills, we need to examine what we know of older people’s learning and what we know of suitable application design for older people. In what follows we will look at implications from what is known of older people’s learning and leave the issue of application design to what has already been covered in the earlier sections. However we need to acknowledge the insight of previous authors in taking recommendations not just from older people’s learning patterns but also from older people’s cognitive and perceptual abilities.

Summary of findings about aging and learning

Difficulties with learning

- Learning takes more effort and takes longer
- Older people can be overwhelmed by younger instructors who go too fast, present too many ideas and tend to be impatient with the slow and uncertain progress typifying older people.
- Older people's learning can be disrupted by the provision of too much information
- Learning may be limited to a minimum or inadequate skill set in some older people
- There may be a long period during which learnt items are easily forgotten and need to be relearned more than once
- Older people are likely to blame themselves for learning difficulties
- Where older people see themselves in negative age stereotyped terms this further impairs their ability to perform

Points with Implications for content

- Older people can learn a wide range of new skills
- Older people benefit from learning on a simplified model before using the more complex real world tool
- Older people benefit from a focus on learning a minimum of essential concepts and techniques
- Older people benefit from learning skills as a set of concrete procedures
- Older people benefit from actually performing skills as they learn
- Older people may benefit from simple background information that places their learning in context but they are disadvantaged by a focus on conceptual material
- Learning techniques such as ways of associating new items with categories in order to assist remembering can show continued benefit over years, but older people need encouragement to adopt such techniques

Points with implications for delivery format

- The speed with which individual older people learn varies widely
- Older people benefit from self paced learning

- Older people appear to benefit from learning in small (2 – 4) groups rather than individually or in large groups
- There appears to be a benefit in having either an instructor from the same (older) age group or an instructor who has adjusted their style to accommodate older learners

2.11.2 Implications for training older people to use applications

Difficulties with learning – relevant changes

- Learning takes more effort and takes longer
- Learning may be limited to a minimum or inadequate skill set in some older people
- There may be a long period during which learnt items are easily forgotten and need to be relearned more than once (fragile learning)
- Older people are likely to blame themselves for learning difficulties
- Where older people see themselves in negative age stereotyped terms this further impairs their ability to perform

Difficulties with learning – design suggestions

The point that learning in older people is initially fragile may imply that the instructional format should be such that older people can easily repeat sections of material, in fact a need to structure learning materials so that they can be used on demand over the period of weeks or months when previously learnt material is forgotten, re-learnt and forgotten again. It also seems likely to be useful to create a learning environment where success is easy to achieve and mistakes are easy to recover from in order to counter older learner's initial negative expectations. The point that some older people will only achieve limited learning may indicate that when deciding on instruction content the instructor should define what constitutes a survival skill set and this should be the first aim of a course for older people. However the variability of older people means that courses should allow those who are learning well to progress beyond this basic skill set.

Content of learning material – relevant changes

- Older people can learn a wide range of new skills

- Older people benefit from learning on a simplified model before using the more complex real world tool
- Older people's learning can be disrupted by the provision of too much information
- Older people benefit from a focus on learning a minimum of essential concepts and techniques
- Older people benefit from learning skills as a set of concrete procedures
- Older people benefit from actually performing skills as they learn
- Older people may benefit from simple background information that places their learning in context but they are disadvantaged by a focus on conceptual material
- Learning techniques such as ways of associating new items with categories in order to assist remembering can show continued benefit over years, but older people need encouragement to adopt such techniques

Content of learning material – design suggestions

The content of courses for older users should be rigorously simplified. Very simple conceptual background that is closely related to the skills being learnt may be helpful but more general conceptual information is likely to hinder learning. Overall courses should present a limited amount of material. Older learners will benefit from a focus on procedural steps rather than conceptual background. Active learning, where older people actually carry out the steps being learnt is important and there needs to be time for sufficient practice. The exercises that are chosen for practice should be appropriate to the current skill level and perceptual, motor and cognitive abilities of the older learners. It also seems reasonable that there should be only a little new material introduced at any one stage of a course and this implies careful sequencing of the skills taught so that earlier skills support the teaching of later skills. However this will not be simple to implement given that the skills learnt earlier will be subject to fragile learning.

Older people may benefit from being taught specific techniques for remembering as part of a course but remember that Kliegel et al. (2003) found that although older people benefited from using such techniques they were skeptical of their ability to benefit and were therefore less likely to use the techniques.

Learning and delivery format – relevant changes

- The speed with which individual older people learn varies widely
- Older people benefit from self paced learning
- Older people appear to benefit from learning in small (2 – 4) groups rather than individually or in large groups
- Older people can be overwhelmed by younger instructors who go too fast, present too many ideas and tend to be impatient with the slow and uncertain progress typifying older people.
- There appears to be a benefit in having either an instructor from the same (older) age group or an instructor who has adjusted their style to accommodate older learners

Learning and delivery format – design suggestions

It seems to be the case that older users learn well in small groups and that the group can provide a rewarding social context in which learning benefits. Note that this seems to depend on the class as a whole being well designed. Classes for older learners should be small, note that SeniorNet classes in New Zealand choose class sizes in the range of two to five students. The speed of instruction should be such that older learners are not hurried and this implies at least double the time taken for younger learners. However the variability of older people indicates that there is likely to be no ideal pace for a group, rather that self paced learning should be supported.

Given that older people need considerable support as they learn but that they learn at differing speeds there is going to be strain placed on an instructor. An overloaded instructor is at risk of triggering older people's views of themselves as poor learners, which can then be self-confirming. It becomes important to reduce the load on an instructor. Having only a very small number of students to teach is going to assist this. In addition it will be an advantage if the learning materials are such that they reduce the requirement for the instructor to be the main source of information, they allow older learners to proceed in a self paced manner with less instructor input and they allow other older people in the group to assist each other.

The claim is made by SeniorNet New Zealand that there is a benefit from having older instructors of a similar age to those being instructed. This has not been verified but seems reasonable, however I have met a few past students of SeniorNet computing courses who argued that their older instructor knew too much to be, “useful to beginners like us”, so not all same age tutors are suitable. There has been research on ways in which younger people fall into counter-productive patterns when attempting to communicate with older people, this is explored in Chapter 8. What seems important is to have an instructor who has adjusted their expectations so as to be accepting of the likely initial level of knowledge displayed by older people, the slow speed at which they will be able to expand this knowledge and the inevitability of fragile learning in this group. It also seems important to have an instructor who does not trigger older users’ negative self stereotypes and a suitable older instructor may have an advantage here.

2.12 Conclusions

The first point that arises from such a literature survey is the sheer breadth of aspects of aging that can affect older people as they try and use computer applications. Following from this is the difficulty of translating this information into terms that are relevant for interface design. The design considerations raised in this chapter are mainly inferred from findings on aging, only a few have been the subject of published interface design research. It is therefore unknown how well the suggestions made for responding to the effects of aging will translate into successful interface design for older people. It is apparent that rigorous research to substantiate or challenge these suggestions would take a very long time so we are cast back on Donald Norman’s argument that establishing workable designs takes “approximate science”. Even so there are so many suggestions that they are likely to overload any designer and it is uncertain in what design contexts they will be relevant or can be ignored or downgraded. In effect what has occupied the rest of this thesis is a search for ways of helping a designer come to terms with the abundance of possibly useful information about aging that has been uncovered here. In the next chapter we will discuss an attempt to provide a perspective for integrating this material through the concept of competition for the older person’s cognitive resources between the user’s substantive task and the tasks involved in manipulating and comprehending the interface. Following this we will look at using increased involvement with and understanding of actual older users as a resource to guide designers through the interface design process.

Chapter 3 The Dual Task Pilot Study

3.1 INTRODUCTION

This chapter of the thesis describes the first study done after completing the literature review. An experimental approach was used but showed unexpected difficulties. The key result was to prompt careful examination of the appropriateness of an experimental approach given the thesis aims. This led to a change in direction for the thesis. The concerns on which this change in direction are based are set out in the discussion and conclusions at the end of this chapter. This discussion on the change in direction gives the core of the effect of this study on the overall thesis.

The literature review was a strong influence on the intended style of the overall research. The literature reviewed came overwhelmingly from the discipline of cognitive psychology and the predominant method was experimental. This led to a presumption that an experimental approach would be the appropriate way of approaching the thesis research. The initial approach was to look for a set of hypotheses that would relate the overall effects of aging to a way in which the presumed poorer performance of older people on computing tasks could be moderated by interface factors. The hypotheses adopted centered on the concept of dual task performance. Older people had been shown to exhibit poorer performance in several dual task situations so it was of interest to see if this could provide a worthwhile model for the role of the user interface for older computer users. The assumption was that older computer users are in a dual task situation. The task that led the older user to use the computer (the substantive task) might be writing a letter. However actually using the computer called for simultaneous performance on the task of managing the user interface (the interface task). It seemed reasonable to propose that as the interface task increased in difficulty then performance on the substantive task would show the effects of competition for cognitive resources from the interface task. Given support for the dual task hypothesis it was then intended to study particular aspects of interface design to see how they contributed to the dual task difficulties. It was decided to carry out a pilot study to evaluate this approach. The result of the pilot study was a lack of support for the dual task hypothesis and the development of a very different view of how the research should proceed.

This chapter will describe the hypothesis developed, give details of the experimental method used and examine the results obtained from carrying out the pilot study. The dual task study actually consisted of three linked studies using the same set of volunteers. The first sub-study looked at font readability in order to establish baselines for manipulating the difficulty levels of the interfaces provided in the second sub-study. The second sub-study examined the older volunteer's ability to carry out a series of comprehension tasks provided in the format of a game while level of difficulty of substantive task and interface task were varied. The third sub-study provided a second look at comprehension tasks while level of difficulty of substantive task and interface task were varied. This second study was done within different context using a web based comprehension quiz. The method description and the results of each of these sub-studies will be presented separately with a discussion of the findings of each sub-study. The key to the importance of this chapter however lies in the closing pages where a general discussion of the results and problems of the pilot study examines their implications for the direction of the overall research.

3.2 Theoretical basis for the pilot study

The approach taken in this study is to consider the user's activity in terms of two tasks, coping with the interface of the application and carrying out the substantive task the application is designed for, writing a letter, sending an email, etc. It has been shown that older people have difficulty carrying out complex tasks or carrying out two tasks simultaneously, see Korteling (1994). People have a limited cognitive capacity and it seems reasonable that cognitive effort expended in coping with the interface should reduce the capacity available for dealing satisfactorily with the substantive task. On this basis a poor interface should reduce task performance, as discussed in Cooper and Reimann (2003). The next issue is whether interfaces which are acceptable for younger users are acceptable for older users, it is possible that an interface which is simple to use for younger people would cause significant difficulty for older people. In the near future older people will be disadvantaged if they cannot complete computerized versions of daily tasks such as banking. Worryingly Rogers et al. (1996) found that older adults generally made high levels of mistakes on a simulated Automatic Teller Machine (ATM) contradicting bank staff expectations that the use of ATMs was self evident. It was decided that it would be interesting to look at comprehension of material presented via a computer interface as a general task and to give the same comprehension task to users under different interface conditions. The interface conditions chosen for manipulation involved text appearance and display style. There has been some previous work on font preferences for older people. Morrell and Echt (1996) suggest that older adults will benefit from san-serif fonts (with a specific recommendation for Helvetica) that are in the 12 - 14 point range and of medium to bold weight. These recommendations are for printed text so it is of interest to see if they hold for on-screen displays. Discussion with older people indicated that some found large font books uncomfortable, possibly because the large font meant that there were fewer words in a given viewing angle and this reduced the amount of information available in the sub-conscious scan ahead activity supporting reading. It was therefore decided to include a test for the upper size limit at which participants found fonts comfortable.

I had observed older people with impaired vision caused by the onset of macular degeneration, both the style of text used and the background against which it was displayed were important to their being able to read successfully. It was therefore decided to compare comprehension when the interface used fonts that were easy to read versus fonts that users could read with difficulty. The expectation was that comprehension would drop as the text quality declined (and more effort had to be put into reading). There is agreement in the literature that the ability to pay attention to relevant information in the presence of distracting information declines with age, Connelly and Hasher (1993), Kotary and Hoyer (1995). One of the display conditions was therefore set to include distracting animated graphics. From the proposition that both the substantive task and coping with the interface compete for the user's limited cognitive capacity there was a further implication. There should be an interaction effect in that difficult comprehension tasks should be more affected by text formats that require greater effort to read information. It was desired to provide a degree of internal replication within the study so two different comprehension tasks were designed.

3.3 General Notes on Experimental Methods

The study was done as a pilot study for a planned larger study. 12 older volunteers each attended three sessions of two and a half hours. They ranged from 66 to 82 years old with a mean age of 76.2. Previous careers indicated considerable achievement, careers included manager, nurse, lecturer, doctor, etc. All volunteers were able to drive themselves, all were members of SeniorNet. All used Windows 95 or 98 and email. The number of years' experience with computers ranged from 1 to 35 years. All but one reported themselves to be in reasonable health and all wore spectacles when using a computer.

There were three software programs used in this study, one for studying font preferences and two for studying how well research participants could comprehend information given a variety of presentation formats. One of the comprehension programs was a text based game and the other comprehension program consisted of a quiz on articles presented in a Web page format. Participants attended the first two sessions in groups of two or three and worked with the experimental software. The final sessions ran focus groups for six participants at a time in which they discussed both their experiences in the experimental sessions and their overall experiences with computing as older people.

3.3.1 Note on analysis of results

Total numbers are small and since this was a pilot study there were some problems with time available and my administration. Three participants did not complete all parts of the Pen Game and Web Quiz studies so analysis using ANOVA was not attempted.

3.4 Font size and preference study

Part of the manipulation of interface task difficulty intended in the dual task study was the manipulation of the readability of information presented on screen. A small study of the readability of different fonts under different conditions was planned as part of the overall dual task study. The aim was firstly to obtain individual measures of acceptable and poor fonts for the volunteers involved in the dual task study that meant that individual baselines would be available in the later parts of the study. In addition there is a basic gap in the research literature, we do not know how the ability to cope with various text displays is distributed in older users. Hence a second aim was to use this study as a pilot for a study establishing the range of fonts and backgrounds that could be considered appropriate for older users.

3.4.1 Font size and preference study - method

Text was presented on a 14" SVGA color monitor using 800 x 600 resolution and the Windows small fonts setting. Participants adjusted chair and screen positions to suit their preferred working conditions. There were four subsections to the font size and preference study

Preferred size within a font – short text passages

Ten passages of the same small paragraph of text in a single font but at differing sizes were displayed simultaneously (Figure 3.1). Participants were asked to find the size at which they could barely read the text, the size at which the text was comfortable to read and the size at which the font became too large to read.

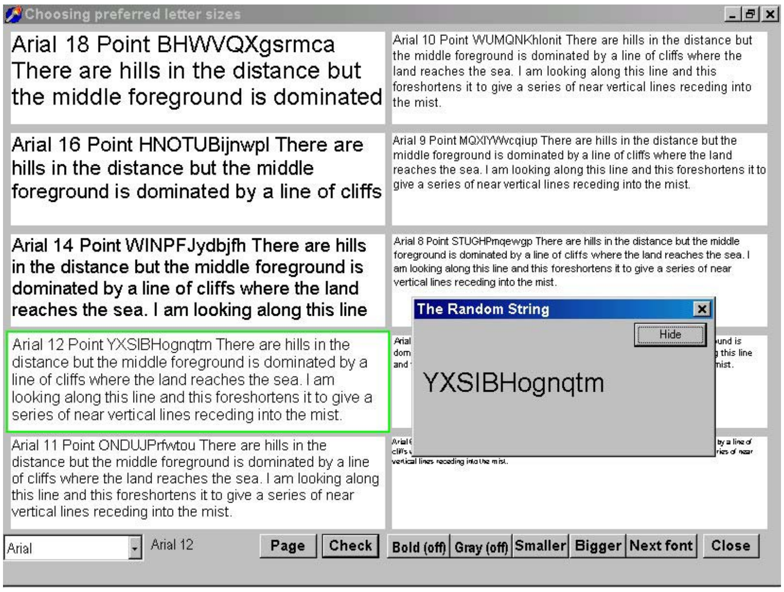

Figure 3.1 Preferred size within a font – short text passages - subjects choose three text sizes: as small as they could read, smallest comfortable and largest comfortable.

The subject was asked to read aloud the string of random letters at the top of each text block and the experimenter then displayed a larger version of the string to check it had been read accurately. To ensure that experimenter and subject both knew which block of text was being referred to, the block could be highlighted with a green outline by clicking on the block, (the Arial 12 point block is highlighted in the figure).This was repeated over a range of fonts. The fonts chosen represented three font families, sans-serif, serifed and a range of fancy fonts.

Preferred size within a font – long text passages

The fonts were also presented in displays that gave a full screen of text and the range of comfortable sizes was again found (Figure 3.2). Subjects choose text sizes that were as small as they could read, smallest comfortable and largest comfortable.

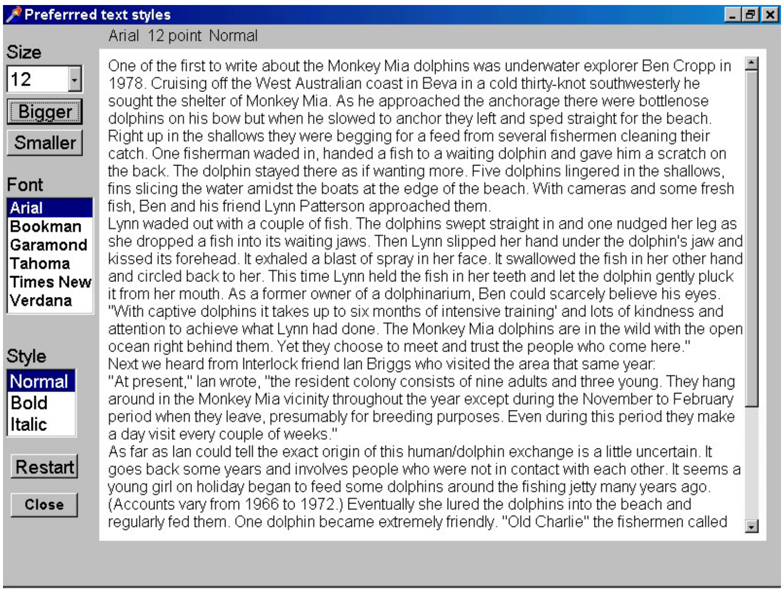

Figure 3.2 Preferred size within a font – long text passages

Font preference within font size

Ten passages of the same text at a single size but in differing fonts were displayed simultaneously (Figure 3.3). Participants were asked to rate the readability of each of the fonts on a five point scale: (excellent, good, fair, poor and horrible).

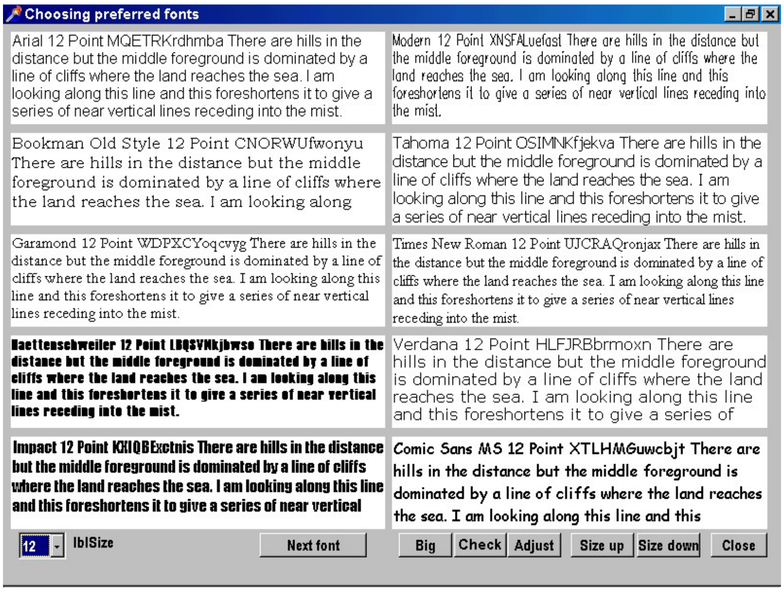

Figure 3.3 Font preference within font size

Effect of background on legibility

Text was shown with differing percentages of colored and graphic backgrounds and the effect of varying the intensity of the background was examined (Figures 3.4 and 3.5). Background effects were studied looking at a split screen where the subject could rate the relative readability of the two halves as background color and background illustrations were varied. Hue saturation and luminance could be altered and a background picture displayed at various percentages of full picture density.

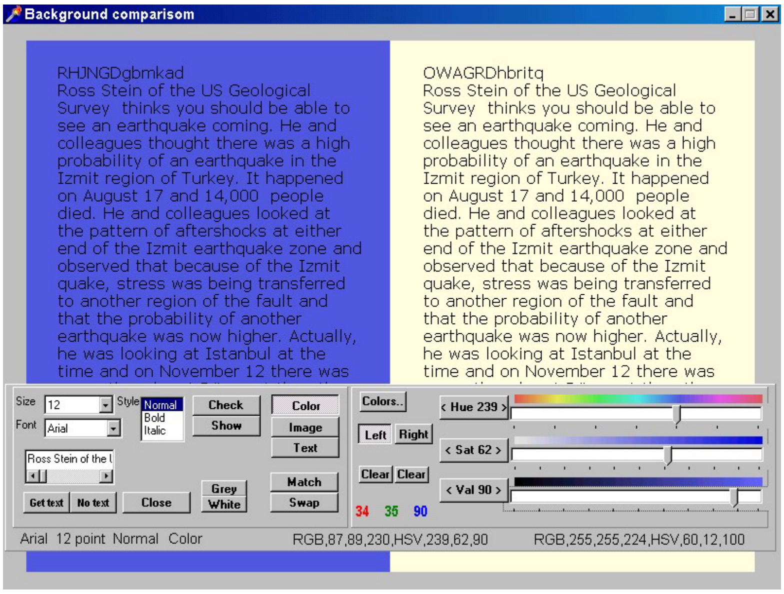

Figure 3.4 Effect of plain background on legibility

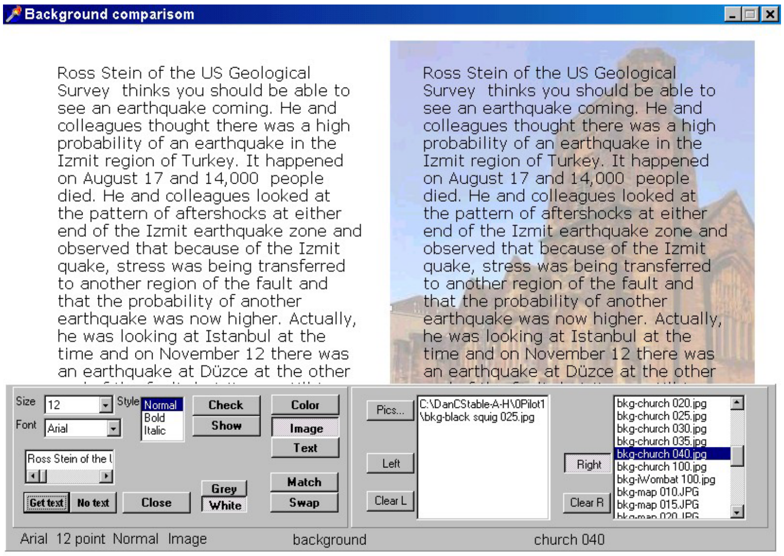

Figure 3.5 Effect of graphic background on legibility. Background effects showing a graphic background with a picture displayed at 40% of full density.

3.4.2 Font size and preference study - results

Table 3.1. Point size where font is just readable

Font>	Arial	Bookman	Garamond	Tahoma	Times New Roman	Verdana
Ave. Range	7.2 6 - 8	7.0 6 - 8	7.8 6 - 10	7.4 7 - 9	7.5 6 - 9	6.8 6 - 7

With corrected vision all participants were able to read very small fonts.

Table 3.2. Point size at which text in this font becomes comfortable

Font>	Arial	Bookman	Garamond	Tahoma	Times New Roman	Verdana
Small paragraphs of text						
Ave. Range	9.1 8 - 11	9.3 8 -11	10.4 7 - 12	9.4 8 - 11	9.9 8 - 11	8.8 7 - 10
Full screen of text						
Ave. Range	10.3 9 - 13	10.5 9 - 13	11.6 8 - 14	10.6 8 - 14	11.3 8 - 16	10.1 8 - 14

It was notable that larger font sizes were preferred for big text displays.

Table 3.3. Point size at which text in this font ceases to be comfortable

Font>	Arial	Bookman	Garamond	Tahoma	Times New Roman	Verdana
Small paragraphs of text						
Ave. Range	13.6 10 – 17	14.0 11 – 17	15.3 12 – 18	13.1 11 - 16	13.9 12 - 17	13.4 11 - 16
Full screen of text						
Ave. Range	14.7 12 - 20	16.0 13 - 26	15.9 14 - 20	13.7 11 - 18	14.1 12 – 20	14.6 11 – 20

Only seven of the twelve participants reported a size at which reading was not comfortable but this was a different seven for small paragraphs and for full screen text displays.

Although some of the older adults could read text at remarkably small point sizes they were seen to strain when doing this. The comfortable size required was consistently larger when screenfulls of text were used than for small paragraphs. Comparing the top of the size ranges where comfortable reading begins with the bottom of the size ranges where comfortable reading ceases, there appears to be no font and size combination which completely suits all the older people in this group. However participants reported that comfort was more affected by undersize text than by oversize text. Therefore if it is not practical for users to adjust font sizes to suit, the best option seems to be 11 point fonts for small blocks of text and 12 – 13 point font where large amounts of reading is involved. However a warning may be seen in the ability of this group to read very small fonts. It seems likely that this group is not representative of older people as a whole and so larger font size recommendations may well emerge from a larger, more representative study.

Table 3.4. The readability ratings given to the different fonts at different font sizes

Size of font >	Just readable		Smallest comfortable		Largest comfortable	
Font	Ave.	Range	Ave.	Range	Ave.	Range
San serif fonts						
Arial	2.5	1 - 4	1.7	1 - 3	1.8	1 - 3
Tahoma	2.8	2 - 4	1.9	1 - 3	2.3	1 - 3
Verdana	1.5	1 - 2	1.3	1 - 2	1.7	1 - 3
Serifed fonts						
Bookman	2.8	1 - 4	1.5	1 - 3	1.6	1 - 3
Garamond	3.6	3 - 4	2.8	1 - 4	2.1	1 - 3
Times NR	2.7	2 - 4	2.2	1 – 3	1.9	1 - 3
Fancy fonts						
Comic Sans Serif	2.4	2 - 4	1.9	1 - 3	1.9	1 - 2
Haettenschweiler	5	5 - 5	4.0	3 - 5	4.2	3 - 5
Impact	3.5	2 - 5	3.8	3 - 5	3.8	3 - 5
Modern	4.6	4 - 5	3.9	3 - 5	3.2	2 - 4

The font preference figures in Table 4 are from a range of 1 (excellent) to 5 (horrible). The ratings could be interpreted in terms of a slight advantage for san serif fonts over serifed fonts with generally poor performance from fancy fonts. However another possible interpretation is that the fonts receiving the best ratings are those which emphasize well rounded, well spaced letters (Arial, Verdana, Bookman and Comic Sans Serif) and this overrides the sans serif, serif, fancy categories. When it comes to preference at small sizes the rounded fonts are highly preferred. (Verdana appears to be ahead but this can be considered an artifact of Verdana's larger characters at small point sizes.) In general the readability of all fonts improves as size increases.

Colored and Pictorial backgrounds

The older people in the study found that marked degrees of background color or anything except very, very faint background pictures interfered with their ability to read text. Blue hues, which are the darkest, were the worst performing backgrounds. It was noticeable however that the effect of background color and pictorial backgrounds decreased as the font size increased.

3.5 First Comprehension Study - the Pens game

As pointed out in the first sections of this chapter the two comprehension studies were intended to examine the issue of whether a dual task model explained the relationship of substantive task performance to interface difficulty. The hypothesis was that because of presumed competition for cognitive resources performance on the substantive task should decline as the difficulty of the interface task increased. As a way of providing an experimental setup that would allow the difficulty level of the interface task to be manipulated, software was constructed that allowed the volunteers to play a game based on combining information about 8 animals paired in 4 pens with a set of rules that stated which animals were safe to pen together and which were unsafe. Thus penning a cat and a rabbit together would result in one safe animal (the cat) and one unsafe animal (the rabbit). The volunteer's task was to provide a total for the number of safe animals out of 8 in each round of the game. In each round the pairings of the animals in the 4 cages was randomly altered. The substantive task could be made harder by varying the syntactical complexity of the way in which the information about the pairings was presented. As well as varying the difficulty of the substantive task, the experiment varied the presumed difficulty of the interface by altering the readability of the font used for presenting the information about the pairings.

The hypothesis under test was that given limited cognitive resources on the part of the older volunteers, interface difficulty should interact with substantive task difficulty. It was also expected that there should be main effects where time taken and accuracy were affected by both syntactical complexity and by interface difficulty.

3.5.1 First Comprehension Study - method

The substantive task is a “game” in which the participant is given a page with a set of rules stating which of nine common animals can safely be penned together and which would endanger other animals. The rules remained constant. The participant was presented with a text passage on screen describing how eight animals are put into four pens two at a time. The participant then pressed a key on the numeric keypad to record how many animals are safe according to the rules.

Interface difficulty
The software accepted as setup information three text styles chosen from the test subject's individual results from the preliminary font study and rated by the subject as excellent, fair and poor (but readable). The format of the text display was varied on each trial using the three fonts chosen at setup.

Task difficulty
Task difficulty was manipulated. Low task difficulty consisted of presenting the information as a list of four lines with a pen number and two animal names per lines with the pens given in order, see Figure 3.6. High task difficulty gave the same information but as a paragraph of eight sentences in random order, see Figure 3.7.

The software recorded the settings for each subject, the settings for each trial and the accuracy and time taken for each response.

A within subjects design was used, participants did 4 sets of 6 trials under the low task difficulty condition and 4 sets of 6 trials under the high task difficulty condition. Within each set participants met two trials under each of the excellent, fair and poor readability conditions. The accuracy and time for each trial was recorded. Participants practiced for 20 minutes beforehand, results of the practice tests were discarded.

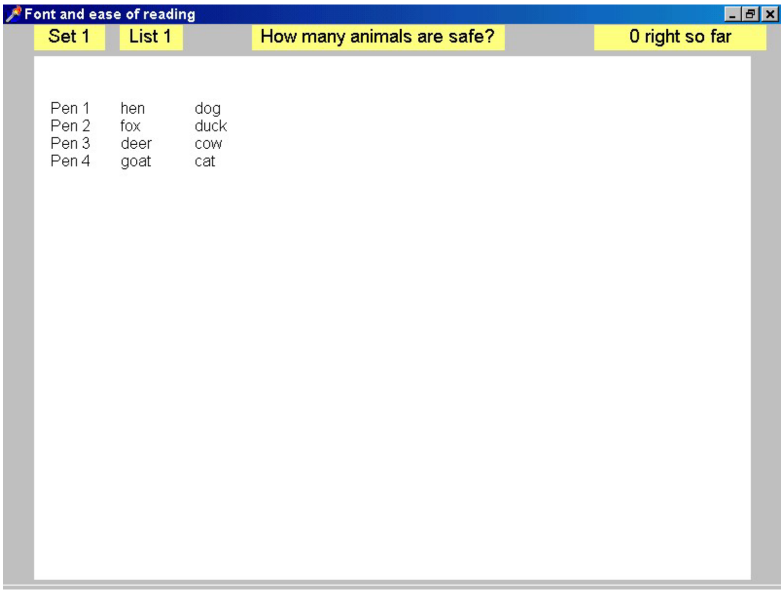

Figure 3.6 Pens game low task difficulty and high readability

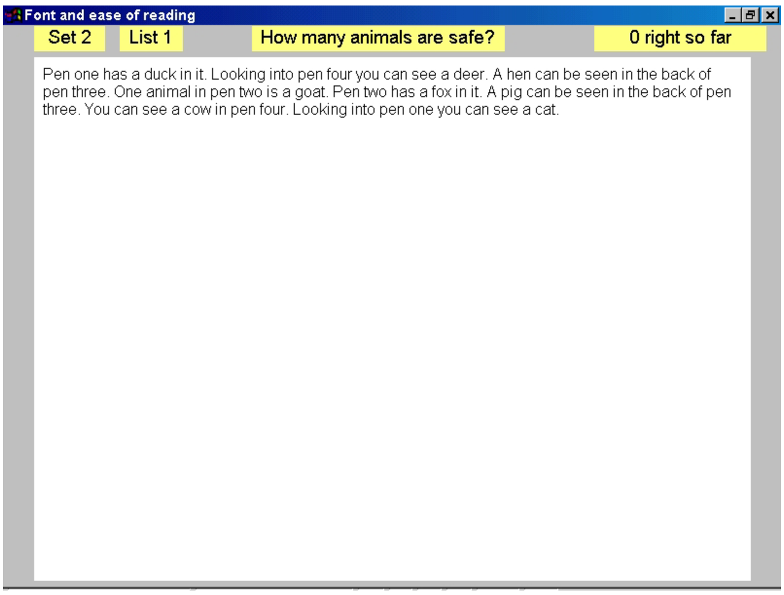

Figure 3.7 Pens game high task difficulty and high readability

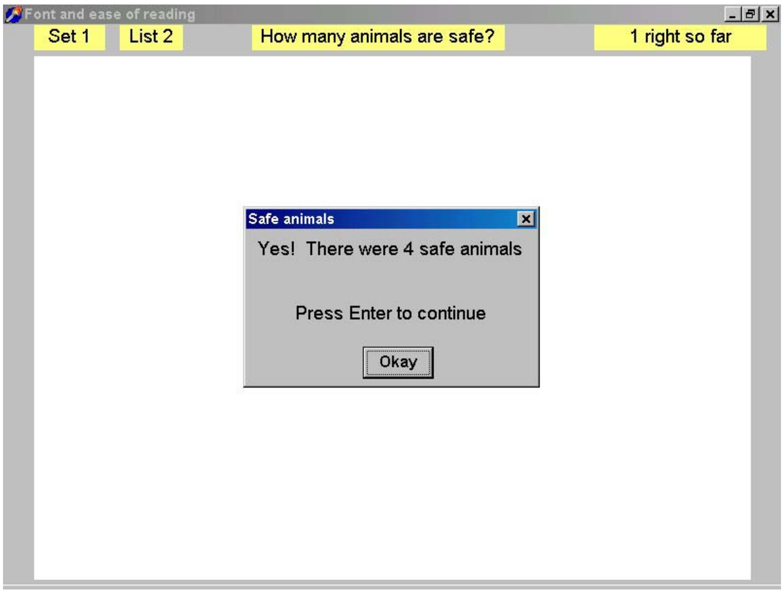

Figure 3.8 Pens game - the subject was given results after each trial

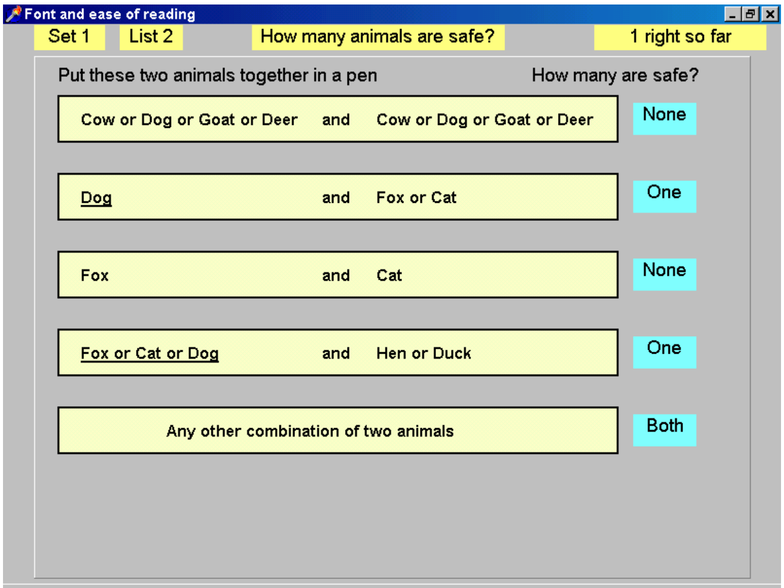

Figure 3.9 Pens game - the screen for displaying the rules. During practice sessions volunteers forgot to use this so it was replaced by a paper version using the same large font and layout in the actual experiment.

Examples of the various levels of task difficulty prepared for the Pens game.

In fact 5 levels of task difficulty had been prepared as shown below. It was found in preliminary work with older users while they were doing practice examples that level 1 and level 2 led to similar performance, level 3 was as hard as the older users could cope with and levels 4 and 5 led to frustration and non-performance. Hence after the practice session levels 1 and 3 were used in the actual experiment as the low and high levels of difficulty. Levels 4 and 5 are of interest in that they were easy for middle aged pre-test subjects and considerably too hard for the older group of volunteers.

Level 1 - simple list in pen order (low task difficulty as used in experiment)

Pen 1	goat	deer
Pen 2	dog	duck
Pen 3	cow	cat
Pen 4	hen	fox

Level 2 - text paragraph version in pen order (not used except in practice)

Looking into pen one you can see a goat. One animal in pen one is a fox. Pen two has a deer in it. A cow can be seen in the back of pen two. Looking into pen three you can see a duck. You can see a hen in pen three. Pen four has a cat in it. A dog can be seen in the back of pen four.

Level 3 - Text version with randomized pen order (high task difficulty as used in experiment)

Pen four has a deer in it. Looking into pen one you can see a cat. A cow can be seen in the back of pen four. A goat can be seen in the back of pen one. One animal in pen three is a dog. Pen two has a fox in it. You can see a hen in pen two. Looking into pen three you can see a duck.

Level 4 - Text with random pen order and extra irrelevant information (found to be too hard, not used except in practice)

Pen two has a deer in it. The hen should be groomed today. A fox can be seen in the back of pen two. Pen four has a hen in it. The pen at the end needs repairs to the wire. Looking into pen four you can see a cow. A cat can be seen in the back of pen one. The duck was shifted yesterday. You can see a duck in pen three.

Looking into pen one you can see a goat. In pen one the animals are not getting along. One animal in pen three is a dog.

Level 5 - Text with indirect naming of pens, random pen order and extra irrelevant information (the older volunteers could not achieve results with this format, hence not used except in practice)

Looking into the pen after pen three you can see a deer. The goat should be groomed today. The pen at the beginning has a fox in it. Pen two has a cow in it. The pen at the beginning needs repairs to the wire. A hen can be seen in the back of the pen at the beginning. You can see a dog in the third pen. The fox needs worm pills. One animal in the pen at the end is a cat. A duck can be seen in the back of the pen after pen two. The hen was shifted yesterday. Looking into pen two you can see a goat.

3.5.2 First Comprehension Study - results

The expectation from the pens study was that poor display formats would affect task performance. This was not found. The following graphs summarize the results obtained. Neither error rate or time taken was highly affected by the use of fonts and font sizes that individuals had previously rated fair or poor. There is no statistical support for an interaction effect and even if one were found with larger numbers of participants it would be unlikely to be of practical effect for actual interface designers as the hint of an interaction seen in Figure 2 only applies to the font / size combination rated as "poor" which should be unlikely to occur in even moderately well designed interfaces.

On the other hand task complexity had a major effect on time taken. It would also have had a practical effect on error rates except that the older participants adopted strategies such as counting on their fingers to cope with the difficulty they were encountering. They did not use these strategies in the simple list condition. Obviously task complexity levels that force users to attempt to supplement what is provided by the interface indicate undesirable levels of difficulty.

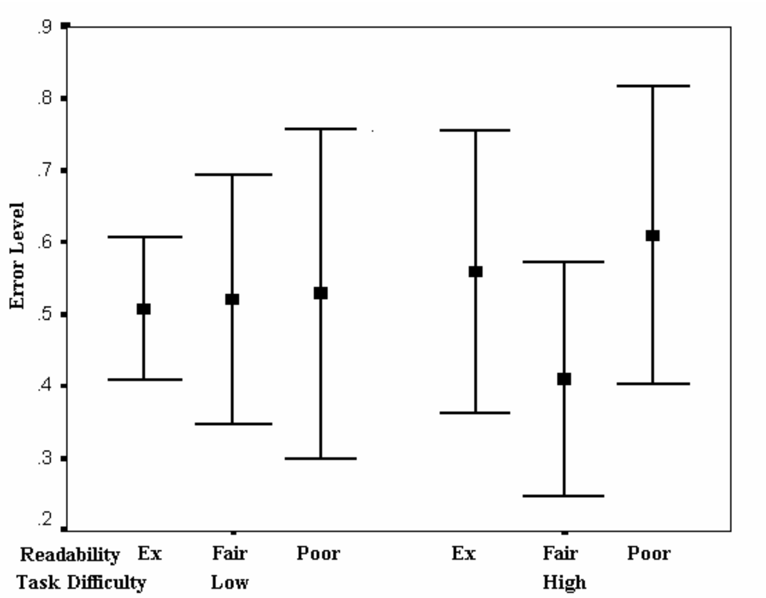

Figure 3.10 Errors made per trial (means and 95% confidence intervals) by task difficulty by readability. In the majority of trials no errors were made. This held under all conditions.

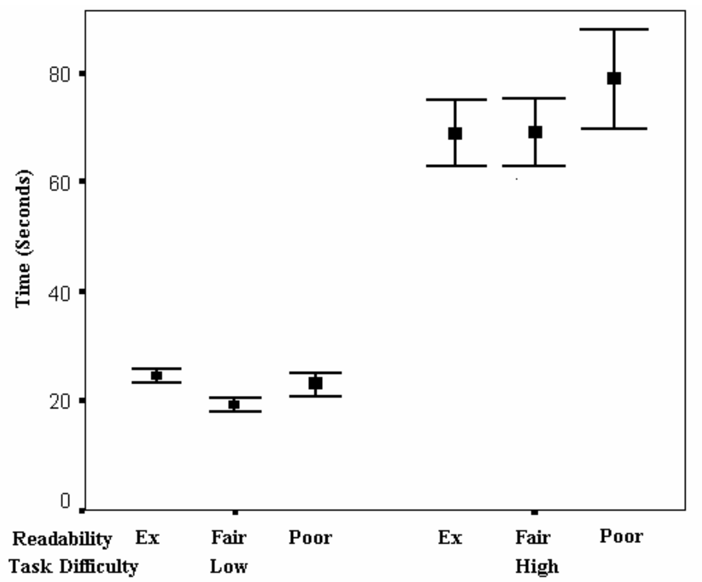

Figure 3.11 Time taken (means and 95% confidence intervals) by task difficulty by readability

3.5.3 First Comprehension Study - discussion

The group proved to have difficulty with an on-line version of the rules of the pen game, the problems were twofold. Firstly participants did not remember to use the rules display when it was needed though they did remember the command to display the rules. A second problem was that the rules display using a large font and a clearly set out design took up most of the screen, this meant that the user had to remember the rule involved, close the display and then look at the information on penned animals. This appeared to disrupt the memory of how many safe animals had been counted to that point. The solution was to provide a paper version of the rules in the same large font format as the screen version. This proved trouble free.

The older users took around 20 seconds per trial in the simple list condition and over 70 seconds per trial in the random order paragraph condition. This compares with the times of 10 seconds (list) and 40 seconds (paragraph) taken by the middle aged subjects used for pretesting the design.

3.6 Second Comprehension study - the Web Quiz

This comprehension study was intended to repeat the testing of the hypothesis of a competition for older users' cognitive resources between the substantive task and the interface task. Again the difficulty level of the substantive task and of interface task were manipulated but within a different context. The intention was to show that if the hypothesis of resource competition was supported, it could be generalized over more than one task/interface combination.

As a way of providing an experimental setup that would allow this manipulation, software was constructed that allowed the volunteers to take part in a web based quiz where they evaluated a set of statements about the information presented in four web pages.

The hypothesis under test was that given limited cognitive resources on the part of the older volunteers, interface difficulty should interact with substantive task difficulty. It was also expected that there should be main effects where time taken and accuracy were affected by both syntactical complexity and by interface difficulty.

3.6.1 Second Comprehension study - method

Software was constructed to present the statements and the web information pages as well as to record the volunteers' responses and calculate time taken and error rates. Three short Discovery Channel type articles were presented in Web page format. The topics covered in the articles were; eclipses, boomerangs and tuataras. Each article was four Web pages long using a large san-serif font. Scrolling was not required to read any page.

A within subjects design was used. A participant read and was tested on each of the three articles and met each of the three display styles while doing so. Data recorded included sequence of moves between pages and test page, time spent on each page, accuracy in answering questions and time taken to answer questions. Participants did a practice session using a fourth article with its own comprehension test. For each of the actual tests, results from the first question were discarded to eliminate settling down time.

Substantive task

The subject first read the four web pages of an article. Then statements intended to test the subject's comprehension of each article were presented one at a time on a further Web page. The subject could make one of four responses to each statement using on-screen buttons. The subject could re-read any part of the article while attempting to answer a question. There were 24 statement for each article.

The participant could make one of four choices about a statement. (Figure 3.12)

1. It was supported by the information in the web pages.
2. The statement was denied by the information in the web pages.
3. The statement was not covered by the information in the web pages
4. The information in the web pages mentioned the topic but was not clear enough to say whether or not the statement was actually supported.

Task difficulty was manipulated by varying the sort of comprehension activity needed to answer correctly. The statements were constructed so as to provide a range of difficulty based on the assumption that statements that simply agreed with material given in the web pages would be easier to evaluate as agreeing with the web information than statements that were not covered by the web information. It was assumed that these in turn would be easier than statements whose agreement with the web information required making inferences based on the web information. Thus variation in substantive task difficulty was achieved by presenting each volunteer with a range of statements that required different types of information extraction from the material in the web pages.

The 24 statements were constructed so that there were six statements whose correct answer corresponded to each of the four choices available to the participant, supported, denied, not covered or unclear. Within each of these sets of six, two statements could be answered immediately from the web material, two statements required inference and two statements were such that the material needed to evaluate them was not available in the web pages. The order of presentation of the 24 statements was randomized.

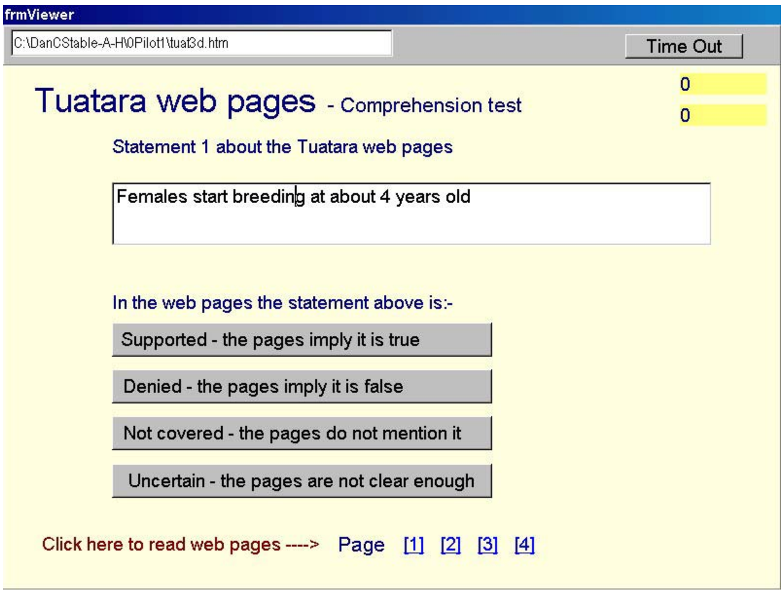

Figure 3.12 The page for presenting comprehension statements. Subjects read the statement, then could use the numbered links at the bottom to browse the web pages containing the article. After they had decided if the statement was "supported', 'denied', 'not covered' or that there was 'insufficient information' they came back to this test page and clicked the matching button.

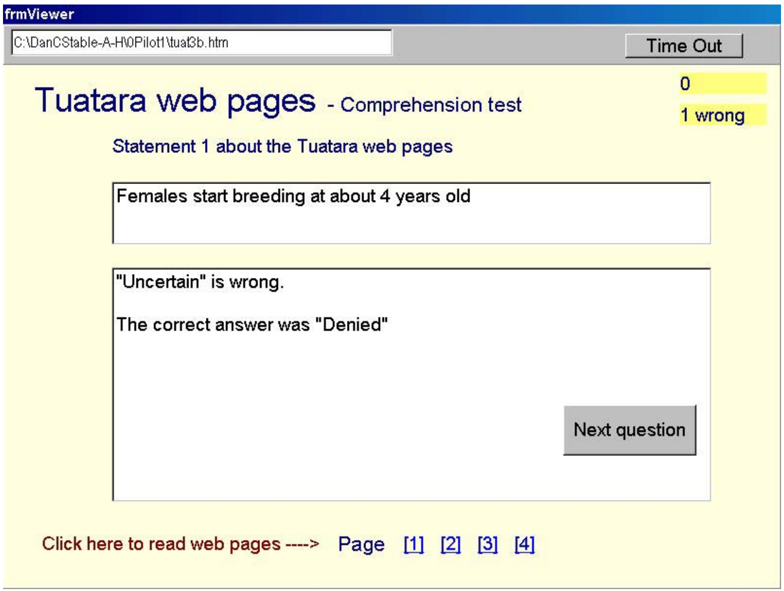

Figure 3.13 The page for presenting comprehension results. When subjects had made a choice they were given feedback and proceeded to the next question via the button shown.

Interface difficulty

As well as varying the difficulty of the substantive task the experiment varied the presumed difficulty of the interface by altering the amount of distracting information shown on the pages that presented the web information. Display quality was manipulated as follows. Each article exists in three formats: “good” - simple display, clear font; “moderate” - italic font, patterned background, “bad” - italic font, pictorial background and distracting and irrelevant animated graphics. Text position on the Web pages remained consistent over each display condition.

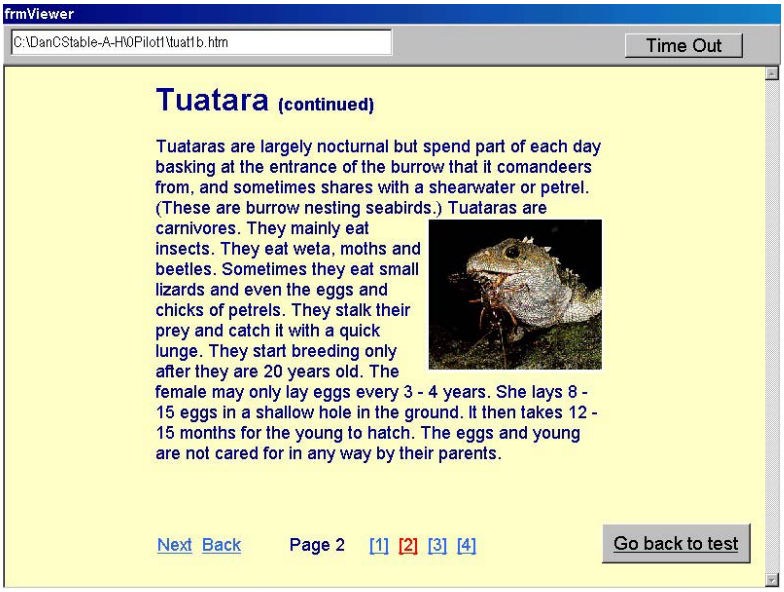

Figure 3.14 The easy level of readability was given by 14 point dark blue Arial text on a light cream background. There was only one static illustration per page. The [Go back to test] button returned the subject to the test page. The links shown at the bottom gave access to the other three pages in the article.

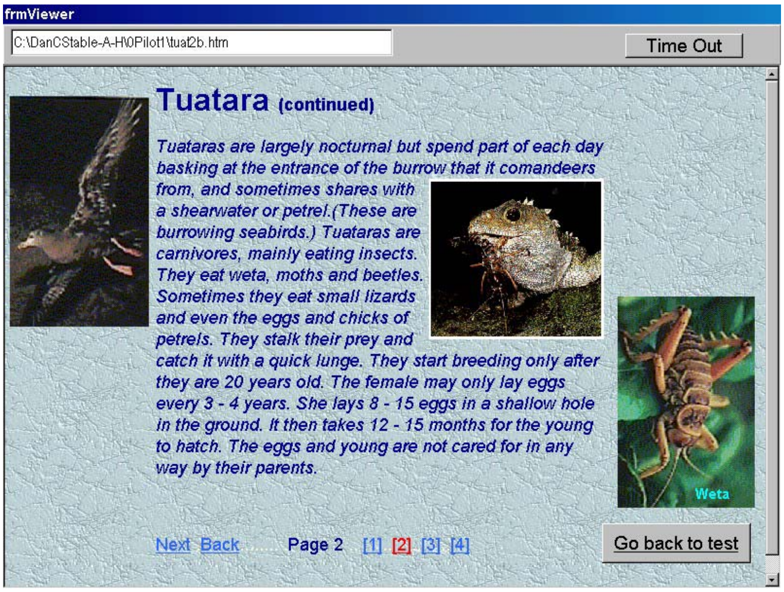

Figure 3.15 The moderate level of readability put a 12 point italic blue Arial font on a medium blue textured background and increased the number of illustrations.

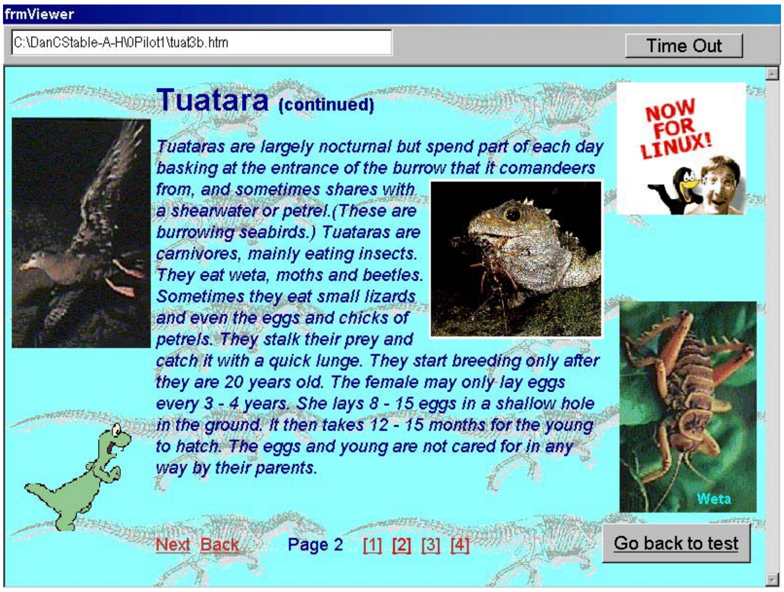

Figure 3.16 The difficult level of readability put the same text on a pictorial background and introduced two animated GIF displays in the bottom left and top right corners.

After the first six participants it was noted that no differences were emerging between good and moderate display formats. For the second six participants the moderate format test was replaced by one where the test was still given in Web page format but the article was given on paper. Font size, text layout and graphics of the paper version were the same as the "good" Web page design with the exception that the paper version occupied two A4 pages compared with the four screens of the Web version.

3.6.2 Second Comprehension study - results

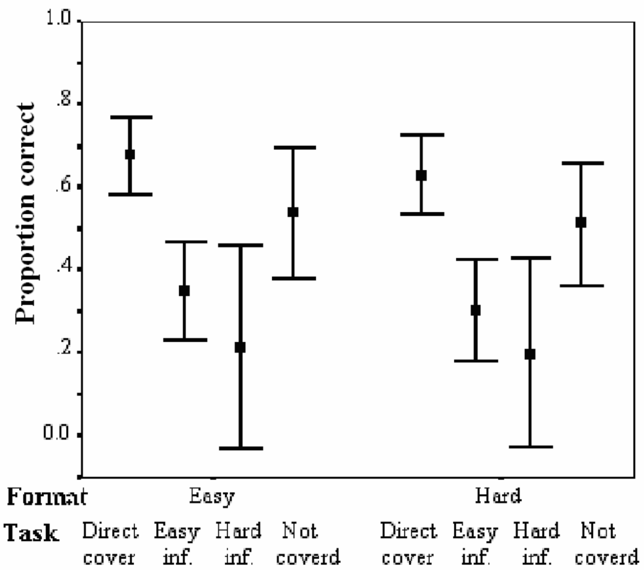

Figure 3.17 Proportion correct (means and 95% confidence intervals) by format difficulty and task difficulty

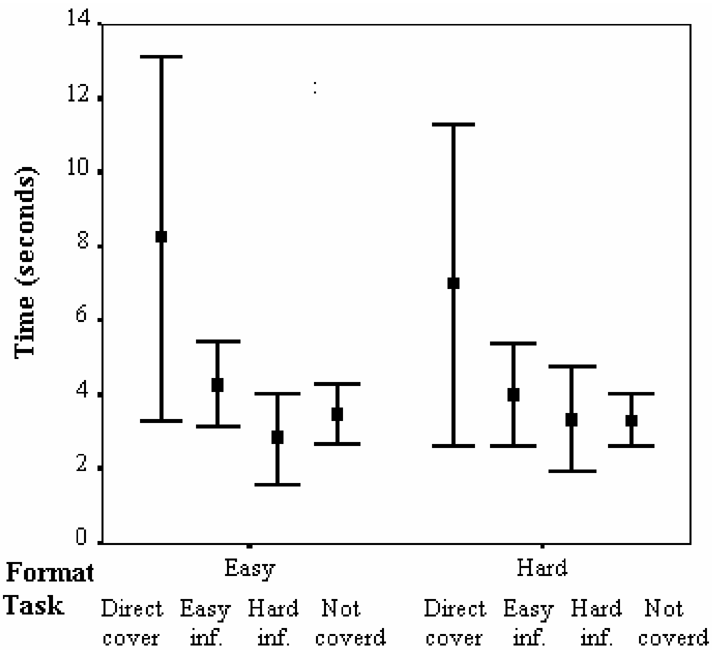

Figure 3.18 Time taken (means and 95% confidence intervals) by format difficulty and task difficulty

"Task" in Figures 3 and 4; task refers to task difficulty: The labels used indicate different ways in which the comprehension items related to the material in the Web articles.
Direct cover – the comprehension item was directly covered in the Web article.
Easy and hard inferences – inferences had to be drawn from the Web article to answer the comprehension item.
Not covered – the comprehension item was not covered directly or indirectly in the Web article.

The task difficulty clearly affected the error rate as shown in Figure 3. Equally the format used for the Web pages did not affect errors. There was no indication of an interaction. After considering the time taken data I was worried that users might be dealing with comprehension items that required inferences simply as if the material was not covered. Therefore the number of times the various possible answers were chosen were compared over types of comprehension items.

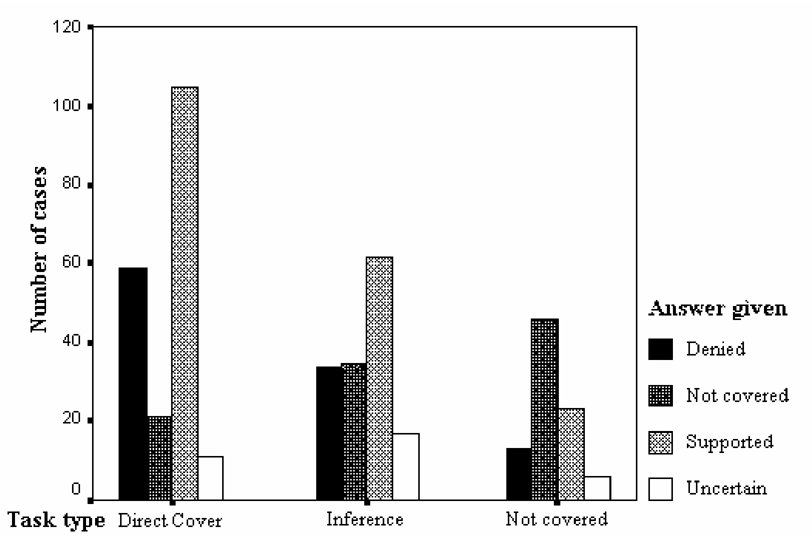

Figure 5. Actual answers given by participants under various task conditions

The results shown in Figure 5 indicate that people responded differently to comprehension items requiring inference versus comprehension items where they needed to identify that the information was not covered. (Because of the small numbers easy and hard inferences are combined).

It remains unclear why items involving direct cover were given longer time by the subjects than items involving inference or items that were not covered. The pattern is the reverse of what might be expected. It is possible that subjects did further reading to check their findings when the material appeared to be covered directly but that subjects disengaged when they did not find easy answers.

Interface format

Although format did not affect performance it did affect participants' ratings of likes and dislikes. This can be seen in Table 3.5.

Table 3.5 Ratings of preference choices for the Web page formats on a 7 point scale. Higher values indicate higher acceptance.

Easy to read		Like - dislike		Use - avoid	
plain	animated	plain	animated	plain	animated
6.6	4.2	6.4	3.7	6.2	2.6

The participants could make use of the Web pages with the deliberately distracting format but they did not like doing so. They were asked to rate the different Web page styles in three ways: did they find the style easy to read from, did they like or dislike the style and given a choice would they use or avoid pages using this style. In all cases the plain style was rated ahead of the animated style. The difference was particularly pronounced on the question of use versus avoid.

Paper versus Web display

Half the group used a Web page format which used a patterned background and italic text as the third presentation style. This format was rated as virtually the same as the plain style by most participants, two participants rated it as slightly worse. The other half of the group used a paper version of the Web pages as the third presentation style.

Here there was a consistent but slight preference for the paper version over the plain on-line version. Table 3.6 shows the ratings for paper versus web display for this group of 5 people.

Table 3.6 Ratings of preference choices for the Web page versus paper on a 7 point scale

Easy to read		Like - dislike		Use - avoid	
plain	Paper	plain	paper	plain	paper
6.6	6.8	6.2	6.6	5.6	6.8

3.6.3 Second Comprehension study - discussion

The lack of effect from Web page format was surprising. The Web page formats were designed to cause difficulty for older people with impaired sight and this group had excellent corrected vision. The filtering effects of selecting volunteers who were existing computer users and who drove themselves also need to be considered. However even within the group studied, the fact that they were able to use a particular poor Web page format did not mean that they enjoyed doing so. In particular animation led to participants stating that they would prefer to avoid pages like this. The most frequently made comments on the animated style were that it was irritating or stressful. Given that use of Web pages is generally voluntary this suggests that pages designed to catch the interest of younger viewers may irritate older users to the point where they do not read the material on heavily animated pages.

The results from task complexity were also unexpected. The group generally did not achieve high levels of accuracy even where the comprehension item covered some fact which was directly stated in the Web articles. They had similar if slightly poorer performance when identifying that a comprehension item had not been covered in the Web article. However when it came to making inferences accuracy sank to chance levels. From Figure 5 it does not appear that comprehension items requiring inference were treated in the same way as comprehension items that were not covered in the Web articles. It appears that the participants tried to find answers other than "not covered" for inference items but usually failed to do so correctly. This is consistent with data provided by Schaie and Willis (1993) indicating that as people age there can be a 25% drop in reasoning ability by the mid seventies.

3.7 General Discussion of the Dual Task Study

The older users involved were generally from occupations indicating a high degree of career success and capacity to learn. They are currently computer users and driving themselves around the city. They are interested in taking part in research. This makes them an unusual group of older people. They still found the comprehension tasks involved difficult. They also showed strong evidence of reduced performance with increased complexity in both the pen and the Web study. This raises concerns about the coping ability of a less selected group of the older population.

The difficulty seems to lie squarely within the comprehension task. The interface manipulations did not affect comprehension task performance. There was no sign of an interaction effect or even a main effect with interface difficulty. This is of interest in that it suggests limits to a simple model in which cognitive load due to coping with the interface competes with the main task for the user's available cognitive capacity. It does not totally rule out the role of large fonts and simple backgrounds in suitable design for older users. Firstly there are older users with impaired sight who were not represented in this sample but whose needs should be considered. Secondly the experimental software itself was designed specifically with easy to read fonts and simple explanations. It won praise from the participants as being particularly easy to read and use.

All users learnt to use the experimental setups in the pen and Web studies rapidly, in under 25 minutes. They sometimes had additional questions when they met the first question of the experimental tasks but then settled down and completed the tasks without needing assistance from the experimenter. There was no evidence of a learning effect in either the Web study or the pen study. The conclusion here is that this older group was very capable when learning a new program with a simply designed and clearly laid out user interface (ie the experimental software itself). This does not translate into satisfying achievement when dealing with complex applications. The group was asked to rate their satisfaction with their progress in general computer use and the average rating was 3.6 on a five point scale where 5 indicated highly dissatisfied.

The focus groups indicated that by far the dominant computing activities of the group were email and word processing. The issues underlying the experimental tasks, decision making and extracting information from complex environments were simply not relevant to the day to day computer use of the group studied. Computer tasks such as on-line banking and tax returns or obtaining entitlement information are more likely to involve older users in the near future and in tasks of this nature comprehension will become of greater importance. The participants were distressed by their failure to do well in the comprehension exercises. They were also not particularly interested in these activities. There was a marked contrast in the attitude of the participants in the font preference study where the idea of finding readable fonts appealed to the volunteers and they were enthusiastic in taking part. Again in the focus groups the participants enjoyed the chance to talk about their experiences and exchange these with other older computer users.

The fact that the older users could cope with the more difficult forms of the interface displays did not mean that they liked them. They clearly stated that given a choice they would avoid situations that involved interfaces similar to the difficult one's used. Bailey (1993) argued that we should be skeptical of interface claims based on preference since they do not reliably indicate performance. This is borne out here, but the preference factor is still relevant to behavior if the users have choices. In an environment such as the Web where sites are competing for viewers this becomes crucial. The other point is that the older users described their dislike of the more difficult interface styles in terms of stress, annoyance and strain. I see it as probable that this indicates that performance could fall off, or older users might simply opt out, given prolonged use of these interface styles.

3.8 General Conclusions from the Dual Task Study

Reflecting upon the dual task study had a pervasive effect on the direction of my research. Its first effect was to raise questions about what was an appropriate research focus for a thesis aiming at guidance for interface designers who were concerned with older users. It also gave me a series of insights into working with older participants that shaped my further work. Rather than being simply a failure to confirm an attractive hypothesis, it proved to be a valuable starting point into productive research.

3.8.1 Appropriate research focus

Even if the dual task hypothesis was supported, given that the aim of the thesis is "how to design usable software for older people", what is the value of the hypothesis about dual tasks and resource competition? Was experimentation in order to examine a theoretical mechanism really a suitable focus for the thesis? Especially since application of the literature review suggestions and development with in-house older users suggested that successful software could be designed without such a theory. Again the variability of aging effects in older people argues against the role of a single mechanism in shaping the responses of the interface designer.

There may be common sources of much of the variance in older people’s performance in such things as cognitive slowing but the interface designer is working at the level of countering the effects, not at the level of countering the original cause. It seems likely that the level of explanation used in the literature survey based on more specific sensory, physical and cognitive aspects of aging is a more appropriate level from which to shape the interface designer’s responses to the needs of older users. Therefore applied research into interface design can usefully address issues at these levels rather than attempting to consider how design may be affected by some overall underlying aspect of aging.

Task competition remains as a possible mechanism underlying older people’s generally poorer performance when using computer applications but I now see it as one of a number of contributions. A simplistic concept of overall interface difficulty may not be useful in estimating the competition between the user’s task and the effort required to manipulate the interface. With hindsight one should analyze the detailed demands of using a particular interface and see how each competes with the perceptual, memory and processing demands of the user's substantive task at particular points in time.

3.8.2 Simplicity means Simple

In terms of improving older people's performance the key issue highlighted here is redesigning tasks to avoid complexity. Where the pen study provided simple lists or the Web articles gave simple facts relevant to the questions that were asked, then the older people performed relatively well. However asked to handle the same tasks in ways that increased demands on short term memory (random order for pen information in the pen study) or required making inferences (Web study) performance decreased markedly. Remember that in the pen study the older users used compensatory strategies such as finger counting to maintain a low error rate in the face of task complexity. A well designed interface should remove the need for such strategies.

It is relevant that I, as the designer, was surprised by the strength of this effect even though I had expected older users to need simplicity. Levels of complexity that the middle aged subjects I pre-tested the designs with, found only slightly more difficult, nearly defeated the older users. This occurred with a group of older users whose career achievements indicate that this had been a decidedly high performing group. Young interface designers are at risk of missing the importance of extremely simple representations of the task. Perhaps young designers are also at risk of not understanding how their view of simple fails to match that of older users. This has subsequently been strongly borne out in Newell et al's (2005) study of the assumptions that designers brought to a project for older users.

3.8.3 Selection effects and Diversity

I am concerned about the generalizabilty of experimental findings using older volunteers. The filtering effect of selection bias means that the computer-using older users who volunteer are probably atypical. Asking participants to come to an experimental site rather than observing users in their daily activity seems likely to accentuate such bias. This is particularly likely in a widely spread out city with considerable traffic congestion and poor public transport.

The individual results were remarkably variable. Even if larger numbers of experimental subjects had meant that small yet statistically significant interface effects had been observed, such results would not have characterized many of those who took part. This illustrates the issue of whether statistical analysis based on measures of central tendency is appropriate when dealing with research on older computer users. It would seem that studies of interface design for older users need to address the point that difficulty with an interface for older users is a very individual matter based on the particular combination of aging effects that the older person has.

What this study underscores is that selecting a representative group of older learners is problematic. Hertzog (1996) has called the problem of selection bias the Achilles heel of research on aging and this study bears this out. The easily available older people for studies of interface design and aging are existing computer users connected to email. They are unfortunately not representative of the general older population.

Studies on designing computer systems for older people should carefully define their aims. Is one trying to improve the access of existing older users, trying to design for older people who are currently not computer users but may be faced with a need to get computerized services or is one trying to design general purpose interfaces and using older test subjects on the basis that they are more sensitive to (some) interface problems. The study aims need to be explicitly linked to selection of participants.

3.8.4 Ethical involvement with older participants

Although the study had received a formal research consent and was well meaning, it ended up exposing the older participants to a situation that led to failure. Further this failure distressed the participants and led them to question their identity as competent people in that what should have been relatively simple problem solving was beyond them. The issue of asking older volunteers to fail and the consequent distress and re-evaluation of their belief in their competence needs to be considered in any research design. In particular the standard experimental evaluation of task performance tends to set tasks that will provide a percentage of failures over n trials. This tends to be taken for granted in the research literature but if there are other ways of obtaining the desired information these other approaches need consideration.

3.8.5 Motivation

One of the crucial points illustrated is that the decision making and information gathering scenarios around which the study based its tasks were not typical of the older group's normal computer use and were not seen as relevant by the participants. They also led to higher levels of failure than the participants were comfortable with. The result was that there was a tendency to partly disengage from the tasks. To increase the realism of the levels of task performance obtained from older participants there should be careful selection of tasks so that the tasks are seen as relevant and so that the overall level of success achieved is acceptable to the participants.
A lesson from this study is that in designing research on interface design for older people we need to look more closely at what older users are actually doing, what they would like to do and what actually prevents them achieving their aims. Information

gathering (which in this pilot study was carried out in the focus groups after the experimental phase) should be done well beforehand and shape the design of any later experimental work.
Charness and Schaie (2003) argue that understanding how older people learn to use new technology is a crucial aspect of designing for older users. Salthouse (1996) points out that acquiring competence on complex tasks in older people takes more time than we have available in laboratory based experiments, he suggests that this means studying older people as they learn in real life. The lack of engagement found in the less rewarding parts of the dual task study suggest that if research moves to areas that are more representative of older people's actual lives we will obtain more relevant and higher quality information.

3.9 Towards a desirable research format

The Dual Task study left me with a concern about the narrowness of the information gained in the experimental setting compared with the focus groups. The question arose of finding ways of studying older computer users in ways that allowed serendipitous findings and in ways that were ethical. There was also an emerging insight into the need for obtaining realistic engagement from the older volunteers by way of tasks that were seen as relevant and activity that was experienced as rewarding. Techniques for doing this looked as if they could be found in making the research occur in settings that functioned as social gatherings and by changing the role of the volunteers from research subject to research participant. It was hoped that enjoyable activities would provide an ethical way of rewarding volunteers. There seemed to be an advantage of exploring the older people's lives in more depth to obtain more insight into the context within which they approached computer use. At the same time the experience from the focus groups in the Dual Task study seemed to offer encouragement for the general thrust of the implications for interface design raised in the literature survey. The older users had concerns about the difficulties they experienced with computing that definitely reflected the issues raised in the literature survey. These points led to a rethinking of the research methodology that would be fruitful in pursuing a study of what interface designers should consider in undertaking interface design for older users. This methodology was refined in the studies that are reported in the next three chapters and the eventual methodology will be discussed in detail in Chapter 7.

Chapter 4 MEETING THE NEEDS OF OLDER BEGINNERS

4.1 INTRODUCTION

This chapter looks at the issues for older beginners by examining insights gained from the development of the WinTutor tutorial. WinTutor is an interactive tutorial for older beginners that was designed after the completion of the literature review. The impetus for constructing the tutorial came from exposure to older beginners attempting to cope with poorly designed instruction. The construction of this system and the accompanying interaction with older learners and tutors of older learners gave a chance to reflect on how the implications of the literature review could be put into practice. The research that led to WinTutor was not initially designed as research into developing for older beginners, rather it was aimed at broadening my understanding of, and exposure to, older people. However the WinTutor project did in fact lead to useful understanding about design for older people and it was instrumental in shaping the direction of subsequent research. There are several threads to the WinTutor study.

- Because WinTutor is an interactive tutorial, its development involved constructing an application that very inexperienced older users could work with comfortably. Hence the WinTutor study provides a basis for looking at the interface design issues when constructing an application for older beginners, both at the level of individual screen designs that communicate well with, and can be successfully manipulated by, older beginners, but also at the level of an overall application architecture that could be understood by older beginners.
- An interactive tutorial constructed in association with older people gives the designer repeated experience with developing screen designs that work for older people and repeated experience in discovering screen designs that may please the designer but which do not meet the needs of the older participants. Developing the 57 screens used in interactive tutorials proved to be an excellent way of sharpening my understanding of the interface needs of older people.
- The interface guidelines used in the development of WinTutor follow the broad outline of the implications for user interface design for older users derived in the

literature review. Hence the success of WinTutor can be considered as offering some support for those implications.

- The WinTutor study makes a start on establishing aspects of a methodology that allows a researcher / designer to realistically explore and address older people's needs.
- The development of WinTutor offered a chance to look at what is needed when providing training for older people. It will be argued that this training is significantly different from that needed for younger people and that providing suitable training in basic skills is important to allowing older people to become effective computer users.
- The WinTutor study provides a look at the difficulties of older people when learning how to use computers. These difficulties should be seen as relevant to the wider issues of older people and the design of user interfaces to suit them.
    1. Firstly the difficulties of older beginners will shape their later attitude to computing and may persuade some older people to give up the idea of becoming computer users. Hence understanding how to reduce these initial difficulties is important.
    2. Secondly the difficulties when older people try to learn a new piece of software will have some similarities to those they faced when they first began computing.
    3. Thirdly some of the gaps in computer knowledge that older beginners display are likely to persist given a.) the poor provision of training currently available for older users and b.) the general difficulties they face in retaining learnt material. Hence the initial gaps found in older people's computer knowledge act as warnings to the designer of knowledge gaps that are likely to be present in at least some of their older users.

In what follows this chapter will first look at the observations of older beginners that prompted the WinTutor study. This consisted of observations of older users in a conventional teaching environment, these gave an, at times, vivid illustration of the issues identified in the literature review. The design of WinTutor is then discussed pointing out the way in which the design features that WinTutor implements and the design approach followed in WinTutor's development are aimed at providing solutions to the identified issues of older beginners. The extent to which WinTutor can be seen as effective is then considered. This will be followed by a section that specifies the design recommendations that emerge from the development of the tutorial, including recommendations for the methodological approach. Having established the contributions of the WinTutor study to the overall research, the conclusion of the chapter looks at the further issues that needed exploring and hence shaped the subsequent studies. For convenience a detailed summary of all the recommendations from the WinTutor study and the other studies is provided in Appendix E at the end of the thesis.

4.2 Study format

At the time the WinTutor study was begun the main format of the research was intended to be an experimental examination of older people's interaction with interfaces. However there was also a need to flesh out the rather academic picture of aging that came from the literature review and allow some observation of older people that was not constrained to what could be framed in an experimental context. I considered that it would be important to make contact with older people in a way that let me gain a wider overall picture of their needs, attitudes and difficulties. To this end I sat in on three courses for older people run by Unitec.

The Unitec courses were aimed at teaching introductory computer skills to older people in a Windows environment. The courses consisted of five two hour sessions run with one or two day gaps between sessions. Two separate tutors were involved, one taking two courses and the other one. Neither tutor had special training in working with older people. Class sizes were around ten people. The age range was from sixties to late seventies. With the agreement of the tutors I chose a flexible role as both an observer and a teaching assistant, this gave me the freedom to become involved in older learner's individual difficulties, to intervene at times and to observe at others. I attended all sessions and the afternoon tea breaks in the middle of sessions.

My personal reaction to the effects of these classes on the older beginners was considerable distress. After the first two courses I intervened, providing a rushed, very crude tutorial that provided some simple interactive exercises on the computers in front of the students. This will be referred to from here on as "the intervention tutorial" so as to distinguish it from WinTutor. The exercises were designed to be easy to read and to carry out. The response observed from the tutor and the students was highly positive.

This suggested that one way of examining the application of the guidelines that were being developed for older users would be to use them in constructing a carefully designed interactive tutorial for older beginners. This led to a decision to design and test an improved tutorial for older beginners. This became the WinTutor tutorial described below. Much of the development involved testing with two 55 year olds who were willing to devote extensive time to short sessions of impromptu interface testing in order to help the project and to learn the skills they needed. These people had jobs that required them to learn Windows skills for the first time and they were finding themselves remarkably unable to do so. It would have been preferable in some ways if there had been usability subjects readily available who more closely matched the target age group, but, as will be seen, the final acceptance of the product suggests that the insights my available test users provided were relevant. There was also the considerable advantage of being able to form a close working relationship with these people so that there could be free discussion of the failings of each version of the topic screens in the tutorial as they were developed and of the difficulties that they as learners were experiencing with their own skills and abilities, with Windows concepts and with skill development.

Once the tutorial was in a state where it could be considered to be a credible product it was provided to a selection of experienced New Zealand SeniorNet tutors and the tutorial was refined in response to their feedback as they trialed it on their older learners and discussed it with their colleagues.

Another useful source of reflections and ideas was to set design exercises based on problems in the WinTutor tutorial to classes of (young) students doing graphical user interface programming and interface design courses. This tended to highlight the incomprehension of young designers when faced with a request to design for older users' difficulties with actions and concepts that the younger designers considered absolutely self evident.

4.3 OBSERVATIONS ON OLDER BEGINNERS

The experience of being involved in the Unitec classes was frankly distressing. Most students gained little, they were frequently confused, much of the material was incomprehensible to them and not relevant to what they wanted, which was practical instruction in how to do simple computer tasks. Though he did not express this to the class, one tutor privately expressed the view that he was wasting his time and that the older people were simply not capable of acquiring computer skills. A number of students left the courses feeling that they were too affected by age to continue with computing. In my view this was unnecessary. The Unitec classes for older users provided a rich ground for observing and intervening in older beginners' issues. However because of the poor outcomes and the negative self evaluation of many of the older students resulting from their experiences, it would be highly unethical to deliberately set up such an environment.

4.3.1 Observed issues for older beginners

Vision

The older beginners in the Unitec introductory computer courses were faced with teaching material intended for younger users. Visibility issues arose quickly, some of the students could not make out the text and features on the datashow display at the front of the class. Some of the students could not see the printed material or use it in combination with the screen display. The default font used on the students' machines was set to a 10 point font that was too small for the students.

These older beginners struggled with small fonts on screen and with instructional material on paper. From the items that these older users had difficulty in identifying it is clear that the need for larger readable fonts applies to all text the older user needs to read; captions on buttons, menu and pop-up menu fonts, help text, listboxes and labels explaining other features as well as to blocks of text to be read or input by the older user. In the quickly produced intervention tutorial, Arial, with its simply formed, well spaced letters, was observed to be easily read on screen by the older users, this accords with the findings of the Dual Task study. Many of these older learners struggled when asked to combine paper documents with on-screen work. There was much shuffling of spectacles, peering closely at screens (this involved body positions that the older people found uncomfortable) and forgetting of instructions as they moved from paper to screen. Corrected vision for comfortable reading does not provide for clear focus at the slightly greater distance involved when reading text on a computer screen.

In the Unitec courses the older learners were noticeably slow to find features the instructor referred to, particularly on those MS Works screens that were more complex. This is in line with the findings on older adults' reduced ability to perform visual searches over complex backgrounds. In the intervention tutorial, the screen layouts were very simple, consequently the problems with locating features practically vanished.

These problems with font size and search were also observed in the older users I involved in the development of WinTutor. The consensus that we reached after experimenting with a variety of typefaces was that an Arial 14 point font was easy to read while an Arial 12 point bold was a possible alternative for short text items such as button caption. We also found that reading large blocks of text on screen in almost any font could be an effort but that a slightly off white background was seen as making this easier.

Manipulation

There is research reported in the literature review that shows mouse movement is less well controlled by older users, see Schieber (2003). This slower and more erratic mouse movement with a tendency to overshoot small targets is a good description of what was observed with older users in the Unitec classes and during the development of WinTutor. In addition some of the older beginners had incomplete control over their fingers as they moved the mouse so that there were instances of inadvertent clicks while the mouse was being moved. Further some of the older people seen in the Unitec classes and in other sessions I ran with older people had learnt a poor style of holding the mouse where the base of the hand is in the air rather than resting on the mouse pad. These people were likely to move the mouse significantly when making even single clicks and needed to be taught a more stable way of holding the mouse. Drag and drop features in this context meant that older users could start unintended drag operations as well as make unintended drops with little understanding of what had happened or why. Even after tuition on how to hold the mouse not all of the older beginners could manage to double click. Also at times older beginners would miss the borders of a window and be bewildered by the consequence of the window being sent to the background, by a click that they were unaware was outside the window. They were also at a loss as to how to recover from such a situation. Aula (2005) notes similar problems for older novices observed in Finland including a striking example where an unintended click on the mouse wheel locked the mouse movements into controlling scrolling. Her users then made their usual response of trying to find the mouse cursor by moving the mouse about and were bewildered by the text and screen movements that this caused.

Menus and Sub-menus

The older beginners in the Unitec classes had difficulty in finding items in Works menus, generally they could find an item mentioned by the tutor but only after effort and occasional false choices. This corresponds to the reports of older people's greater difficulties with visual search and difficulties with acquiring small targets. A further difficulty in searching was provided by the distraction that occurred when the mouse moved over the main menu and triggered successive sub-menu displays. Note that in the Unitec classes the menu text was in the default MS Sans Serif font at 10 point size, this was in itself too small for easy reading or searching by the older students. Once a menu item had been located it was not always a sufficiently large target to be accurately clicked on by the older user and mistakes were not uncommon.

The provision of sub-menus added an extra difficulty in that under the Windows operating system the mouse movements required to capture a sub-menu item assume the user maintains a certain speed and accuracy in order for the sub-menu opened from a main menu item to remain visible as the user traverses to from main menu item to sub-menu item. The older beginners could not reliably produce this combination of speed and accuracy so there were repeated instances of the older user losing the sub-menu display. This occurred either because they ventured off the main menu item while trying to move horizontally to the submenu item or because they attempted to move diagonally directly towards the sub-menu item but moved so slowly that the operating system interpreted their intent as a move to a different main menu item, not a move to the sub menu. Older beginners found these results confusing and frustrating.

Typing

Typing was a major source of difficulty for many of the older beginners observed at Unitec. Their text input was upsettingly slow for both the older users and the tutors. Given their reduced effectiveness in visual search some older typists can be described as, "hunt, hunt, swear, hunt and peck", and they can be observed going through the same agonizing process for the next occurrence of a letter that they have found only a few seconds before. Thus the core problem observed was an inability to find keys quickly while searching the keyboard. However this combined with less than flexible fingers and a lack of knowledge of what keys produced various required editing effects such as entering capitals, a space, a new line, removing text or repositioning the insertion point. The older beginners at Unitec were observed to be confused about the difference between the insertion point and the mouse cursor. Charness (1998), using informal observation, noted that older users had serious difficulty understanding the difference between the mouse cursor and the insertion point indicator. My own observations confirm that this occurs and is important in hindering older people's gaining typing competency.

Because of problems with keyboard skills, errors were frequent in the exercises provided. I watched older users use the mouse when trying to position the insertion point in order to make corrections, and it was apparent that the older users were trying for targets (text characters and the spaces between them) whose size strained the older users' ability with mouse positioning unless the fonts used are very large. Similar problems were noted by Aula (2005).

Although it should be simple to approximately position the insertion point using the mouse and then make fine adjustments using the arrow keys, in practice older users were not seen doing this when revising, they tend to persist with mouse based attempts to position the cursor before switching to the keyboard to enter corrections. Alternately, if errors occurred during typing the older users would backspace-delete even quite large portions of valid text in order to get back to the mistake. What appears to be happening here is the lack of a flexible strategy for swapping between mouse and keyboard or between character keys and position keys.

A further problem was that because older people usually look at the keyboard when typing (as well as having a poor model of what the caret signifies and trouble locating it) they are likely to type into text entry areas other than those they intend to, only discovering the mistake after they look back at the screen on completing typing. Again similar problems were noted by Aula (2005).

Scrollbars

The older users in the Unitec classes were observed to have numerous difficulties with manipulating and understanding scrollbars. They were confused by the reversal of direction, a down arrow meant that the text moved up. They struggled to capture the up and down arrows. They did not know about the functionality of the track and slider and if shown were likely to drop the slider when trying to drag it. They did not understand the information contained in the relative size of track and slider. A typical problem was that they would be typing a fairly long (one or two paragraphs) document into MS Works and at some point they would inadvertently click on the track of the scrollbar while trying to click on the text in order to make a correction. (remember that typing and positioning errors were frequent.) The older user would be unaware that they had clicked the scrollbar instead of the text. Confusingly the scrollbar track would respond to a click by making the viewing window jump to a radically different part of the text, at times to a place where the page was in fact blank. The older users virtually all interpreted this as meaning that they had done something that had destroyed their work. This was especially distressing because typing in one or two paragraphs can be a major effort and achievement for an older user. Faced with having apparently lost their work, the older beginners often proceeded to do things that did in fact cause the loss of what they had typed in, such as starting a new document ready to begin again.

Although the older beginners did gain a general understanding that scrollbars were for moving to different parts of text they did not use the tool effectively and restricted themselves to repeated single clicks on the up or down arrows so that they moved through text one line at a time. They also failed to generalize the scrollbar concept. On the forth day of the course students were asked to choose a piece of clip art and insert it into a document. The tool for selecting from the available pictures included a pair of horizontal arrow buttons [<] and [>] that scrolled the user through the images. None of the older users that I observed made the connection that these buttons were to be used to move through the selection of available images. Each student needed to be told what to do.

Comprehension

It was frequently the case that tutors in the Unitec classes asked the older beginners to start a new topic while they were still unsure about the current topic. It became apparent that material to be taught to older beginners needs to be covered at a sufficiently slow pace to allow students to understand it and that this pace is slower than that for younger users and needs to be accommodated into the teaching schedule.

A number of the incidental topics that the tutors brought into the course appeared to reflect the tutor's concept of what was needed to be a respectable computer user, "well of course everyone should know about binary data". Observation suggested that the course material should be ruthlessly pruned to remove items that are not relevant to the older student's immediate learning needs. A large amount of spoken material was presented between each exercise and the students did not take up enough of this material to succeed in the exercises without considerable step by step handholding. This material included items from the history and theory of computing that were both confusing to the older beginners and irrelevant to what was needed for the subsequent practical exercises. It was also my impression that, in the Unitec classes for older beginners, the provision of background information on computing history and concepts impeded the students. For example there was confusion when the older users were introduced to binary storage, they did not readily see how text characters could really be held as one’s and zeros. When the class then proceeded to learn how to save their work, worrying about the need to understand binary storage, and how binary storage was relevant to what they were doing, appeared to interfere with learning the steps needed to save a document.

Navigation

The older users became confused when attempting to navigate around MS Works. MS Works gives a notable example of an application that combines a lot of features that are unfriendly to older users and older beginners. The older beginners had considerable difficulty in finding how to get to the appropriate part of MS Works in order to do text entry exercises. In part this was because they did not appear to form a usable model of the structure of MS Works and how the Navigation Center let users jump to the various parts. They found problems in finding the Navigation Center, in locating the word processor and in extracting themselves when they visited the wrong locations in MS Works. They also evidenced considerable confusion when faced with the difference between separate windows within a single program that gave access to different functions and the windows of another program that offered yet another function. Why when they were using MS-Paint was there no obvious way to get to the navigation center of MS-Works but when doing word processing in MS-Works they were expected to get to the Navigation center to do other exercises. Throughout the five days of the course the older students frequently became lost and needed to be rescued.

Memory and learning

To say that the older users had trouble learning and comprehending the course material offers an explanation that is at too high a level to identify the multiple sources of difficulty involved, and hence at too high a level to plan effective intervention of interface designs that circumvent these problems.

In the Unitec classes, the tutors used an existing full featured application for younger users (MS Works) as a basis for teaching the older students and asked the older beginners to carry out exercises in this environment. The intention was to teach MS Works as well as teaching elementary skills. While this had been found to be workable for younger learners it badly overloaded the older learners.

The tutors were well intentioned, polite, patient and considerate but had a timetable that they wanted to keep to so that they could compete the scheduled content. The differences in the individual speeds at which students mastered material and the extent to which the students needed individual assistance meant that tutors were forced to leave students behind and to terminate some exercises before all students had succeeded. When older users came to subsequent sessions they appeared to have retained relatively little of the material from the sessions of the previous days.
One of the other points that came up in discussion of learning experiences was that teachers with Windows experience but without experience in teaching older beginners tended to teach a number of different ways of achieving one result. The same approach was seen in Help manuals. Older users were found to be surprisingly united in their condemnation of this. Their strongly expressed preference was to be told one way of doing things and they said that being told of multiple techniques was confusing and made remembering any of them more difficult.

From observation it appears that initially skills such as using the Delete key to delete a character, delete a blank line or delete selected text are learnt individually, the older

users observed appeared to take time to see the overall role of the Delete key and this was complicated by the similar but distinct action of the Backspace key.
Watching the older beginners' efforts and attempting to find out what prevented them from proceeding it was evident that at worst they operated from a mishmash of a partial memory of the large volume of recently presented information by the tutor, a difficulty in comprehending new concepts, disruption from trying to cope with errors, a limited ability to see, interpret and find the features that were being referred to, the fact that some manipulation tasks were likely to generate further errors and a lack of knowledge of idiomatic features and jargon that the tutor assumed were obvious. In the midst of the distress caused by this situation they would then be asked to move on to another equally confusing topic.

Idiomatic knowledge

Older learners faced with a computer for the first time are beset with the need to learn a very large number of "factoids" almost simultaneously. The essence of what is mean here by "factoids" is that they are small simple facts and rules that exist in isolation from each other. There is little connection between each fact and little obvious reason for many of the actions and patterns that make up the user interface of the (Windows) operating system. Consider text selection for example. The basic questions are, how do you select text and what do you achieve when you do this? But there is nothing really intuitive about the available mechanisms for text selection. Dragging over text, using the arrow and position keys with Shift held down, typing Control-A or double or triple clicking words and paragraphs form an apparently unrelated jumble of methods. For any beginner of any age there is a period of needing to deliberately remember each of these skills individually. For young users there is a rather rapid transition to automated behavior whereas older users appear to struggle to remember for far longer than young beginners.

Cooper (1995) makes the point that very little about graphical user interfaces is really intuitive, rather Cooper suggests that what a graphical user interface presents to a user is a rich set of idioms. Cooper argues that what distinguishes an idiom is that it is an easily memorable association between a stimulus and a meaning but that this association is not inherent in the idiom, it must be learnt. What was seen in the Unitec classes was that older people did not learn idiomatic skills quickly or reliably in the midst of learning other skills.

One of the successful features in the design of the intervention tutorial was that the idioms needed by older users to complete exercises were identified in advance of the exercise and the intervention tutorial deliberately taught the needed idioms first as separate and distinct items of learning.

One of the crucial differences between younger and older users illustrated by the Unitec classes is that older users do not readily acquire idiomatic skills through incidental learning while engaged in developing higher level skills, such as learning to use a word processor. Because of the number of idioms needing to be rapidly (and nearly simultaneously) acquired for competent computer use, the idiomatic nature of the graphical interface is initially a barrier to older learners rather than an assistance. Lacking idiomatic skills and not being able to acquire them in the midst of other learning is a major obstacle to further computer learning by older users.

Communication between young and old

In the Unitec classes the resource materials were unsuitable. There was a not very powerful datashow used to project the tutor's computer screen which was set to unsuitably small font sizes. This resulted in a poorly lit display at the front of the class that most of the class could not clearly interpret. There were several pages of printed handouts with boring content as well as small font sizes. The main software used was an early version of Microsoft Works which proved to have a navigation structure that often bewildered the students and that they were unable to cope with on their own. The older students were stressed and largely failing to achieve their goals.

One might have expected armed revolt. Instead the students were unfailingly polite to the tutors and took the attitude that the tutors were doing as best they could in the very difficult situation of teaching "old people like us". The students did not see that there were possibilities in providing different resources that were more suited to their needs as older users. Overwhelmingly the students blamed themselves for their difficulties, they apologized for being silly, forgetful and slow of understanding. They were apologetic about making extra demands on the tutor's time.

Older people repeatedly report that younger teachers and relations, "go too fast, try to cover too much, get impatient and assume I understand things". Remember that in the Unitec classes, the intention was to teach MS Works as well as teaching elementary skills. While this had been found to be workable for younger learners it made too many simultaneous demands on the older learners. One of the design points in the intervention tutorial was that each screen was designed to provide an exercise for a single elementary teaching point. This was observed to noticeably reduce the confusion of the older users. The other point that was evident from the Unitec classes is that being told or even shown a skill was not sufficient for the older learners. They needed to be told, shown and then have repeated opportunities to practice before they felt comfortable with proceeding.

In conversation with SeniorNet members I have encountered a widely held belief that having older people taught by younger people leads to poor learning and unpleasant experiences. What was seen in the Unitec classes lends considerable substance to that. However it should be noted that it is not necessarily the age difference that causes problems nor do same aged tutors always eliminate problems. I have also talked with ex-SeniorNet students who have said that their (same aged) tutors knew too much about computing to adjust to the needs of beginners. Some of the key issues appear to be anticipating the likely needs and knowledge gaps of older people, reflecting this in the teaching materials provided, providing sufficient individual assistance (SeniorNet classes tend to have three students per tutor), and that the tutor and others in the class are sympathetic to, and experienced with, the difficulties of older learners.

Motivation

The Unitec classes were demotivating for the older students. The key factors that could be seen were the lack of readily available success, the lack of instruction and materials that were easy to understand, the frequency of getting mired in errors and needing rescuing, the tutors who were unable to empathize with the older beginner's position and the general feeling of being incompetent and out of place that the classes generated in the older beginners. It was noticeable that the response of the students to the intervention tutorial was more positive, it was when using this tutorial that they gained the highest frequency of successful actions. However the intervention tutorial did not change the overall nature of the course which was to teach older beginners a wide variety of skills such as using a word processor, in spite of the evidence that the older users were inadequately prepared for this sort of learning.

My impression was that older people were more likely to get stuck than younger people using the same application. Looking at the problems encountered by my older testers as WinTutor was developed it became apparent that they did not possess the background knowledge that means that elements in a screen can be rapidly scanned and evaluated for their potential in offering solutions. It was also observed that often the older users appeared as if blind to features that were distant from the area of the screen in which they were working. However there was an additional factor in that the older users were found to be much more cautious about trying any feature whose function was unknown. If they did try an unknown feature and obtained an unexpected and undesired effect they had more difficulty in getting back to the starting point. This increased potential for getting stuck if an older user explores an application may contribute to what I see as less willingness to explore in older users. Older students need an environment in which mistakes are minimized and in which the response to being an older student is encouragement and understanding (from peers, including the tutor), rather than a felt pressure to apologize.

Because of the class numbers, tutor expectations and room layout there was almost no student-to-student interaction and assistance during exercises. Although the class had an afternoon tea break, the stresses and self-judgments that the older beginners took from the class inhibited socializing and the somewhat glum mood of the tea breaks was not socially rewarding.

Later when starting to work with the two older in-house testers they did some of the exercises in the rapid intervention tutorial and commented that while they could do the exercises they did not enjoy them much. Simply acquiring a skill was not enough motivation to persist with learning in a boring environment. And so one of the checkpoints as WinTutor was designed was whether an exercise had been enjoyable and fun to engage in.

Perpetual Newbies and Fragile learning

Watching the older learners at Unitec over time and talking to SeniorNet tutors and to older computer users in the community it seems that a significant group of older people will spend their computing lives as "perpetual newbies". A "perpetual newbie" is someone who in spite of repeated instruction does not master more than a very basic (and somewhat inadequate) set of skills.

Interestingly I find that people I classify as being in this group can recall additional relevant learning if prompted, but, un-prompted, make no apparent effort to go beyond their basic skills. My impression from watching older users is that the effort required to access those basic skills prevents accessing or integrating further material. I have watched one such "perpetual" novice over six years and while their skill range has in fact increased markedly, the slowness of this increase is noteworthy and affects their self evaluation of their computer competence.

My observations suggest that for older users, learning new idioms is slow and prone to forgetting and fragile learning for extended periods. Fragile learning is where material is learnt and can be demonstrated by the older person at the time it is presented but on repeated later occasions it is forgotten or only partly remembered. Thus the older user has been shown and repeatedly practiced an idiomatic skill and they appear to be comfortable with using it in exercises in the same learning session. However the skill may be forgotten after the end of the session and may need to be re-learnt several times before it becomes reliably available. Older people find that having to repeatedly ask how to perform an activity over a period of days or weeks is embarrassing and demoralizing. "I get told about it and I can do it but then two days later I have to ask again. And it still doesn't stick. I've been told three times now and I am too embarrassed to ask again, I am trying to find out from a book, and I am not finding out there either."

Supporting the older person's needs and context

There were payoffs from examining not just the older users but also the context within which they worked and the other people who were involved with them, in this case the tutors and the design of the Unitec course. The Unitec course aimed to teach introductory word processing and desktop publishing. It had not been designed with the expectation that basic skills such as holding or clicking a mouse would need explicit teaching. The tutors were observed needing to make frequent individual interventions in order to tell students how to use features that the tutor had incorrectly assumed would be self evident. The older learners observed in a traditional computer class situation had very varying speeds at which they became comfortable with the material being presented. This meant that when the tutor attempted to set an overall pace for the class some students were hopelessly left behind while others were bored and tried things on their own which often led to situations where they too needed to be rescued by the tutor. This in turn took up more time and left other students unguided and ready to make mistakes of their own. What emerged from these observations were pointers that enabled the intervention tutorial and later WinTutor to be designed in a way that met the needs of those surrounding the older beginner as well as the older beginners themselves.

4.4 DESIGN AIMS FOR A TUTORIAL FOR OLDER BEGINNERS

The design suggestions from the literature review were reinforced and made more specific in the course of observing the older learners at Unitec. This section looks at how this translates into a set of design aims that directed the building of the WinTutor interactive tutorial.

4.4.1 Identify and provide training for the skills needed by older beginners

The observation of older learners at Unitec made it clear that the older learners needed to acquire a wide range of elementary computing skills. Hence the tutorial needed to be based on identifying the skills older beginners needed and addressing training in such skills. When the skills needed in order to be able to get any satisfactory results at all on a computer are broken down into individual items the sheer number of things that need to be learnt is remarkable. WinTutor in fact covers a total of 164 skills and facts, the way that these are distributed by topic is shown in the following table.

The observations of older users struggling with idiomatic skills suggest that older users need to be specifically taught the idiomatic skills that apply in their particular graphical user interface environment prior to teaching older users any significant applications. And it is precisely this idiomatic skill set that is the thrust of WinTutor.

Table 4.1 The distribution of the skills initially needed for basic computer use in Windows

Skill area	**Skill count**	**Screens**
Mouse skills	30	13
Keyboard facts	20	1
Windows concepts	28	5
Scroll bar techniques	13	7
Making choices	34	11
Text skills	39	20
Total	164	57

4.4.2 Vision

From the way that the older learners at Unitec struggled with small fonts, information on paper and displays at the front of the room it was apparent that a useful tutorial would need to address issues of age restricted vision. Hence text displays should be able to be easily read by a wide range of older people. Exercises should be presented on screen without the need for additional information on paper or on a tutor's display.

The instances of visual search in the tutorial should be simple for older people to succeed with. Relevant graphic material should also be such that older people will comprehend it easily. The visual design of the tutorial should not present distracting graphics.

4.4.3 Manipulation

From the issues that presented when the older learners at Unitec tried to work with mice the following design aims emerge. Older users should first be specifically trained in the idioms that underlie mouse use and given opportunity to practice such skills before proceeding to other work that depends on those skills. Older users should always be given targets that are visually obvious and within a size range that allows for easy manipulation. This includes such items as menu options and working with text characters. (Where this is not possible due to operating system constraints on such things as scroll bar display it was found that prior training of older beginners on scroll bar skills appeared to sensitize them to perceiving scrollbars and seemed to allow older users to cope more effectively with the small targets they present.) The design should be such that older users are not exposed to unexpected consequences from inadvertent mouse actions.

4.4.4 Comprehension

Failure to understand the material presented was a significant aspect of the observations at Unitec. This seemed to come from a variety of causes; lack of background concepts that had been assumed by the tutor, departures from topics that were strictly relevant to the training in hand, speed and language used in presentation among others. Thus in the proposed tutorial the material presented should be limited to that required for the older users to be able to acquire the skills being taught, in particular, general background and technical information on computing should be avoided. Information and instructions should be given in a way and at a speed that the older learners understood them and could use them effectively.

4.4.5 Navigation

Remember that the older students in the Unitec classes easily became lost, both when navigating between parts of MS-Works and when asked to transfer to different programs that violated the partially learnt navigation rules that the older students were trying to acquire for MS-Works. Older beginners also stumbled into navigation "pitfalls" when they inadvertently clicked outside of the borders of screens they were working with. Avoiding these navigation problems removes a source of upset and distraction for both students and tutor.

Navigation should be such that older students do not get lost and can effectively navigate to any part of the system they need to reach. Hence the navigation built into the design of an interactive tutorial needed to provide a high level of simplicity and consistency.

4.4.6 Skill sequence

The tutorial was to be aimed at the mass of largely idiomatic skills that are needed as a foundation prior to learning how to use applications. It should be assumed that the older learner knows virtually nothing about computers at the start. Necessary knowledge should be built up step by step in a workable sequence within the tutorial so that the student is not frustrated by not possessing some piece of knowledge. This required a breakdown of the components in such apparently simple acts as a mouse click and ordering the introduction of these components so that the most basic are learnt first.

4.4.7 Exercise structure

The aim of each step in the tutorial should be simple and readily understood by an elderly user. The amount to be learnt at any one time should be restricted. A step to be learnt should be learnt as a topic in its own right with no need to proceed or consider other material until a topic has been mastered. It should be easy to repeat steps.

4.4.8 Motivation and reward

One of the observations from the Unitec classroom observations and the early focus groups was that older people bring a fairly fragile sense of competence to their initial interaction with computers. This was reinforced by the observations in the Dual Task pilot study.

Learning exercises should be such that success is very easy to achieve. There was seen to be a need to combat the readiness of older people to blame themselves when things went wrong and a need to minimize the likelihood and consequences of their mistakes.

The tutorial would need to be designed so that the student could proceed through the material at their own pace. This meant that instructions and information needed to be given in such a way that they could be taken in without reference to the tutor, for most students for most of the time.
The tutorial would need to be reasonably entertaining.

4.4.9 Typing

Typing was a major source of difficulty for many of the older beginners observed at Unitec. Typing speed was often extremely slow and those older beginners who did not have prior typing skills (the majority) were stressed when trying to type. The tutorial would need to be designed so as to minimize such difficulty and stress.

4.4.10 Designing for the older beginners' context

The design would need to reduce the skill needed by tutors or family members when attempting to provide instruction for older beginners. The design would need to provide a way of reducing the level of overload experienced by tutors working with classes of older learners. Finally the design would need to cope with older students' need for relearning of material over a long period of time, longer than the duration of any practicable class.

4.5 RESULTS

WinTutor was constructed from an analysis of older beginners' problems in the light of my reading on aging, my observations of classes, my experience as a teacher and point by point feedback from the two late middle aged people I worked with as the tutorial was developed. The continuing demand for WinTutor and the praise it attracts from older users and tutors suggests that it has addressed some of the issues that older beginners face. WinTutor continues to sell to SeniorNet clubs and members and has so far sold over 1200 copies on word of mouth recommendation alone. Since some copies are for classroom use in SeniorNet clubs and there are some unlicensed copies this figure considerably underestimates the actual number of older beginners who have used the tutorial.

The experienced SeniorNet tutors who reviewed the later versions have said that their concerns have been met and the comments from SeniorNet branches and from users have been positive. A representative sample of these comments follows.

- This is exactly what I needed when I first started to try and use a computer.
- Congratulations on a very good product.
- Both programs are well received by our members and tutors.
- Thank you very much for the WinTutor program, its an excellent program
- Many thanks for WinTutor. We have already installed it on one PC and worked through it. It is just what we were hoping for so we are about to install it on the rest of the PC's
- Both programs (WinTutor and FileTutor) have been well received here, we are using them as the basis for our Introductory and File Management courses.
- I have viewed WinTutor and believe it would help many people get to grips with computing and be more confident much quicker.

- Yes, we did receive WinTutor last year but it was returned as it was decided not to use it at that time. However, in discussion with members from Napier, we find that they are using it very successfully with beginners and it seems that the time has come to change our decision.
- I think this is the best learning tool I have ever seen and I regularly encourage new students who I feel could do with a little help to buy it. I have noticed marked improvements in those who buy one and practice on it at home.

It is this pattern of response from those who use WinTutor as students or tutors that justifies a closer look at the interface design issues for older beginners on which WinTutor is based.

4.6 A BRIEF TOUR OF WINTUTOR

The aim of this section is to give the reader sufficient exposure to WinTutor to capture a feel of how the multiple concerns expressed above can be interwoven to create a workable design for older beginners.

4.6.1 The WinTutor Main Menu

Figure. 4.1 The WinTutor main menu screen.

Having watched older users become confused when attempting to navigate around MS Works gave a strong impetus for providing a very simple system of navigation throughout WinTutor. The initial screen for WinTutor offered a menu of six buttons for the six topic areas. Number keys can be used to make button choices as an alternative to the mouse. This screen provides the home base of the navigation system and as will be seen there is a simple way of returning to this menu screen from the tutorial topics.

4.6.2 WinTutor Navigation within topics

The theme of simple accessible and consistent navigation continued within the topic screens. Once a topic had been chosen the navigation through the screens that made up the topic sequence used [Forward] and [Back] buttons in a standard position at the bottom right of each screen. The menu screen could always be accessed by the [Menu] button.

Figure. 4.2 The standard navigation buttons used in WinTutor were positioned at the bottom right of each screen within a topic.

For those students who were doing revision there was a second system of access via the summary pages that let users step into the main sequence of a topic at a particular point. This navigation system allowed a basically linear approach to navigation through the topic screens for first time users but meant that people doing revision did not have to go through all the screens in a topic if they were only wanting to revise a small part of it.

4.6.3 Developing mouse skills in WinTutor

The points made about the design considerations that drove the development of WinTutor can be reinforced by taking the reader through the designs of the WinTutor screens used to introduce older users to the mouse.

First mouse topic

The first screen in the mouse skills topic presents only a few simple facts in an uncluttered layout. It assumes very little prior knowledge of computer skills. Illustrations are kept simple and are well labeled. The cursor is referred to as a pointer at this stage to reduce the jargon level.

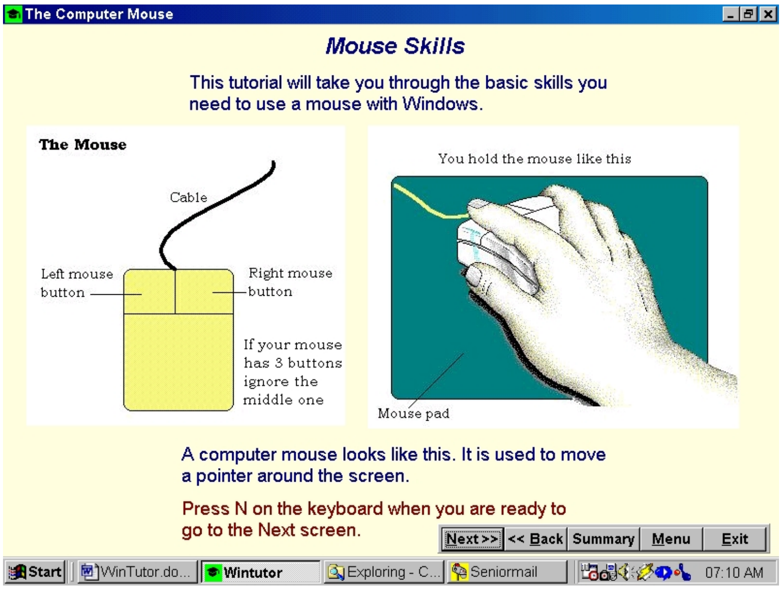

Figure 4.3 WinTutor - Mouse skills Screen 1: First facts

There is no assumption that the older user can use the mouse. Progress to the next screen is by pressing N on the keyboard. However for those older users who are able to use the mouse and are revising earlier work, mouse clicks are supported by the navigation buttons.

The two meanings of "Button"

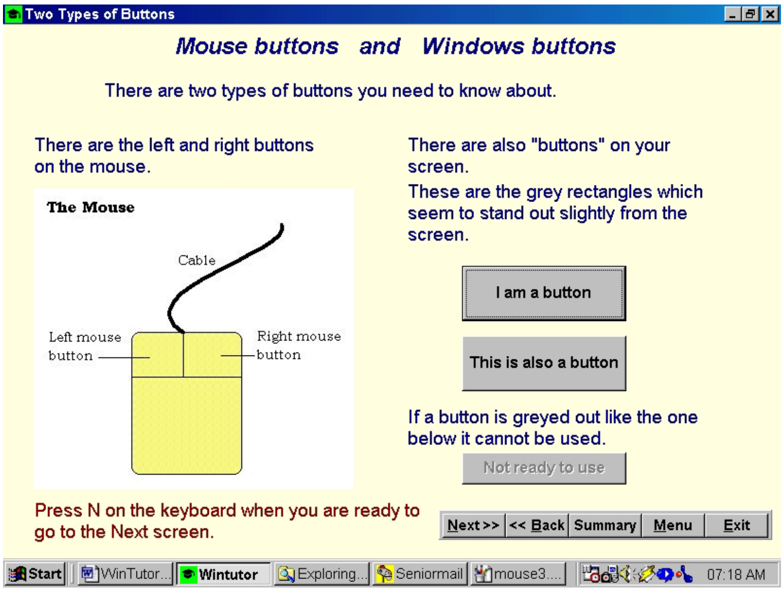

Figure 4.4 WinTutor - Mouse skills Screen 2: Types of buttons

The second screen in the series simply makes obvious the distinction between mouse and screen buttons. Note that it is not being in possession of this sort of apparently "obvious" fact that creates a gap between tutor and older learners. As an aside this is too early to introduce the idea of disabled buttons, at this point in the instruction sequence the concept of a disabled button asks the older learner to "hold on to" a fact that has no immediate relevance.

First use of the cursor

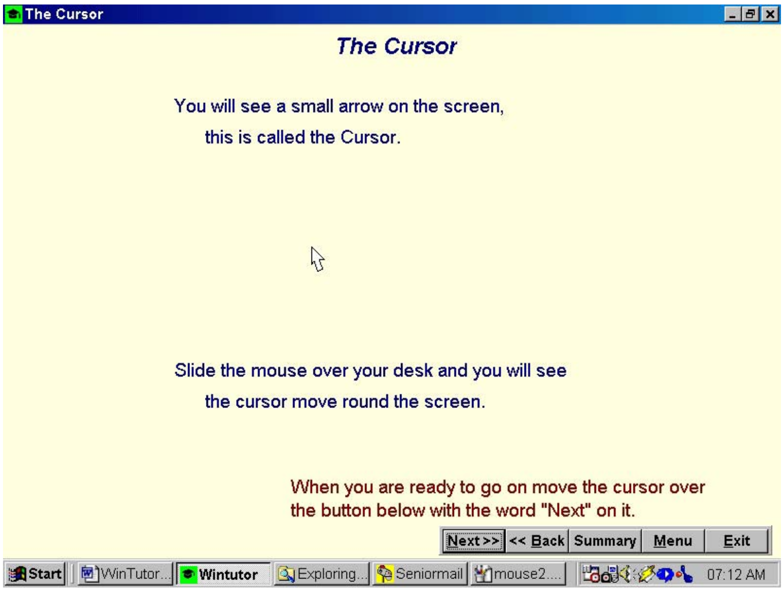

Figure 4.5 WinTutor - Mouse skills Screen 3: The Cursor

The third screen initially shows with the cursor in the position shown with a large area of surrounding whitespace so that movements of the cursor are easy to pick. For the same reason the amount of text is kept to a minimum. Sliding the cursor is actually the first exercise the older student undertakes. Moving to the next screen by sliding the cursor over the [Next] button introduces the idea of the mouse + cursor as a tool for interacting with the computer and this is emphasized in the following screen.

Reinforcing cursor skills

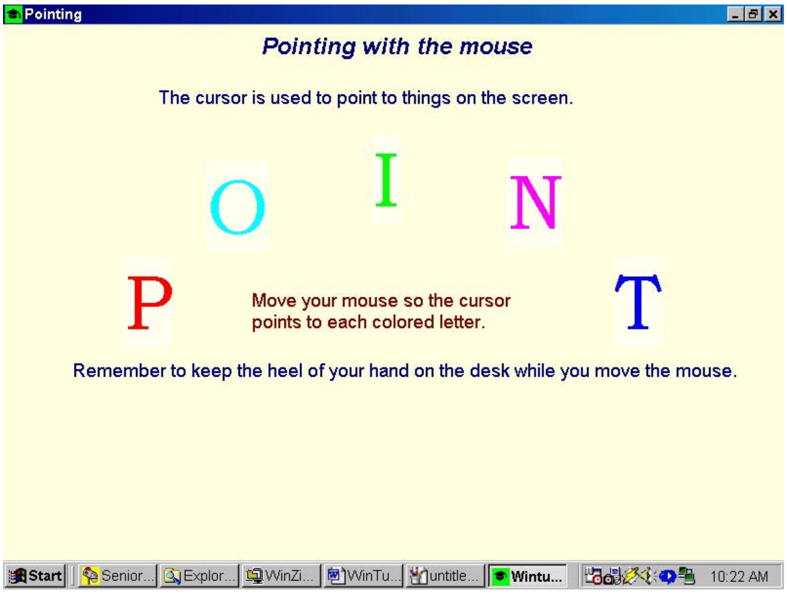

Figure 4.6 WinTutor - Mouse skills Screen 4a: Pointing exercise, before pointing

The targets here are the large colored letters spelling out P O I N T and as the mouse moves over each letter that letter vanishes. The first time the screen is seen the navigation buttons at the bottom right are hidden so that the student cannot make an unexpected jump to another screen by unintended mouse movements, Figure 4.6. After the student has successfully completed the exercise the navigation buttons are shown and they remain visible for subsequent practices so that the student can move on at will, Figure 4.7.

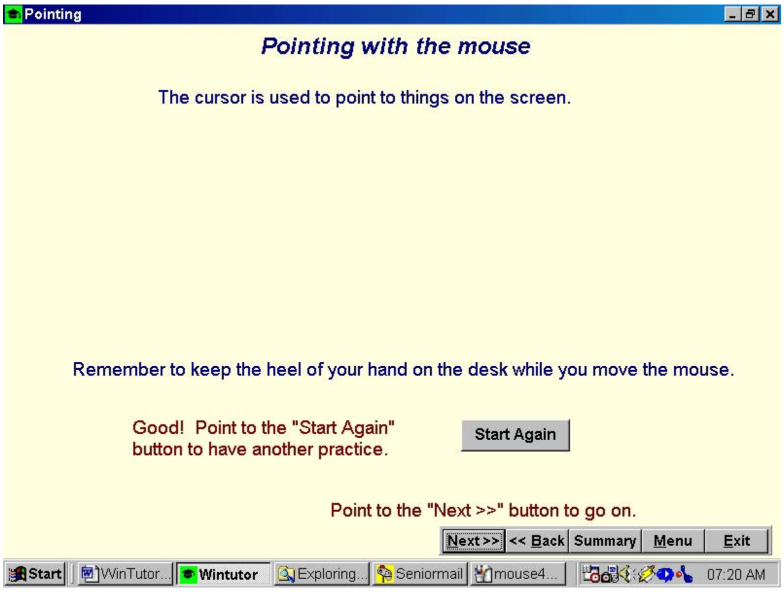

Figure 4.7 WinTutor - Mouse skills Screen 4b: Pointing exercise, after pointing to all targets

When the student has pointed to all the letters in P O I N T and made them vanish, the screen changes and a [Start Again] button appears together with the words "Good! Point to the 'Start Again' button to have another practice." The navigation buttons also appear now that it is assumed the student has enough control over the mouse not to point to things unintentionally. Several issues are illustrated here. The exercise is deliberately set to be easy and non-threatening. The initial targets are made very large. The target letters are given different colors to provide visual appeal but the colours are chosen to maintain a strong contrast with the background colour. The movement from target to target is close to the natural sweep of the hand holding the mouse. There is no penalty for missing a target and no time constraint. The feedback for success is simple and introduces a note of fun, the target letter vanishes! The change when all letters have been captured offers simple reinforcement with the display of the word, "Good!" The screen offers simple instructions on how to repeat the exercise. The user is in control of how many times they need to repeat an exercise. Further the skill needed to repeat the exercise or to navigate to the next screen is the skill that has just been taught. Note that the [Start Again] button is a standard feature of other WinTutor screens where the user needs to return to initial state of the screen needs to repeat an exercise.

Introducing mouse clicking

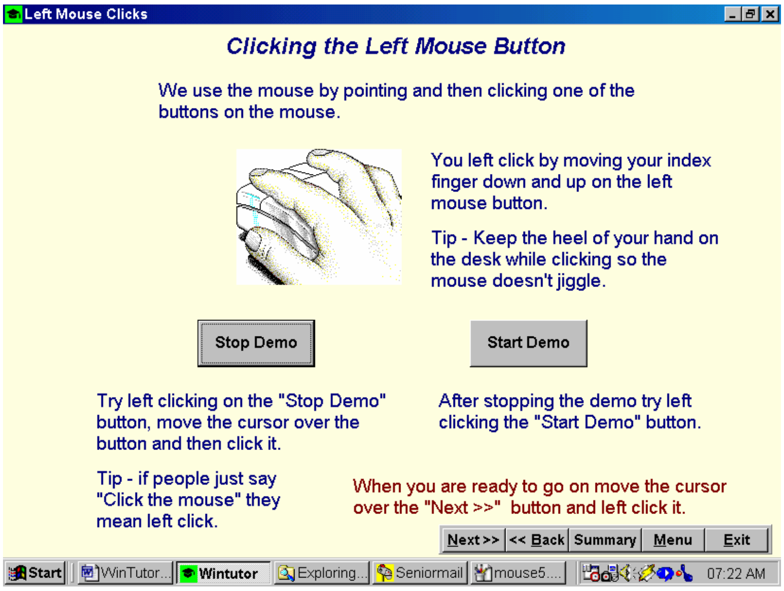

Figure 4.8 WinTutor - Mouse skills Screen 5: Introduction to clicking

The difficulties of the older beginners in the Unitec classes emphasized that there is a real need for progressing slowly using very small steps when teaching older beginners. It is only here in the fifth screen that the act of clicking the mouse is introduced. The action of clicking is shown first, the picture of a hand actually provides slow animation demonstrating the finger action of a left click. Note that again the new skill becomes the way to move to the next screen.

Reinforcing mouse clicking skills

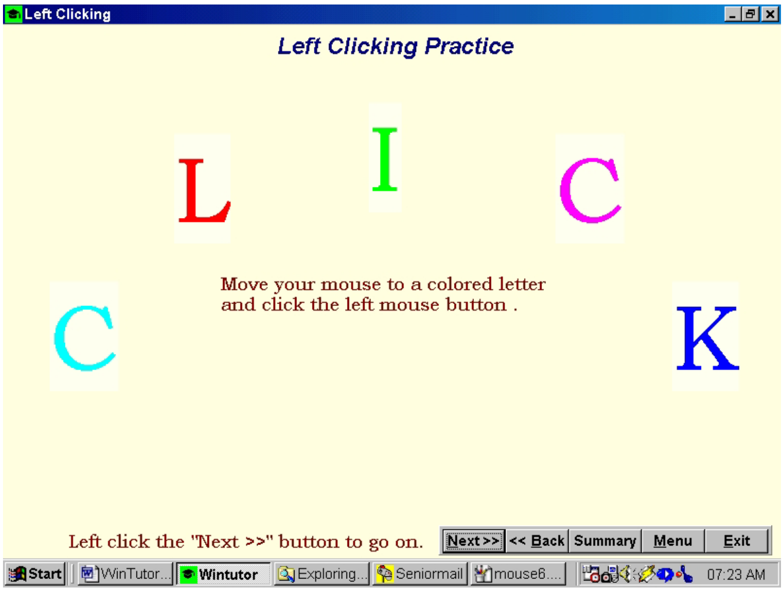

Figure 4.9 WinTutor - Mouse skills Screen 6a: Before clicking targets

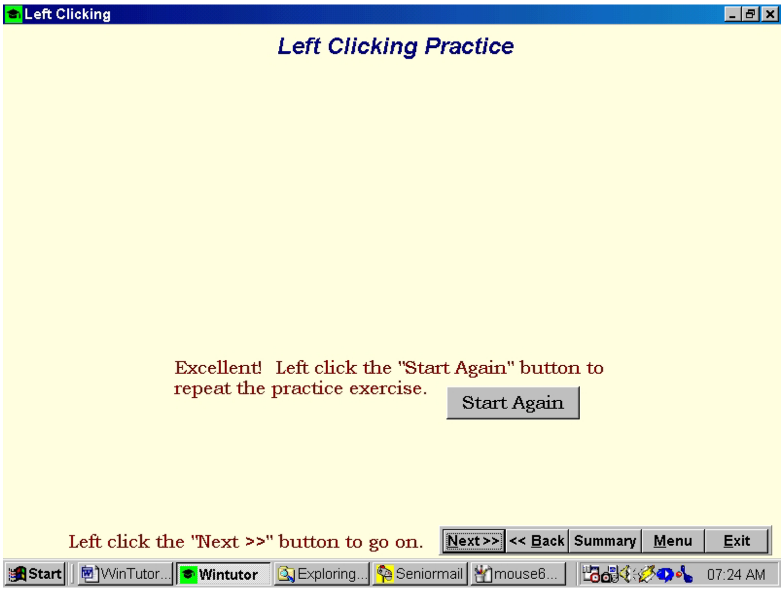

Figure 4.10 WinTutor - Mouse skills Screen 6b: After clicking all targets

Here the pattern of the earlier pointing exercise is repeated although the navigation buttons are always visible since with clicking rather than pointing there is not the same problem with unintended actions. See Figure 4.9.

The assumption is that rather than being bored with the similarity of the pointing and clicking exercises, older learners will feel supported by working in a familiar setting. WinTutor makes the assumption that older learners have no prior computer skills. In reality some of the people using WinTutor will have some background knowledge, although if they have enrolled in a beginners' course this probably implies that their computing knowledge is ineffective. For example several of the older people who enrolled in the Unitec courses did so because efforts by relatives to teach them computer skills had not been satisfactory. I was initially concerned that older people with some knowledge would be bored by repeating material that they knew or would feel patronized. What seems to emerge from observation is that older users are more willing to do exercises that revisit their earlier knowledge than I would expect of younger students. My impression is that, within limits, being able to successfully use existing skills is seen as affirming for older users.

In fact feedback on WinTutor has indicated that this slow elaboration of skills in a familiar setting is well received. The SeniorNet tutors who were consulted strongly supported this approach to teaching older people.

The rest of the mouse skills topic

The tutorial on mouse skills then proceeds to cover the further sub-topics of dragging and dropping, double clicking, right clicking and the meanings of common cursor shapes, finally ending at the summary screen for mouse skills shown in Figure 4.11. The exercises use variations on the now familiar format. For example double clicking is not going to be possible for some older users. The instructions make this clear and there is a colored box on screen that tells the student if they have timed the two succeeding clicks too far apart.

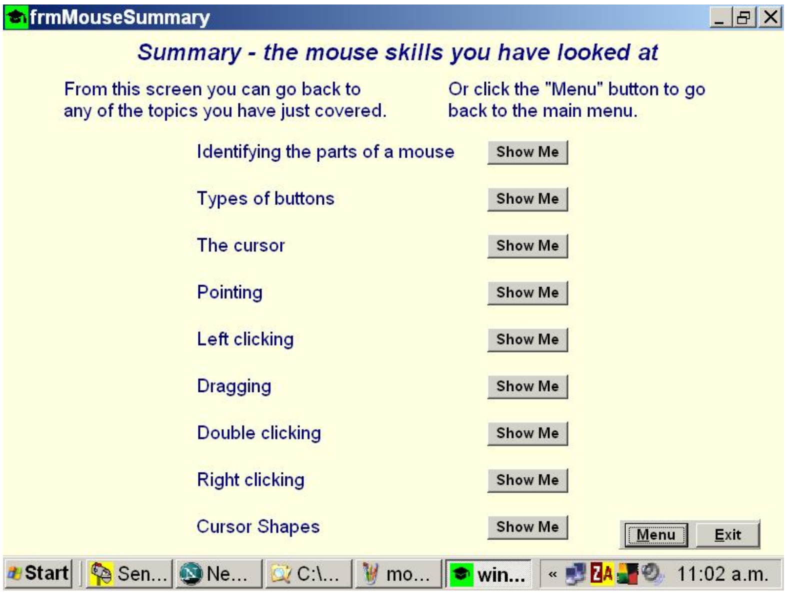

Figure 4.11. The summary screen for mouse skills

The tutorial deliberately does not go into detail at this point about altering the timing required for double clicks or setting Windows to respond to single clicks. These are useful pieces of knowledge but they operate at a level of abstraction (the operating system controlling the definition of a double click), and detail (the steps required to make the change), that are considered will overload older learners at this early stage.

4.6.4 Typing in WinTutor

Remember that typing was a major source of difficulty for many of the older beginners observed at Unitec. There were a number of problems; inability to find keys quickly while searching the keyboard, less than flexible fingers and a lack of knowledge of what keys produced various required editing effects such as entering capitals, a space, a new line, removing text or repositioning the insertion point. WinTutor in fact uses 20 screens to lead the older beginner through 39 useful pieces of knowledge about typing and text entry. Throughout this an effort is made to kept the amount of typed input to a minimum. Once again the concern is to introduce the skills needed for text input in a slow manageable sequence where skills are introduced, practiced and then used for building further skills.

Here are the first two screens in the tutorial on working with text.

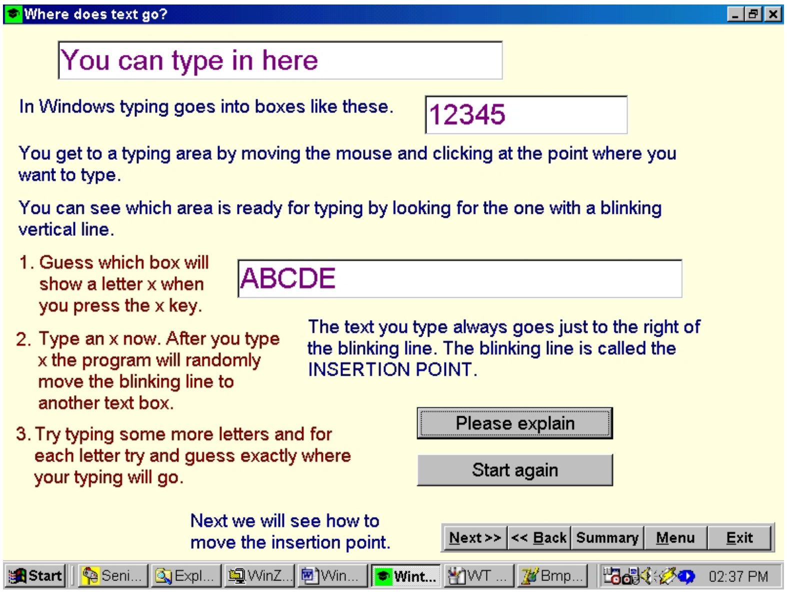

Figure 4.12 WinTutor - Typing screen 1: Where will text go?

The older beginners at Unitec had been observed to be confused about the difference between the insertion point and the mouse cursor. The first exercise concentrates on training the older beginner's awareness of the insertion point. Note that there is little need to find letters on the keyboard and the insertion point is introduced by itself, without reference to the mouse cursor. Also note the very large text used for input. One advantage of using this large font here is that it is accompanied by a correspondingly large insertion point so that the older beginners have a reasonable chance of spotting an important item that is unfamiliar to them and hence harder to search for. The explanation of the insertion point is shown in response to the user clicking the [Please Explain] button.

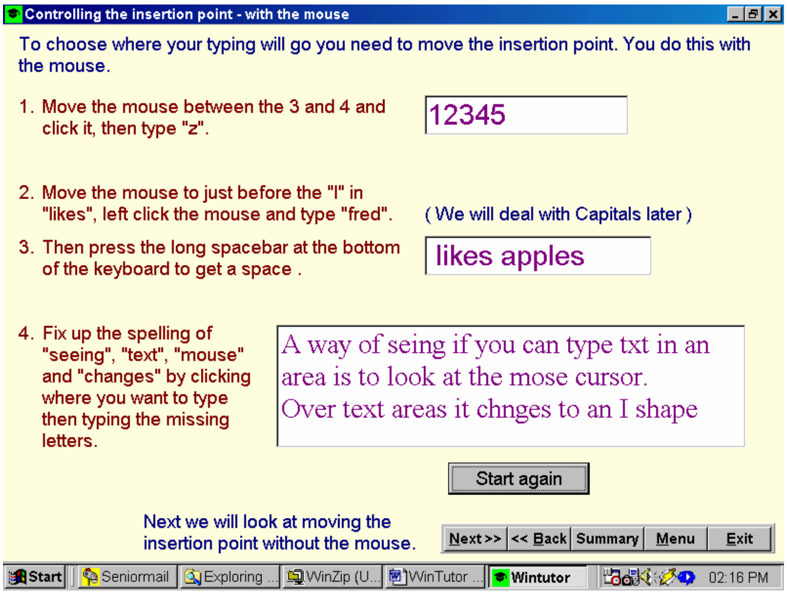

Figure 4.13 WinTutor - Typing screen 2: Setting the insertion point position

The screen shown in Figure 4.13 is the second screen in the typing tutorial. Having established the role of the insertion point WinTutor now proceeds to give an exercise in controlling where to insert text using the mouse. Again the font for the text boxes is very large, this time the advantage is that the targets (such as the space between the numbers 3 and 4) are large enough for most older users to acquire the intended target. Again typing is kept to a minimum. The exercise moves from a very minimal skill level to a realistic task of fixing spelling mistakes. A further 18 screens are used to complete this part of WinTutor, covering basic text entry skills.

4.6.5 Scrolling in WinTutor

Scrolling was another skill that caused difficulty for the older beginners at Unitec. Again in WinTutor a scrollbar was treated as a set of skills that needed explaining, practice and serial development instead of being treated as a single, simple, self explanatory idiom. Here are three of the screens from the sequence of seven screens that covered the 13 aspects of scrollbars that underlie this apparently simple idiom.

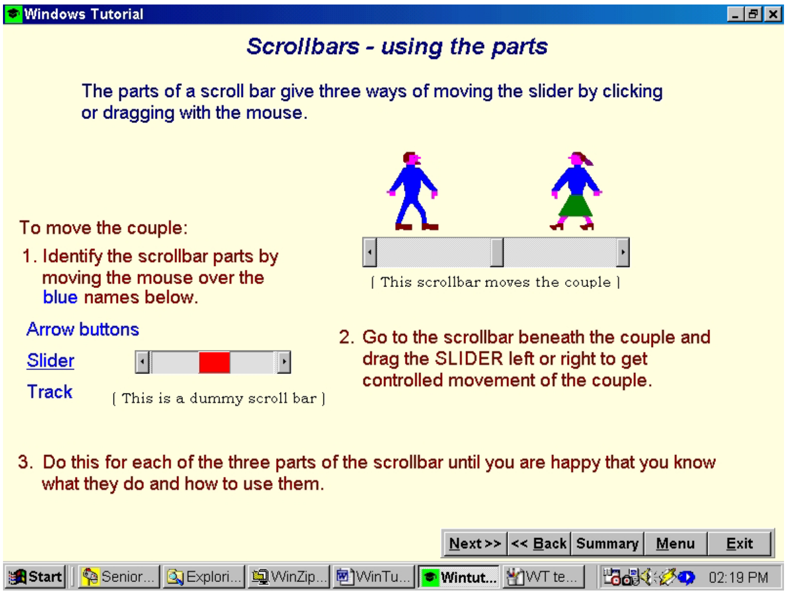

Figure 4.14 WinTutor - Scrollbars screen 3: Exercises in using the scrollbar parts

The observations of older people using scroll bars suggests that they are likely to only use the arrow buttons and that they are unaware of the names or function of the other components of a scrollbar. Hence these features need deliberate introduction. In the first two screens of the scrollbar topic the older learner is introduced to the different parts of the scrollbar and the third screen shown in Figure 4.14 repeats the process of identifying the parts and now gets the older learner to apply the knowledge to a simple exercise. In this screen, as the user moves the mouse over the words shown below instruction 1; "Arrow buttons", "Slider" and "Track", then the content of instruction 2. changes to ask the user to do an exercise based on that part of the scrollbar. Figure 4.14 shows the instructions for the suggested exercise that display if the user moves the mouse over the word "Slider". On MouseOver the word "Slider" is underlined and the slider in the dummy scrollbar is highlighted in red. This aids the older user in remembering the choice they had made, and the part they are dealing with, as they do the relevant exercise. Note that the first choice in the list of parts is "Arrow buttons" so that an exercise is first undertaken for the simplest and possibly the most familiar aspect of the scrollbar.

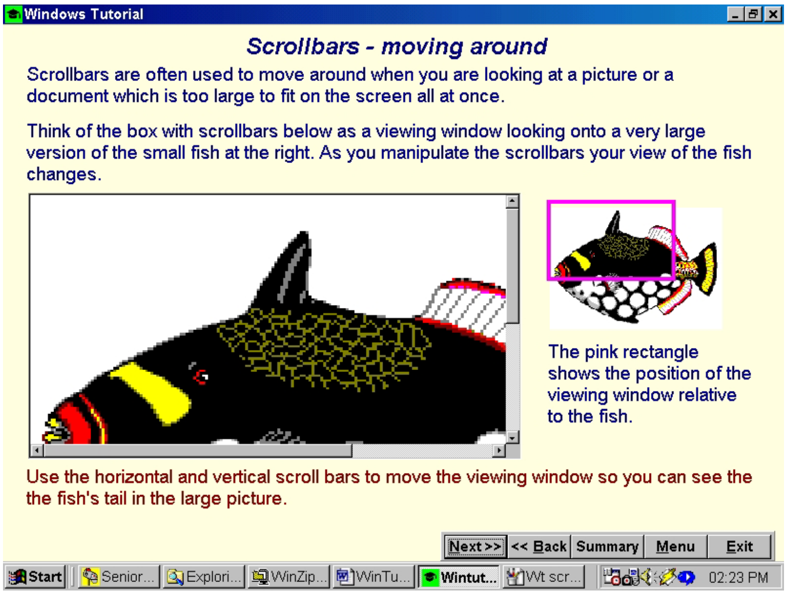

Figure 4.15 WinTutor - Scrollbars screen 4: Seeing part of a larger whole

In discussion with older users I gained the impression that at least initially they found difficulty in seeing the scrolling window as a viewport onto a larger underlying document. The exercise shown in Figure 4.15 attempts to address this directly. Older users were found to be able to carry out this exercise and they enjoyed doing it but they do not automatically generalize what they had learnt to understanding the roll of a scrolling window onto text. Hence this exercise needed to be followed by a similar one using a text based example. This appears to typify older people's learning processes where abstraction and generalizations emerge at a rather slow pace, initial learning appears to be concretely focused on specific aspects of specific tools.

As another example of older people's difficulties in generalizing from prior learning, older users, who had some experience with scroll bars, failed to comprehend the basis of a couple of arrow buttons [<] and [>] without a connecting track bar, that were supposed to allow the user to move through a list of clip art pictures.

The exercises on using scroll bars to navigate the underlying larger document were followed by two exercises that brought to the older users' attention the information available in the size and position of the scrollbar slider and provided exercises in making use of this information. Again my observation was that older learners were much slower than younger users to integrate such extra information into their overall understanding. Sometimes in fact older users remained unaware of the information available in the slider size and position, so WinTutor needed to provide direct instruction on this material. After these two exercises in perceiving and interpreting the information made available by the scrollbar, the older beginners were able to succeed with the exercise shown in Figure 4.16. Again the pattern is that in order to prepare older users for a useful real life skill the elements underlying that skill need to be deliberately taught and practiced, not just explained even if a simple explanation would suffice for a younger group.

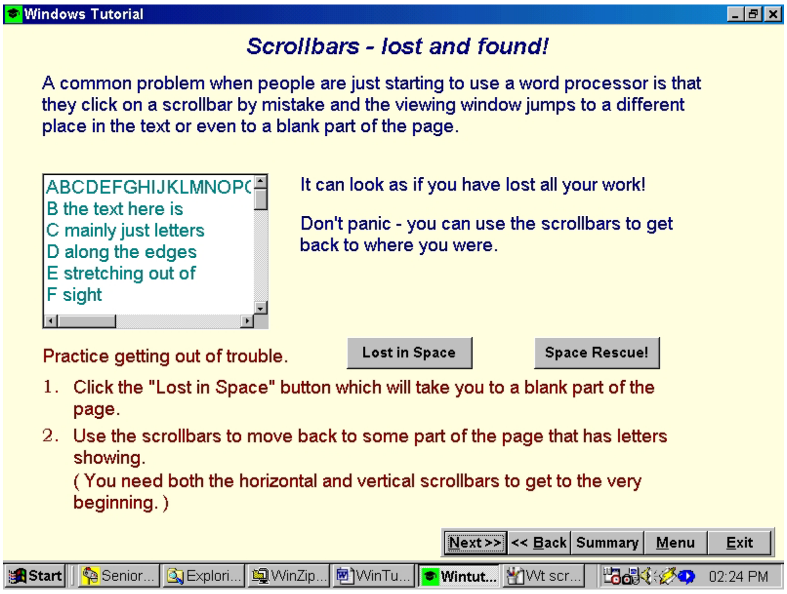

Figure 4.16 WinTutor - Scrollbars screen 8: Lost in Space!

Here the older users can practice placing themselves in a situation where their work disappears and is replaced by a blank screen. They can then use the scroll bars to understand what has happened and to escape from the problem. It remains unclear, however, if older users will reliably remember these skills in the midst of dealing with an unexpected problem.

4.7 DISCUSSION OF WINTUTOR INTERFACE DESIGN ISSUES

The recommendations in this section arise from the fact that developing WinTutor provided considerable experience in developing an application suited to older beginners. Although the skills taught are simple the 57 screens used for teaching these skills present repeated non-trivial exercises for the interface designer in creating interfaces that work for a range of older users. As such these guidelines are relevant to the general question of interface design for older people. The first sub-section looks at issues that are related to application design. The following sub-section looks at recommendations that apply more specifically to designing instructional material for older users. However anyone designing an interactive tutorial will find relevant information in the sub-section on application design while application designers will find aspects of the material in the sub-section on instructional design relevant to making their applications easy for older users to learn and comprehend. The final sub-section of the recommendations looks at the implications of the experience gained in the WinTutor study for guidance towards an effective design approach for developing for older people. Although these recommendations are expressed in terms of their grounding in the literature review and the WinTutor study, they have also been reinforced by additional experience from the two further studies of developing for older people that followed the WinTutor study.

4.7.1 Application design issues

This sub-section covers a variety of issues related to application design for older users. It looks at visual design including thoughts on suitable animation for older users. Manipulation issues are examined including those related to menus and to typing. This is followed by a look at what was learnt about making applications comprehensible and here we also deal with the issue of older people meeting idiomatic knowledge.

Vision

Remember that the older beginners in the Unitec introductory computer courses, faced with teaching material intended for younger users, struggled with small fonts on screen, or on the VDU displays at the front of the class. In the quickly produced intervention tutorial, Arial, with its simply formed, well spaced letters, was easily read on screen by older users. The consensus reached after experimenting with a variety of typefaces while developing WinTutor was that an Arial 14 point font was easy to read while an Arial 12 point bold was a possible alternative for very short text items such as button caption.

Although older users work best with black text on a white background, Charness (1988), my observations suggest that this effect appears to vanish as font size increases if a strong contrast is maintained between text and background. It was felt that unrelieved black text on white could contribute to boredom and possibly to glare and eyestrain over long periods. In WinTutor navy text was used to provide facts that needed learning, maroon text was used to provide step by step instructions for carrying out the exercises. Reading large blocks of text on screen in almost any font could be an effort for the older participants but a slightly off white background was seen as making this easier. User response to WinTutor was that it was particularly easy to read and follow.

Older users also struggled with instructional material on paper. Reading material from paper for application on a computer screen brings up the point that for people with corrected vision the correction for comfortable reading does not provide for clear focus at the slightly greater distance involved with text on a computer screen. There also appears to be an issue that it can be harder to remember instructions when they are read in one place and then applied in another. Hence all instructional material for WinTutor was provided on screen and was closely integrated with the exercises the screen provided.

Older learners were noticeably slow to find features, particularly within more complex screens. In the intervention tutorial, the screen layouts were kept very simple, consequently the problems with locating features practically vanished. This approach was continued in WinTutor. Older users appear to benefit from very simple layouts with few elements all clearly related to a single topic.

Animation

The intervention tutorial provided examples of animation accepted by older beginners while the Dual Task study gave examples of animations older users found unintelligible. From analyzing the differences the following recommendations emerge, aimed at a.) increasing the chance that the animation will be correctly perceived, b.) increasing the comprehension of the relevance of the animation and c.) allowing the older users to examine the rest of the screen on which the animation displays without being disrupted by the movement of the animation.

The animation used to introduce mouse clicking in the intervention tutorial and carried on into WinTutor appears to be an example of suitable animation for older users. Suitable timing parameters for this animation were established by trial and error with older users, the action is slowed down, the change is simple and there is a relatively long gap between repetitions of the action shown. There is also no time limit on how long the older user has to absorb the information. The slow action and the pauses between repetitions reduce the level of distraction the animation offers while the older users are trying to read the accompanying text. The animation has a limited number of elements and these elements are familiar to the older viewer. Most elements in the animation do not move. There are only two moving elements, the button and the finger and they spend much of their time unmoving. The moving elements stay in a nearly constant relationship to the unmoving elements and their identity is prompted by the identity of the non-moving elements. The click animation is running when the user first sees the screen and remains running until the user clicks the [Stop Demo] button. In trying out the skill the user is gaining control over the animation which provides an element of reward. There is a clear emphasis in the instructions on the need to use the left mouse button so that the chance of students making mistakes is reduced.

Manipulation

Some older beginners were likely to move the mouse significantly when making even single clicks and there was a tendency to overshoot small targets. Therefore a designer should provide large targets. This includes larger buttons but also includes providing large fonts for entering text or when using listboxes, radio buttons and menus. Observation of older learners had shown that positioning the text insertion point accurately was an area of difficulty. The use of a 24 point Arial font for the initial text exercises removed this problem, beginners were able to insert and delete characters easily when using text of this size. Slightly later in the tutorial the older learners worked competently with 16 point fonts but the initial use of very large fonts appeared to be useful for the first exposure of older beginners to using a mouse with text..
Older beginners showed slower and more erratic mouse movement with a tendency to wander off constrained paths. Hence with older users the designer needs to allow for slower more wandering mouse movement, more difficulty following tightly defined paths and slower reactions. The designer should not ask older users to capture targets under time constraints.

Not all of the older beginners could manage to double click so that designs should provide alternatives to double clicking. Scrolling was difficult and in part this was due to the small size of the controls on a scroll bar but in part this was due to lack of knowledge of the idioms that are required to interpret scrollbars. It was observed that older beginners who had been given detailed instruction and practice on scrollbars made fewer inadvertent scrolling actions and were better able to recover from those they did make.

Some of the older users' difficulties with the mouse included inadvertent clicks while moving the mouse. Older beginners were likely to fail to observe, or fail to understand the significance of, the borders of a window and be bewildered by the consequence where the window was sent to the background, by a click that they were unaware had occurred outside the window. They were also at a loss as to how to recover from such a situation. The designer should preferably use full screen windows and expect older users to have limited ability to drag or resize windows or to find a window that has become hidden.

Menus and Sub-menus

Older beginners were observed having difficulty in finding items mentioned by the tutor while searching Windows menus. A further difficulty in searching was provided by the distraction that occurred when the mouse moved over the main menu and triggered successive sub-menu displays.

Sub-menus provided a further level of difficulty. While younger users make fast and accurate enough mouse movements to travel diagonally from an item in the first level menu to the desired target in the pop-out menu older users will move the mouse too slowly and the system will interpret this as a move off the menu item rather than a move towards a pop-out menu item. The consequence is that the pop-out menu to the right vanishes and may, confusingly, be replaced by the pop-out menu for an adjacent menu item. Thus in Figure 4.17 an older user trying to use the diagonal white path may loose the "Settings" sub-menu and have it replaced with the "Find" sub-menu.

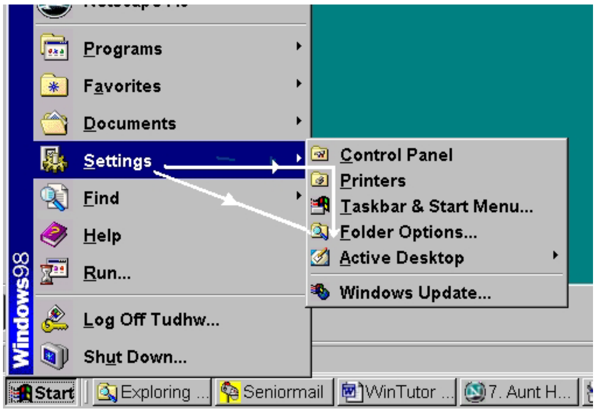

Figure 4.17 Neither of the paths shown in white from "Settings" to "Folder Options" offers a problem to younger users. Both are difficult for older users.

The alternative technique is to move along the menu item horizontally until the mouse is over the space of the pop-out menu and then move vertically. This is more achievable for older users. However older users in my experience often do not know about this technique. If they are told and then try, those with more erratic mouse movements, may, in attempting to follow the required path, wander off the primary menu item and spend sufficient time on the adjoining menu items to drop the pop-out menu for the original item. Hence trying to follow the alternate path in Figure 4.17 shown by the horizontal and vertical white lines can potentially lead to dropping the "Settings" sub-menu and displaying either the "Find" sub-menu or the "Documents" sub-menu. I noted that even those older users who could make adequate mouse movements along the horizontal then vertical path showed signs of concentration while doing so. There is another issue here in that older users are reported as more distracted by and less able to inhibit responses to irrelevant stimuli. Moving vertically and slowly through a sub menu may trigger the further display of sub-sub menus and this will offer considerable distraction.

Remember that older people are less able to inhibit responses to irrelevant stimuli so it was not surprising that this additional distraction appeared to lead to pauses and further wandering in the older person's mouse movement. It was also observed that older beginners were confused by adaptive menus. In general if one is designing for older users it seems worthwhile to consider alternatives to Windows style menus and if one has to use menus then avoiding multiple level menus and exercising control over the menu font size seem useful.

Typing

Typing is a major stumbling block to computer use for many of the current generation of older users. In addition, given the slow pace at which older people acquire and consolidate new skills, typing seems likely to remain a hard task for many of these older struggling typists for years. Applications for older beginners in particular should minimize the amount of typing required of older users.

Typing by older users is frequently error prone but the effects of errors in the text are compounded by small font sizes. The font size chosen for tasks and exercises involving typing is not just a matter of readability but also of how easy it is to acquire text targets with the mouse. For experienced older users my observation is that Arial 14 point is a suitable default font for both entering text and reading blocks of text. However, for older absolute beginners doing short typing exercises involving inserting and deleting text a 24 point font was found to make target acquisition simple.

Comprehension

Any students are less able to cope with new material when they are struggling to integrate previous information. Older students, who take longer to absorb concepts and procedures, are particularly vulnerable to teaching that insists on introducing new material to a fixed schedule.

Designers are steeped in computer expertise and use computer jargon as a normal (and hence unconscious) part of their vocabulary. Older people in contrast are often at the trailing edge of new trends in society and are likely to have less exposure to basic computer concepts and elementary computing terms than younger people. Hence what a designer considers a simple clear instruction, or explanation, may be seen by older users as ambiguous or centered on jargon that does not convey meaning. Instructions should be simple, unambiguous and free of jargon. However because of the gap between (young) designer and older user, the message actually conveyed by instructions should be checked through user testing with typical older users.

Screens should have a minimum of features whose layout provides a clear mapping of the task at hand. Screens should not show features that are irrelevant to the task the older user is trying to complete. A suitable interface needs to work in terms of procedures that have simple (for older users) steps, involving simple actions carried out on obvious features. Comprehension can be assisted by providing the older user with only strictly relevant information. Relevant here means, needed in order to carry out basic task orientated procedures. It seems likely that comprehension problems can be compounded by difficulty in seeing, finding or understanding features, difficulties with manipulation and lack of knowledge of standard idiomatic ways of proceeding.
Keep the application model simple. There should be as few parts to the application as possible and each part should have a clearly designed task. The aim is to make it very easy for the older user to form a simple and accurate mental model of the application. Navigation should have a simple, consistent and easy to follow basis. From observing older users trying to learn MS Works, multi-purpose applications appear to confuse older users, at least initially, especially if some of the application features are irrelevant to the older users' needs.

Idiomatic knowledge

As previously stated Windows has over 150 idiomatic skills that are useful for fairly basic computer use. These skills are usually patchily mastered by older people. A designer should expect older users to have large gaps in their knowledge of basic idioms of the graphical user interface environment they are in. A lot of design depends on users seeing a cue such as a button and jumping to the "obvious" conclusion that they should click it. We interpret the screen based on a wide knowledge of standard ways of doing things in our particular graphical user interface. However in designing for older users, expect older people to have a fragmentary knowledge of such standards. Do not ask older users to learn a number of new idioms for a new application. Unlike younger users, older users will have difficulty acquiring skills and idioms that are intended, by a young designer, to be learnt in a single use. While one should keep instructions simple there is a need to clearly spell out "obvious" procedural steps.

4.7.2 Tutorial design issues

This section looks at recommendations from the WinTutor study that apply more specifically to designing instructional material for older users. Here we cover concerns with accommodating older people's needs with respect to memory and learning, the issues that bedevil communication between young and old, ideas about motivating older learners and the questions of "fragile learning" and older "perpetual newbies".

Memory and learning

Older people repeatedly reported that younger teachers, "go too fast, try to cover too much, get impatient and assume I understand things". The wide variations in the speed at which older people learn imply that some of the learning needs to be self paced, with easy access to repetition. Teaching resources need to be structured to accommodate older learners' likely perceptual needs and manipulative skills as well as providing a workable sequence of skill acquisition that begins from very elementary skills.
Where possible explain a single effective way of doing a task and do not give information on alternatives. Older users' strongly expressed preference was to be told one way of doing things and they said that being told of multiple techniques was confusing and made remembering any of them more difficult. Remember that one of the successful design points in the intervention tutorial was that each screen was designed to provide an exercise for a single specific teaching point. It was also found that being told or even shown a skill was not sufficient for the older learners. They needed to be told, shown and then have repeated opportunities to practice themselves before they felt comfortable with proceeding.

A topic such as text entry or mouse skills should be broken down into a number of very small sub-topics. The sequence of such sub-topics should build skills based on the assumption that one cannot expect that older beginners have any particular initial items of background computer knowledge. The number of skills built within one sub-topic / exercise should be very restricted. Each sub-topic should be provided with a simple hands on exercise that gets the older user to practice the relevant skills. Exercises should be self-paced and allow as much repetition as the older learner feels that they require. Hence, re-starting an exercise should be very simple to do.

Communication between young and old

In the section above it is noted that older people repeatedly report that younger teachers, "go too fast, try to cover too much, get impatient and assume I understand things". It seems much of the expectations of younger people engaged in communication with older people are embodied in a relatively unconscious communication style. Younger people may be slow to notice that their communication is not working and be poor at adapting to older people's needs without descending to "elder-speak". In the other studies that followed the WinTutor study, similar communication problems were found to apply to family members and friends trying to support older users as well as to professional tutors. The contrast between the SeniorNet classes and the Unitec classes when observing tutor pupil interaction and peer to peer interaction was striking. The advantages of the SeniorNet classes appear to offer support for providing older learners with similar aged co-learners and similar aged tutors.

Younger people taking on the role of instructors are likely to need to learn how to communicate effectively and non-patronizingly with older users, yet younger instructors are unlikely to be aware of how much older learners require an altered teaching style. Instructors need to slow, not their speech, but the rate at which they introduce new concepts. Older learners may wish to have time to make notes on procedures in their own words. Instructors should resist the temptation to correct the older learner's language. Instructors should expect, and make allowances for, slow and incomplete learning by some older learners. The emotional response by the instructor should be empathic acceptance of what it is to be old, not politely concealed impatience. It was found useful to use gentle humor to defuse anxiety on the part of the older learners. The company of other older learners is desirable, both as moral support and to reframe learning as an enjoyable social event. Older instructors may be better able to understand, to allow for and show empathy with, the needs of older users but computer knowledgeable older instructors can still overload older beginners.

Motivation

A large part of the levels of motivation I have observed with the older users I have worked with can be linked to the ratio of positive to negative reinforcement that they have encountered in the particular environment that they were working with at the time. Older beginners come to computer learning with an expectation that failure is possible or even likely. What I have observed is that they respond to failure with poorer coping mechanisms than I would expect in younger users. On making an error, older people are likely to be less able to work out what has gone wrong and are less likely to recover from the problem. Older users are also more likely to blame themselves for error and interpret errors as meaning they are "too old for computers" or at least too old to learn the particular skill they are currently having problems with. Errors and difficulties appear to activate and reinforce older people's negative self stereotypes with relation to age, see Levy (1996). It is therefore important that a design for older users establishes a low error rate and a high rate of positive reinforcement.

My experience is that older people are more likely to get stuck than younger people using the same design. Further, older users may not possess the background knowledge to understand the potential of design elements for offering solutions. At times older users may not even see features that are distant from the area of the screen in which they are working. The designer needs to consider that the standard response from older users who get badly stuck is to try Control + Alt + Delete. The other likely response by older users is to stop using the program. The decision in WinTutor to make it very easy to restart any exercise meant that there was an easy and painless exit and recovery from any error.

The older users seen in the Unitec classes were severely overloaded. They were failing repeatedly, they were unhappy and they were bored by typing exercises that asked for paragraphs of typing irrelevant content, they had limited social support from the other older learners. The older learners seen at SeniorNet classes in contrast were happily involved in a social event. Doing (successful) computer learning in an appropriate social setting with other older learners is in itself rewarding so that designing to support a group environment is in itself a useful source of reward and reinforcement. Again the older in-house users I worked with while developing WinTutor baulked at the idea of simply learning facts and doing exercises, they wanted a measure of entertainment, and visual responsiveness. Hence there should be some measure of entertainment (visual interest and gentle humor) in exercises presented in interactive tutorials.

Tasks and exercises should be easy for older beginners to succeed on, so as to counter older users' expectations of difficulty. Make positive reinforcement frequent and easy to obtain for people working at the lowered skill levels of older beginners. A learning environment for older beginners should minimize the likelihood of negative reinforcement from sources such as bewilderment, failure or easily made errors. The interface for carrying out exercises should reduce the likelihood of error and make it easy to recover from errors.

Perpetual Newbies and Fragile learning

The designer should expect older users to spend longer than young users in a state of incomplete knowledge of both the designer's application and of basic computer knowledge. Because of problems with remembering what has been learnt older users' shaky grasp of basic points may be different from day to day. A significant group of the older people who need applications designed specifically for older users will spend their computing lives as "perpetual newbies". A "perpetual newbie" is defined as someone who in spite of repeated instruction does not master more than a very basic (and somewhat inadequate) set of skills. Hence in application design allow for some older users who will not be able to master more than a few basic skills. The design should be such that this basic skill set is sufficient to access the core functionality of the application.

For older people, learning can be filled with examples of "fragile learning" where things that have been learnt are rapidly forgotten after instruction has ended. Older people find that having to repeatedly ask how to perform an activity over a period of days or weeks is embarrassing and demoralizing. Where an older user has been shown and repeatedly practiced an idiomatic skill they can appear to be comfortable with using it in exercises in the same learning session. However the skill may be forgotten after the end of the session and may need to be re-learnt several times before it becomes reliably available. In teaching older users and in tutorial design, plan for limited carry over from one session to the next. Make it easy to carry out revision. For example a tutorial should not assume that all older learners will progress from start to finish. It should be easy to find and re-visit any topic at any stage. Make it easy for older learners to get repeated assistance on a topic without embarrassment.

Teaching idiomatic knowledge

To reiterate points made earlier, Windows has over 150 idiomatic skills that are usually patchily mastered by older people. Older users, in my experience, do not manage the sort of single exposure learning that is expected when younger users encounter idioms. This means that older learners need to be specifically taught the meaning of and actions associated with an idiom where such teaching would not usually be needed by younger learners. When constructing instructional material for older people it is important to analyze the structure of idioms such as a button or a scrollbar and to develop teaching that deliberately introduces the underlying structure in the course of teaching older learners an idiom. New idioms need to be repeatedly practiced and may in fact need to be broken up into simpler steps as was done with the introduction to clicking a mouse in WinTutor.

Supporting the older person's needs and context

The point that started to emerge in the WinTutor study was that it was important to consider the special needs of the people who supported older users as well as the context within which they worked. In this particular case the "class + tutor" context provided a number of tensions with older people's learning abilities. It was useful to include these tensions in the design rational for the tutorial. For example there is a major problem with classes for older people in that older people tend to learn at very different paces so that a tutor is in danger of over pacing the students who need most help in an attempt to keep the class together. Again older learners are likely to need more help in dealing with errors so that the overall demands made on the tutor in a class for older learners are likely to be high. One of the advantages of the WinTutor design was that making the older users more independent had the effect of reducing the demands on the tutor. An interactive tutorial has an advantage in that it lets students proceed at their own pace and changes the role of the tutor to that of a facilitator for individual students. This reduces the level of demand on the tutor.

As another example, there is not enough time in a typical class, or in the time that an older person can maintain concentration over a single session, to master many computer skills or to spend a lot of time on a particular skill. However going over exercises again in their own time increases the amount of information that the older users remember. Make the training materials available for the students to take home and install themselves. This reduces the time constraints of a class situation. There is a useful payoff from making an interactive tutorial very easy to install, by the older person, on their home computer.

4.7.3 Instructional materials and typing

To repeat points made in the design recommendations, typing is a major stumbling block to computer use for many of the current generation of older users. The font size chosen for tasks and exercises involving typing is not just a matter of readability but also of how easy it is to acquire text targets with the mouse. Hence when designing instructional materials one should minimize the amount of typing required of older users. For introductory typing exercises use a very large font, possibly up to Arial 24 point.

4.7.4 Design approach recommendations

This section looks at the way in which the WinTutor study contributed to the design approach that eventually emerged as one of the products of the overall research. Although at this stage the ideas were tentative, they are important as they made a strong contribution to a change of direction away from an experimental approach towards a more observational study. With hindsight an experimental approach was initially adopted simply because it was a traditional way of proceeding but as discussed in the chapter on the Dual Task study it did not seem to be give access to the concerns I was interested in.

Pointers towards a design approach

The research intention that began the WinTutor study was simply to gain a wider knowledge of older users with the object of fleshing out the more theoretical material in the research literature on aging. In a new area such as interface design for older users it is reasonable to open one's perspective to allow a wide range of unstructured observations that are not filtered by pre-existing theory. The aim is to develop the background understanding that will adequately inform later theory building. What emerged was the unexpected utility of engaging with older users and their computer use at a direct and personal level. As I have mentioned, the literature on cognitive and physical aging tends to be reports of experimental work aimed at testing possible mechanisms for various parts of the aging process. The research is not in general aimed at application of the findings to older people's lives. Older people may have a higher frequency of reduced vision or poorer skills with visual search but practical guides as to how large a font is needed or how simple the search space needs to be in a screen design are not spelt out. What the interface designer for older people needs is information about the ways in which design can compensate for effects of aging. I find that my mental model of who I am designing for is always tinged with the assumption of someone like me. But what I found was that it is often in exactly those design features that I take for granted (and hence assume that all other users will also include in their common understanding) that I meet the differences that age creates for older computer users. Direct engagement with older people made me consider aspects of design for aging users that I would have missed or taken a long time to comprehend. Direct engagement with older people was starting to look essential in order for younger designers to overcome the handicap of being young.

Nor does the research on cognitive and physical aging offer a personalized view of the lives of older people or an extended view of the context within which they approach such things as computing. However the approaches to interface design embodied in "Task Centered Design", "User Centered Design" and "User Sensitive Inclusive Design" all ask the designer to be highly aware of the context within which the user will be using the design. What emerged from the WinTutor study confirmed my personal view of how very valuable gaining that contextual view becomes when the group one is designing for differs markedly from the group the designer belongs to.

So the WinTutor study made a useful contribution to the eventual design approach for developing applications for older users that I have developed over the course of my research. From the WinTutor study the following recommendations towards that design approach emerged.

Older users are in fact very different from younger designers in ways the younger designers are likely to repeatedly miss unless they work directly with older users. Hence observation of, and discussion with, older computer users is highly productive. There is a special advantage in doing prototype testing with older users in that the errors they produce are not necessarily those that a young designer expects.

Observing older computer users in pre-existing non-ideal situations can offer useful insight. However for ethical reasons one should not create such situations as part of one’s research.

Consider the context within which an older person will use a product. This includes considering the needs of the people who are supporting an older user in their computer use. There is an advantage in allowing for unstructured or very loosely structured observation of older users in order to allow room for unexpected areas of relevance to emerge.

Because older people are more disrupted by errors there is an extra payoff for them in reducing the chances of error making in an application. Design work needs to aim at preventing ("designing out") the more likely of the errors that older people commit.
In order to effectively do this a designer needs the close support of a few older users on a day to day basis. The process of designing for older users also benefits from support by experts on aging. In the WinTutor study the expertise was provided by the literature on cognitive and physical aging, and by the experience of the SeniorNet tutors as they evaluated WinTutor in the light of their knowledge of teaching older users and then as they trialed the program with their classes. One of the functions of the designer absorbing the available expert knowledge is that it provides the designer with a more sensitive basis for understanding their own observations of older people's problems. Expertise in the nature of aging acquired by the designer also improves the designer's selection of possible interface solutions for older users.

4.8 DISCUSSION

What does the WinTutor study tell us if we are interested in interface design for older users? The first point is that older people are slower to acquire elementary computer skills and are likely to attempt to use the interfaces that are designed for them with a lesser set of skills than designers would expect from younger users. I have observed WinTutor being used successfully with young immigrants and with classes of women returning to work who wanted to acquire computer skills. This suggests that the skills older people need to acquire are not a distinct set from those needed by other users. What is different for older users is the slowness and difficulty of acquiring and retaining these skills.

At the start of this chapter the point was made that the development of WinTutor was important to the subsequent direction of the research. As the chapter has shown, the fact that this was an interactive tutorial meant that in developing it I was engaged in developing an application for older users. In addition I was doing this on the basis of daily engagement with my older design assistants. Thoughtful reflection on this process provided a number of suggestions that could be used as general guidelines in designing applications for older users. The sections on vision, manipulation and comprehension indicate a number of considerations that I see as important in the success of the design that emerged. The design principles underlying WinTutor came from attempts to provide solutions to observations of older learners' problems. These considerations accord with the overall implications for interface design originally derived from the literature review of the physical and cognitive effects of aging. Hence the success of WinTutor as an application that older users could understand and control provides a degree of support for those implications.

The chapter has included a section on a number of points towards a useful approach for developing for, working with and understanding older users suggested by the experience gained in the development of WinTutor. This design approach was expanded in the later stages of the research but it is the development of WinTutor that first gave a strong picture of the benefits of direct engagement with older users and of the virtue of thoughtful and sensitive observation of their needs, successes and difficulties. Obviously developing WinTutor also gave considerable opportunity to consider how to improve training for older beginners. It is worth noting that the use of the interactive tutorial format and the details of implementing this format were derived directly from an analysis of the observed problems that older users found in conventional teaching situations. Thus the WinTutor project offers a different argument for supporting the use of interactive tutorials with older people. Although there have been a number of recommendations suggesting that interactive tutorials are a desirable way of training older users, (and some studies that dispute the virtue of interactive tutorials), these papers tend to do an overall comparison of the learning achieved from an interactive tutorial with the learning achieved from a different teaching format and to be unable to explicate the reasons for the better performance of the interactive tutorial where this is found. In contrast the WinTutor study builds a set of solutions to the observed problems that are found when conventional teaching is used for training older beginners. These solutions are framed within the format of an interactive tutorial. It is not argued that an interactive tutorial is always to be preferred for teaching older beginners but a case has been made that an interactive tutorial offers a useful container for meeting the typical problems older people meet when trying to learn computer skills.

The point was made at the beginning of this chapter that the difficulties of older beginners will shape their later attitude to computing or even persuade some older people to give up the idea of becoming computer users. Hence understanding how to reduce these initial difficulties is important if we want to make computer use available to older people. In fact the conventional teaching approach was seen to lead some older beginners to abandon their attempt to become computer users. In contrast a number of SeniorNet branches now use WinTutor as a required preliminary before older students begin learning specific applications such as a word processor or email. Not all SeniorNet branches use WinTutor but the general approach of teaching elementary skills before tackling applications is common within SeniorNet.
It is my experience that older computer users do not suddenly become computer literate after a basic computing course. They acquire familiarity with a number of idioms but the full range is unlikely to be reliably absorbed. Some computing skills will remain in the realm of fragile knowledge for months or even years. Other skills will be met in training and then simply forgotten. The sheer number of facts and idioms that underpin use of a typical graphical user interface are simply too many to expect most older users to gain overall fluency in them. Hence, as suggested at the start of the chapter, the initial gaps in older people's computer knowledge act as warnings to the designer of knowledge gaps that are likely to be present in at least a number of their older users.

4.9 DIRECTIONS FOLLOWING THE WINTUTOR STUDY

Although the WinTutor development offered a range of insights and appeared to be highly successful in meeting the needs of older beginners there were several reasons for further research. There was no direct formal evaluation of WinTutor and its effect on older beginners' learning, so claims for its success need to be treated with some caution. In spite of the benefits that seemed to come from direct involvement with and observation of older users there was limited observation of older users working with WinTutor apart from the two late middle aged people who provided day to day feedback as development progressed. Another point is that a soft research methodology based on observation but not on an experimental approach needs more replication if it is to offer believable results. For these reasons the decision was made to provide a similar study to the WinTutor study but to include a number of improvements to the research design based on the limitations of the WinTutor study.

In the next chapter the development of a second interactive tutorial is described. This development was specifically aimed to address the weaknesses of the WinTutor study. It was planned from the start as a research study of a design project for older users. It adopted a quasi experimental method where the older people recruited were people who had failed to learn the topic of the new tutorial in previous attempts using a variety of methods, if they could be shown to succeed using the new tutorial this would offer support for the methods that the tutorial embodied. It involved the participation of a relatively large number of older people in the refinement of the interactive tutorial. It involved ways of structuring the participation of the older users so as to increase the amount of understanding of their needs, issues and the context in which they worked. Further it provided a test of the ability of these people to apply information gained from the tutorial. In addition it was intended that this new study could open some new areas of investigation, dealing with how to introduce complex conceptual material into an older persons' computing skill set, looking at older people's ability to learn moderately complex applications and taking advantage of the increased contact with older participants to deepen the understanding of how to turn the implications for design offered in the literature review into a useful application design approach for older users, based on a somewhat more demanding application.

Chapter 5 OLDER USERS AND LEARNING MORE COMPLEX COMPUTER SKILLS

5.1 INTRODUCTION

The WinTutor study had apparently indicated a successful approach to teaching older beginners through designing and using an interactive tutorial. The WinTutor study also gave some indication that working extensively with older users during the development of a product designed for them was a key aspect of creating a successful design. Further the WinTutor study confirmed and expanded the design implications for older users derived from the general literature on cognitive and physical aging. But as mentioned in the conclusion of the previous chapter there were drawbacks to the study, the amount of direct observation of older people working with the program was insufficient (apart from the older in-house testers) and the use of measures such as continuing sales and SeniorNet tutor satisfaction was only indirect evidence of the program's successful design as an interactive tutorial.

It looked as if it would be desirable to carry out a similar study with a design that allowed more direct confirmation of the findings. This would still involve interaction with selected older users during the design stage but would provide a more direct and more objective approach to testing the success of the resulting design. The revised design should also allow for observation of a more widespread set of older users. The problem was that the thesis was intended to address design issues for older users and was not intended to change course and become a study of older people's learning. On the other hand the WinTutor study, though centered round an interactive tutorial, had managed to address a number of themes that were useful to the overall direction of the thesis. It had also seemed to give a broad and useful picture of the early needs of older computer users.

So the aim of this next study was to provide a degree of confirmation of the findings from the WinTutor study while working with older users in a way that added to knowledge about the way to design applications for older users. Again discussions were held with SeniorNet tutors to identify a topic area that was going to be seen by older users as relevant to their needs and where there were likely to be numbers of older people who had had difficulty in managing the standard approaches to the topic. The result of these discussions was the choice of the Windows file management system as a topic area. As this was reportedly seen by older users as a complex and difficult area, it would be a more challenging area to work in but offered the chance to address some themes that extended beyond what had been examined in the WinTutor study.

It was decided that one additional theme of the study would be to examine whether a set of findings on how to train younger users by restricting initial complexity would hold true for older users. Carroll et al (1990) had shown that trainees learnt more effectively if shielded from all but essential features of applications during the initial learning period. Their subjects were young but it seemed reasonable that their findings should apply with equal if not greater strength to older users, given older users' problems with complexity.

It was therefore hoped that a study of older users' issues with the Windows file management system would help address the following points.

- Provide further experience with the emerging design approach for working with older participants during design.
- Provide further experience with interface design for older users as the interactive tutorial itself was designed.
- Provide additional confirmation that interactive tutorials were a useful way of helping older people learn computer skills and extend this finding to cover the case of more demanding computer skills.
- Provide a way of examining the use of Carroll's "training wheels" and "minimal manual" approaches with older learners.

Therefore, working in cooperation with some older people, an interactive tutorial on file management under Windows was constructed and this tutorial (FileTutor) was put through cycles of usability testing. The observations made while conducting these usability tests provide much of the basis of this chapter. In what follows this chapter will look first at the existing literature on training older users in computer skills and the varied views of the value of interactive tutorials for this purpose. The study design is then described. This is followed by a description of the results of usability tests with 25 older users. Having established that the interactive tutorial was in fact useful in assisting older learners the chapter proceeds to provide a description of the design aims behind the tutorial and of the tutorial itself. We then continue with a discussion of the design principles used in the construction of the tutorial and provide observations from the usability study that illustrate the effect of these design principles in practice. The chapter concludes with a look at what was achieved in this part of the overall research and an examination of further research issues.

5.2 PREVIOUS WORK ON TRAINING OLDER PEOPLE IN COMPUTER SKILLS

Previous work on the effectiveness of various methods of training older people on computer skills is reviewed in Chapter 2. Work by Mead & Fisk (1998), Morrell, et al. (2000), Rogers, et al. (1996), Czaja & Lee (2001) looked at a variety of training formats. These studies used limited tutorials constructed purely for use in their experiments. The overall recommendations on training provided by the following authors Morrell and Echt (1996, 1997), Morrow and Leirer (1999), Morrell et al. (2000), Rogers (2000) and Willis (2004), are given in the following list (repeated from Chapter 2).

- Instruction structure: Use lists in a standardized format, language structure and vocabulary should be kept simple, avoid the use of negatives, use an active rather than a passive voice.
- Provide an active learning situation and provide sufficient practice with task components. Ensure that the training environment is free from distractions.
- Content: Emphasize procedural steps and leave out background conceptual information, use concrete examples, some instructions should be accompanied by relevant simple illustrations since some information is not well conveyed in text, slowed animation may be useful. Training material should be well organized and important information should be highlighted.
- Ensure that help is available and easy to access
- Delivery: Allow extra time for training. Training should be self-paced and may work better in small groups

- Instructional materials for older learners should be designed so that attention can be focused on single areas, being mindful of older adult's issues with maintaining divided attention.
- Text formatting: Use a typeface with rounded distinctive sans-serif letters (e.g. Helvetica), use 12 to 14 point with strong contrast between letters and background, use short, left justified lines with a maximum of 65 characters per line, use whitespace to increase clarity.
- General: Be aware of older peoples' problems with: reductions in working memory capacity, reductions in ability to deal with complexity, reduced color discrimination particularly in the blue green range.

Another approach to training people in the use of applications comes from the work of Carroll (1990) who investigated the value of making a ruthlessly simplified version of the application and its manuals the core of the training approach. While this was successful with younger users it has not been investigated with older users. Carroll (1990) summarizes a number of studies in which his team demonstrated with younger users that "training wheels" and "minimal manual" approaches gave better learning of computer programs. The key feature of these approaches is to restrict the options available and the amount of information provided as much as possible. Given that older people are more likely to have problems with complexity, these approaches should be well suited to older learners. Carroll also supported the value of active learning where the user performs the task being learnt. Carroll showed that once users had absorbed basic information they were then better able to handle the extra features, special cases and exceptions that deter users if presented during initial learning. This is compatible with the findings of Morrell et al. (2000) who found that providing older learners with background conceptual information in addition to step by step instructions led to poorer performance both immediately after training and on retesting one week later.

One of the distinguishing features of the FileTutor study is the wider scope of the considerations for constructing the tutorial as it draws on the widespread implications of aging considered in Chapter 2. Again the design approach for the construction of FileTutor involved ongoing participation by and feedback from older users. This is not part of the previous published work on tutorial design. A further difference is that the tutorial examined here was designed as a commercial product for real life training of older computer users in a substantial computer skill and is now succeeding in that role.

5.3 STUDY FORMAT

5.3.1 Initial scoping

After discussion with SeniorNet (NZ) members, file management and the use of Windows Explorer was chosen as a topic that was reasonably challenging to seniors and that seniors saw as relevant and were motivated to learn. Initial conversations were held with SeniorNet tutors that spelt out the sorts of difficulties they encountered with teaching file handling. Samples of instructional material proposed by some SeniorNet tutors for teaching file management to older users were also examined. In the main, this material was worrying in that it presented older learners with a number of technical aspects of data storage that seemed to be irrelevant to their needs and likely, from the experience with the UNITEC classes, to cause the older learners considerable difficulties for no practical gain.

5.3.2 Prototype development

On the basis of these discussions a set of key file handling concepts and skills was developed. The material was analyzed in order to determine a suitable teaching sequence that allowed for the dependencies of some topics on others. Work was then commenced on creating a prototype interactive tutorial covering the file management topics that had been selected. This prototype was developed with the participation of two "in-house" older users who were in their mid fifties, had no knowledge of Windows file handling and found computing in general to be a difficult set of skills to acquire and retain. The interactive screens that demonstrated specific file management topics and skills were tested and discussed daily with the in-house users as they were developed. The in-house testers worked with each individual screen of the FileTutor and WinTutor tutorials. These screens were presented as code based prototypes, the in-house testers were observed trying to use them and comments were collected. New screen versions were then produced and the cycle continued until the issues raised by the in-house testers had been resolved. Once a preliminary version of the whole tutorial had been created it was shown to SeniorNet course advisors and the resulting useful feedback was incorporated.

5.3.3 Usability testing

The resulting interactive tutorial, FileTutor was put through three usability cycles with older users.

A total of 25 older users aged between 60 and 88 (15 male, 10 female, average age 69.8) were recruited by advertising on the internet for people over 60 with Windows experience who wanted to learn about file management.

The usability findings in this paper draw more heavily on the difficulties of some participants than others. Rosenthal and Rosnow (1975) note that volunteers for research projects tend to be more intelligent, of higher status, more articulate and more self-confident than the community average. This was true in this study but because the project offered instruction that was genuinely in demand, and because some of the initial volunteers encouraged other friends to enroll with them who would not have joined the study on their own, there were 7 volunteers who appeared more typical of the general community. They were less educated, less articulate, had clerical or manual careers and were less self-confident. This "more average" group included most, but not all, of those who had greater difficulty coming to terms with file management concepts.

The "more average" group was particularly valuable in the FileTutor project. This group had more difficulties and were of considerable value in showing areas in which FileTutor could be improved. The "above average" volunteers made a useful but different contribution. They personally were more able to cope with the problems in the earlier versions of FileTutor but they were happy to adopt a role of identifying things that they felt might cause difficulties for other older people, these included misleading instructions, and errors in spelling and grammar but they also offered some useful suggestions for style and sequence. However the "above average" group did not spot many of the pitfalls that the "more average" participants exposed. The advantages of partially countering the effects of self selection by volunteers should be borne in mind when selecting older users for product evaluation.

Participants came to Unitec, an institute of technology in Auckland, New Zealand, for three 2 hour sessions spaced two days apart. In the first and second sessions participants worked with FileTutor to gain file management skills. After the first session they took a copy of FileTutor home and installed it on their own PCs and either repeated material they had learnt at Unitec or proceeded to work on new topics as they saw fit. Participants maintained a log in which they rated each example screen and they were encouraged to ask the researcher / tutor for assistance when they became stuck or when they found things that they thought could be more clearly stated, these issues were recorded. Difficulties encountered at home were logged and then examined at the beginning of the second and third sessions. In the third session the participants did a practical file management exercise using Windows Explorer to evaluate how well skills gained with FileTutor transferred to a real life task. The testing protocol for this task is described in Appendix B. Testing on the real life task was followed by a focus group discussion on issues for older computer users and issues in learning about file management. Participants also completed a questionnaire and evaluated the overall usefulness of FileTutor.

The researcher took on multiple roles as observer, usability tester and tutor, the participants were genuine students but also volunteered to assist in finding ways to improve the tutorial for other older people who came after them. Three sets of usability sessions were run, one in December 2000 and two in January 2001. Between sessions FileTutor was altered on the basis of problems found and ideas that were prompted by what had been observed.

5.4 DESIGN AIMS IN DEVELOPING FILETUTOR

The design aims were developed from the material in the literature survey, the experience of designing the WinTutor program and, in the case of designing the simplified version of Windows Explorer, from Carroll's (1990) description of the key aspects of his "training wheels and minimal manual" approach.

Comprehension, Memory and learning

The design aims here were taken from the experience in constructing the WinTutor tutorial. It was assumed that older people would benefit from having a slow pace of introduction of concepts and that learning should be in a form that made the older learner an active participant. In the design of the instructional material the aim was that there should be a careful development of knowledge and skills so that the sequence in which they were presented provided the older learners with an adequate foundation for understanding and acting each time they proceeded to new material. In that older beginners had been observed to have widely differing time and repetition requirements in mastering new material the aim was to make the exercises self paced and capable of being repeated without difficulty by the older learner.

Confirmation, feedback, difficulty levels and motivation

Older learners were observed to be likely to have an expectation of failure and to need assurance that their actions had succeeded. Older people in the dual task pilot study had also been observed to disengage from work where the difficulty levels were set too high. Hence a design aim was to provide easily obtainable success in each exercise combined with clear indications of when success was achieved.

Vision

- Problems with less flexible visual accommodation mean some older users will have difficulty reading from information on paper in combination with carrying out on-screen tasks. Hence a design aim was to provide all exercises and instructions and conceptual material on-screen without relying on printed material.
- Again older people have poorer memory for pictorial information. The design aim resulting from this was that as far as possible graphics and text that explained them should occur on the same screen.
- Older people may have problems with reading text over colored or patterned backgrounds and have problems with small fonts. The aim was to provide easily readable fonts for all text by careful choice of font style, size, color and background.
- Older people may have problems inhibiting responses to irrelevant information so a design aim was to reduce distractions such as purely decorative graphics.
- Older people are poorer at locating visual targets, they also have a narrower effective visual field. Hence a further design aim was to provide a visual environment in which locating features would be simple for older users, the

emphasis here was on simplifying search spaces and reducing distractors while keeping instructions, locations where actions are taken and locations where feedback occurs, close together.

Manipulation and timing

Older users have reduced manipulative ability and when difficult manipulation is performed controlling such manipulation may involve greater cognitive load for older people. Hence in an environment where the older learner should be devoting their cognitive effort to learning new concepts it seems desirable as a design aim to reduce any competition for cognitive effort that could arise from manipulation. This meant making targets reasonably large, reducing drag and drop operations, largely avoiding the resizing and other manipulation of windows and producing designs that did not require double clicking.

Menus and Sub-menus

In line with Carroll's concept of the minimal manual and training wheels approaches the design aim was to restrict and simplify the menus available in the application being learnt, (Windows Explorer).

Typing

Typing remains a severe problem for a number of older users. As in the WinTutor program a design aim was to avoid having older learners put effort into entering more than short passages of text.

Scrollbars

A number of older users were observed to scroll inefficiently. Further where information on a screen required an older user to scroll in order to see all the information it was felt that this would reduce the older person's chances of fully understanding the information presented, both because short term memory problems where what could be seen at any stage would have been a partial version of the whole and because the concentration needed to scroll successfully could interfere with the task of remembering the information that was being hidden and relating it to the information that was being exposed. Hence a design aim for a good learning environment was to reduce the need for scrolling.

Navigation

The design aim was to structure the tutorial into a set of topics where a topic consisted of a set of screens each of which provided a self contained step towards the desired mastery of the topic. The intention was to repeat the simple progression available in WinTutor but with some adaptations because of the more conceptual nature of the topic. Thus it was intended to make additional background notes available for students who wanted extra information.

Carroll's "training wheels and minimal manual"

One of the requirements of effective file management under windows is the use of the Windows Explorer tool for file management. This is in fact a fairly extensive and multi-featured application that had been observed by SeniorNet tutors to cause problems for older people. It seemed probable that Carroll's approach would also be appropriate for training older users on an application and so one of the design aims was to provide training on Windows Explorer in such a way that 1.) instruction was limited to the basic features of the application (Carroll's minimal manual), 2.) training would be done on a simplified "training wheels" version of the application and 3.) training would proceed through a set of "active learning" exercises.

5.5 RESULTS FROM TESTING FILETUTOR

In the focus group discussions in the third and last session all participants reported having tried a variety of methods of computer instruction with generally poor results, the partial exception was training specifically for older people provided by SeniorNet branches. All participants had previously tried (and failed) to find out about file management from a variety of sources. The overall response of the participants to FileTutor was that they were meeting a tutorial that was unusually well suited to their needs as older users. In effect the study design contrasts FileTutor with the variety of existing instructional formats for computing skills instruction that had been tried by these older people. It provides strong support for FileTutor being preferred. Participants praised the overall format of FileTutor as being very easy to work with but, as we shall see, that format is based on a myriad of considerations.

The findings of this chapter are of more interest if FileTutor can be shown to be successful. In response to the question "Would you recommend FileTutor to other older people wanting to find out about files and folders?", using a scale rated from 1 "strongly recommend" to 5 "would not recommend", twenty-two participants responded with a 1, two responded with a 2 and one with a 3. All but three participants said they had gained a lot from using FileTutor and intended to continue working with it.

The practical file management exercise was done with Windows Explorer outside the FileTutor environment, after the FileTutor training sessions. Twelve participants completed the exercise independently, five completed the exercise with minor prompting, five completed the main parts of the exercise with significant prompting and three failed to complete the exercise, see Table 1.

Table 1. Results from the file management exercise. Numbers of participants completing the exercise at various levels of independence.

Level of independence	Percent (n = 25)	Error levels
Completed exercise without prompting	48% (12)	Trivial 0 - 2
Completed exercise with 1 - 2 prompts	20% (5)	Trivial 1 - 4
Completed main parts of exercise with 3 - 5 prompts	20% (5)	Medium
Did not complete exercise	12% (3)	Severe

With respect to the error levels in Table 1, trivial errors were one’s that were understood at once when shown to the user, could be recovered from by the user without further assistance and were the sorts of errors that could easily be made by people who were competent in file management. Medium errors suggested a lack of such competence. The group who needed significant prompting said that they were confident that they would become independent with more practice. Of the three who did not complete the practical exercise and were not enthusiastic about FileTutor, one had limited vision and was unable to see Windows Explorer clearly enough to manipulate it, the other two because of inexperience and disability had made very slow progress through the FileTutor topics and had simply not reached the topics that were relevant to the exercise.

5.6 A BREIF TOUR OF FILETUTOR

This section gives a brief description of FileTutor. This is intended to orientate the reader in preparation for the later section (Section 5.7) where the design solutions for the design aims of the tutorial are discussed.

5.6.1 The FileTutor Main Menu

The initial display was a menu of numbered topics, choice of a topic led to a sequence of topic screens giving explanations and exercises for that topic. Each sequence ended in a revision quiz. Option 10 in the first menu led to another similar menu with ten more topics dealing with Windows Explorer so there are 19 topics involving nearly 80 topic screens in all.

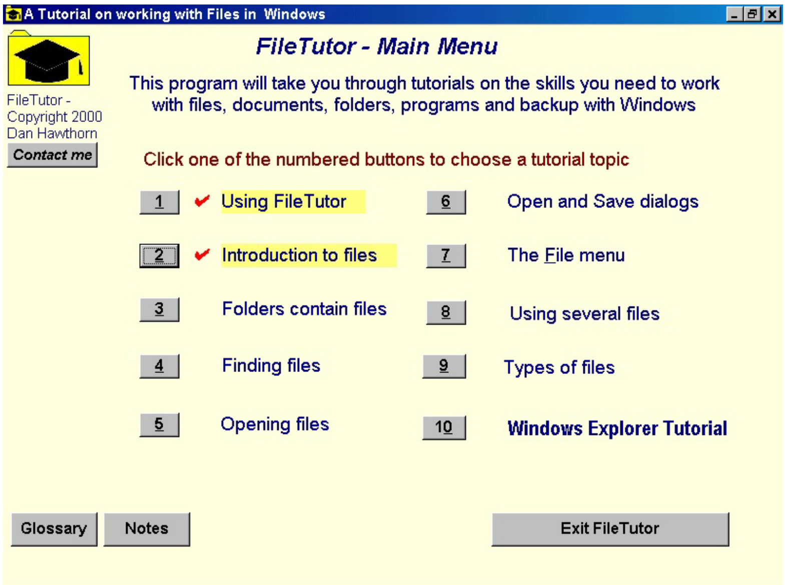

Figure 5.1 The FileTutor Main Menu. Topics 1 and 2 show as completed. The next menu, for the Windows Explorer tutorial, is reached from button 10.

5.6.2 FileTutor Navigation

Topic screens, such as those in Figure 5.2, were displayed maximized and could not be resized, they could only be exited from by a set of Next, Back, Menu buttons at the bottom right. There were no hyperlinks. The intention was to deliberately restrict and simplify navigation. All participants used these buttons easily, without prompting, after brief initial instruction.

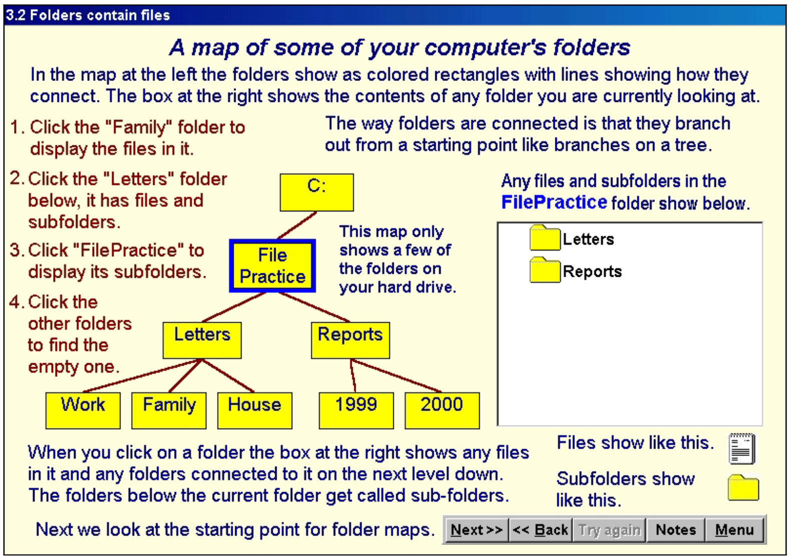

Figure 5.2. A typical FileTutor topic screen showing the navigation buttons in the lower right corner. The screen shows the results of carrying out step 3 from the instructions at the right.

Each screen involving an exercise was provided with a "Try again" button. This returned the screen and the file system to the way it was before the exercise began. Background information was available through a "Notes" button, see Figure 5.3.

5.6.3 FileTutor topics and Interactive Exercises

Each topic in FileTutor consisted of a series of screens that developed the concepts and skills required for mastering that topic. The next series of figures follows the screens from one of the introductory topics where the basic reason for having files is explained and then demonstrated.

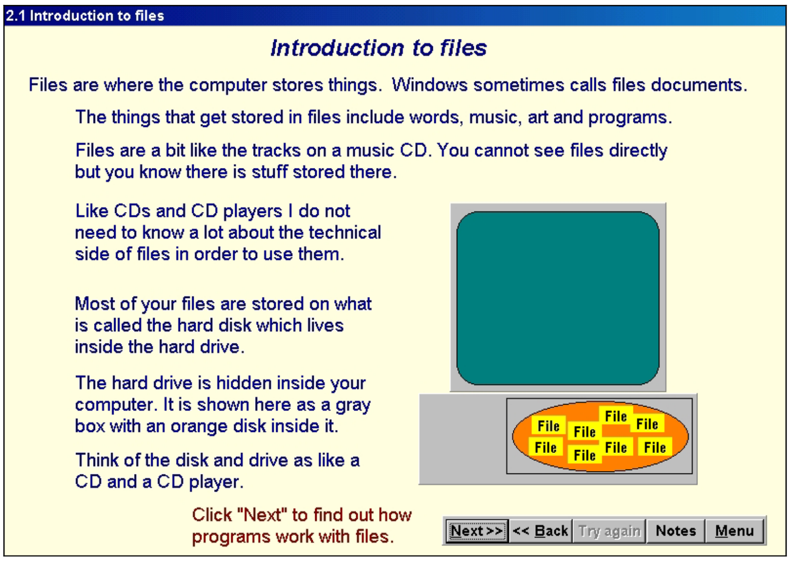

Figure 5.3. First screen in the "Introduction to files" topic.

The screens give simple information backed with pictures that reinforce the text. Technical information is deliberately avoided.

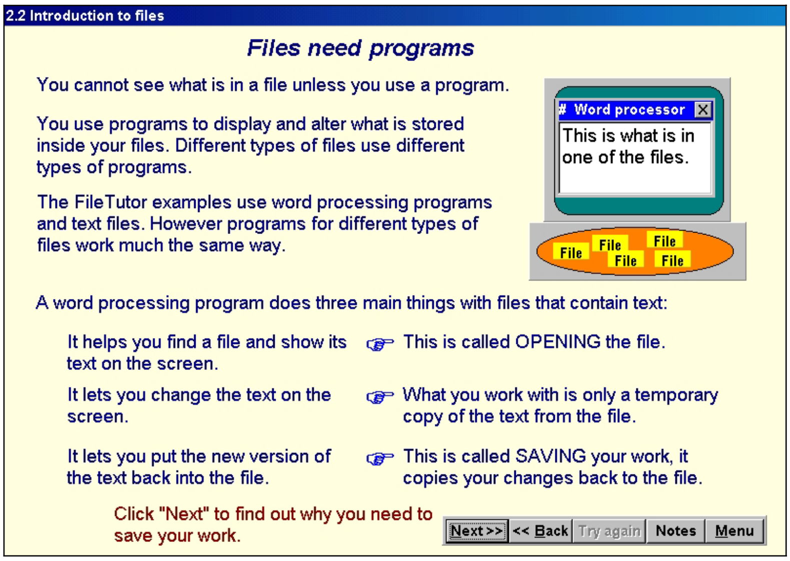

Figure 5.4 Making the link between a file and a program.

Note the very low level of initial knowledge assumed in this series. There was a need to provide very basic background information and definitions of terminology.

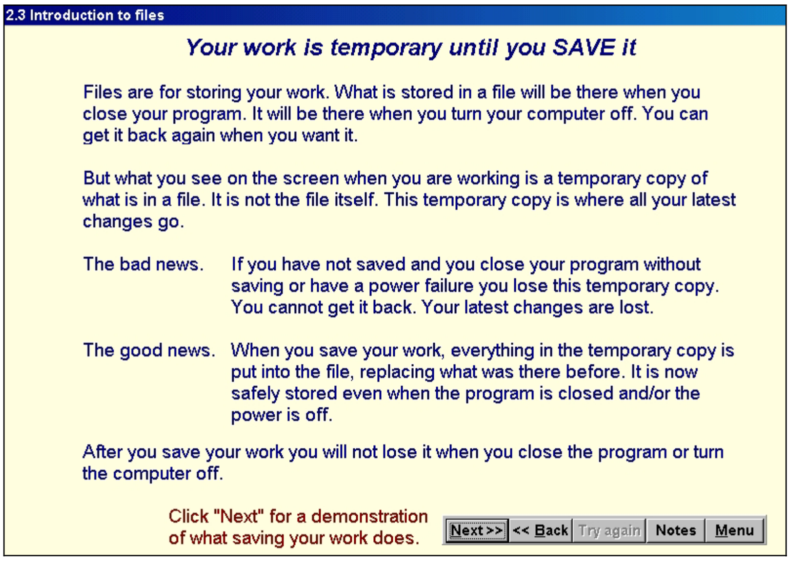

Figure 5.5. Save it or lose it

One of the concerns in constructing FileTutor was to provide the needed information in an appropriate sequence so that each new concept or skill was adequately scaffolded by those that had gone before. There was also a tension between the amount of textual information provided and the more effective activity based approach that is the core of the interactive nature of the tutorial. The problem was that some verbal preparation seemed to be unavoidable as seen in Figures 5.4 and 5.5 (above) but that the older users struggled to retain textual information until they had actively made use of it in exercises such as that shown in the next series of figures. This next set of screen shots shows the steps involved in carrying out the first interactive exercise in the tutorial. This exercise follows the screen shown in Figure 5.5 above and puts its ideas into practice. (Figure 5.6 to Figure 5.9 below.)

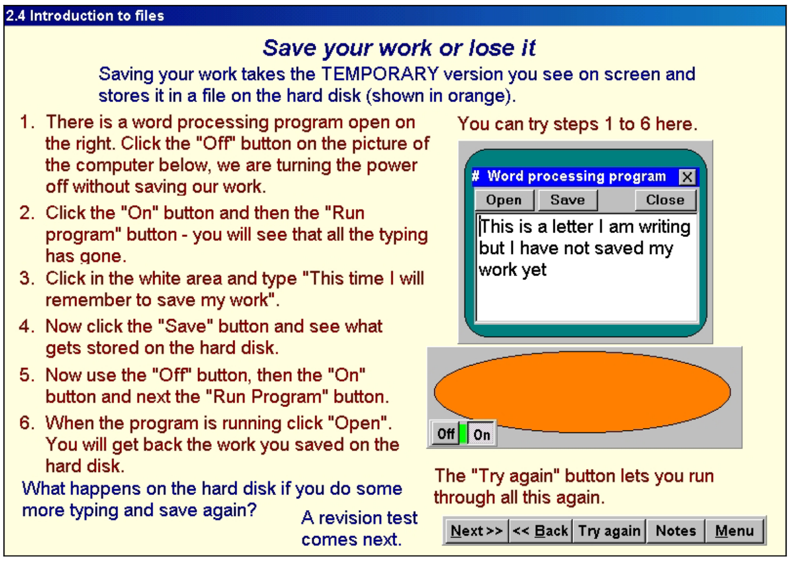

Figure 5.6 The first interactive exercise as it is first displayed. The aim is to create a hands on experience of the effect of saving or not saving work and the link between the Save command in the application and the resulting storage on hard disk.

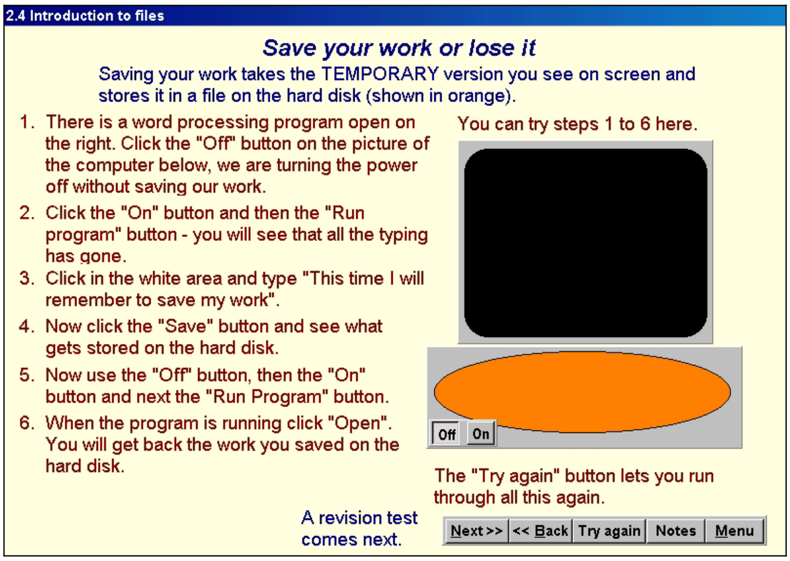

Figure 5.7 The first interactive exercise after carrying out step 1

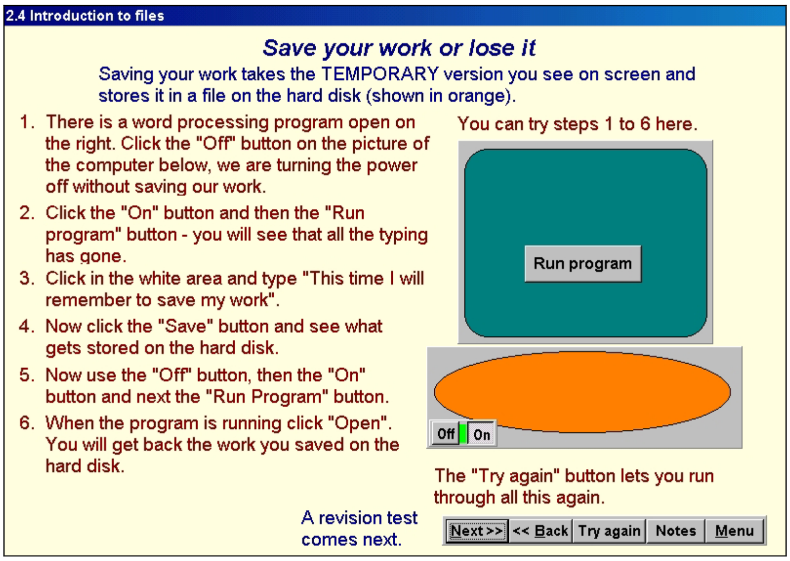

Figure 5.8. The first interactive exercise part way through step 2

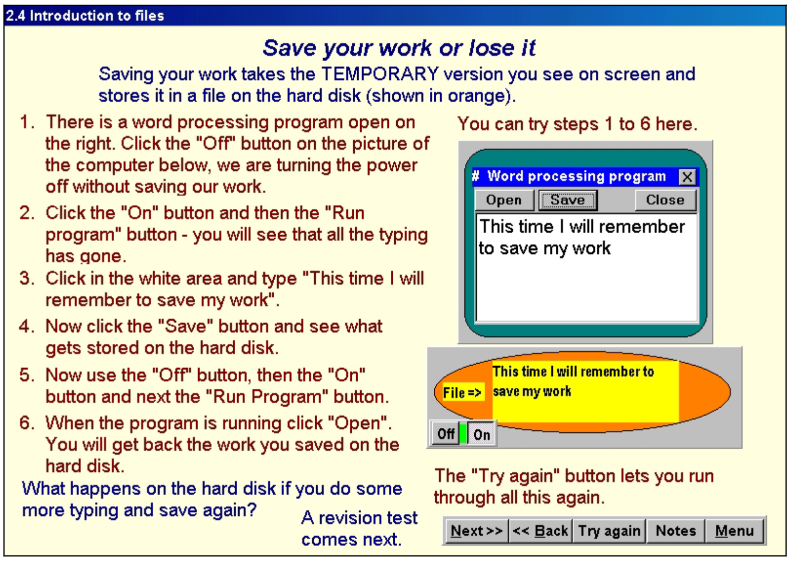

Figure 5.9 The first interactive exercise with step 4 completed showing that saving has stored text on the hard disk.

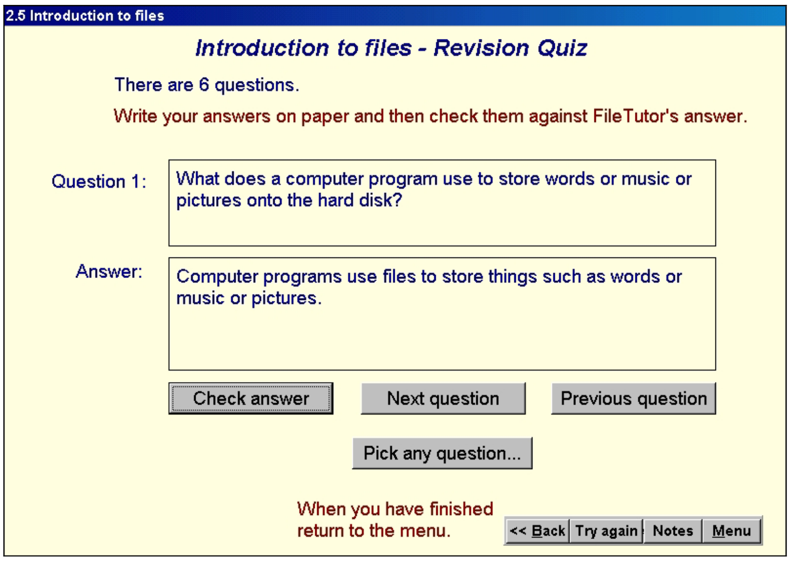

Figure 5.10. Each topic sequence ended in a revision quiz that some, but only some, of the older learners found useful.

Figures 5.11 to 5.14 provide another example of an interactive exercise. In this case older beginners were found to be confused when it came to copying text between documents. Part of the confusion appeared to be in uncertainty about the difference between copying an entire document to another location and copying text from part of a document to a position inside another document. It also seemed that combining four separate operations was in itself a source of difficulty. The beginner had to find and open a file, select and copy some text, find and open another file, find a position in the file and paste the copy into the new position. There was further confusion over what the copying (to the clipboard) step achieved since the clipboard is invisible.

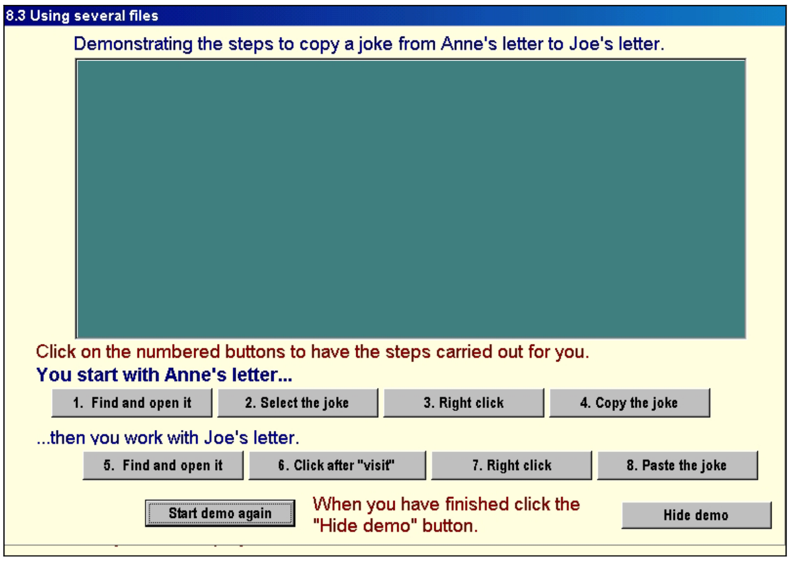

Figure 5.11. Interactive exercise demonstrating copying text between files - as first displayed.

Extended written instructions were tried but did not seem help, nor did more careful phrasing. However the demonstration shown in the next sequence of figures (Figures 5.12 to 5.14) did clarify the concepts.

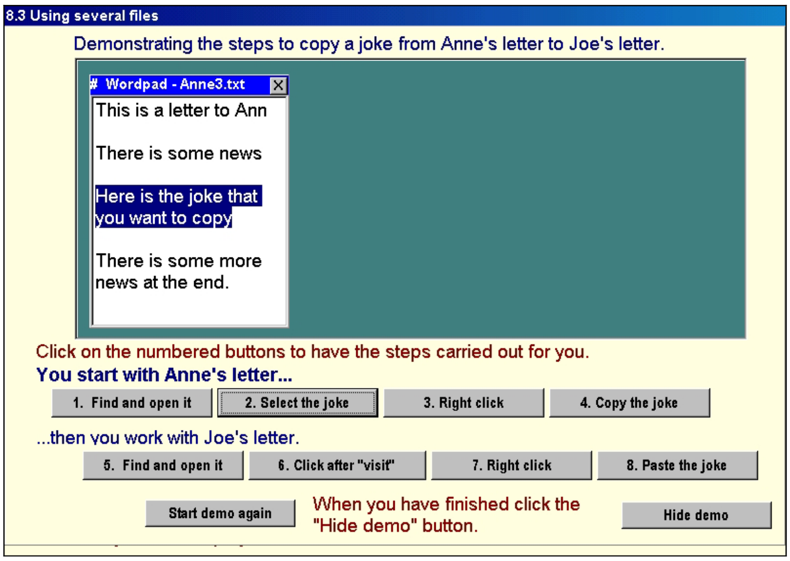

Figure 5.12. Interactive exercise demonstrating copying text between files - after clicking the [2. Select the joke] button

One of the important points about the interaction in FileTutor was that the user controlled the initiation of each new step in the demonstration.

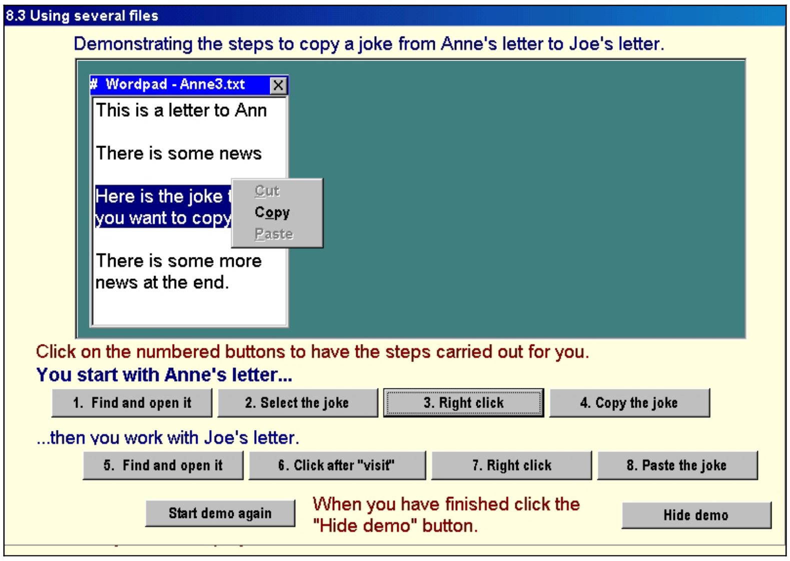

Figure 5.13. Interactive exercise demonstrating copying text between files - after clicking the [3. Right click] button

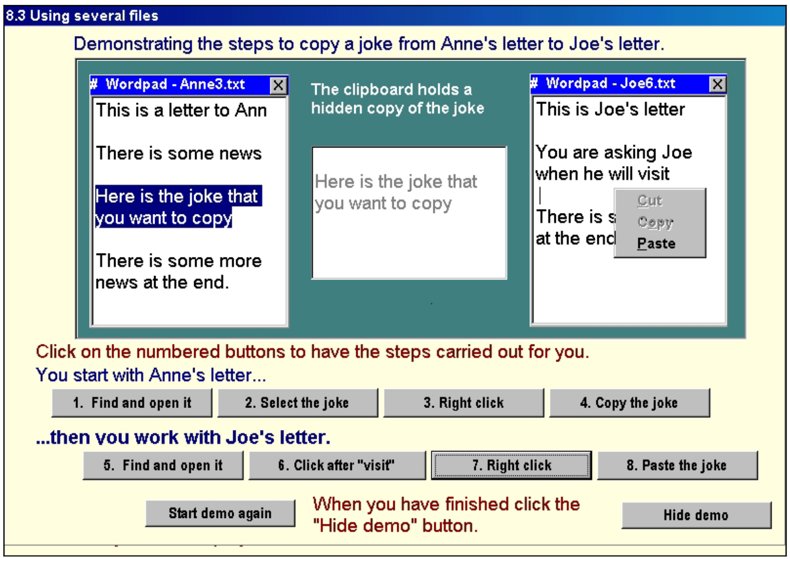

Figure 5.14. Interactive exercise demonstrating copying text between files - after clicking the [7. Right click] button and ready to complete the copy by either clicking Paste in the pop up menu or clicking the [8. Paste the joke] button. Note that the clipboard is made a visible part of the demonstration.

This demonstration of text copying was followed by an interactive exercise in which the older learner was guided through and actually carried out each of the steps previously shown in the demonstration.

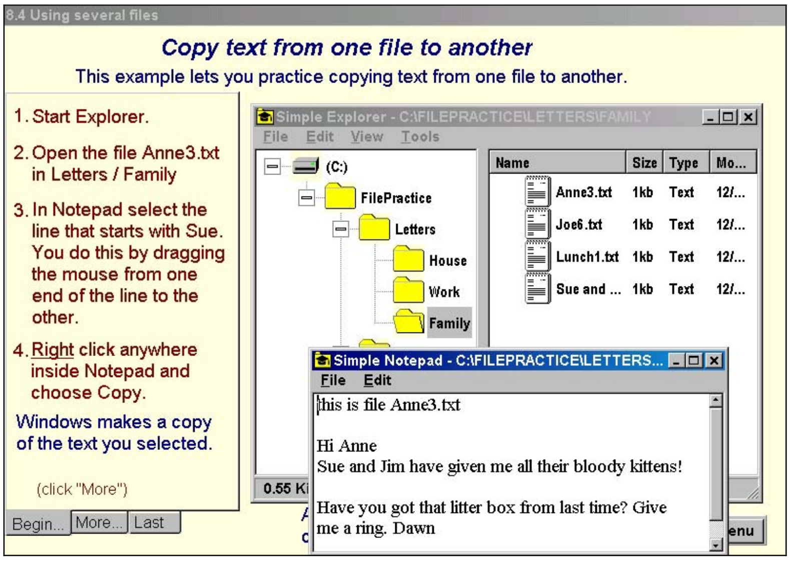

Figure 5.15. Interactive exercise in copying text between files. Step 2 has been completed. Note the tabs used to provide sufficient space for fully detailed instructions.

5.6.4 The Windows Explorer Tutorial within FileTutor

The second part of the tutorial is aimed at teaching the older users how to work with the Windows Explorer tool for managing files. This is reached from button [10] on the FileTutor's main menu. When this button is clicked a further menu is shown giving the topics displayed in Figure 5.16.

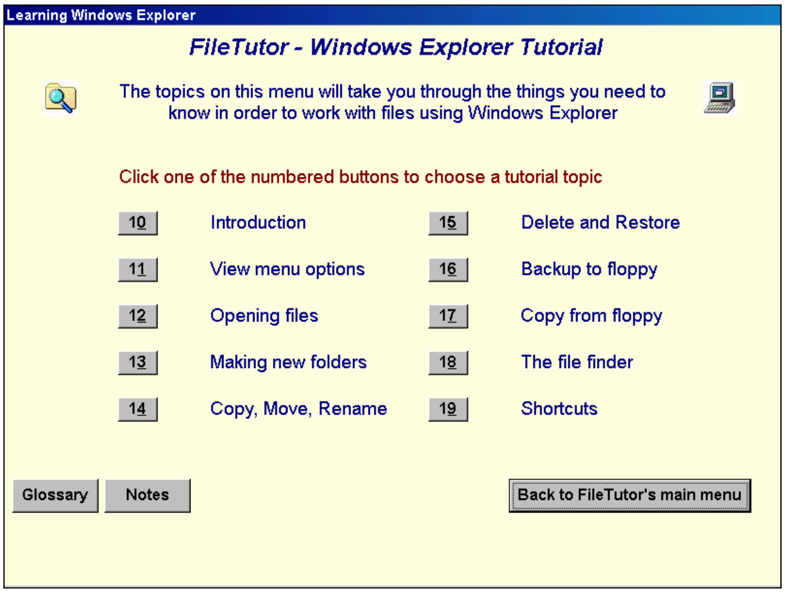

Figure 5.16. The FileTutor sub menu for the Windows Explorer tutorial

One of the central features of the way that FileTutor introduces Windows Explorer to the older learners is by use of a simplified version of Explorer that embodies both adaptations for the effects of aging and aspects of Carroll's minimal manual and training wheels approaches to computer instruction. In the sequence of figures that follows (Figure 5.17 to Figure 5.19) a simple exercise using this training version is shown.

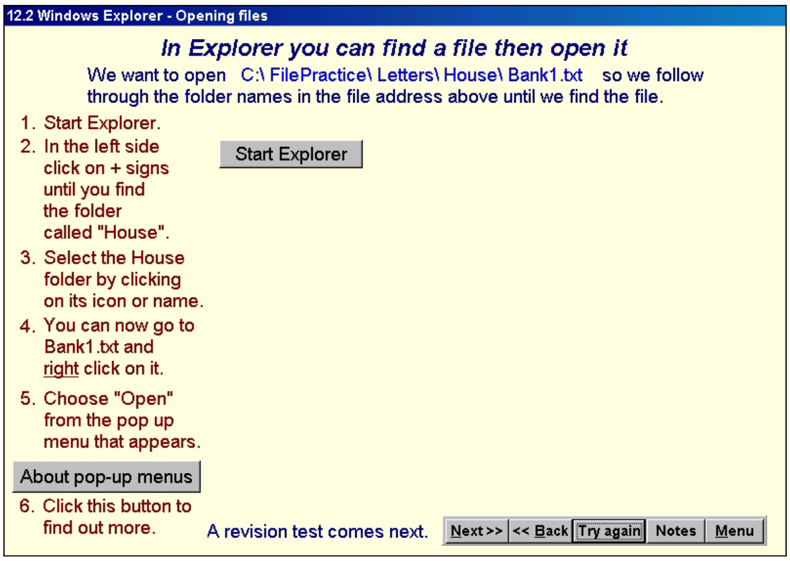

Figure 5.17. The Windows Explorer exercises typically begin by getting the user to start the Simple Explorer program via the [Start Explorer] button. A series of instructions to carry out during the exercise is given on the left side of the screen.

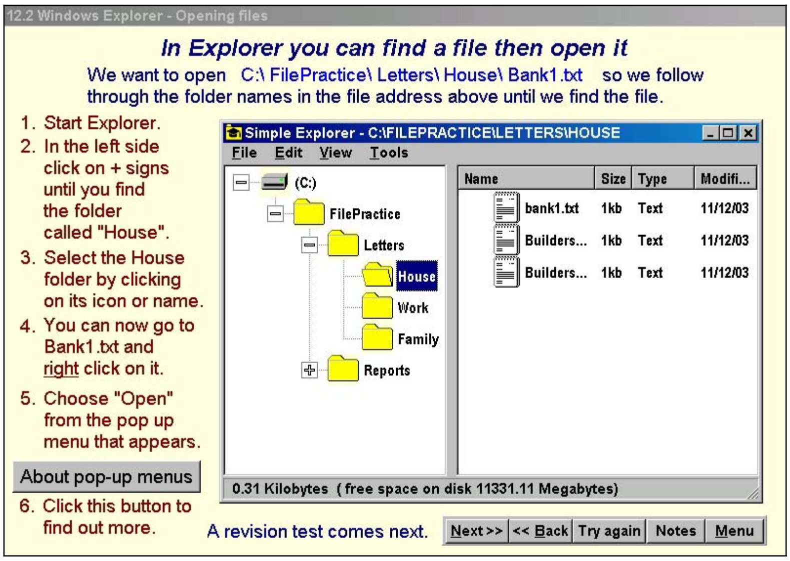

Figure 5.18. Using Simple Explorer - here the user has completed steps 1 to 3.

The simplified and age adapted version of Windows Explorer that can be seen in Figure 5.18 is always displayed in the space to the right of the instructions as a float on top window that will remain on top if the older user inadvertently clicks outside the window. It gives a simplified version of the core functionality of Windows Explorer along the lines indicated by Carroll's training wheels / minimal manual philosophy. In addition features such as the large + and - controls for controlling the tree view, the large icons and the larger font make this version more suited to manipulation by older users.

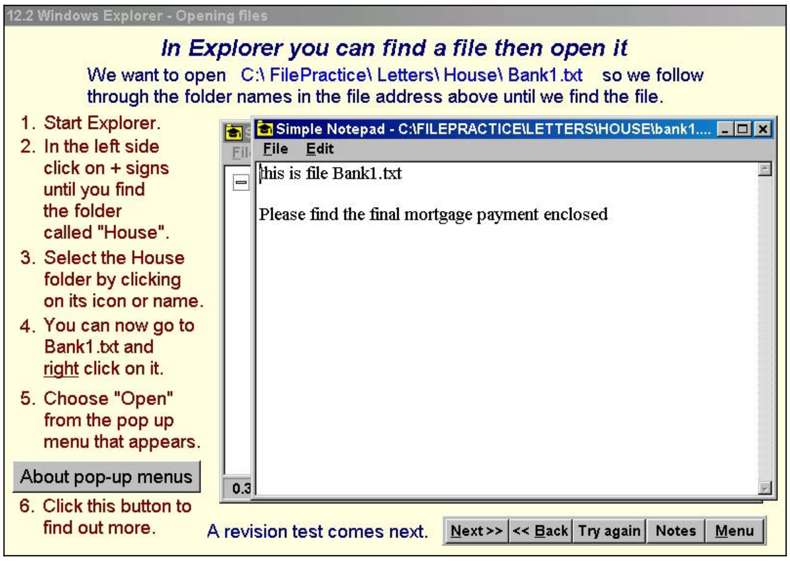

Figure 5.19. On completing step 5 the file is opened in a simplified text editor that displays the text in a large font.

Moving to the next screen in the topic sequence will automatically close the Simple Explorer and the Simple Notepad.

5.7 DISCUSSION OF FILETUTOR INTERFACE DESIGN ISSUES

5.7.1 Designing for the older user's background

Design for older people needs to be shaped by observations of their difficulties and discussion of their needs. Observation of attempts to teach older users computing skills, talking with older people during early FileTutor development and the focus group discussions accompanying this study were all important in shaping understanding of the background within which FileTutor would be used.

Fear of the unknown and fear of not succeeding or of getting lost in confusion were common themes in the focus group discussions of older users' experiences with computing. This affected behavior in many, perhaps unexpected, ways. "I was always scared of the right (mouse) button, I thought it was for something else". Self blame and apology are pervasive features of this older group's description of their experience with computers. "Things go wrong all the time, I have usually done something wrong, or there is something wrong with the program. I am never certain which. If necessary I just reboot and try again." The spirit of senior computing is one of partially overcoming odds, perpetually mixed success and failure. There is also a sense of venturing out with a few rules of thumb but no real picture of why the rules work or in what circumstances they will fail to work. The resulting pattern of activity tends to emphasize avoidance of novel or unexplored features and rebooting as a problem solving tool, rather than building effective schemas. Tutorials for older people need to counter this background. Activities should consistently provide high probabilities of success and likely areas of failure should be identified and "designed out".

In the focus groups participants reported that they were worried by the chance of doing things that might make their computer unworkable and lead to long waits for relatives who could fix the problem or difficult and potentially expensive trips to repair shops. Making mistakes is part of normal learning, hence older users need a safe learning environment clearly allowing mistakes and exploration without penalty. One implication is that older users need an easily understood "Undo" feature. In FileTutor each screen involving an exercise was provided with a standard [Try again] button. This returned the screen and the file system to the way it was before the exercise began. As part of protecting students (and tutors) from the consequences of student errors FileTutor creates its own small tree of practice folders on the hard disk and rebuilds them automatically as needed. In addition the training wheels version of Windows Explorer used in FileTutor does not let trainees work with the file system outside this practice area.

Again in terms of the context in which older users operate, attending courses for computer instruction is regarded as a desirable social event. FileTutor and WinTutor are designed so that they can be used to aid tutors teaching such courses, rather than replacing them. Morrell and Echt (1996) note that there is agreement among those who have worked on tutorials for older people learning computer skills that learning in small groups results in better learning than individual instruction. But there is also agreement that self-paced learning is desirable. There is a conflict here. In order to complete a predetermined session the tutor is often inclined to move on, even though not all members of the group have absorbed the material. Again tutors of such small groups tend to be swamped with many simultaneous demands for assistance for essentially repetitive problems as the older people involved work at different paces and differ in the number of repetitions they need in order to grasp a point. Interactive tutorials, if they are effective, mean that students can work as part of a small group but at an individual pace. The role of the tutor changes to one of facilitator and other students can also provide assistance which increases the social effect of the group. Experience during the FileTutor usability sessions was that, when dealing with topics that had been debugged by earlier usability groups, participants became nearly independent and the researcher's role as a tutor was relaxed and low key.

The focus groups all agreed that the training and support generally available to older people had significant failings. Most of the support that the participants reported came from family members but all complained that the people who helped them went too fast, were too technical and did not give the older people time to practice properly. A particular set of problems lies in the older user's need for repetition over long periods of time which places a strain on helpers. There is also the problem that even though an older person may have completed a task while the helper is present the task knowledge is subject to rapid decay unless practiced. A common report was embarrassment where older people had been shown a task and now needed to be shown again. It is worth remembering that older people observed in poor teaching situations tended to be unfailingly polite and were supportive of the tutor, incorrectly blaming themselves for the fact that they were not learning.

Discussion of older people's experiences with standard manuals and "For Dummies" type books gave a clear picture of the older people being swamped in detail. FileTutor needed to be designed so that older people could control the pace at which ideas were presented and could return to previous exercises without difficulty. Since the time required by older people to become comfortable with new learning will not necessarily fit into class timetables, FileTutor needed to be designed so that older people could use it at home for revision after attending classes. This means that the tutorial itself should be very easy to install and operate.

A striking observation from the usability groups was the amount of variation in preferred learning styles as people used FileTutor. Some people followed instructions in lock step, others skimmed ahead and then came back. Some wrote their own notes, some printed out the FileTutor notes and screens, others took no notes. Some people read explanations and instructions with great care and only proceeded with the exercise when they felt they understood what would happen, others did the exercise and then returned to the text in order to understand what they had achieved. Many people did each exercise once then clicked the "Try Again" button to repeat the exercise but some were comfortable with a single run through the exercises. Some people were almost resentful of the verbal emphasis in FileTutor, they learnt by doing. A few read the background notes in addition to the basic explanations and instructions, most people however ignored the background notes. Some saw the quizzes as valuable revision, many said they did not feel they needed them. Some participants made a lot of use of the tutor/researcher, others were almost completely independent. The time taken varied widely, both overall and within individual screens, by up to a factor of three. About the only common ground was the fact that 24 of the 25 students used FileTutor to revise what they had done once they got home. A strong factor in the success of FileTutor is that it supports such a mix of approaches.

5.7.2 Vision

Morrell and Echt (1996, 1997) suggest that clear, simple and relevant illustrations are needed to convey meaning to older people where such meaning would be difficult to convey simply with text alone. User testing supported the need for such illustrations. Attempts were made to make graphic details large and obvious, remembering that older people are poorer at visual searches involving finding a target in a complex background. However realistic application behavior was maintained. For example older users would have benefited from a more distinctive icon to indicate an open folder in the simplified Windows Explorer folder tree but this was not provided, since dependence on a cue such as a deeper yellow for open folder icons, would not have been applicable in the real Windows Explorer that learning was to be finally applied to.

Because of the large amount of information that needs to be conveyed, even in a stripped down approach to the file system, and because of the limited capacity of any one screen once a large font, short sentence format had been adopted, some FileTutor screens used text without graphics to describe what the user will see and do on the following screen. The older users found more difficulty with these screens and even though some users adopted the strategy of switching back and forth between the text and the following illustrated screen they would have preferred to have illustrations directly combined with text on the same screen. This would have speeded comprehension and reduced working memory demands. This is consistent with findings that memory for visual images declines in older people, Smith and Park (1990) and that older adults have particular difficulty comprehending information that requires linking physically distant passages of text, Rogers et al. (1999).

Note that it seems to be important that visual feedback and results of actions are given close to the site of the actions that cause the effect. The ideal is to work within the reduced width of older people's effective visual field. Early versions of the Drive letters screen shown in Figure 5.25 had a greater distance between action and effect and confused older learners but reducing this distance made the screens effective. As another counter example, creating a new folder with Windows Explorer means working with the File / New / Folder menu options at the top left of the application, followed by renaming a folder called "New Folder" in a different part of the screen. This caused noticeable hesitation for many users. Not only was the new folder often a considerable distance from the menu but the simple addition of another small line to a list of folders was not attention grabbing nor was the display of the "New folder" caption as selected text understood as an invitation to overtype. A much more effective approach is already available in Windows from the standard Save dialog box where if the user clicks the New Folder toolbar button an attention grabbing popup text entry box is displayed that clearly invites text entry, see Figure 5.21.

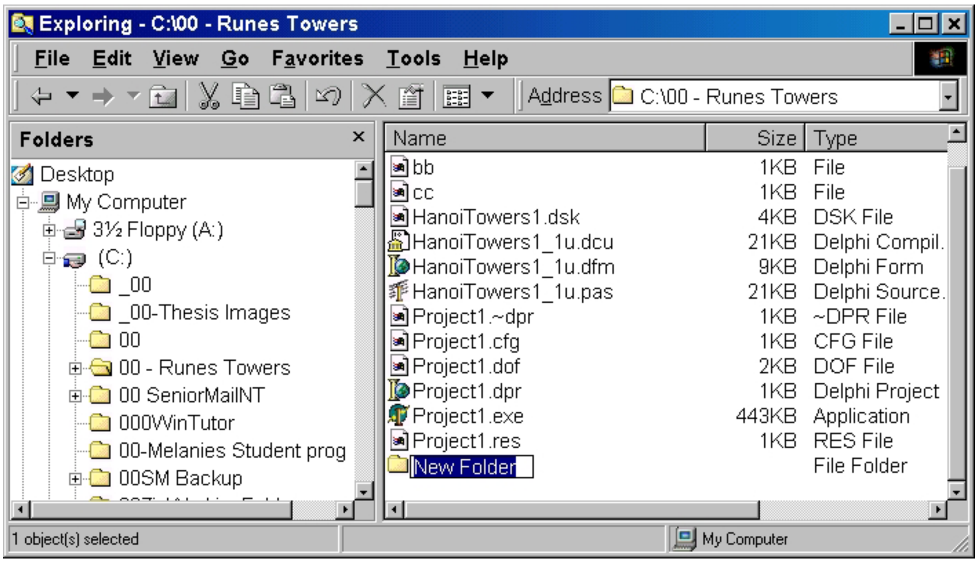

Figure 5.20. The technique for creating new folders in Windows Explorer causes problems for older users because there is too much separation between the File menu where action is initiated and the bottom of the right hand pane where the new folder is displayed for renaming.

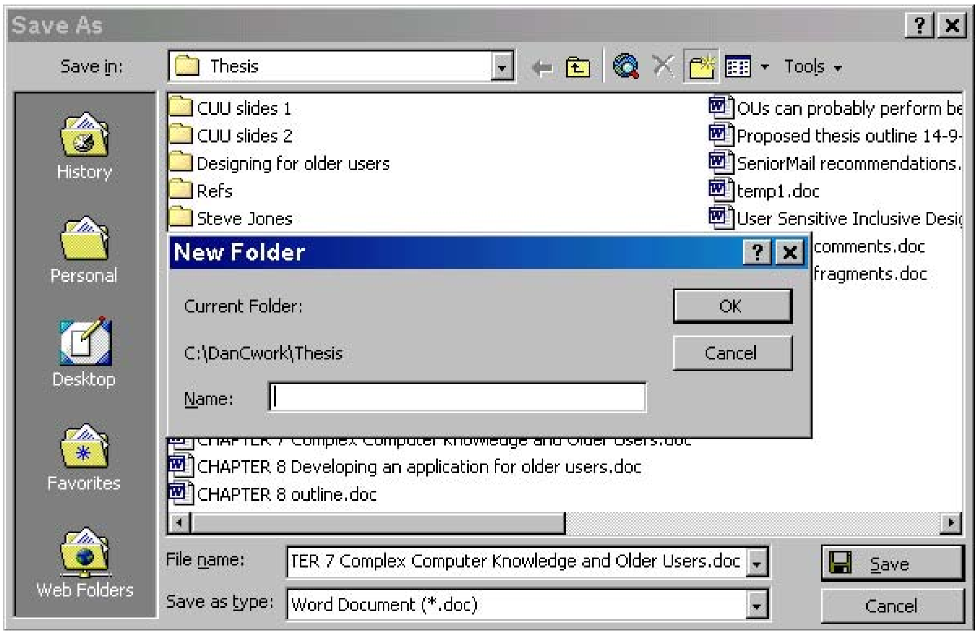

Figure 5.21. Avoiding such separation between action and result leads to a better result for older users as shown here in the Windows Save dialog approach to creating and naming a new folder.

Morrell and Echt's (1996) idea that slow-motion animation might be useful for demonstrating concepts to older students was not applied in FileTutor, partly because animation seems poorly suited to learning skills involving large numbers of small steps as in this particular group of topics and partly because Hawthorn (2000b) found that even fairly slow animation was misinterpreted by some older users. However Morrell (2001) reports that their older users did in fact understand the information conveyed by the animations they saw.

A review by Kelley and Charness (1995) found that in several studies, older people's success in learning a new application was correlated with their scores on spatial ability. This finding was repeated by Echt et al (1998). It is also known that spatial ability declines with age, especially as task complexity increases, see Craik and Salthouse (2000), Morrel et al. (2000). FileTutor made extensive use of two spatial metaphors, folder maps and folder trees. However the maps were kept simple and the same maps and folder tree were used repeatedly with the intention of building familiarity in spite of possible initial problems with spatial concepts. It was observed that, at the end of the tutorial, participants did in fact know which files were located in which folders.

5.7.3 Text format for instructing older users

The text used in FileTutor is 14 point Arial. This could be read by the participants with poor sight but was not seen as too large by the rest of the rest of the group who were able to read fonts down to 10 point Arial. Navy text was used for information, maroon text was used for instructions but instructions were also numbered so that color coding was not used alone. The choice of navy as one of the text colors goes against findings that the eye is poorer at distinguishing fine detail in blue colors. However participants stated that they found the text easy to read, probably because of the very large (sans-serif) font used. A light cream background was used to reduce glare and the navy and maroon colors gave clear contrast against this background. These colors are from the VGA color range supported by older machines. At the time that FileTutor was developed a number of older users owned older machines handed down by their children when the children upgraded. Hence the system needed to work effectively on such machines.

Reviewing previous work, Morrell and Echt (1996, 1997) and Morrow and Lierer (1999) note that older adults are more likely to have comprehension problems with complex text. They suggest that comprehension can be improved by using a standard format, keeping instructions simple, putting instructions in list form, using an active rather than passive voice and avoiding negatives. There is also a suggestion that line lengths should not exceed 65 characters. Hartley (1999) also suggests the importance of whitespace in enhancing comprehension. All these recommendations were followed in FileTutor and appeared to be useful.

During testing with early prototypes, participants worked with a mix of simple lists and numbered lists of instructions, there was a strong preference for numbered lists and these are now used throughout. It appears that numbered lists facilitate carrying out one instruction and then returning to the correct position in the list in order to read the next instruction. This may be due to reduced demand on working memory since less information needs to be held in order to reacquire one’s position in the list.

A few of the older participants had marked short term memory difficulties. Since they moved the mouse to accompany what they were reading they could be observed reading and re-reading the full set of instructions two or three times before proceeding to carry the instructions out. They could also be observed returning to an instruction in the midst of carrying it out. They proved to be vulnerable to multi-part instructions, often the second or third part would be missed out in an instruction of the form "5. Do A then B and follow this with C". When such an instruction was split into separate instructions on separate lines, "5. Do A", "6. Do B", "7. Do C", the problem vanished.

The use of detailed step by step instructions means that in a few places a large number of simple steps are needed. Faced with a body of text that required scrolling older people often forgot to scroll or they found scrolling awkward, involving overshooting and corrections that in themselves placed a load on working memory. Therefore the decision was made to put long sets of instructions on tabbed pages. These pages were placed at the left of the screen in the standard position for FileTutor instructions. Apart from the tabs the instructions followed normal FileTutor conventions. The tabs were at the bottom and as people reached the bottom instruction on the first page they met a note in brackets that said - Click “More” - where "More" was the caption of the next tab. If a third tab was needed it was captioned "Last" and dealt with in a similar way. The first tab was captioned "Begin", see Figures 5.22 and 5.23. This approach succeeded, all participants used these tabs without needing any instruction from the tutor.

Instructions that asked users to type specified file and folder names used dual font labels that put the text to be typed in bold bright blue which contrasted with the maroon of the rest of the instruction. SeniorNet tutors had warned that beginners asked to type "Joe" would often include the double quotes in what they typed. The dual font approach worked well. Double quotes were used to identify names found on features the users needed to interact with, as in: -Click the "Back" button.

Older people have been reported as being more disrupted by mistakes and problems than younger groups, Vercruyssen (1996). It became evident that the older users in the usability tests had a low tolerance for ambiguity. Where participants did not know what to do or where what they did led to something unexpected they tended to stop. There was less exploration of alternatives in order to resolve ambiguity or get around a problem than would have been expected in a young group using such a tutorial, particularly among the "more average" group. One of the key benefits from the usability testing was to ensure clear unambiguous instructions combined with exercises that clearly illustrated the point and worked as the older users expected.

Some of the "more average" users said that at times, with long sequences of instructions, they could carry out the instructions but ended up not understanding what it was that they had done. However they also reported increased understanding on going back over earlier exercises. In response to this, in some places where there were long sets of instructions, explanatory sentences were put into the instruction sequence explaining what had been achieved by the actions so far or what was to come. See Figures 5.22 and 5.23 for examples.

Over half of the older users in this sample reported difficulty in combining reading from printed text with using the screen. To do so they had to change glasses or deal with fuzzy text. Computer screens are typically placed at a distance from users' eyes that is not well served by typical bi-focals, screens sit in the fuzzy gap between reading distances and long sight. Alternately spectacles that make the screen clear are unsuited for reading with. Only two people in the sample could afford (and adapt to) graduated lenses. The interruptions due to the need to change spectacles or to struggle with out of focus text are another source of working memory difficulties for older people. This provides one more reason for using on-screen tutorials rather than printed manuals for older learners. However older people are no keener than the rest of us when it comes to reading vast amounts of text on screen so on-screen tutorials need to keep their text as lean as possible.

In spite of the difficulty of combining text and on-screen work, a couple of participants wanted at least a written tip sheet that would come with FileTutor or be printed from it, so that they could get quick information about files and folders when using other programs. In the focus groups people described their home computing environment as depending on lots of (scattered) bits of paper with notes about how to do things. For older users, the ability to print out summaries of procedural steps may be a useful feature of a tutorial or application. However some of the older users made the point that it was important for them to write down notes in their own words if they were to be able to understand them.

5.7.4 Manipulation

The target audience for FileTutor is expected to have basic mouse skills. However older people are less accurate in controlling mouse movements and so manipulation was kept to pointing, clicking, scrolling and some drag and drop actions all involving fairly large targets. The training wheels version of Windows Explorer was constructed to show larger fonts and to provide significantly larger menus, pop-up menus, file icons and plus and minus symbols for tree manipulation. This meant that the older users did not have to struggle to read file-names or to acquire minute targets with the mouse.

The decision was made to tell users to carry out all tasks on the training wheels version of Explorer with the pop-up menus obtained by right clicking file and folder icons. The drawback is that there is no visible indication that such an affordance exists, the two advantages are that 1.) a wide selection of useful functions are made available at the site of the intended action and 2.) the user does not need to double click which some older people find difficult or impossible, see Smith et al. (1999). Most of the older users in the study could double click but some were unable to do so reliably. It was of interest to see how well older users would adapt to using an invisible affordance. In fact all participants used right clicks without prompting by the tutor after the first couple of screens in which the topic was introduced. Successful use of right clicks continued into the practical evaluation in the third session (done outside the FileTutor environment).

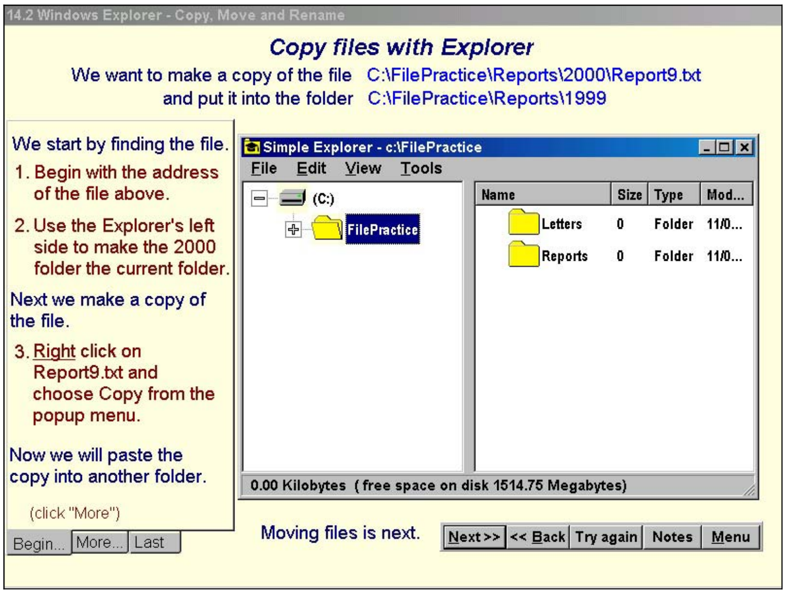

Figure 5.22. The training wheels version of Explorer.

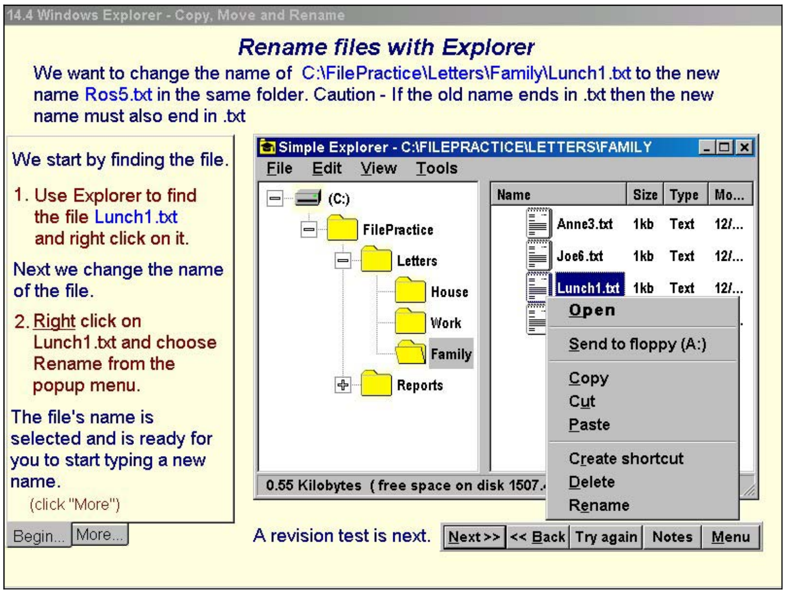

Figure 5.23. The training wheels version of Explorer. showing the simplified pop up menu resulting from right clicking.

In keeping with the training wheels approach the initial pop-up menus were kept to four options (Open, Copy, Cut and Paste) and the extended set of options shown in Figure 5.23 was only available in the later exercises. This set of options is still considerably simpler than the pop-up menu used in the real life Windows Explorer.

5.7.5 Interactive graphics

What are termed interactive graphics are a key feature of FileTutor. The graphics shown in Figures 2 to 4 are all intended for the user to interact with step by step as they work through the instructions. The user clicks and drags objects, enters text and uses menus in the graphics and the graphics alter in response to what the user has done. In addition the approach to interactive graphics used here involves embedding a simplified but working version of the application being learnt into the tutorial.

- We want trainees to learn by doing and to be motivated and engaged while they do so. This means easily achievable success and an element of entertainment in carrying out the exercises.
- We want to provide visual feedback as a guide to the users' progress through the steps of the task.
- We want close (single screen) integration between instructions and the examples and application being learnt and manipulated.

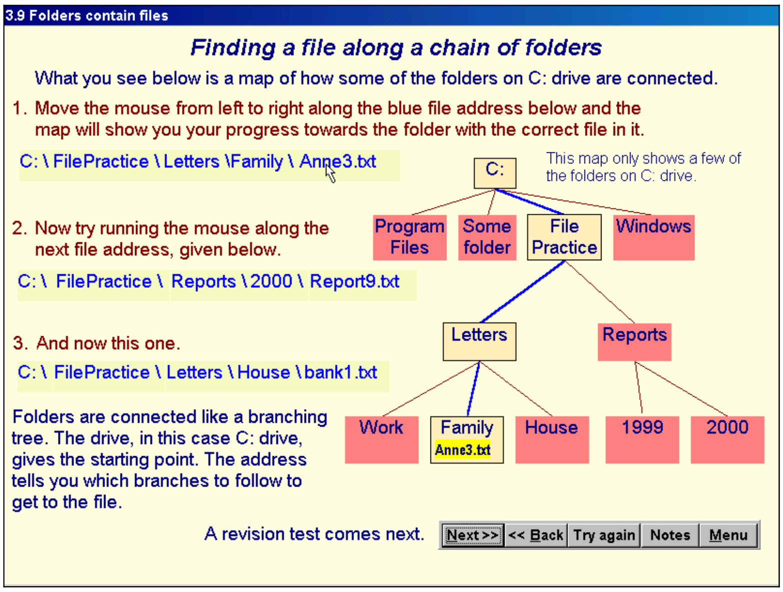

Figure 5.24. An example of interactive graphics.

We want to keep the essential new conceptual material as simple as possible. Here the evolving visual images reinforce and illustrate the concepts being learnt while reducing the reliance on text.

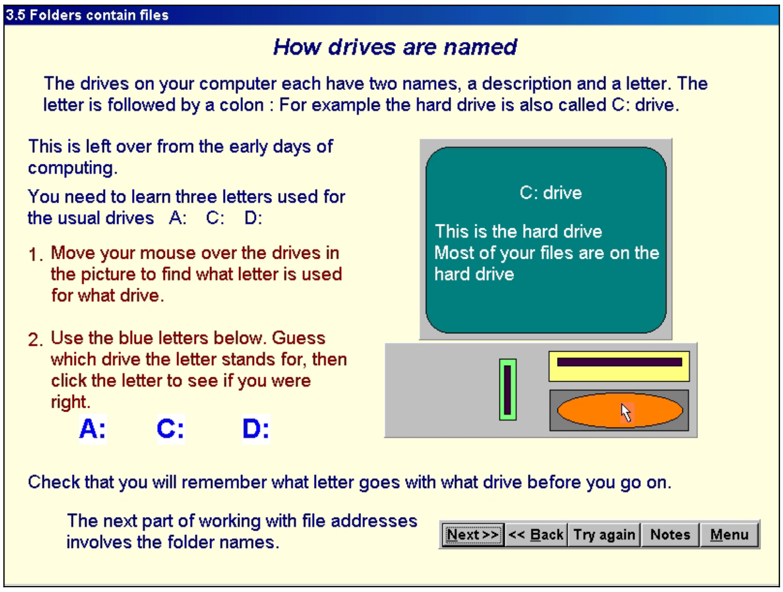

Figure 5.25. A further example of interactive graphics.

Examples of such interactive graphics can be seen in Figures 5.24 and 5.25.

Figure 5.24 is part of a series of screens teaching users how to interpret Windows file paths and relate them to navigation through a folder tree. A map of the standard set of practice folders that FileTutor works with is shown together with three typical file paths. As the trainee moves the mouse along the text in the file paths the corresponding folders light up in the folder map.

Figure 5.25 shows the second of two screens aimed at getting trainees to remember the identifying letters for drives. The "computer screen" displays drive information as the mouse moves over the "drives". Clicking on the large capital letters shows a pointing hand symbol beside the relevant drive and displays the drive description on the "screen".

FileTutor uses interactive graphics to support Carroll's (1990) ideas of the active learner, the minimal manual and the training wheels approach. FileTutor depends heavily on a "training wheels" version of Windows Explorer that is a key element in over half of the interactive examples. This can be seen in Figures 5.22 and 5.23. This version of Windows Explorer is functional but has fewer options, uses an increased font size and the + and - icons for expanding and contracting the folder tree have been made larger for easier manipulation. Further aspects of this "training wheels" version of Windows Explorer are described in later sections. Where FileTutor deals with embedded versions of file management tools there are two aims.

- To reduce the available options and simplify the perceptual demands and the manipulative requirements of the tool while still preserving realism.
- To guide the trainee through real-life tasks that are relatively complex and where the user is working with a multi-purpose tool in which it is relatively easy to become lost.

It is argued that manuals or interactive CDs are less suited to older users in part because of the need to remember instructions as the user swaps between the page or screen containing the tutorial and the application being learnt. In the interactive graphics used in FileTutor, working memory load is reduced by integrating instruction and the example or application being interacted with into a single screen. Another contribution to successful learning is the active role of the learner. In some interactive CDs the student is essentially a passenger on an animated tour with pauses to carry out activities in between animations. In FileTutor there is no animation, each and every change to the graphics occurs as step by step feedback to actions of the student. This seems to place the student far more in control of their learning and to make the student more responsible for and more engaged with, what occurs.

A final point is that the exercises done in the interactive graphics should be as quick and easy to perform as possible. While there are obvious limits to how simple you can make interacting with an existing application such as Windows Explorer there are other areas in which you can assist older learners. For example older users include some people who struggle to type and so the exercises in FileTutor avoid requesting any lengthy typed input.

5.7.6 Menus and Sub-menus

To keep within Carroll's training wheels and minimal manual philosophy the number of menu options available in both the main menu of Simple Explorer and the pop-up menus available from a right click had considerably fewer options than their equivalent in Windows Explorer.

5.7.7 Typing

Typing was kept to a minimum and text entry was done within text boxes that used a large clear font.

5.7.8 Scrollbars

Scrolling was kept to a minimum and where possible the exercises using Simple Explorer used choices of files and folders that could be found without scrolling. As described above tabbed pages were used to avoid the need to scroll long sets of instructions.

5.7.9 Navigation

A variation of the linear navigation format used in WinTutor was repeated in FileTutor. As before the use of standard [Next] and [back] buttons was readily managed by the older users. One change involved dropping the [Summary] button option since topics were kept shorter and were not as sub-dividable as those in WinTutor. Other changes were to place the [Try Again] button on the navigation bar and to add a [Notes] button that gave access to background information if required by the user.

5.7.10 Comprehension , Memory and learning

The approach was taken in FileTutor was based on the "training wheels / minimal manual / active learner" approach described in Carroll (1990). The tutorial and exercises only gave access to essential features and avoided alternative approaches and advanced features. To cater for the few older learners who demanded more detail, extra information was provided as an optional extra through the "Notes" button, however most participants ignored this. Making the extra background information optional allows flexibility while still giving most of the older learners an environment that conforms with Morrel's (2000) finding that that insisting on extra prior conceptual material disadvantages older learners.

Only a subset of file management topics was covered and the examples that participants worked through tended to reuse and reinforce recently acquired skills. At the same time the topics were developed with a view to helping participants develop a workable schema for understanding files and folders, not just a grab-bag of actions for doing file tasks. Feedback from participants who had some prior knowledge went along the lines of, "I have been told about files and folders before but I never had it explained in a way that let me fit it all together like this."

However acquiring the overall picture took time and the initial work was done with the feeling that things only partly made sense. The initial exposure to FileTutor was confusing for some of the less articulate participants. "When I was reading the first screens it was all too wordy, I couldn't see what you were getting at, but afterwards when I had done other topics I came back and it was all much easier". Reasonably clear explanations are not enough to carry all older users through an introduction to a novel environment. There is also the question of whether there is a common vocabulary at the beginning. Older novices cannot be assumed to share the instructor's definitions of terms. What is a topic, wasn't the whole topic about files? What is a screen? If the user thinks of the screen as the physical object they look at, the idea of a number of screens per topic is nonsensical. At the same time providing endless definitions will simply bog the beginner down. We are asking our older beginners to take on faith that things will make more sense over time. A problem with this is that many of them have experienced computer systems and explanations that, for them, have not made more sense over time. One person came armed with this comfort from her friend who had done an earlier set of FileTutor sessions, "Don't worry, it's much easier on the second day". Both in terms of avoiding endless elaboration of instructions to cope with possible misconceptions and in terms of providing initial encouragement, having a person facilitating the first exposure of older people to an interactive tutorial helps considerably.

Botwinick and Storandt (1974) point out that older adults are less able to make use of recently presented material. Morrell et al. (2000) found that providing additional conceptual material reduced performance. These findings present a difficulty in providing training about file management skills since the possession of some conceptual understanding is essential for the learnt actions to be meaningful. The approach taken in FileTutor was to provide extensive training in concepts such as the use of a tree of folders in the early parts of the tutorial. Instead of simply being told about the concept the trainees did several interactive exercises related to such things as using a folder tree before doing later exercises that required this knowledge.

An assumption made in designing FileTutor was that part of an individual's schema for handling file management tasks is a mental map of their own folders and files (a folder tree). Possession of such a map is assumed to significantly help a user in carrying out file management tasks. The participants were generally new to file management and had not worked with folder trees. Folder trees were introduced early in FileTutor but the same set of folders was used throughout so that by the time participants began later exercises with folders in a simplified version of Windows Explorer they were becoming familiar with the layout of "their" set of folders and this familiarity was reinforced throughout the tutorial. Participants then worked competently with a different folder tree in the practical evaluation exercise following the usability sessions.

The first half of FileTutor deals with basic ideas about files, programs, folders and drives. The second half consists of learning to use a simplified version of Windows Explorer for file management tasks. It was found that the older users were happy to go over material they already knew something about. This is in contrast with younger users who become impatient in similar circumstances. Beginning at a very basic level for all users dealt with surprising gaps in older people's computing knowledge that would otherwise have disrupted progress. For example the term "select" was often unknown. At least half did not know about dragging or resizing windows.

Since the aim of a system for older users is to support as many older people as possible the system should aim for fairly low levels of initial ability, a lowest common denominator approach. In an early version of FileTutor the level of detail in the instructions on how to find a file was progressively reduced on the assumption, that, after repeated exercises that involved finding files in the same small set of folders, people would have internalized the steps needed. After testing this was revised and step by step instructions are provided almost throughout FileTutor. Some older users simply do not internalize instructions in anything like the time frame younger designers would expect. Several of the participants displayed examples of fragile knowledge where knowledge gained from FileTutor was present but could not be accessed. For example, people got stuck trying to start Windows Explorer, but if prompted "If you hold down the Windows key what then?" they respond "Oh I press the E key". In addition the ability to use components of a schema does not necessarily correspond to the user's ability to put rules for such use into words. One user was observed attempting to deal with a question in the quiz for the introductory topic on how to use FileTutor itself. She was trying to answer a question asking "In FileTutor how do you move from one screen to another in a topic?" While attempting to find an answer she was in fact busily moving from screen to screen in the first topic using the "Next" and "Back" buttons. Another recurring response to the quizzes was, “I know how to do it but it's hard to put into words.” Older users do consolidate their knowledge over time but with complex subjects such as file management we may be talking weeks rather than eight or nine repetitions. Craik and Salthouse (2000) note that we should not assume that investigation of real-life learning in older people will fit conveniently into the timescale of typical experimental sessions.

5.8 DISCUSSION

What has been achieved in this study? The study confirms that with well designed learning support some older users can be trained to use relatively complex software and computing concepts, including older users who have previously failed in attempts to learn this material. If we return to the aims of the study set out in the introduction we can see that they have largely been achieved

It was hoped that the study would provide further experience with the emerging approach *for working with older participants during design.*

Making appropriate design decisions was markedly assisted by the focus group discussions where the older participants reflected on their work with the tutorial and related it to their previous computing experience. Again the utility of involving older in-house participants in the day to day development of the design was amply verified. Interface design for any group should involve considerable understanding of, and interaction with the users. However it is argued that, because of the degree of difference between older users and the average designer, it is of particular importance to involve older users right from the start of a design. User testing with older people was found to be highly informative, and enjoyable. Note that user testing is regarded as necessary in addition to a theoretical knowledge of the design implications of the various aspects of aging. Charness et al. (1996), and Hawthorn (2000b) both found that putting theoretical interface design recommendations into practice did not always lead to the results that theory would predict. A point made by this study is the value of undertaking usability studies designed in a way so as to increase the amount of background information that is provided by the older participants.

It was hoped that the study would provide further experience with application design for older users as the interactive tutorial itself was designed.

The study provided a further test for the application design principles that had been developed by considering the implications of the general literature on aging, the experience with developing WinTutor and the existing literature on such things as text design for older readers. The study demonstrates the value of using the general literature on aging for implications for interface design. The initial WinTutor design started with observations of older peoples' difficulties in learning basic computer skills. These observations were combined with ideas of the likely design implications of aging from recommendations made in Morrell and Echt (1996, 1997), Morrow and Leirer (1999), Morrell et al (2001) and Hawthorn (1998a, 1998b, 2000a). As the design of FileTutor progressed the dominant influence was extensive informal observation of, and interaction with, older users. The design that emerged and the responses met during usability testing largely reinforce the earlier recommendations on design for older users. In some cases this study specifically extends these recommendations, for example the virtues of numbering procedural lists and avoiding multiple steps within a list item. In other cases this study suggests ways of implementing the more general ideas these authors support, for example the use of tabbed pages as a way of avoiding scrolling while reading long sets of instructions. This is the first time of which I am aware that these recommendations have been combined and evaluated in an actual product intended for use outside an experimental setting.

It was hoped that the study would provide confirmation that interactive tutorials were a useful way of helping older people learn computer skills and extend this finding to cover the case of more demanding computer skills.

Again this study lends weight to those authors who argue that interactive tutorials are suited to older learners rather than those like Gist et al (1988) whose findings were against the use of interactive tutorials for older learners.

It was hoped that the study would allow for examination of the use of Carroll's "training wheels" and "minimal manual" approaches to older learners.

Authors such as Morrell et al. (2000) and Rogers, et al. (1996) have pointed to the need for simplifying the material presented to older learners and for involving older users in active learning. What is new in this study is the explicit demonstration that the approaches to computer training suggested by Carroll for younger learners are suited to older learners. This includes the use of modified "training wheels" versions of the software being learnt and the demonstration that older people learning on such training wheels versions can successfully transfer their skills to the real life version.

Fisk et al. (2004) argue that understanding how older people learn is a crucial aspect of designing for older users. It is easy to argue that Windows Explorer in its various guises suffers from numerous design flaws, see Interface Hall of Shame (1999). We have the apparently ironic situation that a project investigating rules of good design for older users should aim at teaching those older users to cope with a poor design. In fact interacting with poor designs will always be part of people's computing experience and acquiring the ability to do this is a highly relevant skill for older people. It has been shown that it is possible for some older users to cope with a flawed design but the cost is considerable time spent on learning an application that younger users learn to make adequate use of relatively quickly.

Also note that while the older people who took part in the usability tests generally did well, acquired file management concepts and skills and were highly enthusiastic about the tutorial as a learning experience, outside the study environment within SeniorNet organizations FileTutor does not sell as many copies as WinTutor. This may reflect the point that fewer older users are interested in putting in the extra time that they need to devote if they are to gain the use of more complex computer skills. The fact that, given sufficient support and well designed training materials, older people can improve the level at which they work with moderately complex applications, does not mean that moderately complex applications such as Windows Explorer suit older users. The more likely reality is that many older users will avoid applications that demand extensive training and hence these older people will limit their ability to cope in a computing environment.

5.9 RESEARCH DIRECTIONS FROM THE FILETUTOR STUDY

There are some issues that are not resolved, for example the FileTutor design made the assumption that animation would be unsuitable for older learners while Morrell and Echt (1997) recommended slowed animation. Finding more about the conditions under which older people benefit from information contained in animation is one of many fertile areas for future research. The recommendations in the discussion section could be refined and given greater support by more experimental research but this is an area where there is a need for an immediate practical solution for use while research proceeds. The FileTutor study straddles the areas of tutorial design and application design. Future research could usefully look more closely at application design for older users, It was apparent when observing the older participants in the usability study that individuals had developed an number of personal adaptations to support their needs as older people. More deliberate study of such adaptations could be a way of both gaining further insight into the sort of support appropriate to older users and a start on building such support into applications.

The issue was raised of using “intelligent” tutorials that adapt to a user’s level of knowledge as a basis for tutorials for older people. I suspect that the underlying model of reliable learning, where if a student shows correct answers on the start of a topic they can advance more rapidly, will be problematic for older people. Older people’s generally more fragile and concrete learning does not fit this model. From the relatively small group of older people involved in the FileTutor study, repeating already covered material was generally seen as useful and desirable. I would also expect difficulties with older people complaining about perceived inconsistency where “intelligent” tutorials alter the topics presented on the basis of past successes, “Last time it showed me about scrollbars and this time it doesn’t”.

It is worth asking how specific the recommendations are to older people. From the focus group discussions these older people identified themselves as a distinctive group that needed training materials specifically aimed at their needs and for whom most available training was unsuitable. On the other hand the recommendations of this study aim at producing an interface that is easy to use by reducing cognitive and manipulative effort. This has been a standard goal of interface design for many years. What appears to be the case is that older people are more sensitive to departures from the ideal than younger people because of older people's limits in perception, manipulative skill and cognitive ability. It has been suggested that because of this older people are desirable subjects for user testing. This may well be the case for some aspects of any interface design but the reality is that some specialized applications will need to be designed to support highly able people in their prime who are working to the maximum of their physical and cognitive capabilities, we should not hobble such designs to cater for older people. (Though possibly such applications may acquire modes that reduce their power, so as to adapt to older users.) At the same time there are an enormous number of general applications where catering to the needs of the older population should both provide a realistic adjustment to the changing population profile and provide an improvement in usability for all users. Taking interface design for older users beyond the research setting has the potential to provide widespread benefits that are urgently needed in a world of an expanding older population faced with increasing needs for computer involvement.

There is a further possibility that emerges from the work done in the FileTutor project. The aim of the overall research is to extend the range of older people who can make use of computer software. If there are older people who cannot make use of full versions of applications and either do not benefit from training or are unwilling to undertake extensive training, the way in which FileTutor has encapsulated Windows Explorer deserves consideration as a way of making simplified forms of software available to older users. If for example one wanted a file management tool for older users, the interface could be such that the older person started by choosing a file management task from a main menu and then is taken to a screen where a simplified and elder friendly version of a file management tool is embedded within a set of procedural instructions for carrying out the task. This is in effect what FileTutor already does as a teaching approach but there is the possibility of making this approach the normal way that some older people carry out software tasks, where the software is embedded in the sort of lists of instructions to themselves that older people have been found to rely on. If some older people are not able to progress to unaided use of stand alone software, this embedding of software within task specific instructions, that are framed to suit older users, could be a useful way of extending the range of older people who can accomplish software tasks.

Chapter 6 DEVELOPING AN APPLICATION FOR OLDER USERS

6.1 INTRODUCTION

Chapter 4 (the WinTutor study) had focused on the problems that are met by older beginners in first learning to use computers. Chapter 5 (the FileTutor study) had looked at the way in which older users can be introduced to complex applications (Windows explorer) and complex concepts, (the Windows file system). Both studies provided insights into what older users need if an application's user interface is to suit them (as well as providing insight into older users' learning and computer use). The next stage was to focus specifically on application design for older users and see if the emerging principles for interface design for older users would allow the design of an application that allowed older users to achieve more than they were able to achieve on the mainstream equivalent.

In describing the development and testing of an email application for older users this chapter will address a number of issues. First, it tests the argument that the design principles developed in the previous studies form a successful basis for producing an application that older users find useful. Second, the chapter shows and examines an example of successful application design for older users. Then the chapter looks in detail at how various design needs of older users were met in this design. Finally the chapter looks at the consequences of the design approaches used in determining the suitability of such designs for more general users.

What was found in the SeniorMail study was that the design approach and principles of the earlier studies did provide a basis for application development for older users. Extensions to the principles also emerged as the focus became more specifically on application design.

In reporting on the contribution of older participants to the design the chapter considers the limitations of a manageable group of older development participants in representing the variety of older users. There was a definite role for knowledge of the effects of aging in order for the designer to amplify the understanding gained from working with older users. The chapter will examine the way in which designing simultaneously for numbers of specific aspects of aging leads to design decisions that interweave a variety of concerns about older users and make tradeoffs between different aspects of aging. Hence one concern in working with the older users who participated in the development was that adjustments made for a particular aspect of disability would not negatively affect those in the group who did not have a marked degree of this particular result of aging. What emerges again is that, while the design principles for older users are a useful sensitizing perspective for designers, working with older users is also required to assist the translation of awareness of older people's needs into useful design features.

The organization of the chapter is as follows: The chapter will first describe the format that was used to create a case study that would allow examination of applying the design principles to the development of an application for older users. Then the chapter moves to describing the design aims of the email system. These design aims were developed in response to understanding of older users' needs gained from the earlier studies and in the focus groups that began this email study. After this the results of testing older people's performance on the system will be presented. This section will examine the extent to which this system allowed older users to achieve more than they had achieved on mainstream email systems. The resulting email system, nicknamed SeniorMail, will be described. Then the way in which the design aims were met by this system will be discussed in more detail. The chapter concludes by discussing the way in which the design approach developed for older users restricts the universality of the resulting application. The techniques used to realize a design that suits older users, lead to a design that limits the number of features that can be incorporated into the design and hence limits the suitability of the resulting application for younger users who have a higher level of demand for features.

6.2 STUDY DESIGN

In this section the design of the SeniorMail case study will be described.

6.2.1 Application area

The first issue was to choose a suitable application area for studying the development of an application design for older users. The main aim in choosing an application area was to get realistic performance from older participants as they tried to use the emerging design during its development. As seen in the Dual Task pilot study (Chapter 4), this would require an application area that older people saw as relevant to their needs. A second aim was an application area that represented a non-trivial problem for older users. In order to test whether the design principles led to improved performance this should also be an area in which it was possible to recruit numbers of older people who struggled with mainstream applications in this area. After discussion with SeniorNet tutors it was determined that email represented an area in which older users were motivated and in which it would be relatively easy to find a sufficient number of older users who struggled with existing email applications. This turned out to be the case.

6.2.2 Initial scoping

The experience from the earlier studies suggested that the requirements should be specified in response to needs expressed by both older users and the people who were supporting them. To this end three focus groups were held with supporters of older emailers, typically younger family members. Another set of focus groups were held with older people who regarded email as difficult. These included two groups of older computer users living in a residential facility and a variety of community dwelling older people. The focus groups discussed what older users wanted from email and what they found difficult. The focus groups were semi structured with an agenda of discussion items that was used by the researcher to guide discussion and was given to the attendees at the start of the session. Topics covered included level of use, types of interface difficulty that occurred with standard email systems, the nature of support required, typical correspondents, levels of understanding of the email model and responses to examples of early prototypes of the email system.

Because of the exploratory nature of the investigation at this stage attendees were encouraged to bring up any other issues or concerns they had relating to email. The agenda served as a way of maintaining an overall plan within this freedom. The focus groups were tape recorded and the tapes were then analyzed. The picture that emerged was one of very limited email use, rigid learning of a few rules to allow minimal performance within Microsoft Outlook Express (MSOE), uncertainty and forgetting within that limited performance and, although there were relatively few needs, most of these needs were beyond what the older users could achieve. The older users in the focus groups, when trying to act independently, had difficulty at the level of replying to emails, saving emails, saving addresses and finding old emails. The supporters of the older users confirmed this picture and suggested that email tasks at the level of adding or opening attachments were often too difficult to be even attempted by their older relations. One theme that emerged was the considerable effort needed by the younger relatives to support older email users. Repeatedly the supporters described encouraging older relatives to take up email as a way of keeping in touch and then finding that the older users had a painful struggle with email, did not learn enough to be capable and needed a level of support that was beyond what the younger relative had anticipated or could conveniently provide.

As part of giving the focus groups a practical focus a variety of mockups of possible email designs for older users were presented for comment. It was apparent that the older users struggled to make sense of the mockups and struggled to envisage how they would be used. They markedly drew back from versions that suggested any level of complexity. On the other hand the supporters tended to reject versions that did not provide features that they saw as useful in their own email use. There was little tendency for the supporters to take a perspective on what made a suitable email design that really included the older person's reduced needs and reduced abilities.

6.2.3 Prototyping and participatory development

After this scoping stage the study moved to the development of a prototype email system. One of the lessons learnt in the earlier studies was the advantage of having older people participate in the day to day development of designs. To include this sort of involvement by older people in the development of the email system nine older people who found email difficult, or who had decided that they could not use Microsoft Outlook as it was too complex, were recruited to act as partners in the prototype development. This group will be referred to as "the development group". Six of the group were in their late seventies, one was in their early sixties and two were in their mid 50s. The development group provided a reasonably severe challenge to the interface design. They included a person who after a year of using Microsoft Outlook Express (MSOE) did not use the Reply or Forward features - this person sent all emails from their address book. Another two people had left all emailing to their spouses because MSOE was "too complex". Three of the group had only a few hours of computer use. Two had poor vision including one person with the start of macular degeneration and the person with the longest computer experience was one who had been observed to be very slow in acquiring competence with new applications. None of the group had successfully worked with email attachments. Since overall numbers were small, only a few of these people showed any particular disability such as reduced eyesight or failing memory. Discussions were held with these people to determine if their wants matched those of the older people in the focus groups, (they did).

It was clear from the responses of the older people in the focus groups that traditional prototyping beginning with low fidelity designs was not a suitable approach. The response of the older focus group members to low fidelity prototypes had been stressed incomprehension of the partial designs rather than useful insight into possibilities for the final product. Hence based on the focus group discussions and on the design principles developed in the previous studies, a initial credible working prototype was developed. Parts of this prototype were trialed with two of the younger people in the development group as they were developed. Once the credible working prototype had been developed, the other older people in the development group, given an environment that fostered free discussion, were happy to make suggestions for changes that could adapt the prototype to what they wanted.

The credibility of the initial working prototype was established by asking the members of the development group to carry out the tasks set out in a set of scenarios that had the users carry out a wide range of email tasks. In summary a user had to see if there was any new mail, open the 3 new dummy messages provided by the system, go back to one of these messages and save the address of the sender, send a new message to a person in their address book and then go back to one of the initial messages and reply to it. The next task was to add an email address to the address book. This was followed by deleting one of the initial emails and seeing if there were any further new emails. The new dummy email provided at this stage came with an attachment and the user needed to view the attachment as well as replying to the new email. The user was then asked to check the contents of an email they had sent, followed by forwarding an email, finding an email containing a key word and finally sending an email with a specified attachment. For a complete description of these tasks see Appendix C.

The older people were asked to try out the initial version of the working prototype using the scenarios described above. Typically this was done with the older people working in groups of two and discussing what they did and did not understand with each other and with the researcher. These discussions were tape recorded. As well as trying the prototype these older participants were asked to try a number of variations on the basic design that illustrated points where I as designer was uncertain of the best way to proceed. These variations were presented as high-fidelity, computer based, screen designs with working components. After trying the prototype the participants took part in debriefing discussions that covered the versions that they had just used. Again these discussions were tape recorded. The observations and discussions took place in the homes of the older people involved. This also provided the opportunity to observe how those older users who already made some use of email, functioned when using MSOE on their own computers.

The working prototype was modified and the changes checked with the members of the development group. This phase of the study occurred over 12 months. During this time five of the older development partners became long term users of SeniorMail adopting it as their only email system. This allowed the study to explore whether the design met the needs that emerged as experience and long term use occurred.

An aspect of the development approach lay in design for diversity. It was not expected that the older people involved in development would all benefit from all aspects of the design. The approach was to design for many age related disabilities at once. This was followed by checking that the few people who presented any particular disability did in fact benefit as planned from the features that addressed their disability. However another important aspect was checking that the older people in the development group who did not have particular disabilities were not disadvantaged by the changes made to accommodate other people's problems.

6.2.4 Usability study

After the prototype satisfied the development group a usability study was conducted with a relatively large group of older people who found email difficult and had not previously been exposed to SeniorMail. Staff at an Auckland Citizen's Advice Bureau (CAB) were asked to take part in evaluating the current version of SeniorMail. These 22 volunteers ranged from 60 to 82 (average age 72) and were selected on the basis that although answering email enquires was officially part of their duties they were unable to satisfactorily deal with the MSOE email system used by the advice bureau. A set of scenarios dealing with basic email tasks and a follow-up questionnaire had been constructed for use by the development group. This material was reused with the CAB group. The scenarios are outlined in the section on prototype development above. See Appendix C for the full text of the scenarios provided to the test participants and the follow-up questionnaire. The tasks in these scenarios were well beyond the scope of anything the CAB users had previously attempted. The volunteers were given a five minute introduction to SeniorMail consisting of a tour going from the menu where the [Check for new mail] button was emphasized, to the in-box where the use of the toolbar was demonstrated for opening an email. This was followed by a look at the viewer and the editor as the tour continued with the steps of reading the email and replying to it. The volunteer could then ask questions about the use of the system. After this the users were then asked to carry out the tasks from the scenarios while the researcher observed, took notes of each problem encountered and where necessary offered prompting to help the volunteer continue. The time taken and the level of prompting required were recorded. After each day of testing any significant problems were identified and the system was altered accordingly.

This system was also tested with a group of 15 computer literate staff members from the local polytechnic some of whom taught office computing skills and some of whom taught business computing. The average age of this group was 45 and the aim was to see whether a system that had been developed for, and in conjunction with, older people would be suitable for younger more competent users. This group was given the same introduction and the same set of tasks as the (older) CAB group.

The next section will describe the design aims that emerged from the previous studies and from the scooping and the refinement of this scooping during development of the SeniorMail application. The results of various forms of testing of the resulting SeniorMail system will then be described in the succeeding section (Section 6.4).

6.3 DESIGN AIMS IN A SYSTEM FOR OLDER EMAILERS

In general the problems with vision, manipulation and comprehension that had been observed in the previous studies were again seen in the focus group descriptions of older people's problems with email and as the older development partners worked with the prototypes. The design of SeniorMail was planned with a view to minimizing these difficulties. This section will very briefly set out the design aims that were chosen in response to these issues.

Accommodating a range of older users

The system was intended to satisfy the needs of a wide range of older users and so the design proceeded in terms of the issues of aging described from the literature survey, not just from the issues that were apparent in the group of older users who took part in development and usability testing.

Vision

The aim was to provide easily readable fonts for all text. This would involve font style, size, color and background. A further aim was to provide a visual environment in which locating features would be simple for older users, the emphasis here was on simplifying search spaces and reducing distractors.

Manipulation

The aim was to avoid forms of manipulation that had been found to be difficult for some older users. This meant making targets reasonably large, avoiding drag and drop operations, avoiding the resizing and other manipulation of windows and producing designs that did not require double clicking.

Menus and Sub-menus

As some older users had been observed to have difficulties working with menus the aim was to provide an application that did not depend on the ability to work with menus.

Typing

Typing remains a severe problem for a number of older users. This issue has not been addressed in SeniorMail.

Scrollbars

A number of older users were observed to scroll inefficiently. A design aim was to reduce the need for scrolling.

Comprehension

Some older people have difficulty in dealing with complexity, especially if they are in novel situations. It was also observed that the focus groups indicated that older users had very simple email needs. The assumption was made that the presence of any feature that is not required exacts a cognitive cost. The user has to learn to ignore it and has to learn to minimize its influence as a distractor when they are searching for other features. Hence a design aim was to achieve a set of features that would allow older beginners to cope with the system while supporting a reasonable range of needs as the users became more able.

At the same time there are some features of email that are inherently complex such as the use of the file management system. Another design aim was to shield older users from this complexity as much as possible.

Navigation

Older people working with MS Works and with MSOE had been observed to struggle with navigation models that were non linear and required detailed mental models of the possible destinations. On the other hand the linear navigation model previously developed for the interactive tutorials was readily used by older beginners. Further, older people had been observed gaining a more detailed model of a file system with repeated exposure over the course of working with FileTutor. Hence one of the design aims was to provide a linear navigation model that would suit beginners but to provide an additional way of engaging in more flexible navigation as the user's system model developed.

Memory and learning

A key issue was identified as the problems that many older users have with learning new applications. Although the FileTutor study had shown that it is possible to devise an approach that allows an older person to gain competence with a complex application it was also shown that this demands considerable time and commitment from the older person. The older people in the email focus groups did not want to devote days to learning to use an email system. Again the learning of new computer skills was seen as stressful in that for many older users it led to episodes of "fragile knowledge" where material was repeatedly learnt and then forgotten. This was seen by the older users as showing up their lack of competence and as causing strain for supporters. There was a strong awareness among these older people that their supporters had already taught them some skills several times. Supporters in turn felt overloaded by the user support needs of the older people whose computing they had taken responsibility for and felt guilty about this.

This led to the following design aims; the email system should be very simple to learn, the penalty for forgetting what to do should be minimal and there should be an easy way of recovering if a user forgets what is to be done. This recovery should not involve asking for help nor should it involve restarting the application or rebooting.

Idiomatic knowledge

Older people had been observed to have a limited grasp of the idiomatic knowledge needed to operate in a Graphical User Interface (GUI) environment. They were also observed to be slow in acquiring such knowledge and liable to forget idioms unless they were regularly used. Hence a design aim was to make consistent use of a limited range of GUI idioms.

Confirmation and feedback

Older users were observed at times to have an expectation of failure and to need assurance that their actions had succeeded. Hence a design aim was to identify points at which older users needed confirmation of the success of their actions and to provide appropriate feedback.

6.4 RESULTS

The following results support the argument that SeniorMail has made email accessible for older people who previously found it difficult or too hard. It has not however made a comparable difference for middle aged people who do not suffer from the effects of aging that the design is aimed at countering. In what follows "Non-specific prompting" would be where a user did not know how to proceed and the researcher responded with a statement such as, "You want to delete the email, do you see anything that might help you do this". These prompts were deliberately stated in a way that did not direct the user to specific features. "Specific prompting" in contrast would be where, after non-specific prompting failed, the user was directed to a specific feature, "To delete the email first click on the email and then go up to the task bar, find the Delete button and click that".

6.4.1 The older development partners

The two users in the older development group who were involved in the preliminary development that led to the credible prototype completed all tasks in the scenario when it was presented to them at the end of this stage of development. However this was not seen as particularly significant given that these two users had had substantial prior exposure to the ideas behind the design. The other seven users in the older development group (who were not involved in the preliminary development that led to the credible prototype), completed all the tasks in the scenario with enthusiasm and only non-specific prompting using the first version of the working credible prototype during their first encounter with it. They were slow, carrying out 13 tasks took over an hour as they were discussing what they found as they did it. However their work consisted of linear progress towards goals rather than trial, error and frustration. Features in the slow completion included very deliberate reading of screen information, discussion with other older people in the group as to how to proceed and very slow typing. All participants were surprised and pleased by their success rate. The universal question at the end of the session was, "When can I get a copy?" Another telling response was the frequent and heartfelt question, "Why can't other computer programs be this easy to use?"

6.4.2 The long term users

Six of the older development group went on to become long term users of SeniorMail. The experience has been positive, follow up visits over two years show continuing high levels of enthusiasm for the system. There have been no requests for major changes with the exception of more support for working with images. Little further education has been required. The supporters of these users report that the amount of effort expended in supporting their relatives has been reduced while the level of email performance has improved beyond expectations. They are now independent and competent email users. Supporters of these users reported greatly reduced need for supporting the use of email. This was seen as a highly desirable result.

6.4.3 The CAB usability testing group

Of the 22 users in the usability tests undertaken with Citizens Advice Bureau volunteers 19 stated that they found the SeniorMail system easy to learn and rated it as excellent. These 19 all completed the usability tasks with only non-specific prompting and clearly demonstrated that they were moving towards independent use of the system after some forty minutes. When asked these older people did not suggest any extra features that they wished to be added to this email system. Two older CAB users with almost no MS Windows knowledge completed the usability tasks only with substantial specific prompting and would have been unable to proceed independently. One person in the CAB study, who was over eighty simply did not gain sufficient understanding to make productive use of the system.

6.4.4 The middle aged computer literate group

In contrast, a group of 15 staff members of a polytechnic business computing department (average age 45) trialed the SeniorMail system and although they all successfully and quickly completed the usability tasks without prompting, only 3 of them said that they would want to use the system as their home email system. This, they stated, was because it either ignored, or made less available, features that they regarded as necessary. Interestingly there was little agreement on what extra features were desirable. It appeared that in order to satisfy this group's wishes an email system would need to include a very wide range of features.

6.5 A BREIF TOUR OF THE EMAIL SYSTEM

This section provides a quick tour through the main screens of the SeniorMail system. This is intended to orientate the reader before the next section (Section 7) which provides an in-depth discussion of how the design aims were achieved.

6.5.1 The SeniorMail Main Menu

The main menu screen displays on startup and functions as a "home base" for users, It is shown in Figure 6.1. The design points that underlie the main menu screen are the decision to simplify and expose the conceptual model and to reduce the level of manipulation by avoiding Windows menus, overlapping screens or screen segments such as a preview window. The main functionality of the system is laid out for the user to see.

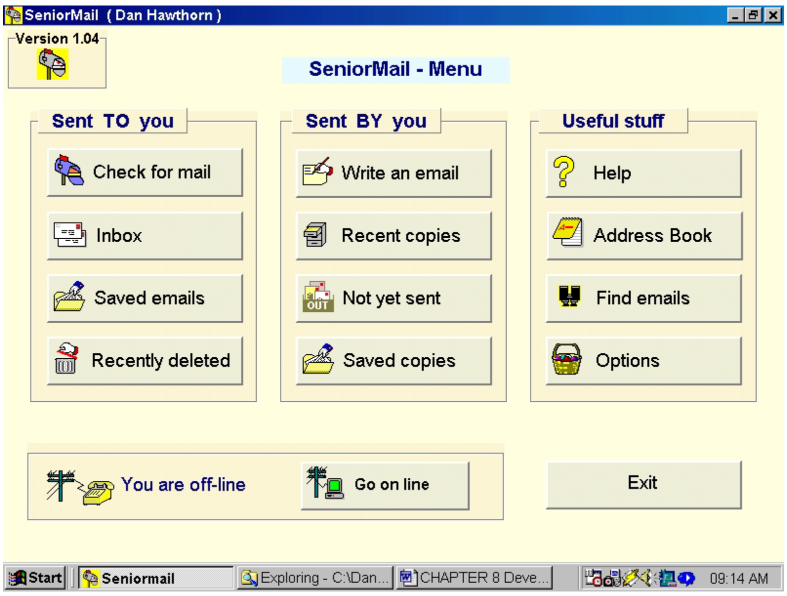

Figure 6.1 The SeniorMail main menu.

Visual search is simplified by grouping the buttons into three groups for inwards mail ("Sent to you"), for outwards mail ("Sent by you") and other features ("Useful stuff"). Within each grouping the requirement is for a simple linear visual search (downwards) and this is backed by enclosing the buttons for each group in a separate panel. Buttons use a larger text and a lighter background than standard Windows buttons. By way of contrast standard Windows buttons can be seen on the task bar at the bottom of the figure. There are some additional features of the system but they are not required for basic functionality and so to keep the system as simple as possible for the older users the additional features have been effectively hidden in that they are reached from the [Options] button. Considerable work was put into finding wording for the hints and the button captions that the older development team found intuitive but it was not possible to get complete agreement on ideal wording.

In order to begin the user clicks the [Check for mail] button and is show a dialog box that shows progress in dialing out, connecting to the user's internet provider and downloading any new email. To avoid overlapping forms, small fonts and a further level of complexity of involving a step that is external to the email program, the code for dialing out is internal to the SeniorMail program, the standard Windows "Dial out" dialog box is not displayed. If there are no new emails, a message box displays this information, otherwise the progress window tracks the downloads and then, once all new emails have been downloaded, the user is automatically taken to the Inbox where the headers for the new emails are displayed.

6.5.2 SeniorMail Navigation

The main menu sets out an easily available display of all the main features of the SeniorMail system. Once a main menu button has been clicked to go to another screen each of the screens reached will have a standardized toolbar at the top of the screen. The toolbar of the Inbox screen layout (Figure 6.2) shows some of the basic features that are common to all the SeniorMail screens apart from the main menu and the dialog boxes. The commands that can be carried out are displayed as large button options on a toolbar located at the top of the screen. The number of options is restricted. If the user pauses the mouse over a toolbar button a hint is shown, in the Inbox example the hint for the [Open] button can be seen.

Those options specific to the window being displayed are grouped at the left of the toolbar. There is a title giving the purpose of the screen in the space to the right of the first group of buttons. There are always [Help] and [Menu] (or [Back]) buttons displayed in a second group at the right of the toolbar.

6.5.3 New email and the Inbox

The Inbox is shown in Figure 6.2. It has a number of differences from the MSOE Inbox. There is no preview panel and the whole screen apart from the toolbar is devoted to showing a list of new email headers. Getting new emails from the user's internet provider is separated from the Inbox functionality and is only done when the user clicks on the [Check for mail] button in the main menu. There is no display of folders into which new mail can be dragged. This simplifies the concept of email headers to items in a list rather than thinking of them as files in a folder, makes less demand on mouse skills and, if the older user has a relatively low volume of email, reduces the need to scroll. The action required to work with an email header is to click on the header line and then click the relevant toolbar button. Email headers stay in the Inbox until the user either deletes them or saves them. If the user deletes or saves the email headers are transferred to the Recently Deleted or Saved Emails lists, both of which are available from the main menu.

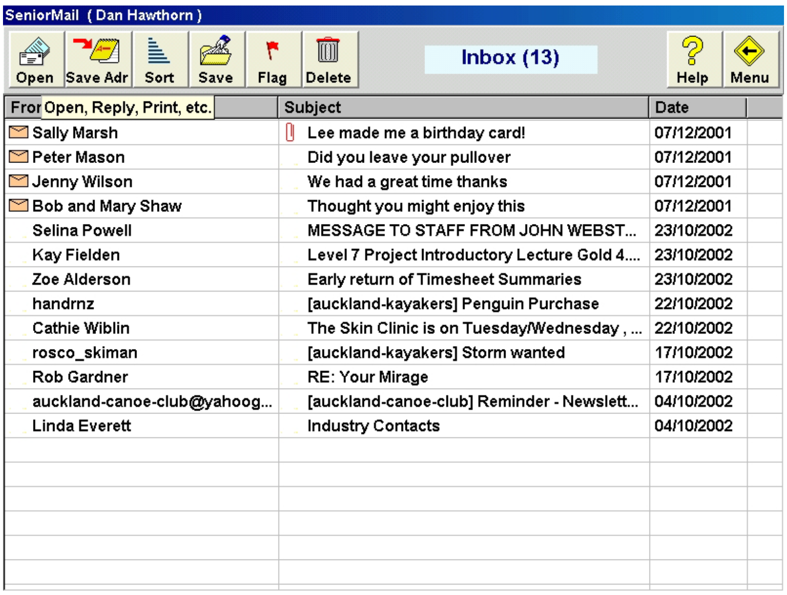

Figure 6.2 The SeniorMail Inbox showing the hint for the [Open] button

6.5.4 Email lists rather than folders

Instead of user-customizable folders SeniorMail has fixed collections (lists) of email headers for new mail (the Inbox) and for Saved and Recently Deleted emails as well as for Recent copies and for any copies that the user wants to save long term (Saved

Copies). These lists of email headers are displayed using the same layout as the Inbox and can be reached from the main menu. Unread emails are shown at the top of the list with an unopened envelope icon. A red paper clip icon is used to indicate attachments. Although a user can double click on a header line to open an email, the system supports those older users who cannot reliably double click, these users click on a header line and then click on the [Open] button. This displays the email in the Viewer window.

6.5.5 The email viewer

The screen for viewing email content is shown in Figure 6.3. Again this screen uses the standard "toolbar at the top" layout. The default font for displaying emails is Arial 14 point though this can be adjusted by the user or their supporters. An advantage of the full screen approach is the reduced need to scroll if messages are reasonably short. Tasks such as saving an address to the Address Book have been simplified and made available from the toolbar. The available email header information has been stripped down to recipient, date and subject. Information such as file size was found to be of limited relevance to older people and information such as the CC field while somewhat more relevant was found to add too much visual detail for the older users to be comfortable in extracting the core header information.

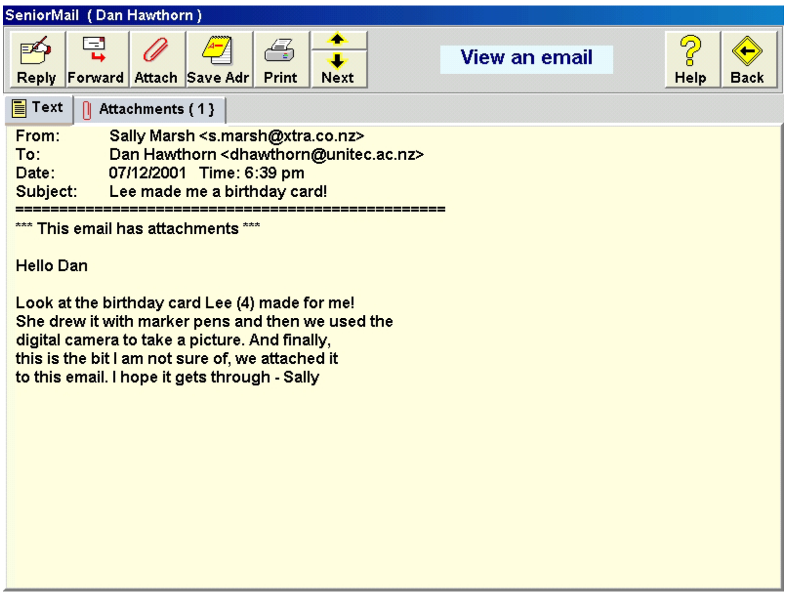

Figure 6.3 The SeniorMail Viewer Window

The older users tended to have problems identifying that an email had attachments. Therefore an extra line of text, *** **This email has attachments** *** is added to the email as well as displaying the paperclip icon in red and giving a count of attachments on the caption of the attachments tab. A striking problem was that having been given a rule that said "To do anything look at the buttons on the top toolbar" the older users were remarkably blind to other features on the screen. Most of the older users ignored the tabs captioned "Text" and "Attachments" even though they were positioned just below the toolbar. This blindness to the tabs persisted even when icons were added to the tabs to make them as similar as possible to the toolbar buttons. The [Attach] button on the toolbar is a late addition to the design that successfully lets the older users get to the attachments display while keeping to the "use the toolbar" rule. (Note that in the latest version of SeniorMail the tabs have been dropped altogether.)

When the user chooses to view an attachment, image files can be previewed within SeniorMail but all except small documents need to be opened using the appropriate program by clicking the [View] button. This was because the available preview component was very slow to open even moderately large documents.

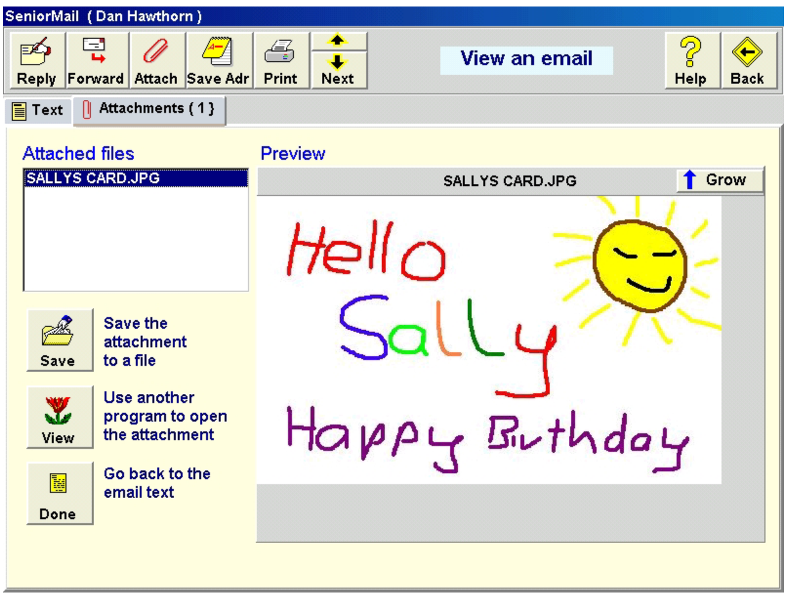

Figure 6.4 Viewing an attached graphics file

6.5.6 Writing emails - the Editor

The editor screen is shown in Figure 6.5. If the user clicks the [Reply] or [Forward] button on the Viewer toolbar they are taken to the Editor screen. The Editor can also be reached from the [Write an Email] button on the main menu. Again this screen uses the standard "toolbar at the top" layout.

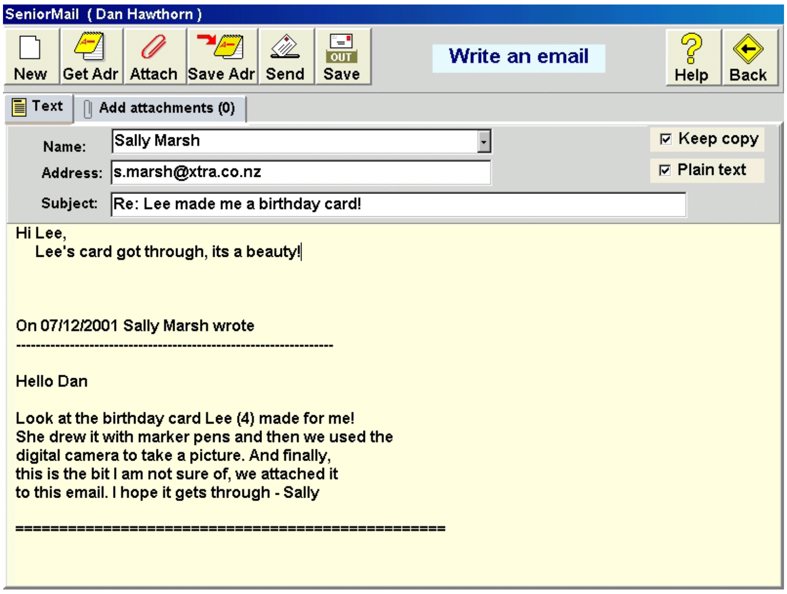

Figure 6.5 The Editor screen in SeniorMail

Emails can be saved into the Outbox using the [Save] button and sent when the user decides to go back on line, but the usual approach is to click the [Send] button when finished and SeniorMail will re-connect with the user's internet provider if needed. If the user is writing a new email or forwarding an email the Name field can be set by the older user's supporter to predict the likely recipient based on the first letters typed, a type ahead approach. However if the older user finds the resulting pattern, of names that change as they type, confusing it can be switched off in the Options screen. The alternative to type ahead is to display a modal dialog displaying a list of names from the Address Book. This can be seen in Figure 6.6, it is reached from the [Get Adr] button.

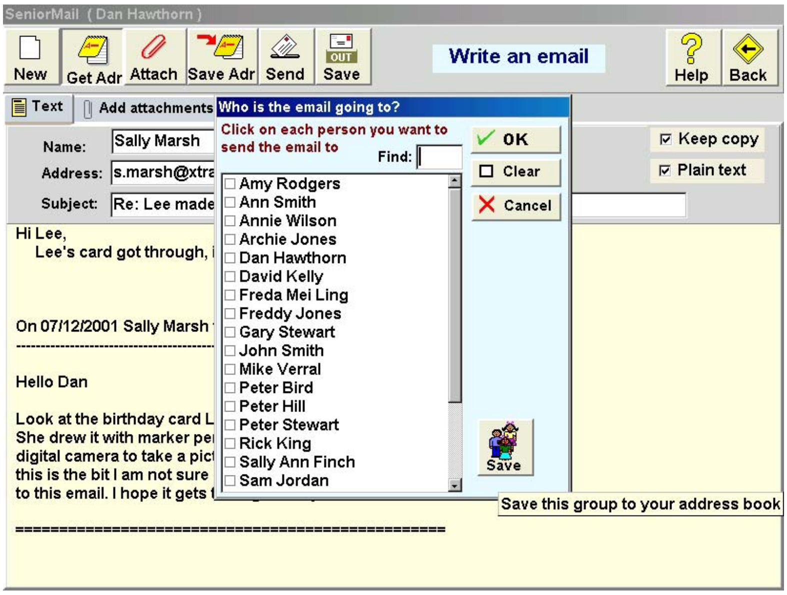

Figure 6.6 Dialog for choosing one or more addresses.

The user can send an email to more than one recipient using this dialog box. It is also possible to select a set of recipients and then to save this set as a group entry into the Address Book.

6.5.7 Sending attachments

The tabs for text and attaching files provide the same problem as found with the tabs in the Viewer and again a toolbar [Attach] button provides a solution. The screen used to add attachments is aimed at providing a way of simplifying the amount the older user needs to know about the Windows file system. It is intended that a supporter chooses a few folders that are the likely source for attachments that the older person wants to send. These are additional to three folders automatically selected by SeniorMail; My Documents, My Pictures and My Attachments. This latter folder is created by SeniorMail and is the default destination when a user saves an incoming attachment. Once the user selects a folder they can then see and select a file from that folder and then attach it to the email. The use of numbered instructions is taken from the development of the FileTutor tutorial and appears to be a useful way of guiding an older user through an unfamiliar or infrequent process.

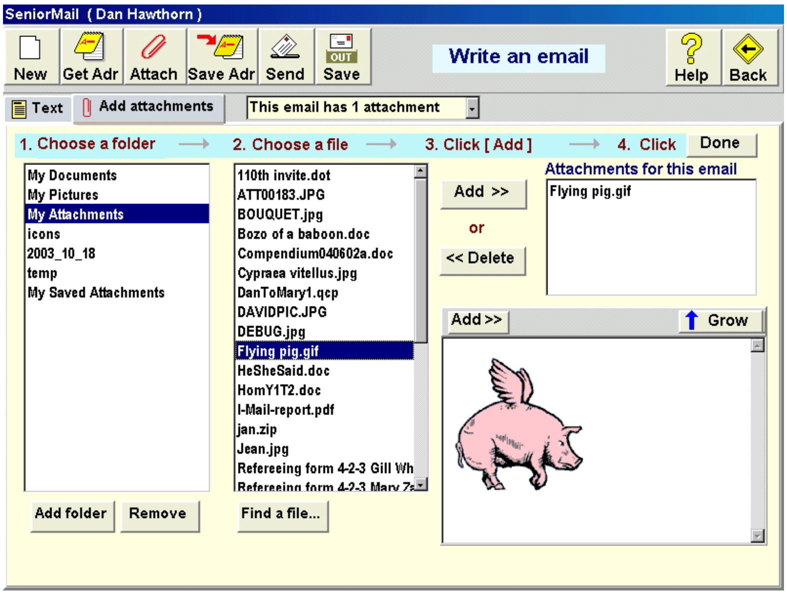

Figure 6.7 Adding an attachment to an outwards email

It was observed that the older users did not feel comfortable that an attachment had really been added to the email when they returned to the tab displaying the email text. This was in spite of the fact that they had added an attachment and that the Attachment tab now displayed the count of attached files. The older users apparently did not model the tabbed pages as parts of the same whole, for them the text was the email and it was the text view that needed clear confirmation that an attachment had been added. A solution to this problem can be seen in Figure 6.8 where a prominent drop down list now shows at the top of the email's text page if attachments have been added.

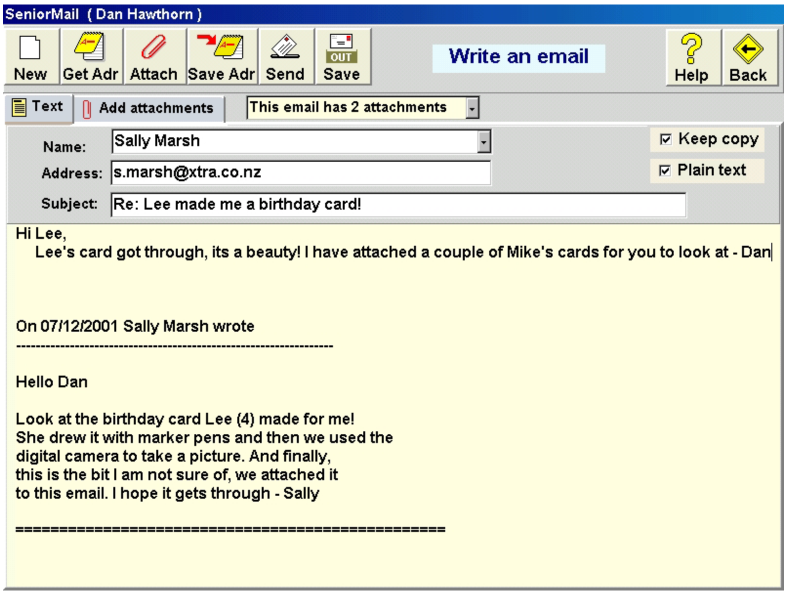

Figure 6.8 Older users want confirmation that an attachment will be sent with an email

6.6 DISCUSSION OF SENIORMAIL INTERFACE DESIGN ISSUES

SeniorMail allowed a group of older users to succeed on email tasks at a level beyond that which they had previously achieved. The experience of carrying out these tasks was seen positively and the users typically ended by wanting to own copies of the application. These results indicate that the design issues tackled in SeniorMail are worth describing. This section will describe the issues and concerns that shaped the design responses in SeniorMail to typical difficulties that older users find with learning, vision, manipulation, navigation and complexity of the system model.

6.6.1 Managing the design environment

One of the key features of developing the SeniorMail application has been the way in which the group of older people contributed to the design. Although there is a separate chapter on working with older people is should be re-iterated here that the design approach consisted of starting with a credible working prototype that arose from two sources. It reflected the expressed wishes of the older people (and their supporters) when they talked about email in the focus groups. However the other starting point for the design lay in the design implications that had been extracted from the literature on aging and had tested in the earlier designs of the two interactive tutorials. Thus when the initial design is referred to a credible working prototype, the implication is not just that it was capable of sending emails at this stage but also that it was credible in the sense that it already addressed basic concerns of older people such as conceptual simplicity, ease of getting started and issues with memory, learning and vision, etc. But given this credible working prototype the other key aspect of the design environment was to combine a feeling that the work the older contributors were doing was useful for other older people, with a sense of fun and play. In this situation failing to see how to use a feature was a matter for amusement and discussion. To this end the fact that the prototype was already surprisingly easy to succeed with boosted the older people's sense of being capable and the decision to have the older design contributors work with other older people when exploring SeniorMail meant that problems were commented on and discussed with peers as they were encountered. This increased the level of insight available to the researcher / designer.

6.6.2 User sensitive inclusive design

Again this point is covered more fully in the chapter on working with older users but the question of how the older people in the development group contributed needs to be considered when looking at the discussion of the SeniorMail design issues that follows. Newell and Gregor (2000) make the point that the designer should be sensitive to the various needs of different older users. Newell and Gregor extend this to argue for designing to include these older users (and other users with special needs) by adapting the design to allow for their needs while still being usable by the wider population. I am more concerned with design that is specifically for older people and am less concerned with the fully able population. However design for older people still contains a version of the inclusion issue that Newell and Gregor identify. If one identifies a particular disability then most of a typical older population do not suffer from it in a severe form. Therefore they are either not particularly assisted by the design changes for that disability or they potentially disadvantaged by the tradeoffs required in the way the overall design has been adapted for a disability that is not central to them.

Therefore one of the key issues in working with the older design contributors was to ensure that all of the group could cope with the email system without being overly inconvenienced by features that did not address their own particular forms of aging.

There is however another aspect that is captured by the term "sensitive". In a realistic size for a group of older people involved with shaping a design there will be only a few representatives of any particular problems with aging. Thus as well as considering those with good eyesight when designing for the people in the design group who had poor vision it was also important to be aware that the people in the design group with poor vision did not provide a widely representative sample of vision problems in aging. The design response was to engage all the members of the older design contributors in discussion on particular disabilities and try and deepen the designer's understanding of each issue from a moderately broad perspective. This was backed by the information available in the general literature on aging. However the narrowness of the sample is a basic reality of the design approach and has the implication that as the user group widens other variations on aging related problems may be met that are not well served by the current design. One of the design principles that emerges is a degree of humility and an acceptance that the approach does not necessarily produce an ideal design for all older people. As can be seen from the results, the approach does seem to have resulted in an application that suited a reasonably wide group of older people taken from the Citizen's Advice Bureau but it would be useful to have more examples of the design approach being used and the breadth of its success evaluated before the approach is established as a clearly acceptable way of developing designs for older people.

6.6.3 Simplicity

One of the central issues in the system design was to reduce complexity. The starting point for doing this was to remove features that were not needed by older users. Focus groups with older people were used to examine the use patterns of older email users and identify the features that were most important for an email system tailored to their needs. The key points that emerged were that these older users had fairly simple emailing needs and sent relatively few emails per week to a very small group of people. However the ability to send and to receive emails was important to them.

One could design an email system stripped right down to a [Get new email] button, a viewer and [Reply] and [Send to…] buttons. Such a system would use predefined addresses and would not store email once read. However such a system would be too simple for many older users and would be unlikely to be accepted by the people who advise older users on their software choices. Further from the standpoint of research on designing software for older users it would avoid rather than address most interface issues. Therefore the challenge that has been taken up was to design an email system that achieved easy use by older users with restricted needs and at the same time could be used as the regular email system for users who make somewhat more extensive use of email. The current long term older users did not identify any extra features that they needed over the first year and indicated that the number of features provided is in the upper range of what they feel comfortable with. However an exception emerged later, with the rise in the popularity of digital cameras, older users were now eager to receive and view images (particularly of younger family members) as attachments.

6.6.4 Learning

Older users are typically slow learners of computer applications, reasonable effectiveness with a low level of mistakes can take weeks or months to achieve, Bosman and Charness (1996). This is a demanding period in which older users can experience considerable levels of frustration and may abandon attempts to use the application. A central principle of SeniorMail was to design a system that required almost no learning to use effectively. Typical systems ask users to find and remember the purpose, name and location of features buried in menus, to experiment and to remember a plethora of small details and to transfer knowledge gained from other Windows packages. As younger or as experienced users we take a large number of simple skills for granted and perform them at an automatic level. We manipulate and remember menus, tab to new fields, Alt-Tab to different applications, resize and manipulate windows, drag and drop, select, copy and paste and use a host of other skills with little conscious thought. It is sobering to watch older users who lack such skills and who find difficulty in acquiring them. Competent computer use (and typical interface design) depends on a large number of automated user skills, each of which is individually simple but needs initial learning. Few computer actions are really intuitive for absolute beginners. If such learning (and automation) does not occur, users are simply unable to act in ways that designers take for granted. Particularly for older users, actions, that we would assume to be standard and straightforward screen manipulation, become an exercise in frustration and in trying (and failing) to remember and co-ordinate a multitude of sub-tasks.

What was done in SeniorMail to reduce learning was to make it easy for the user to search for the feature that they wanted if they failed to remember where it was located. The search was restricted to a linear scan over a few standard buttons. In the main menu shown in Figure 6.1 the buttons were grouped and the search was within a vertical group. All the other SeniorMail windows followed the pattern shown in Figures 6.2 and 6.3 onwards, where the buttons that gave access to features were always located on a toolbar at the top of each window. The basic learning required was, "Look along the toolbar at the top for a useful button". Novice users were found to be able to perform tasks successfully with almost no errors, although they were initially slow to select the right button.

Crucially, the design let users to perform relatively complex tasks without previous experience. It was observed that the older users had begun to remember the location of the most commonly used buttons after completing only two or three tasks from the scenario. The expectation is that the older users will, over time, remember the button locations reliably, increase their speed and build an effective mental model of the system. This appears to be confirmed by the experience of the long term user group.

An important point here is that this design protects older users from the frequent experience of forgetting parts of previously learnt skills. Termed "fragile knowledge" this phenomenon is common among older learners and a significant barrier to competence, but with this design there is relatively little penalty for forgetting exactly how to carry out a particular task, one simply resorts to searching the top toolbar again.

6.6.5 Training wheels

SeniorMail has also benefited from the FileTutor study in that a set of practice exercises and a training version of the system are part of SeniorMail. When this version is activated the beginner can receive a set of dummy emails and send replies to them following a script that is available as a document. This means that the support person can let the beginner go repeatedly through “sending” and “receiving” emails without needing to generate real emails or worry about who the dummy emails will be sent to.

6.6.6 Visual and Manipulative design

The ideas behind the screen designs used in SeniorMail came from previous work by Morrell et. al. (2001) and Hawthorn (2000) on designing for older users as well as from the experience gained in constructing the two interactive tutorials described previously. Usability testing was then done with a group of older users to fine tune the designs.

SeniorMail uses a full screen design rather than using overlapping Windows. This increases visual simplicity and allows the use of larger fonts and larger components. Further reasons for using full screens are covered in the section on navigation below.

A number of older users suffer from a degree of impaired vision. SeniorMail used several simple approaches to counter this. The font used is Arial, this had been found to be easily readable for older users in earlier work, Hawthorn (2000b). The basic font size for message headers and text was reasonably large (14 point) and could be further increased up to 16 point. A larger than normal font was also used on buttons and hint windows. Standard Windows error message dialogs were replaced with message boxes using a large Arial font on a light background.

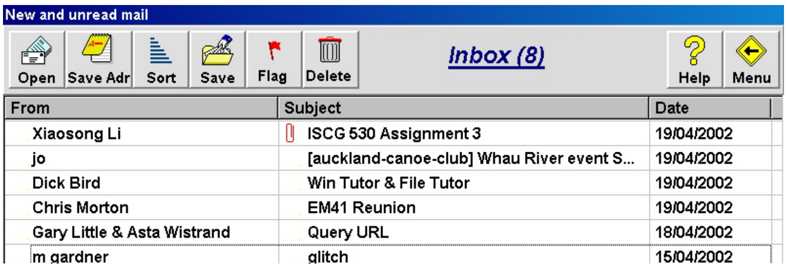

Figure 6.9 The screen layout used for lists of email headers.

With macular degeneration in particular, sufferers struggle to distinguish text against colored or patterned backgrounds. It was observed that this included reading the captions of standard Windows buttons prior to Windows XP, (black text on a mid gray background) even with an increased font size. The solution was to use a non-standard button background color, a very light gray ($00DFDFDF) with a slightly darker window or toolbar background ($00DBDBDB). The result was much improved readability for older users with poor eyesight. In some ways it would have been desirable to move away from the standard Windows button color scheme altogether but it was considered that doing so would break the users' expectations of what a button looked like. Large blocks of text as in the Viewer, Editor and Help screens were displayed on a very pale yellow ($00EAFFFE) background to reduce glare, another area that older users find difficulty with. A couple of users with deteriorating vision, including one with the onset of macular degeneration, noted that the system was exceptionally easy to read.

Older people are less able to filter out extraneous information so that the presence of information in the display that is irrelevant to the immediate task increases their cognitive load. This was part of the reasoning behind the decision to use full screen windows rather than tiled or overlapping windows. Again in order to reduce irrelevant detail no decoration was used apart from icons on the buttons. Older users were asked if they desired icons on buttons and the balance of opinion was that they did. The icons were not necessarily interpreted accurately but they served to make it easier to distinguish between buttons when searching. The icons used with the toolbar buttons needed to be reasonably distinctive. However the captions and hints given to the buttons were intended to be the primary source of understanding what a button was for. It was assumed that not all of the older users would see the icons clearly or understand the intended meaning. The icons were intended to make the buttons distinctive so that they could be located more quickly during visual search and there would be less chance of clicking the wrong button. This also serves to allow a user who has become used to SeniorMail to continue to use the system in spite of declining eyesight. It is also possible that this distinctiveness despite blur could facilitate learning of the system by partially sighted users. As a way of checking whether this distinctiveness was achieved the Gaussian blur test used by Schieber (1998) for evaluating the legibility of road signs was adapted as a tool with which the designer could check that as blur increased the icons remained distinctive. As the following image indicates this was achieved. In fact the full color version of this test shows that icons remained distinctive for users with color vision down to the greatest level of blurring used.

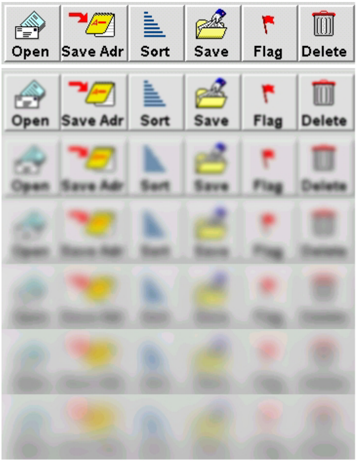

Figure 6.10 Blur testing on the icons of the Inbox

Icons were also used to direct attention to buttons that were off the main toolbar. For example when updating details in the Address Book the user needs to click [OK] or [Cancel] buttons, these were missed by some users until the buttons were provided with icons. "Flat" toolbar buttons should, in theory, be desirable (they provide an additional cue for successful target acquisition and offer a reduction in extraneous detail by removing the borders of irrelevant buttons) however when given a choice older users definitely rejected flat buttons. From discussion it appeared that in order to search comfortably for buttons the older users required buttons that remained recognizably buttons at all times.

Older users are poorer at visual searches unless there are preparatory positioning cues and / or restrictions on the search area. At the same time older users have a reduced effective visual field and may miss tool or navigation features that are widely separated from the area of the screen they are working with. Watching older people working with MSOE indicated that they had problems in scanning a two dimensional space for appropriate choices. Older people are also slower and less effective in scanning lists, older participants in the SeniorMail project have been observed missing MSOE menu items they were searching for, apparently because of the sheer volume of choices. Therefore, as far as possible, all SeniorMail features were accessed from a few, consistent, large toolbar buttons at the top of each screen. The number of buttons was restricted to eight at the most even where this meant restricting the available features.

For example [Reply] and [Forward] buttons would have been convenient on the toolbars for the email header lists but, because extra buttons would overcrowd the toolbars for these screens, these options are only available from the Viewer. There is a deliberate tradeoff in the direction of achieving visual simplicity even if access to features then requires more steps. It is worth noting that where the pattern of relying purely on toolbar buttons was broken, as in the tabbed pages used in the Viewer and Editor, novice users did not see or understand the tabs until these were pointed out to them. A later version of SeniorMail, using icons on the tabs so that they are more akin to the toolbar buttons, slightly increased the ease with which older users found the tabs but finally an [Attach] toolbar button was needed to give access to the attachment window in a form that the older users could reliably find.

Flexibility is restricted in the basic version of the SeniorMail system by a decision that the task bar button at the top of each form should only offer options that were directly relevant to the window on display. Hence the task bar on an email list will offer options to open or delete items or sort the list but not to begin a new outward email. Limiting the available buttons in this manner increases the immediate intelligibility of the toolbar options but at the expense of making it harder for the user to switch tasks, say from viewing inwards mail to writing a new unrelated email. In the basic version the user is required to go back to the main menu in order to make a task switch of this sort. Some novices needed to be reminded several times to return to the main menu if they could not find the option they required on the toolbar of the window they were currently working in. Another area that troubles novices when first using SeniorMail was the need to open an email to get access to options for replying, forwarding or printing. There are arguments against making these options available for an unopened email. Potentially an older user may reply to or forward the wrong email if this is done from the header line instead of from a fully opened message. The trouble is with a naïve user faced with a list of emails and no toolbar buttons for the job they intend to do such as replying to a previously read email. The rule in SeniorMail is to open the email if one wants to read, reply, forward or print but this conflicts with the other SeniorMail rule of returning to the main menu if one cannot find the option wanted. The hint or tool-tip associated with the [Open] button was changed to “Open, reply, print, etc.”. Experienced SeniorMail users showed no difficulty in either of these areas and beginners appeared to learn what was needed after two or three trials so the inconsistency has been left.

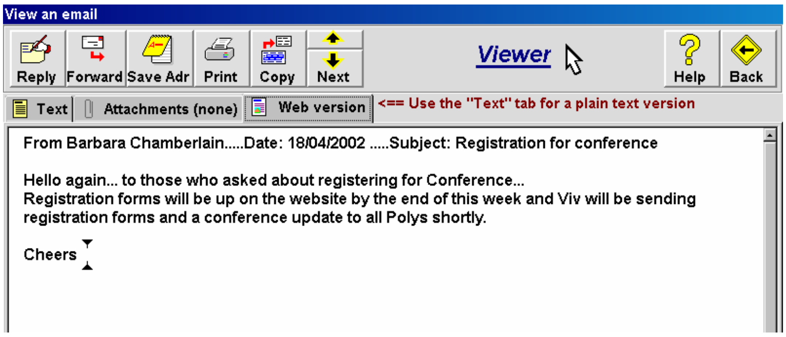

Figure 6.11. An earlier version of the Viewer design. The Viewer with the HTML view showing and a plain text view available. Note the oversized cursors added to the screen dump, the default cursor is to the right of the word "Viewer" at the top, the text cursor is to the right of the word "Cheers" at the bottom.

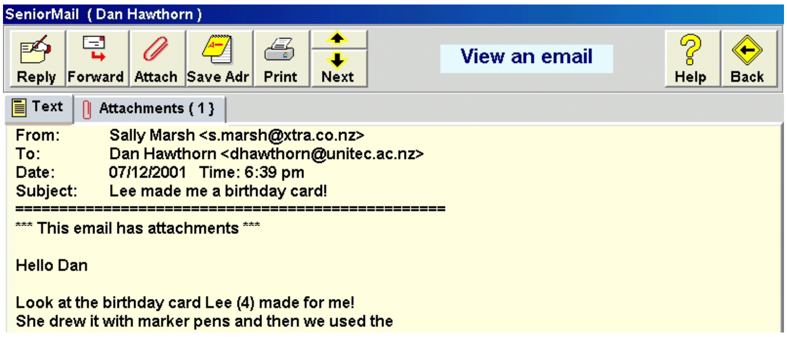

Figure 6.12. The version of the Viewer used at the time of CAB testing. Changes include an [Attach] button, a light cream background for the email text, greater contrast for the title of the window and a change in the wording of the title from the technical "Viewer" to the colloquial "View an email". The [Copy] button, intended to make it easier to copy and paste text has been dropped as it was neither used nor well understood.

Moving away from the tabbed page design also allowed the design to remove another similar source of difficulty. In the version of SeniorMail used at the time of CAB testing the tabbed page for displaying attachments still retained the Viewer toolbar and had a second group of buttons for managing attachments. As with the tabs the older users often did not see the second set of buttons.

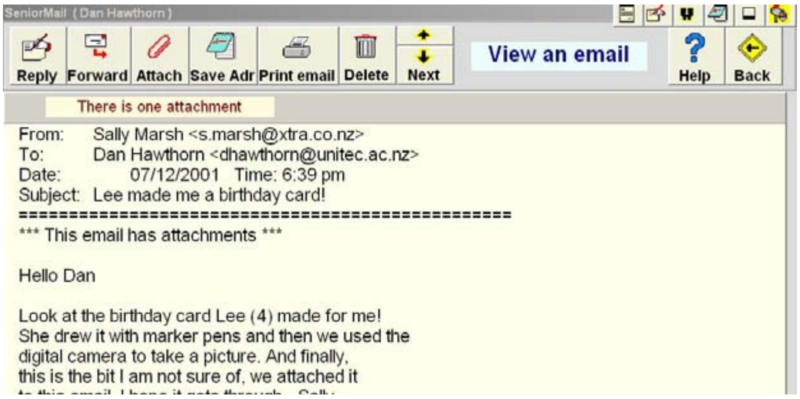

Figure 6.13. In the current version the troublesome tabbed pages have been removed altogether and the background cream has been made lighter.

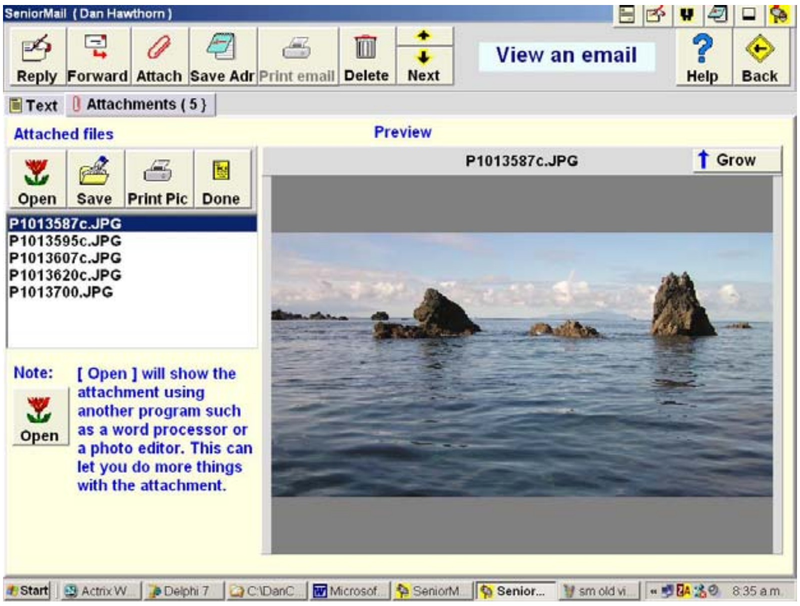

Figure 6.14. Two frustrations were seen in attempts to use this version of the attachment viewer. The [Open], [Save] [Print Pic], [Done] buttons were not seen by older users intent on searching the toolbar and users did not understand why the [Print email] button on the toolbar would not print the image. A newer version of the attachment part of the viewer now has a toolbar with only buttons that are relevant to working with the attachments.

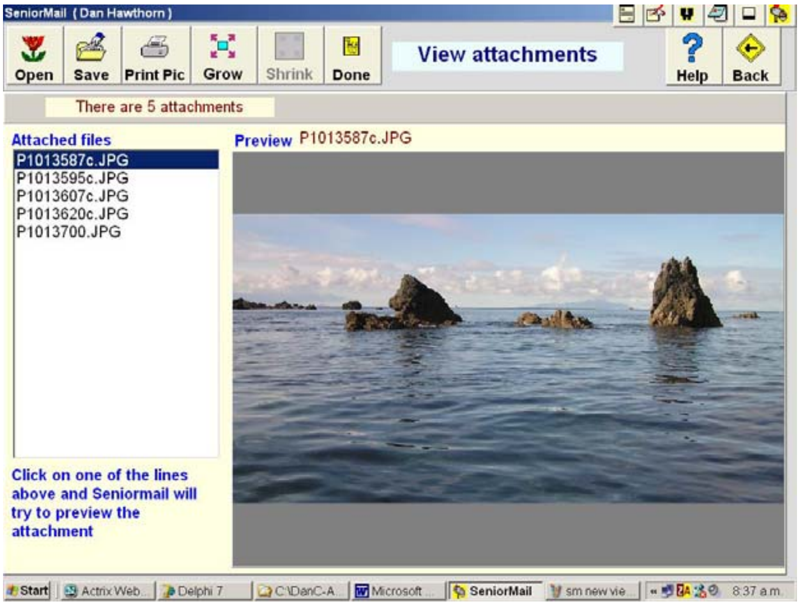

Figure 6.15. The current version of the attachments screen is redesigned to be consistent with the rule that all features are found on the toolbar button and the toolbar button only has features that are relevant to the display. Printing now refers to printing the image.

Another example of the problems of older users with visual search is the observation that some users had difficulty in locating the standard cursors against a background of email header lists or message text. Hence SeniorMail uses a very large default arrow cursor with a double width black outline and a new, large, text cursor that is particularly easy to find, see Figures 3a and 3c.

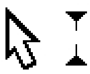

Figure 6.16. The cursors used in SeniorMail were designed to be easy to find

The cursor designs were developed and tested by trying to hide a variety of cursors in email text and against the toolbar features and then getting older users to attempt to find them. Finding the cursors was treated as a game and the older participants responded with enjoyment. Standard cursors were relatively easy to hide and the older users did not reliably find the standard cursors even when they moved the mouse to try and detect cursor movement. Possibly the lightness of the cursor lines, the relatively high speed of the movement achieved and the limits to the older user's effective field of view contributed to this effect. However the modified cursors proved virtually impossible to hide from the older users in the development partner group and were much easier to spot when moved around. These modified cursors were enthusiastically supported by the older users in the study.

The Viewer is intended to display emails that include HTML or enriched text formatting instructions. However, since the format chosen by the sender may be poorly designed from an older reader's perspective, SeniorMail provides a plain text view as the default with a web browser view as an alternative if required.

Older users are likely to find it difficult to resize overlapped or tiled windows by dragging the edges. The edges of windows are too small a target for many older users to acquire. Older users are also likely to unknowingly click outside the boundaries of foreground windows and be mystified when the foreground window vanishes. These arguments contribute to the decision to use full screen windows in SeniorMail. In addition all pop-up windows were displayed modally so that clicks on the background had no effect.

Scrolling is another area of difficulty where attempts to scroll through a long document can frustrate older users who typically are unsure of the differing consequences of clicking different parts of the scrollbar and may have problems dragging the slider along the track. The use of full screen windows for email header lists and viewing emails in SeniorMail reduces the need to scroll but does not eliminate it. One could provide buttons that allow the user to control scrolling without using the scrollbar but a useful alternative is already available in the use of the Page Up and Page Down keys and Up and Down arrow keys. The issue is how to make older users aware of these keys. A possible approach that has not yet been implemented would be to monitor mouse movement and provide suggestions about using the keyboard alternative if trouble was evident with mouse use while scrolling.

Tool tips or hints are the small text displays that appear beside a mouse when the mouse hovers over a control. It would seem that, as age restricted users have difficulty in remembering what to do, hints would be an obvious contribution to increasing usability. However, a number of complications arose when the effect of hints was examined in SeniorMail. It should be remembered that age restricted users tend to have poorer eyesight and to be slower in processing new information, thus small rapidly flashed hints do not work for them. Because age restricted users typically have a fairly limited useful field of view and have problems integrating spatially distant sources of information they are less likely to be able to take advantage of status bar information at the bottom of the screen although this would be one way of eliminating the time and size constraints of hints. Hence the first consideration was hint font size, the standard MS Windows font for hints is simply too small for most age restricted users. So Arial 14 point font was adopted for hints. This size of font was easily readable but it became apparent that the time that the hint displayed on the screen was too short for the age restricted adults to read any but very short hints. The problem with reading the hint within a restricted time period was tackled in two ways. The hint text was shortened and simplified following the recommendations in Hawthorn (1998a, 1998b, 2000) and Hartley (1999) so that it could be understood in as little time as possible. The age restricted users were still found to need more than the standard time allowed for hint displays so this was raised from the default of 2.5 seconds to 4.5 seconds. These changes led to readable hints but led to further difficulties. Older people tend to be more disrupted by unexpected events than younger people. They are also less able to make sense of partially obscured visual displays. The effect of bigger fonts and longer hint display times was to create a somewhat disruptive environment in which large hints would appear, grab the user’s attention whether this was desirable or not and be slow to vanish. Further, because of the text size the hints obscured more of the screen, in addition standard hint behavior in MS Windows is to appear close to the mouse cursor. These two factors combine to mean that the enlarged hint often displays on top of the control to which it refers. The combined effect of the changes to this point was that readable hints were reducing usability considerably. The solution involved two changes. Since age restricted users tend to be slower in their mouse movements they have more chance of triggering an unwanted hint display as they move over controls. Therefore the time that the mouse had to be over the control before the hint was displayed was increased from the default of 0.5 seconds to 1.5 seconds. The effect is that hints are only seen when the user makes a significant pause over a control. (If the user moves immediately to another control after the first hint display the next hint is displayed immediately). The second change was to control the position in which hints are displayed. The controls on which hints were available were the toolbar buttons on the top of each screen, the system was altered so that hints always displayed just below the toolbar, under the button the hint referred to. These final changes prevented the hints from obscuring useful information and causing unnecessary distraction. Younger users however found the large hints unnecessary and intrusive.

6.6.7 Navigation

Older users have been shown to perform more poorly in navigating complex web sites, advanced searching or working with complex programs, (Czaja and Lee 2001, Sharit and Czaja 1999). Unfortunately moderate levels of complexity are usual in the design of popular email systems. Typical email systems provide a flexible navigation model where the user can jump to nearly any folder or tool from any starting point usually in one or two steps. There is also a mixed pattern of tiled and pop-up overlapping windows, intended to present as much of the system as possible. This is combined with menus, toolbars and a forbidding level of jargon.

For older users there are drawbacks to having multiple visible windows. As noted above the overall screen display is more complex because it presents more navigation choices and this requires the user to have a reasonable mental model of the system and to remember more about the location of features that allow access to parts of the system. Older users often have significant difficulty with both remembering navigation features and with searching for them in a visually complex space.

Complex screens also imply a need to reduce the font used in order to give space to all the competing features. Another implication is the reduction in target size as well as the proliferation of targets. There is the implied expectation that users will be comfortable with relatively frequent navigational jumps and windows management acts such as resizing, repositioning, maximizing or minimizing. For older users with poor vision, reduced manipulative accuracy and poor short term recall of immediately preceding actions, this is likely to result in misplaced clicks that can mean unexplained jumps to unknown parts of the system with no self evident way of getting back. Again the argument supports the use of full screen window displays.

The main SeniorMail task windows are accessed from a simple main menu screen, see Figure 6.1. Options on the main menu screen are grouped so that visual searching is through a vertical linear space within one of three main groups. A choice on a main menu button typically leads to a window displaying a list of email headers. These list displays are standardized with some large buttons on a toolbar at the top and a list displayed below, see Figures 6.2 and 6.3 onwards. To open an email the user clicks a line in the list of email headers and then clicks the [Open] button.

Navigation is usually linear. Users move outwards by selecting options such as the [Open] or [Reply] button. They then return step by step to the main menu using a consistently located [Back] or [Menu] button. Typical patterns are:

Viewing:

menu -> list -> viewer
menu <- list <- viewer

Replying:

menu -> list -> viewer -> editor
menu <- list <- editor

Write email from menu:

menu -> editor [-> popup address list]
menu <- editor

Write email from address book:

menu -> address book -> editor
menu <- editor

This system of toolbars with limited options and consistent [Help] and [Back / Menu] buttons has two basic implications, the user can always return to a previous screen and eventually to the main menu screen so that simple navigation back to a known starting point is always possible. Secondly if the older user forgets what to do at any stage the one rule that they need to remember is, "Look along the toolbar and see if there is a useful option". Elderly novices were observed to succeed very rapidly with this constrained but simple model.

However the standard email browser design does address a useful issue where one wishes to do things like writing an email while referring to an unrelated email. The SeniorMail solution is to provide a small “float on top” navigation bar that lets users jump between the main parts of the system; the Menu, Viewer, Editor and Address book. This navigation bar (shown at the top right of Figure 6.13) is convenient once the user has become familiar with the system but it was felt that initially age restricted users should learn on the basic system first before increasing the navigation options.

Another problem encountered by older users was the terminology used in many email systems. This does not lead to the sort of simple understanding of what features are available that leads to effective navigation. For example in MSOE the button labeled [New Mail] does not indicate if this is inwards or outwards mail, a window captioned "Composer" does not clearly express that this is the window to be used for writing a new email. The design approach used was to discuss button and list captions with older users and select those that gave greatest clarity in indicating the purpose of the button or list.

It is assumed that the typical SeniorMail user will have some support from a more competent Windows user and so some features such as the details for connecting to one's internet provider, setting up a list of commonly needed folders to search for attachments or setting up email categories for classifying stored emails are available from the Options window rather than directly from the main menu.

6.6.8 Confirmation and feedback

Many age restricted users appear to operate with a low expectation of success. This low expectation of success was noticeable in a two situations in SeniorMail where the user requested an action such as sending an email and/or saving an address. In earlier versions of SeniorMail the system responded by doing the job and simply closing the Editor or the Address dialog. However, age restricted users were frequently uncertain as to whether they had done the correct thing and asked whether their action had been successful. The solution adopted in SeniorMail was to insert an artificial pause in which the system displays a message for about one second telling the user, “Email saved to the 'Not yet Sent' list” or “Saving address” and then the message is automatically hidden and the Editor or Address dialog is closed. Age restricted users were now confident that their actions had succeeded but younger users, when questioned, said that these messages were superfluous. Other examples of adding more explicit feedback and confirmation for older users can be seen in the progress dialog boxes that accompany getting new mail and sending emails as well as the redundant displays used to indicate that attachments have been added to an email.

6.6.9 Managing complexity

Designing for older users highlights the tension between providing simplicity and providing features. There are a number of features that can be excluded as irrelevant to a basic email system but there are other inherently complex features that are required for various reasons. For example managing attachments requires some way of dealing with the file system and older users can have considerable difficulty in conceiving of, or using, a hierarchical tree of directories. Other areas of difficulty involve organizing and finding one's emails. The tasks required here are all potentially difficult for older users; creating new folders, dragging and dropping, remembering or finding where items were actually stored and maintaining folders. Another area of complexity can lie in the navigation model itself. A typical email system like MSOE aims to provide the user with quick access to a wide variety of features, tools and folders. To do this the multiple screens and menus provide so many options that older users frequently feel overwhelmed, older users are not particularly good at visual searches of complex displays, nor are they skilled at routine windows management tasks.

The point will be made in the discussion of solutions to these problems that the solutions involve trade-offs that limit the number of easily accessible features and hence the suitability of the system for power users. The challenge in the SeniorMail project is providing a reasonable set of features while maintaining a sufficient simplicity of interface design such that older novices are able to function and to increase their skills over time. In what follows the paper will look at details of how the areas of complexity described above are handled in SeniorMail.

Avoiding File System Complexity

Observations from the email study and from the previous studies suggest that many older users do not achieve a good understanding of files and directories and continue to have difficulties using them. With email this becomes an issue when attachments are to be saved or more particularly, found and sent. Discussion with groups of older users and with groups of supporters of older users identified attachments as a significant area that older people had difficulty with and usually avoided.

Opening attachments was not a major problem, although older people usually reported having been initially puzzled by the meaning of the paper clip or similar icons used to indicate attachments. Again some older users are not confident about task swapping or may not immediately consider closing a window in order to return to one that has apparently vanished. Hence when opening an attachment transfers them to another program they may find difficulty in returning to SeniorMail. Opening attachments as embedded documents was tried but is not completely successful because of the slowness with which large documents load and the limited viewing area available. In the current version of SeniorMail images are shown as previews within SeniorMail but all except small Word documents require the user opening them in MS Word.

The major difficulties older users had with attachments were in saving them and in finding files, attaching and sending them. The central issue was the (unmet) need for older users to have an understanding of file management in order to save or find attachments.

SeniorMail tries to sidestep this issue. Firstly an additional special folder "My Attachments" is created by the program under "My Documents" and incoming attachments are saved there by default. Secondly the older user's support person is asked to select a few folders that are likely sources of attachments that the older user may wish to send with outwards email. The program then uses these folders and the Windows special folders as the basis for a simplified process for finding and sending files as attachments.

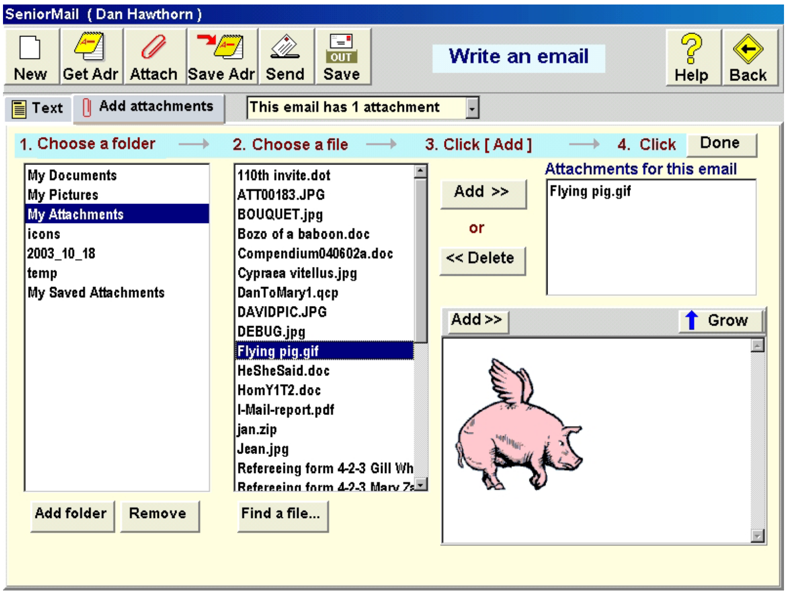

Figure 6.17. Adding an attachment in the editor using numbered instructions

Since this may be an infrequent process SeniorMail leads users through sending an attachment by using numbered instructions, see Figure 6.17. Numbering instructions was an approach that succeeded in earlier work with older users, Hawthorn (2002a). However the form shown above was not ideal as the wide spacing of the instructions and possibly the horizontal orientation meant that novices initially took time to find the next step and to see that the steps were spelt out along the top. A later modification has been to try and emphasize the grouping and to use color changes to highlight the next step. As with the viewer the tabbed pages have been dispensed with.

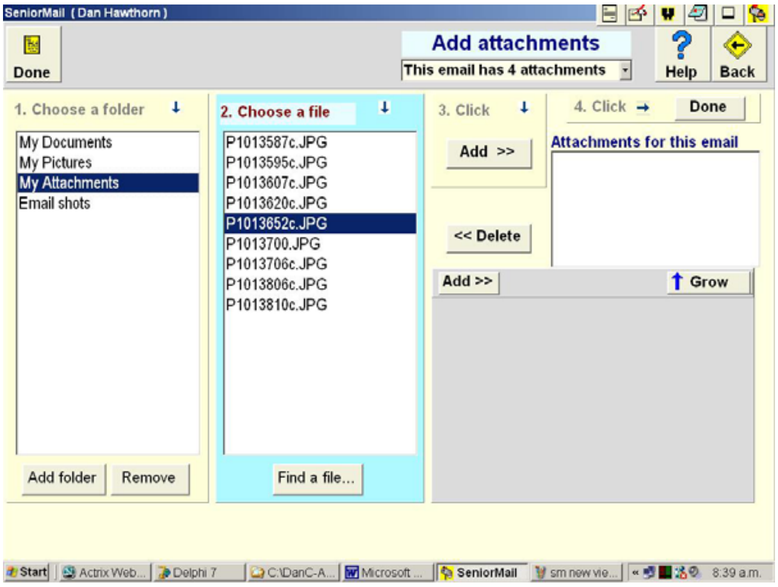

Figure 6.18. This approach to attaching files worked with older novices and it can be argued that it makes sparing use of supporters' time. However it is a distraction for those older users who are competent in file system usage, even though they can obtain a standard open dialog box by using the [Find a file] button shown at the bottom right of Figure 3.

Handling information storage complexity

The next area of significant complexity lies in organizing one's emails. The standard solution is to use folders and allow the user to create extra folders. Folders typically require levels of manipulation that are not easy for seniors, the standard drag and drop approach to moving messages to and from folders is unworkable for a number of seniors who have poor mouse manipulation skills.

Folders also increase the level of complexity in finding and disposing of mail. When finding saved mail the older user has to think of the correct folder, or use a finder that in itself introduces a further level of complexity. Much of one's personal correspondence does not classify neatly, a letter may be from one's daughter and refer to one’s house, one’s grandchildren and a planned trip overseas. With poorer long term memory (and possibly a higher proportion of multi-topic social messages rather than single topic business messages) some older users can be expected to find difficulty in using the classification that folders provide. "Did I put that in there? I thought I did but I cannot find it. I wonder where…?"

SeniorMail in fact uses a number of fixed folders; the Inbox, Saved emails, Recently deleted, Recent copies, Not yet sent and Save copies. These folders are referred to as lists and displayed as such in SeniorMail - reducing the level of jargon to be coped with. Emails are transferred between these lists by selecting lines in the list and clicking [Delete] or [Save] buttons thus avoiding drag and drop. The user cannot create additional folders thus preserving a simple and understandable structure.

The tools for locating mail after it has been read or saved are a column sort within individual lists and a Find option that generates a temporary list of email headers by applying a simple search for a single word or phrase to all the fixed folders. This avoids the problem of an older user having to search several folders to find a saved email.

An issue is that older users may forget to regularly clean out their folders. SeniorMail automatically removes old items from the Recently Deleted list but there is the potential for the Saved list and Copies of Sent Mail to grow. As lists get larger the manipulation involved in scrolling becomes more difficult as more precise manipulation is required with a smaller slider.

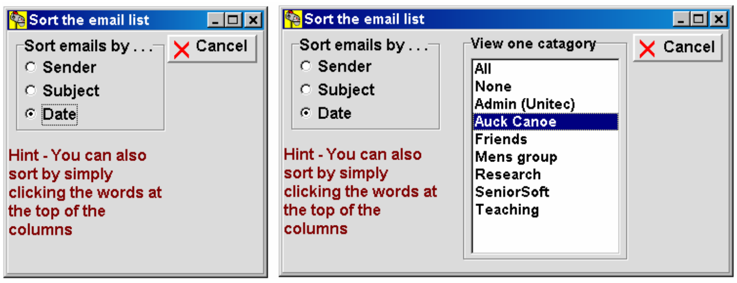

Figure 6.19. The Sort Dialog changes if categories are in use

In addition older users have trouble with moving text so that searching a list as it scrolls is difficult.

There is a way of adding further structure for those who desire it. An option is available to let the user place the list items into categories when transferring them from the inbox to the saved emails. A window for maintaining a set of categories is available from the Options screen. If the user is working with categories the behavior of SeniorMail changes at a couple of points. The display resulting from the Sort button is enlarged to allow filtering of the saved emails by category, see Figure 4. In addition the Save button now displays a dialog box where the user chooses a category to save under. Note that the system only adopts this more complex behavior on demand, users who do not need to further classify their mail do not have to consider the features that work with classification thus preserving the design simplicity.

It is worth considering that older users may have trouble remembering that a feature has been switched on or in fully comprehending the implications of a feature being active. When categories were introduced into SeniorMail the Saved list was left in the state in which it was last accessed including any filtering by category. The user response on returning to the Saved list was not, "I am looking at only the emails in the 'Bridge Club' category" but, "I have lost most of my emails". SeniorMail was altered so that any filtering by category is removed on leaving a list and the unfiltered list is what is seen the next time the user views it.

As it stands the Categories feature in SeniorMail is usable by seniors but of limited value, since classification is only done when saving mail. A set of rules for classifying incoming mail was considered and rejected on the grounds that seniors were expected to have trouble in effectively formulating rules for incoming mail and in remembering and understanding the implications of a rule over time. This expectation is based on the difficulties that older subjects show in using rule based searches as reported by Sit (1998) and others. Given the small volumes of mail the likely effort and stress seem disproportionate. However this does make it likely that the Inbox will grow to unmanageable proportions if older users join mailing lists, so the issue of folders and classification rules may need to be revisited.

6.7 DISCUSSION

One of the strands in modern HCI is to provide innovative features that partner the users' needs and abilities and extend the affordances of traditional features in order to allow the system to be as responsive as possible to the requirements of the user's task. Yet in the current chapter a rather old fashioned version of a mainstream application is presented that avoids all but a very basic subset of Windows features. So what is there in this prototype to interest or excite an HCI researcher? The interest comes from the intensity of the response by the older users who have tried the system. The limited group of older people who have so far tried the system are saying that this system provides what they need as older users in a way that other systems do not. They are also saying that they (strongly) want other applications to be like this.

Testing suggests that the email system described is considerably easier for older users than standard fully featured email systems such as MSOE. See also Newell et. al. (2005) for another study confirming that MSOE was found to be difficult for older users. The design techniques that provide this ease of use depend on trade-offs that limit the number of features available or their accessibility. Simple, large font, large target, full screen windows without menu bars only allow access to a fairly basic feature set. Presenting a simplified substitute for the file system when dealing with attachments sharply limits the number of file system tasks that can be achieved. The limited solution provided for classifying emails highlights the question of whether older users dealing with small volumes should attempt the sorts of classification rules younger, busier users need. While the system appears to meet its target of providing a reasonable set of email features in a manner that seniors find easy to use, the interface design techniques used are not one's that scale up to increasingly complex applications.

Interface design approaches that work for the current generation of older users are old-fashioned in more than one sense. They are fashioned using feedback from older users and using knowledge of the implications for interface design of the changes due to aging. But they also hark back to the time of relatively unsophisticated users of graphical user interfaces when simple interface design was appreciated by a user group that included a high proportion of novices. A number of current older users seem likely to remain in this novice group. Their uptake of new techniques is slowed by both the limitations age places on learning and by the fact that they do not need to make extensive use of their computers.

If it can be argued that there is a gap between the needs of current older and younger users, will this still apply to succeeding generations of older users who have significant computer experience prior to becoming old? Work on elderly retention of expert knowledge by Bosman and Charness (1996), Salthouse et. al. (1990) and others is not encouraging. Where older people retain expertise this appears to be within very narrow limits. There is no evidence of increased ability (in older experts) to master new tasks based on apparently closely related skills. In an ICT industry that thrives on rapid change and is economically driven by new features there seems to be a case for arguing that succeeding generations of older users will continue to want software that is simpler than that used by younger people. Firstly they are likely to have more modest computing needs once they exit the workforce. Secondly they are likely to need software that trades a reduced feature set for an interface that accommodates their aging cognitive, manipulative and perceptual abilities. Thirdly they may well want software that works within the paradigms that they were familiar with in their late 50s as many of us are less likely to learn new skills after this age.

Finally there will be some applications designed to make as much use as possible of (younger) users' abilities in order to apply their abilities in perception, manipulation and cognition as fully as possible to a problem. Such applications might present large amounts of information on screen implying small fonts, or provide contextual richness by way of a wealth of hyperlinks implying an ability to remember multiple threads of information. In providing such power in an interface it seems legitimate to offer whatever features are suitable even if these features are unsuited to the abilities of older users. It is hard to argue for crippling the power of an application to assist a younger user on the grounds that the interface features that best do this make excessive demands on older users. Again the argument seems to lead towards the provision of easy to use but more limited software for the older group. There are, however, positive aspects. As well as making suitable software available to older users, conscious design for the needs of the older user group could provide a range of well designed and highly usable applications that might be welcomed by younger people in the wider population who do not need, or wish to be, power users.

Schneiderman [2000] has argued that "dumbing down" of applications and the "innovation restriction scenario" are avoidable in creating interface designs that lead to universal usability. "Dumbing down" refers to techniques for increasing usability that restrict the complexity of applications. The "innovation restriction scenario" deals with a related concern where the limitations placed on designs in order to increase the usability of an application for some disadvantaged group leads to restrictions on the techniques that can be employed in the interface design in order to assist high end users. Note however that Schneiderman [2003] is now arguing for layering of applications where the layers for old or disabled users do in fact present a simplified, dare one say "dumbed down", version of the application.

What this chapter has tried to suggest is that design for age restricted users does not proceed from isolated facts about aging. Rather the possible designs arise from considering a number of aspects of aging in combination and such design decisions then impact on the possibilities remaining for future aspects of the design. Thus, it is not simply a matter of providing larger fonts but also of providing simple, linear and predictable search spaces. And once an interface design expression of these decisions (such as large toolbar buttons) has been adopted there is a substantial impact on the number of features that can be offered.

Further, because of the number of possible inferences from our understanding of aging and the wide gap between the designers' personal experience and the experiences of age restricted people, designers for age restricted users will remain very dependant on testing with a range of age restricted users in order to verify the assumptions made in their designs.

Overall, the techniques used in creating a successful email system for age restricted users are directly at variance with the techniques used by designers for supporting a modern, feature rich application. In designing for age restricted users we expect much less of the user and we limit the complexity of both screens and overall application structure. We preclude crowding an application with features if we foreswear menus and decide on a limited number of screens with large simple features and minimal scrolling. In some cases it may be possible to provide layering as a way to allow more complex features to be introduced when the user is ready for them. However, it is suggested that the application complexity required for full featured applications will be hard to implement in a way that both suits age restricted users and does not disadvantage younger users wanting nearly instant access to all the power that the application provides. There is also the issue of how one migrates between an age restricted users' and a power users' version of an application. Age restricted users are unlikely to be able to configure a simpler version of a complex application while younger users are likely to be impatient with any application that requires even one time configuring to make available what they see as basic and standard features.

There appears to be a tendency in some of the published papers on Universal Usability to think in terms of some idealized software plus hardware combination that makes everything available to everyone, see Schneiderman (2000). This could be seen as the UU equivalent of artificial intelligence, it makes for endless academic research, may lead to wonderful results in 30 years time and does not help much right now. The old quote applies here that the perfect is the enemy of the sufficiently good.

There is the question as to whether one should make multiple different products for different groups, make user scalable products, make variable products that are purchased as the senior version, the younger version etc? There are some reasons for concern about user scalable products, the age restricted users I have worked with are likely to have difficulties with managing such scalability. There are also notable communication barriers between would-be supporters and age restricted users which limit the solution of relying on supporters to manage scalability. Personally I mildly favor making multiple different products where those specifically designed for age restricted users are fairly basic. Given experience of what age restricted users need and find usable, versions of mainstream products that suit age restricted users are relatively easy to produce. However there is an argument for making products for age restricted users that can act as simplified training versions of more complex products for those age restricted users whose disabilities focus on learning rather than performance. Carroll's (1990) "training wheels" approach could be adopted to give a simplified version of an application that resides inside a more complex application. The complex application could be configured to present its simpler version on startup by the supporters of an age restricted user. There could however be problems where, as more features are made available, the interface design principles for age restricted users become compromised. Generally though, there are limits on the amount of complexity that age restricted users can cope with. The argument to be drawn from this is that fully featured applications will remain beyond the capability of many age restricted users and that it is not going to be possible to magically "seniorize" a complex application while retaining its full functionality. It may often be possible to retain universal access when we are dealing with information as in web pages, but as we shift to application design and look at the availability of functionality it is more difficult to envision making all levels of functionality available to all users.

Chapter 7 Research Methodology

7.1 Introduction

This chapter describes and discusses the research methodology that was developed and used in the course of the overall project. Note that the research methodology emerges from reflection on what worked as a greenfields investigation was carried out, hence the unusual positioning of the research methodology chapter after the chapters describing the research. The research methodology is a product of the investigation, not a primary driver of it. However the research methodology chapter offers an examination of the thinking behind the research decisions made in framing and conducting the case studies, it offers a picture of how research in applied aging can be carried out from a greenfields beginning and it gives an independent derivation of a research methodology that is very similar to that used by the UTOPIA team. The parallels between the two approaches are considered in detail in Chapter 9.

7.1.1 Methodology chapter outline

The problems raised by the Dual Task pilot study provided the basis for the questions that led to developing this methodology. The rest of this chapter will first look at the aims of the overall study in order to assist in clarifying what the research methodology needs to support. Experience from the dual task pilot study led to a decision that the subsequent research would not use a strict experimental approach and this decision is enlarged on in the following section. The chapter then examines possible methodological approaches among established research techniques and concludes that while they each offer valuable perspectives none of them by themselves can support the aims of the overall study. An outline of the research methodology actually adopted and its links with established methodologies is then provided. After this the research methodology used is explored in more detail.

There is a problem in that the research methodology is intertwined with the techniques I used for interacting and working with older people and intertwined with the design approach for creating interfaces that suit older people. However this chapter will focus on the research methodology and defer discussion of the two other areas until Chapter 8. This should facilitate reading of the thesis by people who are interested in designing for older people rather than in research. In the current chapter on research methodology, areas where the material referred to is expanded in Chapter 8 will be pointed out where necessary. A further chapter, Chapter 9, looks at the way in which the research and design methodologies that have emerged independently in the research for this thesis parallel the approaches developed independently by Newell and co-workers in the UTOPIA project at the University of Dundee.

7.1.2 Research issues raised by the Dual Task pilot study

It should be noted that the Dual Task pilot study was undertaken after a wide-ranging look at the literature on the cognitive and physical effects of aging. This literature had a strongly experimental focus and was largely designed to address theoretical issues in the mechanisms underlying aging. The research on which the literature is based comes almost entirely from the results of laboratory experiments. This literature is open to question as to how the findings fare when older people are dealing with basic well practiced routines in their lives or when older people deal with new tasks that combine multiple aspects of aging that are covered individually in the general research on aging. There is a challenge in extracting information from theoretical research and applying it to the much messier world of real life design and use.

The Dual Task hypothesis made a relatively straightforward jump from theoretical findings on dual task performance to a possible model for understanding the relationship between older people and their substantive and interface tasks. The indication of the pilot study was that the relationship (if it existed) was not as simple as expected. One option at this stage of the thesis would have been to conduct more detailed studies trying to find how (and if) the expected dual task effect actually operated in older people's computer use. There were several considerations for not proceeding with this. The first was a recognition that a theoretical mechanism, even if supported, was not likely to be widely useful to designers in this area. It was felt that designers would be more receptive to more specific suggestions on vision, manipulative skill levels, complexity etcetera.

The Dual Task pilot also raised ethical issues about requiring older people to fail. In that study the older subjects were distressed when confronted with tasks that challenged their view of their competence. There was also a question of whether the contribution to the general good made by such a study justified the involvement of the older subjects with tasks that they felt were boring and unrelated to their wants. Along with this came the issue of getting realistic levels of motivation from the older people involved. However some tasks, such as trying to determine a suitable font or participating in the focus groups, clearly engaged and rewarded the participants.

At the same time the experience gained with observing older people trying to use and learn existing computer applications appeared to offer insights that were not available in the research literature though they could with hindsight be related to the research findings. One of my conclusions was that the area of older people and computer use was (in 1999) at a pre-scientific stage where hypothesis testing was premature. A wide rather than a narrow focus seemed to be appropriate. A further conclusion was that basic observations on what older people had trouble with and what they typically did not know could be of more direct use to interface designers than a set of experimentally supported hypotheses. It was, however, felt that it would be useful to try and link these observations to the effects of aging reported in the general literature on aging. This would give the observations a context in terms of what was known about the aging process and should allow the designer a better basis for generalizing to the particular system that they were trying to design. Finally the richness of the material provided by the focus groups and observation of the older learners at Unitec and the apparent direct relevance of this information to design issues, suggested that the research design should be such that it provided considerable opportunities for more observation of older people in naturalistic settings.

7.2 Aims of the overall study

In this section we shall restate the aims of the overall study as a way of focusing the issue of selecting a research method. The overall aim of the study is to produce a useful interface design approach for older people. To be useful an interface design based on the approach will allow older people to succeed with tasks that they have been unable to achieve when using designs with interfaces that ignore the design guidelines developed in the thesis. Inherent in this is the intention to look at a wide range of interface design issues for older users rather than to concentrate on detailed examination of one or two issues.

The research thus aims to

1. Identify the main areas of concern in designing for older people
2. Develop a design approach that address those issues

and

3. Provide support for the overall impact of using this approach to address these concerns in interface designs for older people.

The areas of concern include the following

1. The implications for interface design of the cognitive and physical effects of aging
2. The implications for interface design of the context within which older people use computers
3. Bridging the difference between the (younger and more computer experienced) interface designer and older people

The claim to be justified by the research method is that the design approach to be developed represents improved practice in terms of leading to systems that are more usable for older people than standard systems. This does not mean that the design approach has an exclusive claim to represent best practice.

What do we mean by guidelines in the design approach? The key is in describing sensitizing issues rather than prescriptions. For example in the course of this research some older people have been observed having difficulties with menus, this is a sensitizing issue. But instead of a prescription to avoid menus the guidelines as envisaged will first offer more detail on the nature of the difficulties observed - the list of difficulties is X, Y, Z. Then the guidelines offer the suggestion that designers of interfaces for older people either avoid menus or redesign the way menus are presented so as to address X, Y, Z. Or they might include menus in an interface in such a way that their use is not crucial to succeeding with the user's task.

One of the needs that the research methodology should meet is that it allows the design recommendations to be built from a wide base of knowledge about older people and their computer use. Ideally the research methodology should allow a way to integrate findings on older people's visual acuity, manipulative skills, cognitive ability, memory and visual search skills with observations made during the research of particular aspects of interface design such as menu use.

Given that the research draws together a large number of interface design recommendations for older users and examines their overall impact, how confident do we need to be in the individual recommendations? For example if the older people observed having difficulty with menus were unrepresentative it is possible that the guidelines end up advocating an unnecessary restriction on design for older users. The decision made was that the research methodology should provide a reasonable set of recommendations that could be shown to be useful when applied overall but that the research would not be concerned with proving the individual validity of each recommendation. However it was also of concern that the research methodology used provided checks that the adopted solutions for individual issues did at least appear to be suitable for those older users tested.

The research methodology should provide ways of evaluating whether systems using the design approach and its guidelines increase the level of usability for older users. The overall research methodology should also support the development of an interface design approach for interfaces aimed at older users.

This is intended to be applied research. The study aims at the development of an effective response to a problem (the difficulty that older people find with standard computer applications) and justifying the claim that the response is effective. In doing so the study is intended to cover a broad overview of the issues that surround older people using computers and interface designers attempting to improve the lot of those older people.

7.3 Reasons for not using an experimental approach

Following the Dual Task pilot study it was decided not to use an experimental hypothesis testing approach. Since experimental research is widely seen as providing a gold standard for research this decision requires justification. An experimental approach is valid within the context of well sampled populations, the use of randomized controls and precise but limited hypotheses that are well operationalized, Gribbons and Herman

(1997). Each of these areas meets problems in doing research with older users on an overall interface design approach.

Random sampling of the older population.

Getting truly representative samples of the older population is a major difficulty. Older people consist of multiple overlapping populations of persons with differing degrees and types of age related difficulty and in addition these difficulties are such that they are likely to amplify selection effects in sampling, this is discussed further in Chapter 8.

A precise but limited hypothesis

Given the number of possibly useful interface techniques and the trade-offs that may occur between them an exhaustive experimental study of suitable interface design is a task so large as to be impractical. There is also the issue of whether the field of interface design for older users, as a relatively new field, is mature enough to form robust hypotheses. Again there is a problem with the scope of the findings. Either, as in the dual task hypothesis, the findings may potentially be too abstract to guide practitioners or the findings may be too specific and it may not be clear how far they can be extended from the context in which they were obtained. An experimental study could contrast an overall design incorporating the design approach for older people with an interface aimed at a similar task that was not designed to the design approach. A problem here is that if the system that embodies the design approach is found to be effective there is very little that can be said about the relative importance of individual design points within the system and within the design approach guidelines.

A well operationalized hypothesis

Another problem with contrasting a system based on the proposed design approach with a system that fails to meet the design approach is the validity of the non-compliant interface, does it really represent a valid design for non-elderly users or does it simply represent an artificial, but meaningless, stalking horse for comparing the preferred interface against. A well operationalized hypothesis typically requires that subjects engage in an artificial activity allowing the hypothesized behavior to be expressed under relatively pure conditions. This was found to be de-motivating for older users yet it is desirable that older participants engage in the tasks being studied with levels of motivation that are comparable to those expected on real life tasks.

An experimental approach to studying human performance also typically requires that subjects work with tasks that in at least one experimental condition will involve high levels of failure. Chapter 8 deals with the ethical issues in working with older people. In effect older people are more likely to self blame and can in fact engage in enduring and potentially harmful self stereotyping if they are required to work on tasks where there is frequent failure. This rules out, on ethical grounds, setting up control tasks for older people when there is good prior reason to believe that such groups will experience high levels of failure in situations that are sufficiently realistic that the older participants generalize the failure experienced in the experiment to negative conclusions about their own real world competence.

The requirement for an objective stance and a controlled environment limit opportunities for making and reporting observation outside the framework of the experiment. An experimental approach also places the people being studied in a subordinate role and distances the experimenter from them. This was felt to be undesirable since the situations where I was informally involved with older people seemed to offer numerous insights. It was also felt to be undesirable to keep a formal distance between researcher and subjects, This was because the relationship between the designer and older people was starting to be seen as one of the issues in successful design and that the researcher could better explore this by encouraging more involvement with, and less control, over the older people taking part.

Thus an experimental approach was likely to meet difficulties in almost every aspect. Sampling to get representative samples of the older population is problematic. There appeared to be difficulties in framing hypotheses that would offer both precision and usefulness within the context of looking at the overall topic of design for older people. Operationalizing any hypothesis appeared to be likely to have problems with ethical treatment of the subjects, forming control conditions that have a degree of external validity and with obtaining realistic levels of motivation, especially in the control condition. Finally the objectified approach to research subjects that avoids the experimenter influencing the results also limits the researcher's ability to undertake the sort of informal exploration that was starting to emerge as a desirable feature of researching design for older users.

The rapid intervention tutorial, described at the start of Chapter 4, had shown that by observing a situation that led to difficulties for older users and then drawing on the issues highlighted in the review of the effects of aging presented in Chapter 2, it was possible to make an effective intervention. A range of established research methodologies was examined, searching for an approach that would frame such interventions in a format that led to more detailed reflection on the sources of success and led to publishable results. This is described next.

7.4 Candidate research methodologies

A variety of established research methodologies offered some aspects of what was needed in this research. These will now be briefly summarized.

7.4.1 Quasi experimental research

The key feature of a quasi experimental study is that the situation studied contains some but not all of the requirements of an experimental study, to the extent that a case can be made that a causal inference about the results can be justified, Gribbons and Herman (1997). A possible format for a quasi experimental study could take the form of finding older people who were already failing to benefit from standard software and then getting them to carry out representative tasks on software that had been constructed using the design approach. In such a design the older people serve as their own controls. This has the ethical advantage that it does not involve asking older people to fail further and it has an element of external validity in that the software that caused difficulties can be argued to be representative of standard available software.

However many of the problems noted in the section on the difficulties of an experimental approach still hold true while the lack of control over the subjects' prior experiences with the standard software further reduces the power of the approach. By itself a quasi experimental approach seems to be insufficient.

7.4.2 Case study research

A case study is an in-depth report of a significant bounded episode, as defined by Stake (2000). The derivation is from medical and legal cases where a key element in professional practice is the examination of the details of the case of a disease in a patient or of a law case brought before a court. Stake (2000) makes the point that the defining factor of case studies in the social sciences is the choice to study a single case rather than a particular methodology. Thus within the range of case studies very different methodologies can be employed. However there are some common factors. Stake (1995), and Yin (1994) suggest that these are the typical data sources in case study research:

- Interviews
- Direct observation
- Participant-observation
- Physical artifacts
- Documents
- Archival records

The first four of these fit well with the sources used in this research.

Stake (2000) divides types of case studies into intrinsic, instrumental and collective. Intrinsic case studies are those done for the interest inherent in the particular case rather than for any interest in generalizing to other cases. Examples could be the cases of general practitioners or lawyers or case studies aimed at organizational review. Instrumental case studies in contrast are undertaken to advance understanding of a wider concern. Instrumental case studies fit Ragin's (1992) defining question, "What is it a case of?" while intrinsic studies deny the importance of that question. Collective case studies are simply studies where several instrumental case studies are undertaken to address the same body of knowledge. This is similar to Yin's (1994) concern with the repeated case study where the power of the case to contribute to knowledge is strengthened if similar findings can be obtained from case studies that address the same issues in the context of different situations and events.

Case study research does not specify the stance of the observer/researcher. Case study research is typically used where the researcher examines a situation over which the researcher has no (or limited) control. This research approach can be used to disprove a general rule Yin (1994) but it gives limited support for evaluating the effectiveness of an intervention because of the lack of replication and the lack of controls. Case study research can be made more powerful if the key findings can be replicated in other cases in different situations. Becker (1992) notes that inevitably issues of generalization and proof will linger in the mind of the researcher so that a tension will remain between the limits of what a case study can establish and what the researcher would wish for it to establish. This tension is acknowledged in my own research.

The individual studies in the research for this thesis can clearly be seen as case studies in working with older people in relation to their computing activities and the WinTutor, FileTutor and SeniorMail studies can also be seen as case studies in appropriate software design for older people. These are clearly instrumental studies, they aim to inform a wider understanding of what makes effective software design for older users. Thus the methodology used in the research for this thesis fits within the framework of a series of replicated case studies.

It is worth pointing out that in each of these three studies my personal focus shifted from intrinsic to instrumental. While creating each of the interface designs involved my focus was on the design process of that particular application and how to use whatever information I could in order to make it effective. This is a straightforward intrinsic focus. As the designs neared completion I shifted to an instrumental mode in which I analyzed the process that had been used and considered how it might contribute to understanding of more general knowledge about designing for older people. I would argue that this shift in focus is in fact appropriate since in part what is being studied is the interaction of a designer and older testers and potential users. Where some future designer is attempting to create a useful product for older people their focus will be intrinsic, a focus on the product development in hand. This initial intrinsic focus has been replicated in each of my design studies and then later analyzed in a more instrumental mode.
One of the aspects of case studies emphasized by Stake is that they place the events that make up the case within the situation in which they occurred, in terms of the personalities and organizational, physical and historical context. The aim is to allow the reader to draw their own conclusions and to give material to the reader that can assist in evaluating the researcher’s conclusions. It is this need that has partly shaped my decision to maintain a narrative style in my reporting.

It is argued that case studies allow the description of the convergence of diverse factors in the observed outcome, Stake (2000). This corresponds well with a view of design for older people being in response to wide ranging effects not merely to older people’s declines due to aging but also to the situations within which older people approach computing. Again Stake points to case studies as a way of “inviting attention to ordinary experience” and making that ordinary experience more understandable by linking it to theory while at the same time theory is illustrated and made accessible by ordinary experience. In the background of my reporting of “reduced effectiveness in visual search” and methods of designing to compensate for this, the reader should be aware of the figure of an elderly woman or man peering at a screen full of icons and failing to find the icon they need.

There are two points where case studies do not cover important features of the methodology used in this thesis. Case studies are typically done in situations where researcher and research subjects share a common culture. It will be argued that for younger researchers or designers there is so much that is unfamiliar about the experience of aging that this assumption of a common culture is no longer valid. In addition the typical case study is a study of a process or set of events external to the researcher and to which the researcher does not contribute. In the work for this thesis the researcher (as designer) is a key participant as well as observer, further the experiences of the researcher as designer are themselves seen as a valid subject for observation and reflection. For these reasons it is not enough to classify this research simply as case studies, we need to go further and consider the contributions to the methodology from ethnology and from participant-observation research.

7.4.3 Ethnographic studies

Before considering ethnographic approaches, can we make an argument that older people do constitute a distinct sub-culture? After all older people share (most of) a language with younger people and have been part of the mainstream experience that we all (partly) share. My basis for suggesting that there are gains to be made from treating older people as a distinct sub-culture are based on the following.

- My observations of the failures of younger people to communicate effectively with older people. This is coupled with the further failure of these younger people to understand the basis for this miscommunication or to easily find ways around it.
- Statements by my older informants that they behave differently when in the company of other older people.

- The existence of stereotyping and prejudice (from younger people) for the older group, as well as the existence of self stereotyping within the older group.
- The key experiences of being old; retirement and age related disability, are not shared by the younger people who interact with the older group.

There is also the argument for using an ethnographic stance that the observational skills and techniques of the discipline have already been successfully applied to product design. For a useful and well written description of the use of applied ethnography in product design see Sanders (2000).

Thus I am interested in exploring an ethnographic view of older people as representing a different culture from that of the computer literate, younger and more able generations, as well as a tool for observing their behavior. In this view the ability of the researcher to fully understand the reality of the other culture is problematic. Objective reporting of the behavior and responses of informants from the other culture is seen as a partial way of bridging the gap between the researcher and the researched. In my particular study the difficulty in bridging the gap is also reduced by limiting the scope of study to ways that older people can interact effectively with artifacts from the dominant culture or ways that the dominant culture can construct artifacts that suit older people.

Ethnographic studies emphasize the people being studied as having a culture that is different from that of the researcher. The traditional format has been for an academic from a Western culture to study a group from a different culture, reporting back on the structure, beliefs and practices of that culture. There are concerns about the validity of the observer's view as a representative of a dominant culture and a representative of a particular system of values. Tedlock (2000) comments that though the classic concept of ethnography came from many sources it was Bronislav Malinovsky in particular who enshrined the importance of fieldwork and participant observation in the methodology. The classic tradition assumed there was little problem in the process of reporting back. The researcher provided an authoritative description of the world of the savages or natives.

However a series of events occurring in the climate of the rise of post modernism and deconstructionism has left ethnographic research divided and very conscious of the issue of what an outsider can validly say about another culture. Malinovski's private diary was published posthumously and revealed the heroic figure of classical ethnography to be racist, imperialist and to have been less involved with the activities of his subjects than might be assumed from his reports. Another icon of classical ethnographic research, Margaret Mead had her field studies revisited after her death by Derek Freeman and in Freeman's analysis it appeared that Mead had colluded in a fable that conveniently coincided with her personal views, Freeman (1983). The debates that followed were acrimonious, there is still debate and there are still concerns about rehabilitating Mead, see Cote (2000). The confidence of the field of ethnography in its ability to achieve objective results was further shaken as anthropologically trained students from other cultures started doing ethnographic research within their own cultures and thereby drawing attention to the shortcomings of ethnography done by outsiders. As reported by Tedlock (2000) this left a discipline that had major disagreements within itself as to how much validity could exist in ethnography's attempts to find out the objective reality of other cultures and how inevitable was the biasing of reported findings by the view of the observer.

While academic ethnography has suffered, applied ethnography has expanded. Ethnography has contributed a thoughtful basis for observing other people and combining observation and elicitation of spoken information, behavioral observation and examination of artifacts and their use. As Sanders (2002) points out, this is well suited for gaining useful understanding of actual and potential users of products and so can be of vital assistance to product development. Saunders provides a good summary of issues to consider in the use of ethnographic techniques in product development.

There are common aspects between traditional and applied ethnography.

- There is a strong emphasis on fieldwork, placing the researcher in the natural environment of the people being studied.
- The approaches taken are open to change and refinement throughout the process as new learning shapes future observations.
- Study combines a range of research methods, including observation and open-ended forms of inquiry.
- Work is more likely to be exploratory rather than evaluative.
- Ethnography stresses discovering the local point of view and culture.

Applied ethnography will also engage in observing representatives of the target population working with existing versions of products or simulating work with proposed prototypes. The difference from the usability studies found within HCI is the placing of the observations within the user's natural environment rather than within a usability lab. Applied ethnography, while still time consuming, is much shorter in duration that traditional ethnographic fieldwork. Sanders suggests that while applied ethnography is more expensive than techniques such as focus groups, it can achieve a deeper level of insight about customers' emerging and unmet needs than other techniques. In part Sanders argues that this is because the use of observation in a natural setting allows the researcher to discover what people actually do rather than what they are able to put into words.

What is absent from typical applied ethnography is the gap between the culture of the researcher and the culture of the studied group. Here, I suggest, is where if we are to apply ethnographic methods to the study of design for older people, we need to go back to the concern of traditional ethnography with understanding a culture different from that of the researcher's.

But if we return to the traditional role of ethnography in reporting on and attempting to understand a different culture, do we bring in the question of the impossibility of obtaining an objective statement of the reality of a distinct culture? Remember that this is the issue that has mired and divided modern ethnography. My stance on this is twofold. Acknowledging the difficulty of reporting or understanding another person's reality is a very useful caution for people researching aging. However in working with older people on product design we are able to focus more on observable behavior and we need a relatively limited understanding of the totality of existence as an older person. Thus we can benefit from being sensitive to older people as significantly different from ourselves, we can benefit from the research methods aimed at partly bridging those differences and our aims are sufficiently limited to mean that they are achievable despite the gap between the experiential world of the younger researcher/designer and the experience of older people.

A further thread can be gained from the internal debates over the validity of ethnography. One of the shifts in ethnographic concern is from the observation of the informants (where the basis of their experience is partly unknowable) to self observation and reporting of the experiences of the participant observer, Tedlock (2000). In sharp contradiction of the objective stance associated with scientific reports, this viewpoint holds that there is value in reporting the responses of the researcher to the new culture that they experience since this experience is in fact something that the researcher can validly share with readers from the same culture as the researcher. While I do not propose making my thesis purely an ongoing reflection on my own experiences with older people, I argue that making some aspects of my responses available to the reader provides useful information for those readers who will in turn work with older users.

7.4.4 Action research

Action research provides a methodology where the researcher is actively involved in intervening in the problems faced by the people being researched. As discussed in Greenwood and Levin (2000) and Semmis and McTaggart (2000) there is much disagreement about the correct approach and many variations on the suggested format. There can be an element of activism in that the researcher is seen as taking part in a political conflict between competing interests. On the other hand there are studies that are reported as action research that investigate ways of resolving organizational problems, Baskerville(1999).

The position underpinning action research is that complex social processes cannot be understood by reductionist techniques and that further, the personal interpretive position that the researcher inevitably brings to the study is to be understood as a part of the researcher's process in extracting meaning from their attempts to understand the system. As such the researcher becomes one of the subjects. This is strongly aligned with the postmodern rejection of objective meaning. As its name suggests action research is based on introducing an intervention to a social system and then observing and recording the unfolding results. "The fundamental contention of the action researcher is that complex social processes can be studied best by introducing changes into these processes and observing the effects of these changes", Baskerville (1999). Action research designs involve a team that includes researchers and subjects as co-participants in the enquiry and change process.

Note that Baskerville suggests that “Action research is primarily applicable for the understanding of change processes in social systems.” This seems to suggest that action research is aimed at a somewhat different target than this thesis. Designing easier to use interfaces for older people may impact on the social systems surrounding those older people. Again some of the design factors may come from the study of the social systems that form the context within which older people use software. However the prime focus in this thesis is on understanding guidelines for software design for older users, not on deep understanding of the effects of such designs on the social worlds that contain older people. Again while an argument can be made for the inevitability of subjectivity in attempts to understand social systems, I see little benefit from wholesale generalizations about the socially constructed nature of knowledge and the impossibility of objective knowledge. For the purposes of this research statements such as “some older people have difficulty in double clicking and the usability of design for older people can be improved by providing alternatives to double clicking” are regarded as adequately objective statements if justified by observation and research.

Shorn of its post modernist rhetoric, action research appears to offer a common sense but not radical approach to examining a problem in a social setting. Susman and Evered (1978) describe the key steps as being;

- diagnosing the nature of the issue
- action planning, deciding on the nature of the intervention
- action taking
- evaluating the results of action
- specifying the learning that has resulted

Baskerville (1999) in his review cites these steps as still being current practice. This is a common sense description of the process followed in the research for the thesis and indeed in many other studies. The distinguishing feature of action research is the partly ideological and partly pragmatic demand that all of these steps contain involvement from all participants.

It should be noted that action research is not well established as a methodology outside the social sciences. Action research tends to involve the researcher in advocacy for the rights of the client group. A research stance based on advocacy for rights (of older and disadvantaged users) is already established in the Universal Usability movement in HCI, Schneiderman (2000) but it does not specify a specific methodology. Action research provides a way in which the researcher can justify wide ranging involvement with the group being studied. Action research also accepts that one of the ways in which research can proceed is to attempt to make a beneficial change to the conditions of the group being studied and for all involved to reflect on the results. In the field of Action research there are considerable issues over the shape of the intervention. In more recent work the stance is that the disadvantaged group must shape this for the research to be valid, see Semmis and McTaggart (2000). My assumption is that the older group is not able to be proactive in designing suitable interfaces but can be responsive to the suitability of different interface details within those interfaces and can take a major role in defining the main tasks that they want to achieve with such interfaces.

7.5 The derivation of the selected methodology

None of the candidate methodologies offered a full fit to the aims of the research. However each of the candidate techniques did have some features that offered a partial fit to the research aims. I therefore decided to use a selection of perspectives from each of the candidate methodologies; quasi experimental research, repeated case studies, an ethnographic stance, participant observation and action research.

7.5.1 Use of quasi experimental methods

Although an experimental approach appeared to be inappropriate for the reasons discussed above, I still wanted to provide the reader with a degree of proof that the design principles did lead to the construction of applications that were more suited to older users that standard applications. To this end the three studies following the dual task pilot study all chose participants who had difficulty in benefiting from the standard training approach or from standard software and then demonstrated that these participants had a much higher level of success when using email or training software that used an interface constructed according to the design principles. This quasi experimental approach was followed indirectly in the first WinTutor study. It was observed that standard training methods caused considerable difficulty for a group of older people. It was observed that a very simple interactive tutorial loosely following the interface design issues identified in the literature survey reduced the older beginners difficulties. When an extensive beginners interactive tutorial was constructed with careful attention to the design principles for older users the tutorial was widely praised and adopted by SeniorNet tutors and still continues to be used in SeniorNet training.

With the FileTutor study and the SeniorMail study the quasi experimental approach was implemented directly. The older volunteers who tested the products were specifically selected from people who had tried and failed to learn about file management using available forms of training (FileTutor study) and from people who had failed to learn how to use Microsoft Outlook Express (SeniorMail study). After training in the use of FileTutor or SeniorMail the volunteers were asked to carry out a series of test actions that were representative of the tasks that would be undertaken by typical users doing simple file management or emailing. The success observed was taken as an indication that the design principles led to software that was more suited to older users than standard software.

The lower power of a quasi experimental approach meant that there was a case for repeated studies to establish the usefulness of the design principles more fully. This led to the construction and testing of three different systems covering two different application areas (interactive tutorials and email).

7.5.2 Themes from Case studies

One of the aspects of case study research that fits well with the current research is the concern with utilizing a wide variety of available sources of information, hence the use of interviews, focus groups, observation and the study of the interactions of older people with artifacts – their computers and installed software. Another of the themes that is often taken up in organizational case studies is the roles of different groups in an unfolding event. In order to understand what is occurring the event is examined from the perspectives of the different groups involved.

This was picked up in the research for the thesis in terms of including discussion with people from groups that were related to, but distinct from, the older people using software. Thus the studies included conversations with those teaching older beginners, both teachers without specific experience in teaching older beginners (those at Unitec) and teachers who had specialized in teaching older students (the SeniorNet tutors). The studies also included focus groups held with people who were supporting older relatives to gain the perspective of another significant group involved in older people's computing experience.

Case studies also allow the researcher to provide an interpretation of what was seen usually in terms of whether the case being examined conforms to a particular theoretical background, Yin (1994). Thus the picture of aging derived from the literature review provides the theoretical background used in interpreting and explaining the actions of the older users. As with the arguments for using a quasi experimental approach, case study research implies that the contribution to theoretical knowledge is strengthened if repeated cases are observed over different situations. As discussed above the cases in the research for this thesis combine aspects of the intrinsic case and the instrumental case, the topics studied are of interest in their own right but in each case they are to be seen as cases of design for older users.

7.5.3 Themes from Ethnography

I regard it as useful to take from ethnography a concern with older people as members of a different culture set apart by the experience of aging, by shared experience with other older people, by appearance, by reduced abilities and by separation from mainstream working culture. From ethnography the study takes a concern with observing and letting the members of the culture talk about what is important to them. A key concern here is that the older people are seen as other, they are distinct from researchers and from potential interface designers who may want to use the design principles. People who do not belong to the culture cannot fully understand what it is to be a member of the culture and the knowledge transmitted to non-members is always approximate because the non-members lack the crucial experiences of aging.

Also from ethnography the study draws the need to consider the potential for older people to defer to the researcher and tell the researcher what they believe the researcher wants to hear. There is a need when working with groups of older people to grant shared authority to the older people in the group and to increase the relative status of the older informants in relation to the researcher. To this end some of the usability studies were done with groups of older people for FileTutor and for SeniorMail. It was found that a group of older people was more likely to challenge bad design than a single older person working one-to-one with the researcher. Another aspect of giving more authority to the older people contributing to development was to work repeatedly with the same groups of older people including the in-house older testers. Familiarity with the researcher led to expectations that critical comments and drawing attention to difficulties would be well received and acted on. Continued exposure to alternative prototype fragments (some of which were unsuited to older users) means that the older people become used to expressing their own preferences and to being valued for their insights.

An ethnographic stance stresses the need for the observer to go “out into the field” so that the people being studied are observed in their own territory. Hence in the overall study opportunities were taken to visit older people in their homes and observe their computing environment and observe how they worked within this environment. Older people were also observed in SeniorNet classes where they were learning in an environment specifically designed for teaching older learners. Again the use of an ethnographic stance argues for the value of observing older people in context where the observer does not shape the situation or influence it, where in fact the observer tries to avoid influencing the situation and takes on the role of an unobtrusive observer. This was true of the early observations of teaching older people at Unitec and offered useful information that was essential background for the later stance of action researcher where interventions were designed to improve the teaching situation. Finally an ethnographic stance requires that the investigator adopts forms of behavior that are seen as appropriate by the cultural group being studied. It became clear from listening to the stories of older people recounting their experiences with younger people trying to explain computing terms and skills to them that younger people simply lacked a concept of appropriate communication with older people. The question of what does constitute appropriate behavior will be expanded in Chapter 8.

From the more modern developments of ethnography comes the perspective that the responses of the researcher are a valid subject for reporting and analysis. It is argued that the researcher’s responses are an important part of understanding the process that occurred and are useful to those intending to make use of the research in understanding their own potential role in interactions with the culturally distinct group. It is from this viewpoint that I maintain limited reporting of my personal involvement throughout this research. This concern with the reporting and understanding of the researcher’s involvement is also shared with action research.

7.5.4 Themes from Action research

Ethnographic research emphasizes minimizing the influence of the researcher on the reporting (by participants) of their culture. However in studying software design for older users the intention was to first find out about the existing culture and then to alter a part of that culture by providing (hopefully) better software. Action research provides a framework for such interventionist research. The perspective emphasized is observation of an intervention in situations that are a natural part of the settings of the participants in the intervention. This study does not take the action research perspective that the researcher is engaged in challenging the aims of a vested interest group. However from action research the study did take the perspective that it is legitimate within a research activity to try to advance the aims of a disadvantaged group. One of the features of action research is that the presumed benefits of the action being undertaken with and for the disadvantaged group gives the justification for the time the people being studied make available to the researcher. This means that there was a concern with making the products of the research available to the older people who contributed to developing them. With one significant exception (the final testing of SeniorMail with the CAB group) this was done in this research.

Another concern of action research is the extent to which the action being undertaken is shaped by the researcher or shaped by the disadvantaged group. Some authors, see Semmis and McTaggart (2000), suggest that the researcher should have virtually no part in shaping the action in order to avoid paternalism and a patronizing approach to the people being studied. I took a pragmatic approach. In my experience older people had little skill in suggesting overall interface designs. They had expertise in their wishes for the tasks that they wanted to achieve. They also had little difficulty in pointing out features that did not suit them, provided they could critique the possible interfaces from within a group of peers. They could at times suggest individual features. This led to a situation where my discussions with the older people and their supporters created the proposal for the initial content. The initial approach to implementing interfaces to contain this content could then be decided by the researcher on the basis of the researcher's greater technical knowledge. These implementations could then be refined and reshaped by the researcher working with the in-house older testers and the older usability groups.

7.5.5 A note on participant observation

Participant observation is derived from ethnographic approaches and has further extensive use in the action research approach. Participant observation emphasizes the researcher taking part in the activities of the studied group as a participant rather than as simply a detached observer. Jorgensen (1989) in his classic introduction to the subject suggests that participant observation is particularly appropriate in cases where little is known about the phenomenon, were there are important differences between the views of insiders as opposed to the views of outsiders and where the phenomenon is in some way obscured from the observation of those not in the group. The beneficial effects of this form of research have also been covered under the previous sections on ethnographic fieldwork and action research. However there is a problem in applying participant observation to older people in a way that is distinct from the issues around participating in activities of other cultures. If one takes part in an initiation, digs crops or takes part in a hunt one has a shared stance with respect to the other participants. One is uninitiated, one is removing weeds, one is harvesting food to be consumed, one is chasing an animal. This common stance is seen as part of what makes it possible for the researcher to gain extra understanding of the group being studied through participant observation. I would suggest that direct participant observation with older people is frustrated by lack of such a common stance. When sharing the experience of learning or trying out new software with older people, the researcher is not, at any time; a novice, afflicted by age restrictions or subject to stereotyped expectations about limits to his or her own performance. Thus while I see fieldwork as being a useful part of design with older people and I obviously support being present while older people work with software I would argue for caution in calling the researcher's experience in such settings "participant observation".

7.6 Detailed description of the research methodology

The target of the methodology is to allow the construction, evaluation and support of a set of principles for interface design for older users. As such it relies on repeated studies of software development for older users that apply the available principles, allow refinement and extension of those principles and, in so far as the applications developed are successful, offer support for the use of the principles. Because of the very recent emergence of interface design for older adults as a research concern, my initial literature search was dominated by the more general literature on physical and cognitive aging. Hence the initial set of design principles arose from a study of the available research literature on aging, looking for the implications of the effects of aging on the interface design needs of older people.

If one were starting such a study as this currently, (in 2005) there would be a temptation to focus on the recent literature on interface design for older people. With hindsight I believe this narrowing of focus would be a mistake. My experience is that bringing an awareness of the implications of aging to a study of older people's interactions with interfaces gives considerable assistance in interpreting what is observed.

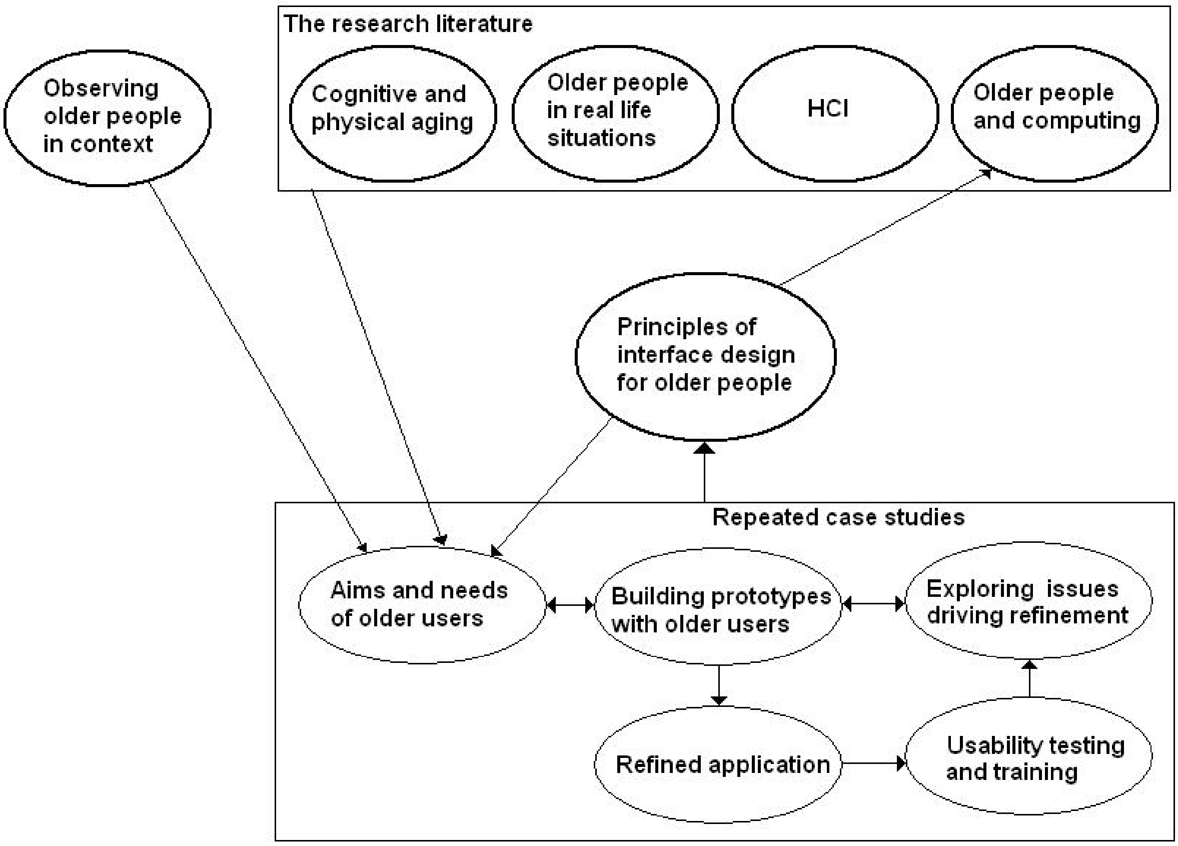

Figure 7.1. A diagram of the research methodology

The basic methodology can be depicted as in the diagram in Figure 7.1. The top level of the diagram indicates sources on which the study is based, a) observation of older people and their supporters in natural situations relevant to their computer use and b) the relevant literature within which the overall research is grounded. The middle level indicates the aim of the overall research, establishing a set of useful principles for creating user interface designs for older people. The bottom rectangle sets out an idealized format for the individual studies conducted as part of the overall study. The components of this methodology and their interconnections will now be discussed in more detail.

7.6.1 The role of observation of older people in context

Here the issue is to ground the research in a knowledge of the older participant's lives, at least as related to actual and potential computer use. As noted above, when investigating a new area the research design should be such that information gathering is not narrowly focused so as to increase the chance of serendipitous discoveries. Simply put, because of the gulf between the experiences of older people and generally younger researchers there needs to be a conscious effort on the researcher's part to broaden their experience of what it is like to be an older person. To this end the overall research involved wide ranging focus groups, not just with older people but also with their supporters. It involved home visits and discussions with older users of their current computing practice. It involved discussions with older people who did not wish to be involved with computers. It involved teaching older people computing skills and observing other people attempting to teach older users in various environments with varying levels of success. It involved casual discussions with chance-met older people about how they did or did not use computers. It also involved examining the performance and acceptance of younger people using the software I had developed for the older users to highlight areas where older users shared characteristics with younger users and where they showed significant differences. Although results from this work are discussed in the thesis the main aim of this aspect of the methodology is an informal and opportunistic effort to change the background understanding that a researcher brings to people much older than the researcher. The aim is to deliberately broaden the researcher's or designer's personal experience and understanding of the reality of aging.

This body of understanding based on interaction with older people contributes to the set of aims and needs of older users that need to be embodied in a particular design. In fact there is overlap between the information gained in the ellipse in the diagram labeled “Observing older people in context” and the information gained in the individual studies in the ellipse labeled “Exploring issues driving refinement” since the individual studies offered a wide variety of chances to learn from the older participants.

It can be seen that the interaction between researcher and older users is a vital part of this methodology. Simply put this methodology is ineffective unless it is used in the context of interaction with older people. However experience suggests that there are a number of issues that make working with older people a discipline that requires its own set of skills. It is not sufficient to simply work with older people, what is needed is an awareness of their needs and concerns that lets the older people involved give free expression of their needs and responses to the researcher. At the same time awareness of the vulnerabilities of older people can assist the researcher or developer in avoiding harm or discomfort to the older people who volunteer to take part. Thus Chapter 8 of the thesis will set out some practical approaches to working with older participants that have been found to be appropriate in the course of the research.

7.6.2 The role of the research literature

There are four groupings in the relevant literature within which the study is grounded. The literature on cognitive and physical aging has a key role. It is here that the overall study obtained its initial selection of the changes due to aging that were considered to be candidates for affecting the interaction of older people with user interfaces. It is here that the study can be grounded in relevant findings on vision, manipulative ability, attention, memory, learning and intelligence. It is this part of the literature that I drew on to obtain the initial set of implications of the changes due to aging for user interface design for older people, Hawthorn (1998a, 1998b and 2000). These initial implications have then been developed in the course of my research into the principles for designing for older users that emerge from the overall study. The literature on cognitive and physical aging has a further important role in that it provides a way of relating work on the interface needs of the current generation of older users to the needs of later generations who will enter old age with increased computer knowledge but still exposed to the cognitive and physical changes that age brings.

The published research on older people in real life situations, shown as part of the relevant literature in the figure, covers a small but wide ranging literature of applied research on aging as it applies to older people's lives. As there was initially very little published on interface design for older users it seemed useful to seek for any work on older people that had an applied focus. The argument was that such work would have made the same transition that this study was seeking to make, taking findings from theoretical research on physical and cognitive aging and using these findings to underpin applied research on older people. Hence the literature review includes work on a widely varied set of issues ranging from older people's reading of information on medicine containers to driving by older people and the changes that age appears to make for older pilots.

The third grouping in the relevant literature covers the traditions of user interface design that this study draws on, taken from the literature on people centered design, task centered design and participant design. This wide-ranging literature is not specifically covered in the literature review but it is assumed as part of the background in which the overall study is founded.

The section on older people and computing, (the fourth and final grouping in the relevant literature) was initially of limited relevance to my work on user interface design for older people. At the time the overall study began, the published research in this area had some studies on whether older people could use computers, some conflicting studies on recommended ways of training older people on computer tasks and papers that asked if older people could benefit from computer use. It had almost nothing of substance on user interface design for older users, see Czaja (1998), Hawthorn (1998a) and Czaja and Lee (2003) for backing for this contention. However over the later course of the thesis there has been a marked increase in the number of papers that address interface design for older people, both looking at specific topics (such as the order of selecting a feature and selecting an action to apply to that feature) and looking at general recommendations for interfaces for older users. As the research available in this area has grown so has the amount that it contributes to the emerging principles for designing for older users. As an aside these recent recommendations for interfaces for older users are largely in the area of web design. One of the distinguishing aspects of the current thesis is that it is one of few pieces of work looking at user interface design for applications to be used by older people.

7.6.3 An outline of the structure underlying the case studies

There is a common structure to these studies, more fully realized in some than in others. It is this common structure that is the concern of this and the following section. This section will simply outline the steps that underlie the structure of the individual studies as a set of numbered bullet points so as to allow the reader an overview of the approach. The subsequent section will then provide an expanded discussion of the concerns that underlie each point and the experience that supports them.

1. Find a development area where older people indicate that there is relevance and a genuine need.

2. Explore this development area, working with older people and their supporters to outline the requirements and context within which the system will be used and the need(s) met.

3. Examine the requirements and needs from step 2. in relation to the nature of aging as expressed by the literature, in relation to previous work on design for older users and in relation to previous observation of, and discussion with, older users.

4. Work with older people to develop a system that is designed using the interface design approach for older users. The interface design approach used here is described in detail in Chapter 8.

5. Recruit older participants who have not been able to adequately satisfy their needs in the chosen area by using mainstream software.

6. Conduct an evaluation of the performance of these participants on the system and of their satisfaction with the system.

7. Put the refined version into long term use with suitable users and obtain on-going feedback. Make further refinements and get the long term users to report on them.

8. Evaluate the observations from the study and report on what has been learnt about suitable interface design for older users.

9. Repeat the cycle within a different area of relevance to older users so as to check on and extend what has been suggested.

7.6.4 The rationale for the structure underlying the individual case studies

In this section (providing extended discussion of the steps that form the methodology underlying the research), the aim is to provide an indication of why the step was included in the methodology, a discussion of its rationale and implications and in addition, examples or extra description indicating how the step is actually applied.

1. *Find a development area where older people indicate that there is relevance and a genuine need.*

The overall aim of the research was to investigate suitable interface design for older users, but this implies that the older users involved in the research should be working at a level that gives a reasonable representation of the amount of effort and commitment that older users would be willing to apply in everyday use. The problems with user motivation in the comprehension experiments in the Dual Task pilot study showed that if older users did not see the tasks they were involved in as realistic or relevant to their needs their motivation suffered to an extent that made it hard to see their performance as representative of their real life abilities. Subsequent work with older users in the FileTutor and the SeniorMail studies supported the argument that, given an application that was felt to be credibly related to what the older participants wanted to achieve, the levels of motivation and the extent of persisting through initial difficulties increased greatly. It is argued that this more involved and motivated response is also more representative of realistic behavior by older users. Hence when researching older users' interaction with computer systems the example systems chosen or created should engage the older users. One route to obtaining such engagement is by developing example systems that are seen as relevant to the older users, by the older users. The way in which topics were found in the overall research was

a. By observing older users and seeing what they struggled with,
b. By talking with older users and their supporters about their use pattern, difficulties and wishes
c. By consulting with people who had a professional role supporting older users, in this case the SeniorNet tutors.

2. *Explore this development area, working with older people and their supporters to outline the requirements and context within which the system will be used and the need(s) met.*

Because the world of older people is very different from that of the researcher or designer there is a need to explore the nature of the area and the desired tasks and achievements that it contains from the perspective of the potential older users. This exploration was carried out personally by the researcher, it was not delegated to research assistants. One of the aims of the methodology is to give the researcher/developer direct engagement with older users.

It was also seen as important that this exploration was of a form that allowed, adapting Eisma et al's (2003) phrase, "answers to questions I did not know I should ask". Questionnaires were administered face to face with discussion about possible interpretation or answers that while true for a person did not fit the mandated format for filling out the response. Older people were observed working in the chosen area with mainstream solutions and their difficulties were noted. Focus groups were held not only with older users but also with their supporters. What was seen was not always what might have been expected. For example older users frequently carry out computing tasks with ongoing support from family and sometimes friends and this support can place considerable stress on the relationships involved, support was found to overload the older people's children at times and to be yet another theatre in which the guilts and demands of family relationships played out. It was much rarer that the idealized and romantic view of computer support as a route to expressing closeness and shared moments was found in focus group discussion, though this was often the children's initial intention in involving their parents with computing. Hence, as an example of emerging answers to important but unrecognized questions, one of the opportunities in successful design for older people may in fact be the reduction of the load that the older person's computing puts on supporters, with a consequent reduction in strain in the older person's relationships with family and / or friends.

3. *Examine the requirements and needs from step 2. in relation to the nature of aging as expressed by the literature, in relation to previous work on design for older users and in relation to previous observation of, and discussion with, older users.*

The design recommendations do not appear of themselves. As the designer considers possible solutions there is a major role for the knowledge of older people embodied in the literature and / or the ongoing observations of the older people who took part in the research. One way of viewing the literature on physical and cognitive aging is that each finding on the effects of aging represents a departure from the assumptions that a designer could reasonably make about what would work for younger users, hence the importance of checking ideas for interface design against the literature on physical and cognitive aging. But this background against which the interface design is prepared also includes building a personal skill set for the designer based on their ongoing interactions with, and observations of, older people in the context of the designer’s knowledge of aging.

The observations of the older participants during the background investigation and during usability trials should support the desirability of the individual recommendations, if I recommend that menus are not ideal for older users then this will be because I have observed cases where older users had problems with menus, typically in the background investigation that began the study. By itself such observations provide only a weak level of support for the recommendation, hence it is useful if the observations can in turn be supported by examining possible explanations for them in the light of findings from the literature on physical and cognitive aging.

Note that the older population is seen as being very diverse. It is not the case that each recommendation should suit all older users. In our ongoing example a number of older users may use menus with success. Instead what each recommendation should contribute is an increase in usability for some of the older population without significantly disadvantaging other older people. So can we design an alternative to menus that assists those older users who find them difficult while remaining satisfactory for older users who can use menus? Such trade-offs, I suggest, form an important part of designing for the mixed disability group that constitutes older users. For another example, recommendations on font size for the older group whose vision declines with age are potentially irrelevant or disadvantaging for those older people who retain acute vision in old age. In part what is needed in the recommendations is to establish workable trade-offs that mean a design for older users can be of use to a population with a wide mix of age-related disabilities. Providing the knowledge to decide what is "workable" in such trade-offs is again the role of the accumulated body of knowledge about older people's abilities as well as experiment and trial and error estimation.

The next four points (4, 5, 6, 7) deal with the way in which the research approach depended on observing the design process. Since the process of designing for older people is covered in Chapter 8, expanded information on these points is provided in that chapter.

4. *Work with older people to develop a system that is designed using the interface design approach for older users. The design* approach *used here is described in detail in Chapter 8.*

This step is in fact a series of steps that constitute an interface design approach for working with older users to produce interface designs aimed at the needs of older users. This interface design approach is described in detail in Chapter 8 and is one of the key components of the design guidelines that have emerged from the overall study. From the point of view of this chapter on research methodology the key point is that shaping the initial credible prototype involves considerable work with groups of older users in ways that are informal and promote discussion of problems involved. Such discussions provide considerable illumination of the issues that older people can face in using software.

5. *Recruit older participants who have not been able to adequately satisfy their needs in the chosen area by using mainstream software. Further detail is provided in Chapter 8.*

This reflects the concern with providing a quasi experimental approach in my studies. These people provide a good test case for showing that the design does provide the intended advantages. They are also people with a level of personal involvement in a useful design and so are well motivated to interact with the development process in a way that leads to a workable design. These were the people who found they needed SeniorNet assistance simply to get started with computers (and hence were good candidates for testing WinTutor), the people who had failed to learn how to manage files and folders (and hence were good candidates for testing FileTutor) and the people who had been unable to satisfactorily use standard email systems (and hence were good candidates for testing SeniorMail).

6. *Conduct an evaluation of the performance of these participants on the system and of their satisfaction with the system. Further detail is provided in Chapter 8.*

One of the key aspects of the way in which I worked was that the older users were supported by other older users as they did the usability tests or explored the design alternatives. The testing format allowed groups of people to "co-test" a prototype and discuss it as they did so. Groups of people who had attended different testing sessions were merged in later focus groups and commented on their experiences.

Some readers with a strong commitment to an experimental approach may be repelled by the fact that this means that the design principles include input that is distinctly impressionistic. My counter argument is that carefully collected impressions are not automatically an invalid basis for starting investigation of a new area and by making my design principles and research findings explicit I am making them available for later challenge and re-evaluation.

7. *Put the refined version into long term use with suitable users and obtain on-going feedback. Make further refinements and get the long term users to report on them. Further detail is provided in Chapter 8.*

As pointed out by Salthouse (1996) one of the significant limitations of laboratory investigation of older people is that the rates at which behaviors change will occur outside the timescale that is available to a laboratory study. There was also a concern that enthusiasm for a prototype during usability testing might not correspond with behavior during long term use in situations where the researcher was not present. Again it was felt that long term use gave a wider range of situations in which difficulties could manifest themselves and so by providing ways of capturing such difficulties one could both make a design more robust and obtain a wider set of relevant information for the overall research on older users.

Hence as part of the research informal long term follow up studies were included. The two interactive tutorial systems that were intended for relatively brief use by older users as they learnt computing skills were never the less capable of being placed in a situation of long term use and evaluation by making them available to New Zealand SeniorNet branches and obtaining feedback as tutors gained more experience of using the tutorials and tracking sales to confirm that branches continued to find the products useful, instead of having had a first flush of enthusiasm that died on further acquaintance with the tutorials. Similarly for SeniorMail which is a product intended for long term use, although the usability testing was short term and did not really address long term suitability, a small pool of long term users was established to check if they would continue to find the product desirable. They did.

8. *Evaluate the observations from the study and report on what has been learnt about suitable interface design for older users.*

Another departure from the typical model of user centered or task centered development is that there were at least two outputs, not simply the refined product but also a contribution to understanding of the interface issues that arose for the older users. It should be noted here that two of the projects, WinTutor and FileTutor also contributed useful understanding of the context in which current older users operate, within recently and partially acquired computer knowledge. This involves looking at the areas of understanding they may have trouble with (WinTutor) and at the way in which on-line instruction can be designed so as to be useful to older learners (WinTutor and FileTutor). The point here is that, in making provisional recommendations for a new area of understanding, there is a shortage of situations in which researchers can interact with older users and challenge, reshape and extend the knowledge gained so far. Each attempt at developing with and for older users, whether successful or unsuccessful, offers a chance to add to the observational base and to analyze the existing understanding in terms of the new results.

9. *Repeat the cycle within a different area of relevance to older users so as to check on and extend what has been suggested.*

Repeated demonstrations of success with different exemplars of the design approach are needed in order to provide an acceptable level of support for the findings. Given the quasi experimental and observational approach used, a single study provides a limited level of support for the findings. Hence the current thesis consists of several studies that examine older users' performance with designs that were developed using the design approach. It is argued that, by this means, the thesis provides an acceptable level of support for the recommendations that emerge by repeatedly showing examples of interface design that follow the for older users and provide a way for older users to perform tasks that they could not achieve using other applications or approaches.

7.7 Conclusion

In this chapter the rational for the research methodology developed in this thesis has been described. The aims of the overall study were first revisited. Then the lack of fit of an experimental approach with the overall aims was discussed. This was followed by a critical look at other established techniques and what they could offer to a research approach given the aims of the study. A composite technique that borrowed from these techniques was then set out. This will now be followed in Chapter 8 by a discussion of the design approach that was developed to work appropriately with older people during such development. Further reflection on the combination of the research methodology and the design approach occurs in Chapter 9 where my approaches are compared and contrasted with the independently developed approaches of the UTOPIA project.

Chapter 8 Designing and working with older people

8.1 Introduction

One might question why a thesis devoted to HCI recommendations for developing suitable interface designs for older users should devote a chapter to appropriate ways of working with older people. The first reason is that the design recommendations include a strong recommendation that the interface design is developed from a basis of frequent interaction with older people as to the suitability of the interface details. This in turn is based on the experience gained in the difference between my expectations of what should suit older users and the reality. Even though I have deliberately acquired a level of knowledge of the effects of aging that would be unusual in most interface designers I still found that I would not have achieved workable designs for older people without the on-going guidance of my older testers.

Having reached a position where I am recommending that continuing interaction with older people is essential for good design for older people I then turn to my observations of interaction between older people and younger relatives, supporters and teachers and include reflections on my own interactions with older people throughout the research. From my experience it is easy to create difficulties in interacting with older people that impede efforts to assist them, threaten an on-going relationship with those people, reduce the accuracy of the information obtained and may in fact influence some older people to make decisions about their potential competence with respect to computing that are not in their best interests. There is another side to this. In those interactions with older people where I have avoided the various pitfalls, I have found working with the older people who took part in this study to be a thoroughly enjoyable activity. I suggest that interaction with older people that is free flowing and enjoyable on both sides gives a greater chance of improved design quality.

This chapter will look at a summary of the approach used in designing for older people and then move to the difficulties that can occur in working with older people. The chapter will then look at three aspects of techniques for reducing these difficulties. The three areas of technique covered are; appropriate communication with older people, techniques for developing applications with older people and finally considerations on how to work ethically with older people. In fact these divisions are somewhat artificial and in actually working with older people the techniques used draw from all these areas.

8.2 An approach to creating interface designs for older people

The thesis gives wide ranging consideration of issues to be considered when designing for older people. As previously noted the design approach can be considered as an adaptation to User Centered Design or Task Centered Design rather than a radically new approach. What is attempted here is to summarize the recommendations for doing interface design for older people as a bullet pointed list. However one of the contentions of the thesis is that there is no narrow or simply expressible solution to designing for older people, hence a list such as this is regarded as a lead in to a wider set of concerns.

1. Before designing for older people, designers need to sensitize themselves to the realities of older computer users. This involves study of the literature on aging as related to design, including study of the rationale behind successful examples of design for older users. Each of the effects of aging that are relevant to interface design examined in the literature review can be seen not only as a need of some older users but also as a gap in the in-built assumptions of (younger) designers that they are designing for someone who is generally similar to themselves. As it stands the literature review has identified over one hundred and fifty such departures from similarity between the younger designer and older users. This is before differences (from the younger designer) in older people's specific computing or operating system knowledge are considered.
2. The process of designers sensitizing themselves to the realities of older computer users also includes sensitive observation of, and involvement with, older people. This is not part of a typical design process for a young to middle aged target group. It is suggested that even skilled designers for a young to middle aged target group need to acquire extra skills and understanding in order to undertake effective design for older people and it is suggested that designers without experience of older users may find difficulty in appreciating how important this "enculturation" stage is.
3. Requirements definition obviously needs exploration of older people's needs and aims related to the proposed application but this exploration needs to be done

within the social and physical context in which older people will use the application. This includes working with older people's supporters, visiting older peoples' dwellings and discussions with experts in aspects of aging. However the core is in finding ways of communicating with older people themselves about what they need and can do. This moves requirements gathering for older peopele to the area of applied ethnography as described by Sanders (2000).

4. Unlike most product development the focus of requirements definition for older people is not on adding new features to standard applications but on pruning features not needed by older people and in designing the remaining needed features so as to be usable for a variety of age restricted users.
5. Where the application is a version of a standard computing application that is being designed to be suitable for older users, observation of older people attempting to work with standard applications in the application area is used to identify core areas of difficulty that these applications pose for older people. It is possible however that some applications for older users may be novel, such as games for memory training or increasing dexterity.
6. The design team needs to recruit older people who can act on a near daily basis as in-house testers. It may also be useful to recruit a further pool of older people who can be involved in additional testing during development on a less frequent basis so that there is a check on "capture" of the in-house testers by the design team.
7. The design team needs to construct hi-fidelity code based initial credible prototypes that can be seen to address the general concerns of older users and the core areas of difficulty in the application area being designed for. Unfortunately it is possible that the initial attempts at a credible prototype may be sufficiently far from what would be usable that they could discourage the in-house testers. It may be that there should be an initial period of investigation of what constitutes an initial credible design with a group of less involved older people before the in-house testers are asked to take up long term involvement with the project.
8. The initial credible prototype is then refined and extended by working with the in-house testers in order to increase the ease with which the older people involved with the development can meet the aims identified in the requirements definition.

9. The exploration of older people, started in the early stages of the project, continues over the life of the project. Firstly because of the difficulty of adequate communication between the culture of the younger highly technical designer and that of the older users there is no clear point at which the designer can say they understand all the requirements. Secondly because the older population is highly variable and the number of in-house testers is limited, experience with different older people has a high chance of giving fresh insights.
10. As in any standard interface design process the prototype is then tested with people from the target group who were not involved in the design development so as to identify remaining usability issues. These usability issues are noted, fixed and undergo further usability testing. However the process of usability testing may be more informal than it would be with younger users and involve group evaluation and discussion in order to support the needs of working effectively and ethically with older people. Depending on the application, testing may also need to consider learnability and to be conducted over longer time frames than would be the case for a younger target group.

8.3 Problems in working with older people

This section of the chapter may appear to paint a picture of unrelieved gloom about the issue of communication between younger researcher/designer and older people. In fact some errors are inevitable and older people are used to dealing with communication problems from the young. Part of what makes dealing with these issues practical is good will, persistence and effort on the part of the older parties to the interaction. Another part of what the younger person can bring to the interaction is awareness of the issues, good humor, patience and an appreciation of the older people as people who are finding strategies to cope with difficulties that will affect us in turn.

The points that follow cover the main problems that were encountered when working with older people in this research. After that section 8.4 will examine these issues in more detail and discuss the solutions used to overcome them.

- **Differing experience**

  It would be unusual for a younger researcher / designer to share the limits of perception, manipulation, memory and cognition that are part of being old. My experience is that these effects are difficult to design for when one is designing from an impersonal knowledge of aging. Bluntly you as a designer will not adjust your expectations of what older people can and cannot manage to a realistic level until you observe older people working with computers. Working with older people in a way that lets them share their perspective on possible designs becomes a key aspect of producing successful designs for older users.

- **Issues of respect**

  We live in a culture where older people are stereotyped as being generally incompetent in many areas including working with technology. In this situation the younger researcher / designer is in danger of confirming the older person's expectation that they will be treated as less than competent and inferior. Older people are likely to "buy into" a picture of their general incompetence. The older person in turn is likely to collude with the younger researcher / designer in producing unrealistically low levels of performance.

- **Balance of power and deference**

  In communication between a younger researcher / designer and an older person about technical issues the younger researcher / designer has more power. There are negative consequences that can come from this. If the older person responds to the situation by "going along" with the younger researcher / designer, then the younger researcher / designer is largely left with their own view of the older person's world (which in my view is inadequate to support good design). The older person may experience such interaction as unsatisfying and de-motivating. A response to this may be that the older person withdraws, offering less, becoming less motivated and being less likely to be available for further work with the younger researcher / designer.

- **Communication style**

  The way we as younger people speak to older people can lead to failures in communication. Younger people can be observed adopting two styles of speech that do not suit older people. Either they make no allowances for the older person's age and inexperience and talk to them as they would to younger people leading to overloading the older person with jargon and a too rapid flow of new concepts. Alternately younger people can adopt a form of baby talk known as "Elderspeak" which is not simply demeaning but also has been shown to be confusing for the older recipients. The younger researcher / designer walks a thin line between being seen as patronizing and being incomprehensible. Either situation destroys the effective two way communication that is needed to support realistic development for older people.

- **Time issues**

  Tasks, especially unfamiliar tasks can be expected to take longer for older people. If older people are asked to hurry on tasks they are likely to show a drop in performance that is larger than younger people facing a similar request to speed things up. This can lead to problems where the younger researcher / designer is insufficiently aware of these issues and plans such things as testing sessions on a time scale suited for younger people or where the younger researcher / designer is tempted to rush some part of an encounter with older people.

- **Information gathering**

  The standard methods of information gathering have some particular problems when used with older people. Interviews can be badly affected by the issue of power imbalance and may in addition constrain the researcher from venturing outside of a set range of topics. Questionnaires may stumble on the lack of a shared vocabulary for technical matters between younger researchers / designers and older people. Focus groups with older people have been reported to be hard to conduct in a way that stays on topic and avoids frustrating the rest of the group, Barret (2000).

- **Care of older people**

  Older people may have more difficulty in coping with unfamiliar environments with respect to route finding and access issues. Asking older people to drive to a campus and then find their way to a usability lab can add extra stress that potentially may impact performance. Problems anticipated by older would-be volunteers in this regard may affect the self-selection of those who end up volunteering, see the next section.

- **Sampling issues**

  There are two common problems in getting representative older people. In general the people who volunteer for all types of research are usually better educated and of higher status than the population average. This selection bias effect may be increased with older people in that the older people more affected by age may be; less able to get themselves to the research setting, less likely to hear about research requests for volunteers, more likely to see themselves as unworthy or to feel that they would perform poorly. Yet as found in the FileTutor study the less able older volunteers made a disproportionately valuable contribution. The overall effect of this sort of sampling bias is that researchers and designers interested in working on interface requirements for older people are likely to miss the very volunteers who will be most useful.

  The other issue is that the older population is not a single, simple, normally distributed population. Age is a surrogate variable and the effects of aging are loosely associated with actual age and with each other. So the older population is actually many sub-populations ranging on different disabilities and these populations overlap with some older people having no major disabilities, some having only a single significant age related disability and some having more than one such problem. Given that each different disability can have different implications for interface design it will not be easy to sample a range of older people representing all or most of the levels of disability in the older population.

8.4 Appropriate ways of working with older people

A younger designer for older users needs to work with older people during needs analysis, during product development and during product evaluation. A younger researcher may be involved with older people in similar areas or in more general information gathering. This section looks at ways in which working with older people was facilitated in the current study. I have tried a variety of ways of working with the older people who participated in the study, some appeared to be productive and resulted in cheerful participation by the older people, some did not. This section is an attempt to report on how I have worked in a way that allows other people to benefit from my experience. We will look at the following points:

- Working with older people as if they came from a separate culture.
- Issues of establishing a framework where the older people see themselves as respected.
- Questions of the balance of power between researcher and older participants.
- Concerns about communication styles used.
- The problems in building time constraints into work with older people.
- Appropriate techniques of information gathering.
- Care of older participants.
- Approaches to sampling when acquiring groups of older participants.

8.4.1 Differing experience – older people as a separate culture

The first issue in working with older people is that the older person is operating from a basis of a different experience of being a person that the younger one. Younger professionals usually do not have experience of personally coping with a degree of memory loss, learning disabilities, bodily discomfort, reduced ability to direct attention, restricted manipulative skills, poor hearing and poor vision combined with limits to one's cognitive ability when venturing outside familiar situations. Nor are younger professionals yet realistically engaged with having a limited lifespan and a general expectation of decline. Nor are they likely to exist in a situation where reduced respect occurs because of stereotyping.

While gaining experience of older users may be difficult to fit into a development budget it is important in forming realistic expectations. It appears that simply being told of older people's issues does not have sufficient impact. Newell et al (2005) found that telling professional and competent interface designers about the difficulties faced by older people did not adjust the designers' expectations to a realistic view of what older people could cope with. Newell's group arranged for the designers to meet with and observe older people who were representative of the group being designed for and recorded the designers' vocal amazement at the gap between the older people and the users the designers usually worked with, "…they know absolutely nothing..". In fact the behavior that the designers observed corresponded well with the behavior that Newell's group had told the designers to expect, but the designers had discounted the advice in favor of their experiences with younger, more competent users.

One of the problems that younger computer professionals or even friends and relatives may bring to dialog with older people is that the younger people are embedded in a culture where personal respect can be gained (or lost) by their level of understanding of computer terms and techniques. This is a potential barrier to being accepting of older people when they display much lesser skill levels. In the Unitec classes it appeared that, without directly communicating the viewpoint, both students and tutors shared the view that the older users were unsuited for learning computer skills. This blinded those involved to the potential for simple technical interventions to alter and improve the learning situation.

Because the world of older people is very different from that of the researcher or designer there is a need to explore the nature of the area and the desired tasks and achievements that it contains from the perspective of the potential older users. There is a need to go "out into the field" so that older people are observed in a realistic environment. In my own research this exploration was carried out personally by the researcher, it was not delegated to research assistants. One of the aims of the design methodology is to give the researcher/developer direct and personal engagement with older users. Actually visiting older people and seeing (as well as talking about) how they worked with computers in their homes was useful.

My experience is that there is a difference in the way that older people behave among other older people compared with the way that older people behave with younger people. As one of my informants said, discussing memory lapses, "its embarrassing to have younger people know about my memory, my older friends just take it as normal". One of the approaches I have used extensively is to work with groups of older people. This has, I believe, several effects. The older people can be seen interacting with each other in a way that is more natural. The older people are also in the majority during the interaction and so the younger researcher is more likely to adapt to the temporary majority culture rather than dominate it. There may also be advantages in being somewhat more accepted by older people if one is a late middle aged and graying researcher, I was in my mid to late fifties while this research was undertaken.

As part of gaining a wider background experience of older people there is value in talking with those who are associated with older people, such as relations and supporters, tutors who specialize in training older users and rest home staff. I found there was also considerable benefit in observing people who were not especially sympathetic to older people, in situations where they needed to work with older people, such as the Unitec tutors.

It is not enough to simply ask that interface developers get involved with potential older users. There are a number of pitfalls that skilled computer professionals are likely to fall into when trying to work with older users that can make the experience unproductive. Newell's group has tried to address this by using academics who are already skilled in working with older users to effectively act as middlemen between older research participants and industrial developers. This is a useful approach but may not be readily available to all developers who want to develop for older users.

8.4.2 Issues of respect

Older people are coping with a significant change from their younger selves. While some cultures such as traditional Chinese or Maori culture regard older people as automatically deserving of respect, current Western culture is less respectful. Older people are facing a shift to a less respected role, some of the loss of respect is external and some of the loss of respect is internal. Assuming that their competence has declined and coping with threats to their internal self respect can lead to older people adopting a number of strategies that can affect useful communication. These include deference and apology. Older people are likely to "go along" with opinions that they receive from the higher status young researcher/designer. Older people are also likely to give false assurances about the value of the design because the designer "ought" to be rewarded for having put in, "all that work for older people".

Older people are likely to apologize for their perceived incompetence, what I refer to as the "silly old me" syndrome. One result of allowing this form of behavior is that the older person is likely to underestimate their potential ability and to interpret not knowing some key fact as evidence of general incompetence rather than evidence of the much more neutral point that they have not yet learnt the particular skill or concept. There is a value in gently challenging "silly old me" responses and both reframing the issue as a need to learn a specific item and getting the older person to try out actions on the computer rather than living in their expectations of what might happen. As an illustration of redirecting older people's self perception, in the FileTutor study almost none of the participants had installed software. As part of the study they needed to take a copy of the program home and install it on their home machines. None of the participants initially felt that they would be able to do this. In each of the groups involved I asked who felt least confident about doing this. I then got this person to sit down at a PC and follow a set of printed instructions with guidance from me, (installation was actually very simple). After this first experience of succeeding I got the same person to repeat the installation without guidance and to do this again if necessary while the rest of the group watched. My assumption is that the other members of the group both saw repeated examples of how to do the installation and that they also revised their expectations of their own ability in terms of "If she can do it then I can". The end result was that all of the participants in the FileTutor study successfully installed the program at home.

Failures on assigned tasks with prototypes can potentially be seen, by the older person attempting the task, as evidence of their own incompetence. Giving the older participant a single prototype and asking them to complete a task seemed to feed into the older person's expectation of failure. This was in spite of emphasizing that the test was of the software, not the user. A better approach was to present alternative design fragments and ask the older participants to try them so as to see which one was better for them.

This focused the source of the problem on the interface design rather than on the older person's limitations.

In small group situations individual failures seemed to be handled more robustly with the older people using humor to note the fact that they were having problems and then using group support and suggestions to either try other approaches or to suggest that the problem lay with the current version of the software. Older people observed working alone tended to explore less and to give up at an earlier stage. The presence of multiple older people does not, however, automatically constitute a supportive group. An example of this was that in the Unitec classes the older people were effectively isolated by a situation where talking with each other would have been "talking in class". Testing or exploration sessions with small groups need to be explicitly structured so that interaction and mutual support among the older participants are seen as approved activities.

There is a need to show the older people involved that they are valued and that there is a strong possibility that their ideas and understandings of their experience with the test software or with computing in general are going to be valued, understood and acted on. There was a very positive response when older participants found that suggestions that they had made in a previous session had a) been acted on and b) that the changes turned out to make their use of the software easier. Again the older in-house testers were motivated when they saw their suggestions taken up.

Respect and acceptance of the older participants seems to be a necessary stance. Computer professionals tend to be competitive with respect to the depth of computer knowledge that they possess. In addition there are reports of developers blaming "stupid" users for difficulties found with interfaces, Knight and Jefsioutine (2002). Older people can represent extreme cases of uninformed users and could potentially trigger strongly negative responses from developers with respect to the gaps in the older people's computing knowledge. One should expect older people to be fairly accurate in evaluating the underlying attitude of the researcher over prolonged periods of informal interaction so that even politely disguised rejection will be counter-productive. My personal stance is one of understanding the extent of the learning problem older people face, respect for their making the attempt, empathic pleasure when they succeed and respect and patience in the face of even prolonged difficulties. I can still expect things that are currently beyond the older person I am working with, become impatient or expect knowledge that is not present but overall I do not find that these responses are a major feature of my interaction with older people. It appears to be the case that with more exposure to a wide variety of older people attempting to work with computers the amount of respect I have for them has increased. Generally I found I liked being in the company of the older people who have taken part in these studies and that this attitude improved my work with them.

8.4.3 Balance of power and deference

Interactions between younger researchers / designers and older people typically have an obvious imbalance in power in favor of the younger person, especially if the conversation is defined in terms of technology transfer. Apart form the ethical concern about lack of empowerment there is a practical concern since the imbalance of power is likely to put the older person in a passive role where they react to suggestions by the younger researcher / designer but do little volunteering. This raises some issues, given the younger researcher's / designer's lack of deep experience of aging, they are in a poor position to guide a two way conversation that is really about aging in combination with technology transfer. Again the aim of the investigation is to elicit understanding of how the older person will behave with the technology in their own environment, and this environment does not include a dominant younger researcher / designer . Finally one of the characteristics of power imbalance in communication is deference.

The problem where older people defer to the younger researcher / designer is that this distorts the information provided. In situations of deference the subordinate person is less likely to volunteer information. They are also more likely to self-censure and to support the expressed views of the dominant person even when these run counter to the views and experiences of the person doing the deferring. In part older people can be grateful to the younger researcher / designer for regarding them (the older person) as useful and worth talking to and for being concerned with the worthy aim of helping older people. In part the older people may censure negative responses as being ungrateful or indicators that the older person has failed to understand things yet again and the younger researcher / designer should not be pestered with this. So older people working with a younger researcher / designer can tell them what it is thought that they want to hear, "this is a wonderful design, its very clever and it should be very good for older people” (<unspoken> “except for silly old me”). Since this is in fact exactly what I do want to hear, as distinct from what I need to hear, this message is seductive.

It seems useful to reframe the way of looking at an interaction between a younger researcher/designer and an older person. A person with deep experience of technology is talking with someone who conspicuously lacks that experience. Simultaneously a person who lacks direct experience of being old is talking with a person who has deep knowledge of being old. In both cases a knowledgeable and experienced person is talking with a much less competent person. I made it plain to the older people I worked with that I did not know as much as I needed about what it was like to be old and that I was looking to them for guidance.

Working with small groups of older people became a key technique in my research. The enjoyment that the older people took in being part of a small group trying new software or learning new skills was evident. It seemed that they found the experience socially rewarding. It could also be said that by being in a group the older participants were empowered judging by the increased willingness to voice criticisms and to try out new actions with the software. The older participants seemed to benefit from working in a setting where the limitations of aging were accepted and understood.

Small groups had been used in the Dual Task pilot study and it was apparent that it was important to the volunteers to have other older people as company and moral support during the sessions. The presence of other older users also encouraged informal comments that helped understand how the participants were experiencing the interfaces being tested. Small groups were used again in the FileTutor study evaluation and in the development (but not evaluation) of SeniorMail.

8.4.4 Communication style

Younger people seem to find difficulty in finding an appropriate style of talking with older people. For example the common experience that older participants referred to was of relatives and friends who intended to be helpful but who left the older people bewildered and feeling inadequate. The key points made were that such “helpers” went too fast, introduced too many new ideas, did demonstrations the older people got lost in, missed explaining key steps, were impatient, did not give the older person time to practice, became frustrated when the older person made mistakes, assumed that the older people knew terms and concepts that in fact they did not and assumed that what was simple to the "helper" was automatically simple to the older person. I tended to joke about this with older participants, using what we ended up calling the "flying fingers" situation. The "helper" sits in front of the screen, the older person looks awkwardly over their shoulder and the "helper" proceeds with a rapid hands on run through of the task involved saying, "you see, you do this, then this and you follow it with this, there, its simple". The "helper" thus overwhelms the older person with actions performed at a pace deriving from the "helper's" near automated performance of the task (and by the nature of automated performance leaving out explanations of significant aspects of that performance), then the "helper" ends with a statement that double binds the older person by stating that the incomprehensible task just seen is simple and implying that the older person should also see it as simple. The sad thing was that <u>all</u> of the older people I talked with said that this situation was familiar.

Although the focus of section 8.3 is on communication that facilitates development, because of the frequent gaps in older people's computing knowledge some of a developer's time in working with older people will involve training the older people in simple (to the younger researcher / designer) procedures. Effective communication in training older users, in my experience, must not be rushed and must not be flavored by the attitude that the younger researcher / designer thinks the point is trivial. My approach in training older users involves a very basic explanation of the intended aim, followed by talking through a slow, step by step demonstration of the technique. This demonstration is done sitting beside the older person in such a way that the older person is directly in front of the screen. This is followed by a guided hands on repetition of the task by the older person after which the older person attempts the task with minimal and reducing levels of guidance, possibly several times. It was very common that the older people would then ask to make notes of what they had covered. Several of these older people made the statement that it was important to them that these notes be in their own words.

Particularly in the Unitec classes for teaching older people computer skills it was apparent that some of the material that gave the older beginners difficulty was introduced because the tutors had a somewhat rigid concept of what people "should" know about computing. One of the tutors characterized such knowledge as needed to have a "respectable" understanding of computing. A more useful approach is to ask whether particular pieces of computing knowledge are actually needed to support useful (and basic) computing behavior by older people. If not needed, extra knowledge is a distraction and a source of confusion for older beginners. The success of the “minimal manual” approach of the FileTutor study points to the positive benefits of stripping non operational knowledge from any syllabus for older people.

When communication with older people feels difficult younger people may mistakenly attempt to fix matters by unconsciously adopting a communication pattern described under the name “Elderspeak”, see Kemper et al (1998a). Older people report that they find elderspeak demeaning. In general elderspeak consists of a pattern of language where the younger speaker

- Uses a singsong voice, with changing pitch and tone and exaggerating key words.
- Speaks more slowly.
- Uses terms like "honey" or "dear."
- Uses statements that sound like questions but which in fact coerce the older person. “We are ready for our dinner aren’t we dear”
- Uses limited (childish) vocabulary.
- Simplifies the length and complexity of sentences.
- Repeats or paraphrases what has just been said by the older person but in a way that puts the older speaker in a role as an incompetent communicator.

Elderspeak appears to be more common when dealing with frail elderly people. It is noteworthy that older people do not use it with each other. One of the key messages that appears to emerge from elderspeak is that there is a significant difficulty in communicating with the older person and that this difficulty is the older person’s fault.

It appears that elderspeak actually impairs communication, see Kemper et al (1998b). Experiments where older people were paired with younger partners in a map reading task and the older partners were instructed not to ask the younger partner to adjust their communication style two points were observed. The younger partners tended to lapse into elderspeak and the older people (who had in fact found the required map location) expressed uncertainty as to whether they had really found the place of interest to the younger partner.

The latter three components of elderspeak may in fact be helpful if used in ways that accommodate to the older person rather than belittling them and without the patronizing baggage of the first four aspects listed, see Kemper. and Harden (1999).

- Using limited and simplified (but not childish) vocabulary (with respect to jargon).
- Simplifying the length and complexity of sentences.
- Repeating or paraphrasing what has just been said with an explicit aim of allowing the older person to correct or amplify the younger person's understanding.

When talking with older people or with older groups I found that I needed to be cautious in not rushing older people to conclusions and to allow time for them to clarify their statements or to allow the older group to amplify and re-interpret comments before I did.

Extended analogy and conceptual explanation are not regarded as useful in skill training for older adults, Morrell et al. (2000), but I found that limited analogies taken from the presumed experiences of the older generation did appear to be useful in explaining things from the role of prototypes. As an example to explain the limited functionality of prototypes an analogy to the false shop fronts used in Western movies worked well. As another example when explaining the role of folders in email systems, "Suppose you use some shoeboxes to store your mail. You go out and get the mail and come back in and drop it in a shoe box, that's your In Box. Then you go through and read the mail and put anything you want to keep in a second shoebox, that's your Saved Emails". However I found that there was always a danger of my explanations becoming over involved and I needed to be aware of indications of disengagement or lack of comprehension from my older listeners.

8.4.5 Time issues

Older people are slower to complete activities, especially novel activities. It is also suggested that the performance of older people is detrimentally affected by pressure to complete tasks under time restrictions. However younger researchers /designers who are not aware of these issues may in fact both upset the older participants and obtain unrealistically low levels of performance, by setting schedules of activities with older participants that are suited to younger people. This sort of effect was evident in the

Unitec classes where tutors essentially abandoned those older people who could not keep up.

My approach to reducing time pressure was to schedule multiple sessions with the same older participants so that there was less pressure on me or the older people to achieve a particular piece of testing in a particular session. Although the literature is ambiguous on the ability of older people to maintain long periods of sustained attention, the people in the Dual Task study complained that they had been worked too hard for too long so that testing sessions were redesigned in the subsequent research. This redesign involved much less in the way of formal protocols. There were shorter periods on any one activity, breaks for refreshment and discussion and the older people were allowed to both self time and to talk with other older people engaged on the same task.

8.4.6 Information gathering

The standard forms of information gathering, interviews, questionnaires and focus groups have been developed with a focus on adult and task or domain competent respondents. For a variety of reasons when used with older people these techniques appear to require some modifications.

Interviews

One problem with one-on-one interviews is that the power imbalance between the researcher/designer and the older person, combined with the researcher/designer's lack of knowledge of the older person's culture, can lead to interviews missing important information and to the older person not taking opportunities to expand on some of their concerns. Although I engaged in informal discussions with almost any older person I could find I made the decision that in formal interview situations my existing views would be too likely to dominate the exchange. Discussions with groups of older people replaced interviews in my research.

Questionnaires

Questionnaires can be problematic when used with older people to gain computer related information. Because of the difficulty of clearly expressing computer concepts in ways that will be understood by people without some knowledge of computer jargon and computer function it is likely that questions will receive unintended interpretations both when answered by older people and again when the answers are being considered by the researcher. It is also likely that because of the difficulty with the question framer's obtaining a realistic overview of the context within which the older person will answer the questions useful information will be missed.

Questionnaires were used face to face often as a warm up activity for groups of older people. One of the observations from this was that the assumptions that the older people initially brought to the questions were often distinct from the intention intended by the researcher. This was despite pretesting of the questions. Discussion of the questions (and of why they were so easy to miss-interpret) by the group tended to add extra information. This matches the experience and recommendations of Eisma et al. (2003). In addition the discussion of what the questions (and answers) should be, shifted the power balance so that the older people felt encouraged to speak out. One factor contributing to this effect was that the researcher's wishes as (miss-)represented by the questions were seen to be much more flexible than the older people had imagined. Another factor is that within groups of older people there is a culture of greater tolerance and support for the mishaps of old age, given group support there was less concern as to whether the researcher approved of an answer or disapproved of a misinterpretation. The older people initially seemed to focus on there being a right or wrong answer and to be stuck when they did not know how to make the question fit with their own experience. My impression is that the older people were uncomfortable if the question could not be answered literally. "How often do you use the internet per day", could cause anxiety in older people who used the internet possibly once a week or many times on one day and not on others, the question in effect forced them to make a wrong answer. Remember that making mistakes has been found to have a greater effect on older people than on younger people. Older people faced with a series of forced errors such as this are unlikely to find a self-administered questionnaire a good beginning to a usability session.

Focus groups

It has been noted that focus groups with older people are difficult to run effectively, see Barret (2000) for a summary of the problems and possible responses. The problems reported are that it is difficult to keep the group to the intended topics and that some older persons are insensitive about the effects of their communication on other people so that long and irrelevant communications may alienate the other people attending the group.

However in the focus groups I tried, working with independent home living older people and with rest home volunteers, these themes were minor. One possible difference was that the focus groups were carried out after the participants had all undertaken a similar activity, either the dual task study experiments, the FileTutor evaluation sessions or had listened to a rest home presentation on email. It seems possible that the common experience and the fact that one of the main themes of the focus group was to discuss and evaluate that experience meant that there was mutual interest in what other people had to say and that the participants all had recent experience that was relevant to the discussion. This may have explained the observation that they were less likely to make irrelevant contributions. Again in the rest home situation the group of older people already knew each other and may have developed suitable patterns for workable communication.

It may be worth considering the personality of the younger researcher / designer when looking at how easy the researcher finds it to control a focus group of older people. I am a somewhat authoritarian middle-aged male with considerable experience in managing discussions in small classes of adult students.

Informal group work

Groups of older people, especially groups comprised of existing friends can help overcome the typical deference to the researcher/designer. They may also create a situation where the researcher/designer more readily adapts to the majority culture within the group. The pattern used in much of the research was to work with groups of two to four older people rather than individuals. Several times this was done by having "Computerware" parties where an older couple would invite another couple to their home and the four would work as a group using laptops on the dining room table to evaluate alternative software features. These were found to be enjoyable social events and productive in establishing better alternatives or in critiquing software features. Note that acceptance of home visits is culture dependant, another researcher working in North England pointed out that inviting another person into one's home was uncommon in a North England context and it seemed likely that older people in that culture would feel uncomfortable doing so, Zajicek (2004). However for Zajicek, gatherings of older people in social centers that were already part of their everyday lives served a similar purpose.

Usability sessions with older people were structured so that afternoon or morning tea breaks occurred in the middle of the sessions and the researcher later made notes on any informal discussion in these breaks that added information about the participants responses in the evaluation sessions.

When working with groups of older people there is an issue for the researcher of paying attention to multiple users. I used a number of techniques to work around this. The participants were given an explicit role in pointing problems out to the researcher. In addition when people encountered problems and asked other participants for help, the shift from working alone at a task to discussion was easy to notice. It was then acceptable to change position and join the discussion, usually after allowing enough time to pass so that the older people had formed their own clear idea of what was wrong and possible solutions if any. This worked well. Applications and design fragments had been already examined by the older in-house testers and modified in response to their views. This reduced the rate at which new problems were discovered. The interface development and testing was broken up into testing of small fragments and sections of the software rather than testing the whole application at once. The testing was repeated on different groups so that for example in the FileTutor study there were 8 groups (a total of 25 people) involved in the testing. Group size was kept small, ranging from 2 to 4 and in a single case 5. My experience was that groups of 3 or 4 were optimum.

Given these techniques one observer could cope with the amount of data generated. For example in the FileTutor study, the interactive tutorial was already partly "debugged", it had been informally tested as the screens were developed on the in-house testers and on any available person over 50 and this reduced the rate at which problems were found during usability testing. Up to 30 problems were reported in a two hour group session , but many were simple, or repeats of problems found earlier by other volunteers so that recording problems and assisting the student to progress was not time consuming. It was found that a single observer was able to cope reasonably well. Notes taken during each session were revised at the end of the session. Understanding of the problems recorded was checked against the FileTutor screen involved. There was usually a fair amount of time between problems so that there was time to observe ordinary interaction and to intervene to ask participants what they understood at particular points.

8.4.7 Care of older people

Some older people will have, or may expect, difficulties with getting to new venues. They may have difficulty way finding in new areas of a city, following complex directions can be a problem, walking may be restricted to short distances, there may be problems in activities such as climbing stairs. Bladder control may be such that easy access to a toilet is important. Remembering to keep appointments made well in advance may also be an issue. Maintaining task focus over long periods of time may be unpleasant. Some older people may have expectations of getting lost and a lack of confidence in new surroundings. The key point is that issues that may seem non-issues to the more able younger researcher / designer can be significant for older participants and require the younger researcher / designer to think (yet again) outside of their usual assumptions.

Meeting strange people in strange surroundings may disconcert some older people. I made a point of making initial phone contact with the older volunteer and explaining what was intended, how they would find the place where research was going to be done, ask about any difficulties they might have, for example a non-driver might need to be picked up from a bus stop or a volunteer may need reassuring that there is lift rather than stair access. If there is a signage trail (recommended) from the parking area to the site this can be explained at this point. This initial conversation serves to provide the older volunteer with a realistic expectation of what is involved and thus defuse worry but it also serves as a social icebreaker, in that the older person now has had a friendly interaction with the researcher / designer. Finding a particularly clear signage trail from car park to lab resulted in older people who arrived feeling pleased, cared for and in an environment that the researcher was willing to adapt to cater for them as older people.

I also used the initial phone contact to describe what the volunteer was going to do and check (without being patronizing) that this was understood by the older person. I also checked the older person’s existing computer experience if the particular project assumed pre-existing computer knowledge. An example was the FileTutor usability studies, twice against my better judgment I was persuaded by an older volunteer to let them take part when it was clear they had minimal experience. In both cases the older person had a miserable experience and with hindsight should not have been included.

It is obviously desirable that older users are comfortable and feel cared for during sessions. Part of this lies in looking after a number of simple nuts and bolts issues. When participants were accepted onto the project they were sent a letter or email confirming the location, times and dates of their 3 sessions as well as a further explanation of what was involved in the project and a statement that they would be given a reminder shortly before their sessions were due.

A lot of attention was given to providing advance information, giving reminders as sessions approached, accessibility, booking nearby parking and signage trails. Reception staff around a large and scattered campus were alerted to approach and direct participants if they got lost. The research area was new, tidy and well furnished and attention was paid to lighting and adjusting seating, keyboard and screen position. Nearby toilet locations were pointed out at the start of sessions. Some of this may sound trivial or nit-picking but the points listed do address older people's issues in attending new venues and the result was happy and co-operative participants. The older people also noticed the care taken and stated that they appreciated it.

Home visits are another solution and can add depth to the information gathered. It was easy to obtain information from discussion groups that email was not a major part of my participants' lives and that they were tentative about computer use. However this information was strongly reinforced when seeing the relative lack of importance indicated by the location of their computers in their homes and the proliferation of small notes that were needed as tools to guide them in remembering the steps needed for all but the most frequent tasks. In the SeniorMail evaluation using older CAB workers the study was done in a spare room of the CAB offices so that the older people were in an environment with which they were already familiar and traveled to regularly. Another solution to getting field experience with older people might be to get co-operation from older people's social clubs and to carry out research in such settings. If the clubs used were not exclusively intellectual in pursuits this might have the effect of extending the range of older people who could be sampled.

To summarize the following points should be considered when ensuring that older participants are cared for in the research or design process.

Housekeeping issues - Pre session

- Ensure clear prior understanding of what is involved.
    - I had a short telephone conversation with each volunteer to check that they met the project criteria and understood what was involved.
    - I told them I would send an email confirming the details
- Be firm about excluding people who do not meet the criteria
- Some older people forget easily.
    - Send confirming information giving clear written information given about dates and locations and contact information
    - Send a reminder shortly before cycle begins
- Session times set to avoid traffic peaks

Housekeeping issues - Session format

- New locations are difficult for seniors. Accessibility, nearby reserved parking and signage trails are important. Reception staff were alerted to direct participants if they got lost.
- Session times 50 min then tea break then another 50 min
- The research area was new, tidy and well furnished
- Attention was paid to lighting and adjusting seating, keyboard and screen position. Mice were cleaned and checked.
- Nearby toilet locations were pointed out at the start of sessions.
- Tea breaks provided a varied choice of good quality biscuits. Range of cup sizes.

For another discussion that provides extensive support for these points see Chisnell et al. (2004).

8.4.8 Sampling issues

Older people consist of multiple overlapping populations of persons with differing degrees and types of age related difficulties. In addition these difficulties are such that they are likely to amplify selection effects in sampling. Selection bias is one of the known areas of difficulty in research on older people, Hertzog (1996). Rosenthal and Rosnow (1975), note that volunteers for any form of research project tend to be more intelligent, of higher status and more self-confident than the community average. This effect may be strengthened with older volunteers by factors such as the need to cope with city driving and the greater range of ability in the older population. From the point of view of interface designers or researchers this means a systematic shift of the sample group towards people who are more able than the target population the designer is aiming at.

Acquiring a "more average" group seems particularly valuable in evaluating how a design will fare. Volunteers in the FileTutor study were generally of higher status and had high levels of educational achievement but because the project offered instruction that was genuinely in demand, and because some of the initial volunteers encouraged other friends to enrol with them, there were 7 volunteers who appeared more typical of the general community. They were less educated, had lower past occupational status and were less self confident. This "more average" group had more difficulties and were of considerable value in showing areas in which FileTutor could be improved. The "above average" volunteers made a useful but different contribution. They were more able to cope with problems in the earlier versions of FileTutor but they were happy to adopt a role of identifying things that they felt might cause difficulties for other older people. However the "above average" group did not spot many of the pitfalls that the "more average" participants exposed. This should be borne in mind when selecting older users for product evaluation.

How many older people are needed? Nielsen and Landauer (1993) argue that usability testing with around 5 people is enough to find all the significant problems in a version. Various authors have argued that this is simplistic and depends on the complexity of the application under test and the likelihood of any individual detecting the errors needing to be found, see Woolrych and Cockton (2001), Spool and Schroeder (2001). Older people are more variable than the younger population so we might continue to get useful results with more test subjects than if our participants were younger. In the FileTutor project there were three main usability cycles, one in December (6 people) and two in January 2001 (9, 10 people) . All reported problems were fixed before the start of the next cycle. However people continued to find problems in material from previous cycles. My argument from this is that if testing is aimed at older users 5 people is likely to be insufficient. My tentative recommendation is for around 8 older users based on the point that 8 people formed the core group for testing during the development of SeniorMail and that this seemed sufficient to produce an acceptable application. Again in the

FileTutor study the most realistic testing came from the "average ability" group and there were in fact only 7 in this group scattered through the three usability cycles.

There is the question of why an unrepresentative sample works at all. It is clear that a group of 6 – 8 older people who are self supporting and willing to take part in research about computers is unlikely to be representative of the older population. Further the initial development with WinTutor, FileTutor and SeniorMail depended on the in-house testers who were in their mid fifties and showed mild visual impairment and some problems remembering information. Yet the designs that finally emerged were greeted as exceptionally good when presented to a wide group of older people. There are two possible arguments; firstly that the study of the possible implications of aging on interface design reported in Chapter 2 (the literature review) helped guide the designer in suitable directions. The second argument is that most older people in fact have age related deficits in a number of areas but that these deficits are sufficiently small that the older people are able to compensate for the effects and maintain normal functioning. However in this scenario the process of maintaining such compensations takes effort and so older people will choose design alternatives that reduce the amount of effort required for compensating age related deficits that are not obvious. Salthouse (1996) has made a similar point with respect to vision in older adults where older people who tested in the normal range for visual acuity could be shown to have significant decline in vision when tested under conditions that were deliberately less ideal than the standard test conditions.

In pursuit of a quasi experimental approach this study recruited people who had difficulty with using standard applications. This focuses research and design on a useful group of participants. This meant that the group chosen were either selected by their care givers as unable to use an application effectively or they self-reported themselves as “poor” users of the application. However it seems worth asking the question of how competent are older people who report that they can use Word or MSOE? There may be useful information to be gained from exploring the behaviour of self described “competent” users.

8.5 Developing applications with older people

The overall research has involved developing three applications for older people that have been well received by the target group. Within those applications nearly 200 screens suitable for older users have been developed in conjunction with older people. This section takes that experience and looks at modifications to the development process that allowed me to usefully involve older people in the shaping (and eventual success) of the designs produced.

8.5.1 Needs analysis

Newell and his group have been working largely in the area of new products for older people. However my research has focused on redesign of standard applications for the needs of older users. One of the differences between the two approaches is that, when imagining new products, the driver is features that are unique to the product and appropriate to older users. In contrast when providing a redesign of a standard application such as email for older users, the emphasis is on restricting features to those actually of use to older people and then redesigning those features to be age appropriate. There are two benefits to restricting features, the older user has fewer things to learn and the interface designer, given a simpler feature set, has more scope to focus the interface on design that suits older people's abilities. Note the further difference from developing new versions for younger people. In developing new versions of standard products for younger users, the driver is to provide new and extra features not provided by competing versions.

In doing needs analysis for older people I have found several steps useful. The start is a background investigation that asks what are the key features of an application such as email that older people will use and need. This involves discussions with groups of older potential users covering their likely needs, their concerns and any experiences they may have had with standard software. There is discussion and observation with older people who are users of standard applications in the area chosen, such as older people using MS Outlook Express, the focus here is on what features are actually used, what things are difficult and what features does the older person want to use but finds too hard. There can also be an interest in the frequency with which various features are used. My current focus is to use this part of the background investigation to counter my own expectations of what makes a worthwhile application in this area (my personal preferred list of features if I were the intended user.)

Another aspect of the needs analysis when designing for older users is discussion with the older people's supporters. As an example the SeniorMail study included a series of focus groups with relatives of older people, part of the longer term investigation of SeniorMail included discussions with rest home staff. Here the concern is only partly with the older person's needs and difficulties as seen by the supporters. A useful topic in discussion with supporters is details of the supporter's role in assisting the older person's software use. This not only indicates features of current software that the older person may be unable to use unaided but it also indicates possibilities for the new design in alleviating some of the tasks currently undertaken by supporters and thus relieving the burden that support places on supporters. In passing, my experience so far is that supporters find supporting an older computer user of standard software a much larger task than they initially expected and that reducing the size of the support task is not a matter of removing a welcome link between middle aged children and their parents but a matter of making the support job manageable and removing a largely unacknowledged and unexpected source of overload, duty, guilt and exasperation.

It is also useful to consider the supporters' technical competence in computing or in the specific application area under consideration. One of the potential tricks for providing older people with a highly simplified application is to design some of the setup tasks so that they are intended to be done by the older person's supporters. Obviously obtaining a feel for the skill level of the supporters is helpful.

Another aspect of interest in working with supporters is the supporter's own views on what makes a desirable application for themselves in the application area. One can also consider how willing the supporters are to modify these views with respect to a different version of the application for older people. One design problem is that supporters are potential gatekeepers for older people's software acquisitions and may reject software that does not meet their own preferred feature set even though that feature set may not in fact be needed by the older people they support.

A further resource when looking at design for older people is the existence of training organizations devoted to teaching older people computing topics. Both talking with tutors and observing classes can be informative almost irrespective of whether the training organization does a good or bad job of addressing older people's needs. As a younger researcher / designer you should simply be cautious about accepting the organization's own claim to be a good training provider until you have evaluated the evidence for this.

8.5.2 Creating the basic design

Newell and Gregor (2002) argue that user centered design contains inbuilt assumptions that the user is reasonably similar to the designer and that the users form a relatively uniform group. Both those assumptions can also be seen in task centered design as described by Cooper (1995). Given those assumptions it is possible to proceed from the knowledge of the user's situation, needs and tasks to produce an outline of a workable design. To an extent what the designer does is to use their knowledge of the user to put themselves in the user's place and create initial designs that seem to allow the target users to carry out the identified tasks. The product is typically a low fidelity prototype and this is then refined in design sessions with the users.

When designing for older users this process runs into difficulties. In my experience older users can be sufficiently different from younger people in ability and in computer experience that the designer will have considerable difficulty putting themselves in the older person's place. Additionally older people have difficulties working effectively with low fidelity prototypes. However if the designer wishes to have an on-going relationship with a group of older people in the course of product development then what the older people work with must carry sufficient promise of a credible design for older users that the older people are not alienated.

A partial solution involves:

1. Intensifying the initial investigation of the older user's difficulties with existing software so that the first designs presented to older people clearly solve some real and common issues. A concern here is that, in the initial work presented to older people, the observed benefits outweigh the inevitable shortcomings so that the older people are willing to remain involved with the project.

2. Using knowledge of the effects of aging to inform design. It can be said that each finding on the effects of aging represents a departure from the assumptions that a designer could reasonably make about what would work for younger users. The problem is that the findings on aging are much less specific on how an interface design should compensate for the effects of aging or about when particular effects of aging come into play.
3. Using high fidelity prototypes and abandoning the considerable advantages of low fidelity prototyping. This puts a number of costs on the development process but it does allow older people to give realistic responses.
4. Building in almost daily consultation with representative older people into the design process so that the designer's assumptions about what is feasible for older users are checked sufficiently frequently so that errors in these assumptions do not snowball.
5. This requirement means that selected older people need to be readily available as part of the day to day design activity. In effect some older people are needed as part of the design team.

The older contributors to the designs

I was fortunate in that I had available two people in their mid fifties who were working close to where I worked and who needed to learn computer skills but who had found themselves surprisingly unable to do so. They were competent, intelligent individuals in semi-professional occupations but computers were a remarkable and enduring blind spot. They came close to fitting the stereotype of "perpetual newbies". They had virtually no knowledge of elementary computing conventions. They did not understand basic concepts, the "file thingy" was used in a way that did not distinguish between the file icon, the (lost) data on the disk and the program that allowed display of the data. They had considerable difficulty in interpreting screens and appeared blind to features that are taken for granted by even minimally experienced users such as an [OK] button. One of them had bifocal lenses that allowed good reading and distance vision but were unable to provide good resolution at the intermediate distance represented by the computer screen. Further they had considerable difficulty in retaining information about either procedural steps or about concepts. In short, despite being relatively young, they showed many of the characteristics of older beginners. They have since become competent computer users. I owe them a considerable debt of gratitude that they were willing to allow me to carry out endless impromptu tests of design fragments as I was developing them.

The SeniorMail project was the third application developed in my research and by this time my in-house testers had benefited from their involvement with the interactive tutorial projects and while they still could not use email they were too knowledgeable to act as older beginners. While I still used the in-house older testers as a resource I also recruited a group of 9 much older people who were unable to learn email using MSOE. The drawback here was that they often lived some distance away (up to 50 kilometers) and so organizing and going to testing sessions was time consuming. Another problem was that there would often be a backlog of features that I wanted to test, this delayed progress and threatened to overload my volunteers when test sessions were organized. (Remember that testing needed to be relaxed, exploratory and done in a group context, this meant that testing of any feature was relatively slow.) My opinion, based on the number of problems found in my initial designs, is that without the contribution of these older people and the in-house testers I would not have produced suitable designs for older users. Finding a suitable, convenient and ethical way of making older people part of the development project remains an issue. Working with residents in a nearby rest home was examined but there were difficulties in finding enough people who were interested and who were sufficiently unimpaired to make computer use feasible.

Prototyping

Developing low fidelity prototypes with older users was tried and it was found that they had considerable difficulty with relating to paper prototypes as precursors to a screen design. Not only were there problems of conceiving of a paper design as a stand in for a screen design but it also emerged that a number of the issues that affected older users were in the actual implementation of a design on a screen, font sizes, colors, precise layout etc. The question became how could older people usefully participate in the development of the design? The approach that was finally adopted was to build high fidelity prototypes of several alternative design fragments at points where there was uncertainty as to what older people would want as a design choice or I was unsure of the validity of the responses of my older in house testers or they disagreed with each other. These fragments included working code as it was found that older people tended to be disrupted by explanations from the usability tester of what would happen after they performed an action on a zero code prototype. As a group the older people were more comfortable if the intended response from the prototype actually occurred, instead of being talked through by the researcher or demonstrated by the researcher intervening and displaying new screens. I found older participants could become quite worried where effects depended on the researcher doing a quick alteration. The response was confusion as to what steps they themselves would be expected to do as distinct from those carried out by the researcher. If I had made an intervention such as swapping to a new screen representing a view of the prototype after an action by the older user, I persistently encountered a belief that in the real application they would need to carry out extra steps similar to those I had just done. This belief appeared to be resistant to my explaining that in the real system action A by them would be automatically followed by appearance B. No, they had seen that I needed to follow action A by some complex or fast fiddling before appearance B eventuated and they wanted no part of it. This did not mean that the prototype had to be a full featured final version but that for the parts of the prototype under test, the sequence of action and response needed to be believable. In addition the way of reaching the part of the application being tested, either with the researcher's verbal preamble or the test participant's actions needed to effectively set the context within which the part of the application under test was relevant to the older participant's understanding of what they wanted to achieve.

These alternative design fragments were then presented to groups of older people and to the older in-house testers. I got the older users to carry out simple scenarios with the design fragments while I observed. They were then asked for preferences. This allowed us to choose the preferred approach for selected design issues and often to consider ways in which the approaches developed to that point could be improved.

I found in early work with older people that their continued interest in participating depended strongly on their belief that the outcome would be useful. Shown a prototype with major features they found unworkable, their response was to disengage rather than to discuss improvements and maintain engagement until the improved version was available. As an aside I wonder if this is because the older people I chose to work with were people who had had repeated experience with unsatisfactory computer systems and so were quick to place poor prototypes into the category of, "yet another computer program I can't use"? So my aim was to build a working and credible prototype as a starting point for involving older users in making major contributions to the final design. In building a preliminary credible prototype of an entire system I worked from the emerging design principles for older users, from identification of the older user's needs and wants and from trialing various specific pieces of the prototype with older users. I also relied on ongoing involvement from my two in-house testers who were able to devote considerable time to trying out preliminary versions of the parts of the various systems I developed without becoming discouraged. Thus by the time I looked at the usability of the systems with groups of older people I had developed prototypes that were seen by the older participants as already usable and meeting more of their needs than other systems that they had tried. They then found no difficulty with using the preliminary credible prototype as a basis for suggesting numerous improvements and for discussing why such changes would represent improvements to them.

This is a fairly radical change from the orthodox recommendations for participant design when working with younger groups. The use of prototypes based on high fidelity design fragments with working code is recognized as having several problems, it tends to slow the pace of development, it gives less flexibility for discovering alternative designs than the rapid modifications available with low fidelity prototypes. Again high fidelity prototyping leads the designer to be egoistically involved in designs given the level of work and skill required to build them. This reduces the willingness to make radical changes as does the designer / developer's awareness of the coding costs of re-design as opposed to cosmetic changes. All of these points are forcefully covered by Cooper (1994) where he argues for the highly desirable nature of paper prototyping over code based prototyping. Cooper in fact suggests that there should be complete separation between coder and interface designer on the very reasonable grounds that the job of the interface designer is to solve the user's problems rather than design to ease the programmer's workload.

I acknowledge these issues but argue that, for the reasons discussed above, the drawbacks do not outweigh the advantages of having working hi-fidelity, code based prototypes as a basis of participant development with older people. In particular the extra focus on the older user's needs and problems and the increased personal involvement of the researcher / developer / designer with the older users are seen as techniques that off-set the concerns with ego capture and capture by programming convenience identified by Cooper. Certainly the work with the in-house testers repeatedly found aspects of my designs that were unworkable in spite of my hopes for the design. Because I was working in close conjunction with the older in-house testers I had to do three things to preserve the relationship. I needed to accept that the design was wrong when their behavior with the prototype and their comments showed that the prototype did not work as intended, if one wants to have an ongoing relationship with a messenger, shooting them or denying what they say is unproductive. I needed to show responsiveness to their concerns and to value the work they put in if I wanted ongoing involvement from my in-house testers. If this meant a major redesign then that was better than asking them to allow me to ignore the original design failings, implying that I was not really taking them seriously. I also discussed the intended direction of a re-design with the in-house testers and then had them re-check the final result. Thus there was a check on the tendency of a designer / developer towards both wishful thinking and laziness in facing coding difficulties when working with high fidelity prototypes. This was also the way to maintain an effective relationship with well-motivated in-house testers.

In a number of situations it was not simple to see what should go into a credible prototype in spite of having access to in-house testers, partly because any manageable number of in-house testers is going to under represent the variety of combinations of disability in the aging population. There could be uncertainties as to what would be desirable trade offs as they would affect a wider group of older users. There could be questions about the usability of particular techniques. At times there were concerns that the in-house testers had acquired too much knowledge or too high a level of skill. At times I doubted the suggestions of my in-house testers or they each had different responses or they themselves were uncertain, at other times I had a simple gut feeling of caution. There were also questions of the proper interpretation of the research literature on aging when extending the findings beyond the original studies in order to apply them to an interface issue.

In these situations the approach was to construct several functional versions of the design that captured different responses to the uncertain issues. These were then presented to the informal backup pool of older people who were observed trialing the alternative designs, made comments on how usable they found them and gave opinions as to their design preferences. Usually a preference emerged or a new and better solution emerged from observation and reflection.

8.5.3 Usability test cycles

One of the key aspects of the way in which I worked was that the older users were supported by other older users as they did the usability tests or explored the design alternatives. In passing, my experience does not support the claim that presenting a high fidelity prototype always tends to stifle discussion. Where the older users worked with groups of other older people in using the prototypes, when they found problems in the designs they were very able to identify the difficulties and to discuss what changes could address these. In contrast the final evaluation of the SeniorMail system was done by older people working alone with the researcher and here it was noticeable that although people still encountered difficulties, they were less likely to discuss them or to suggest improvements.

To allow a broad scope for examining what was happening, most of the research projects involved periods during which the participants could discuss their experiences with each other as well as with the researcher, both during tea breaks within the testing sessions and in focus groups held in separate sessions occurring after the testing sessions. These focus groups combined older people from several testing sessions. This allowed for lively discussion of the benefits and failings of the system being examined in terms of how each individual experienced their own aging. As noted above the final evaluation of SeniorMail did not fit this pattern and this is felt to be a drawback, although earlier work on SeniorMail included and benefited from considerable group discussion by older users.

8.5.4 Long term use

As pointed out by Salthouse (1996) one of the significant limitations of laboratory investigation of older people is that the rates at which behaviors change and at which new behaviors are established are much slower in older people. Salthouse suggests that some of the important changes we need to observe in older people's adaptation to situations will occur outside the timescale that is available to a laboratory study. A full scale follow up study involving repeated observations would be an ideal although one needs to be cautious about the training effects due to the intervention effect of the follow up evaluations themselves. Baltes and Willis (1982) showed that relatively small amounts of training (in effective memory techniques) had effects that showed in retesting five years later, it seems possible that even the knowledge that evaluations would happen in the future could affect the course of an older person’s skill development with a system. In the research for this thesis the two interactive tutorial systems that were intended for relatively brief use by older users as they learnt computing skills were never the less capable of being placed in a situation of long term use and evaluation by making them available to New Zealand SeniorNet branches and obtaining feedback as tutors gained more experience of using the tutorials and tracking sales to confirm that branches continued to find the products useful, instead of having had a first flush of enthusiasm that died on further acquaintance with the tutorials. Similarly for SeniorMail which is a product intended for long term use, although the usability testing was short term and did not really address long term suitability, a small pool of long term users was established to check if they would continue to find the product desirable.

Long term involvement with a product means that users are likely to engage in a wider variety of actions and to try to satisfy a wider variety of needs. This gives further opportunities for the developer / researcher to obtain information about what works, what needs changing and what level of enthusiasm about the design is sustained in the long run. It is seen as important that this feedback does in fact reach the developer / researcher. One of the tools for making this happen is to respond positively with new versions of the product that address any issues raised by the long term users. Another technique is to arrange visits to the long term users and discuss the product with them and observe their current patterns of using it and levels of enthusiasm for it. Standardized evaluation forms were not used with these long term evaluations as there was a strong aspect of the older users being pleased to receive ongoing attention and to want to reciprocate by pleasing the researcher. It was felt that it would be harder to maintain an artificial level of approval in discussion and so the long term users' satisfaction was rated on this basis. Which does lead to some rather unorthodox items indicating approval and that the system under test is important to the user, such as baking a cake as thanks for promptly resolving a bug, gifts of fruit and vintage wine or a wish to come to the researcher's graduation.

8.6 Ethical issues in working with older people

This section arises from reflections on ethical issues that arose during the course of the study. I do not want to increase the difficulty of obtaining ethics consent for research in design for older people but with hindsight there appear to be some ethical issues specific to working with older people that are not typically addressed in the framework of standard ethics consent procedures. Designers as well will want to look at ways of working that treat the older people they work with fairly. So this section looks at some of the ethical pitfalls in working with design for older people and considers ways in which these can be avoided or minimized.

Let us quickly recap the responses from older participants that illustrate the ethical issues around the study for this thesis. In the Dual Task study, interface and problem solving conditions were used that meant that the older volunteers failed in around half of the apparently simple tasks they attempted. Instructions to participants were that we were looking at conditions that made it harder for users to succeed. This made the participants passive recipients of bad design while setting them up to try and succeed. The volunteers disliked the experience, ascribed blame for poor performance to their own failings as older people and were not highly motivated. Participants who initially saw themselves as reasonably competent computer users had their self confidence reduced. In the same study participants also looked at a range of fonts to see what was readable. Here good and bad seemed to be ascribed to the fonts used and the volunteers were interested and motivated.

In contrast the FileTutor project was designed to maximise success while placing a positive construction on difficulties. Participants found that they were understanding things that they had previously puzzled over. They also saw themselves as actively taking part in improving the design. When they failed to understand a point they more often saw it as due to their discovery of a problem in FileTutor rather than their own weakness. They saw themselves as making a useful contribution in pointing out where they became stuck. On coming to later sessions they could in fact see that improvements had been made based on the problems they had identified. Participants reported that their self confidence was boosted.

In the SeniorMail study the in-house testers, the long term users and the people who contributed to the “ComputerWare” parties all showed clearly that they appreciated involvement in the study and found it personally rewarding. However in the later usability testing with the CAB volunteers, remembering that this was not done in a group situation, a number of the people involved appeared to have come because this new email system was part of a possible change to the way the CAB was run. While they succeeded in using the program it is hard to argue that all of them saw this as a preferred use of their time. In addition the email program at that time still had some periodic bugs that made it harder to support and so it was not possible to provide the participants with their own simplified email as a reward for participating.

With this background let us look at some of the more general concerns about ethical treatment of older participants in research. Levy (1996) has done provocative work on the effects of activating negative self stereotypes in older people. These include significant physiological stress and negative influences on long term decision making. In the light of this putting older people in front of a screen and having them fail may breach the ethical commitment to protect the volunteers' personal welfare. This is in spite of the apparently harmless nature of the computer activity. A problem here is older people's apparent use of self blame (the "silly old me" syndrome) as a coping mechanism. At the very least the study's orientation, design and de-briefing procedures must help volunteers to ascribe blame to the experimental set-up rather themselves. However note that positive debriefing has not been established as effective in protecting older people, Levy (1996). It is my impression that the pattern adopted in the three studies following the Dual task study led to the older participants maintaining a positive view of themselves and their role in the research. The key aspects were a mix of the following:

- Providing older participants with rapid responses to their suggestions
- Using alternative design fragments where the question becomes, “Which do you prefer?” rather than, “Can you do this?”
- Working with an initial credible prototype so that there were reasonably high levels of initial success.

Aging is a time when previous views of one’s competence as a person are challenged. It seems dubious ethically to put older people in situations where they are likely to conclude from their experience that they are less worthwhile as functioning members of society than they had assumed. Levy (1996) suggests that there can be long term consequences from such experiences. Such a possibility in working with older people and computers is that their experiences may lead them to incorrectly decide that they are unsuited for using computers and to avoid further experiences with what could possibly be a useful tool for them. In work by Hess et al (2004), older, but not younger people showed altered performance on memory tasks when exposed to implicit versus explicit priming with aging stereotypes. Implicit priming with positive stereotypes led to improved memory recall while implicit priming with negative stereotypes led to decreased recall. When explicit priming was used there was an effect due to the strength of the stereotypes. With exposure to subtle stereotypes older people showed little effect but blatant stereotype exposure led to decreased performance irrespective of whether the primes were positive or negative stereotypes. A possible implication of this work is that older people will be able to cope with minor inadvertent prejudice on the part of the researcher or designer but will be negatively affected by exposure to stronger prejudice. It also seems possible to interpret Hess et al's work as implying that a falsely positive presentation of the researcher's attitude to older people is detected and will in fact activate negative self stereotyping. However anxiety was not associated with poorer motor performance in older adults in a study by Horgan (2003).

Work by Claude Steele (see Steele 1997, Aronson et al. 1999) explores a related concept of stereotype threat. Steele suggests that more needs to be done to create social settings in which people can function as a comfortable part of the whole. Organizations can have features - ways of being organized, group compositions, philosophies about diversity - that can cue people to worry about whether they may be disadvantaged by their social identity - their gender, age, race, religion, nationality, profession and sexual orientation. This social identity threat can be significant enough to interfere with their performance in such a setting. Most recently, Steele's research has focused on identifying ways that these settings can be made more "identity safe" - that is, reducing the social identity threat people can feel. Since, when working with older people, we do not want to subject them to demeaning experiences, considering the possibility of, and countering, any stereotype threat is important. The experience gained in the research for the thesis is that older people being placed in situations where they were "objects" of study because they were old were more likely to show depressed performance than when such situations were reframed as ones where the older people were taking active steps to find out what suited older people. Again the use of group situations was seen as providing a situation where the older people had more of a role in constructing a social situation in which being old was seen as normal and accepted and thus reducing effects from stereotype threat.

In developing the conceptual underpinning of Universal Usability, Schneiderman (2000) has argued against dumbing down applications for older users partly on the grounds that this is an ethical stance. Dumbed down applications, Schneiderman argues, could well be seen as patronizing and hence demeaning to the older users. The older people I raised this issue with were dismissive, simple software was seen as useful rather than demeaning and there were so many more significant demeaning issues from the effects of aging that concern for one size fits all software was seen as irrelevant. This does not rule out the possibility of cultural differences, with older people in a culture outside New Zealand being more concerned about universality, but this does suggest that the ethical approach to this issue is to allow older people (and younger people) to make decisions for themselves as to what best suits their software needs. At the least this argues for the availability of “dumbed down” versions, if these are simpler to construct and hence more readily available, and is neutral about the desirability of universal versions until the reactions of potential users of all ages are considered.

Norman Alm (1994) in a paper on the ethical issues for researchers engaged in Augmentative and Alternative Communication research (AAC) noted that there are several issues that arise when working with people who are unable to communicate effectively by reason of such conditions as cerebral palsy. Alm and co-workers were looking at technological approaches for improving aspects of their ability to communicate with other people. This was intensely significant to these people as where the interventions succeeded the temporary freeing from being “locked in” was very important. Since the devices being tested were prototypes that could not be supported for the volunteers after the research ended the loss of such communication assistance could be upsetting. From this background Alm wrote a searching paper on the ethical issues involved. In what follows I have selected issues from Alm’s paper that in my experience also apply to work with older people. Where appropriate I have translated Alms wording relating to communication impaired people to wording related to older people. Alm cautions that there are two areas in which the participants need to have their expectations managed. If the device or software being tested can only be made available to the participant during the course of the research then this needs to be made very clear to the participants in advance. Again Alm notes that in working with people who suffer from extreme communication disadvantages it is likely that the participants will receive a lot of attention and interest from the researcher. This, Alm points out, can raise false expectations of friendship and long term links with the researchers and the participants may feel let down when the researchers withdraw at the end of the project. A similar effect can happen when working with older people where loneliness may be alleviated by the researcher's involvement, only to return when the researcher withdraws at the end of the project.

Other issues that Alm has raised include:

- If a person has limited time remaining in their lives is participating in the research a good use of that time? Where studies of older people involve group work with enjoyable social aspects it is easier to answer this positively.
- Videos of older people's difficulties can be excellent for communicating older people's needs to developers but such videos may expose levels of incompetence that are demeaning to the individual older participant. Newell's team has suggested using actors to portray older users. There is no immediate equivalent in my own work, but there is the question of individuals exposing such incompetence in front of the group of people they are working with and the researcher. What appeared to happen is that in a group of older people individuals felt (and were) supported by their peers. Further since the designs did not present insurmountable tasks the results of exposing difficulty was usually assistance followed by success. Supporting the expectation that exposing difficulty or incompetence, would be followed by achieving competence and congratulations from the group, does change the nature of such exposure inside the group. However Newell's proposed use of actors seems valid in response to displaying lack of competence outside a supportive group.
- Claims of eventual benefit for "older people in general" so that the older person sees their contribution as philanthropical are dubious in that the actual benefit to the researched group is uncertain and may also be considerably delayed. In addition such a claim draws attention away from the personal benefits to the researcher in terms of career and grants (and in my case software sales).
- Alm makes the point that if older people are to be paid, if for example they are contributing to commercial development as in-house testers, it is important for

those paying the older people to consider the effect of any such payments on the older people’s entitlement to retirement benefits or continuity of such benefits

- The designer or researcher needs to consider how to deal ethically with imbalances of power between the researcher and the older person. These may be subtle. For example, older people get tired, get bored and are strong believers in being polite and cooperative. When using in-house older testers there is a risk of exploitation of tester’s good will, “Look while we are here can we test just this one extra feature?”

Ethical approval tends to miss important issues in working with older people. It has been traditional to evaluate harm on a strictly physical basis. In such a view there is little possible harm in sitting in front of a computer for an hour and trying to complete a variety of tasks. However for people whose belief in their own competency is threatened placing them in situations where they fail on tasks, such an experience can lead to these people making inappropriate long term decisions based on an under-estimation of their own ability induced by the experiment. For those tempted to say that this can be tidied up by talking to the participants at the end of their participation, I repeat Levy’s (1996) point that positive debriefing has not been established as effective in protecting older people.

My impression is that research consent forms tend to be filled in without the older people really being willing to apply the safeguards that are offered. In no case have I had older people request that they withdraw from a testing situation but there have been several cases where older people have appeared to be uncomfortable with the testing situation and where at times they have opted for superficial involvement. It is worth noting that these cases with one exception occurred in situations where the older people were working one on one with the researcher. The exception involved a person who appeared to make very limited communication with the two other older people working alongside.

Note that the quasi experimental approach used in this research assists in achieving an ethical stance with respect to older participants in that it does not require a control situation in which older people demonstrate fresh examples of poor performance. As practiced in this research, the quasi experimental approach provides ways of alleviating past failure and in fact re-casting past failure as a useful source of knowledge for increasing the coping ability of the older participants.

8.7 Conclusions

This chapter has taken the stance that in order to design for older people, or to research appropriate design for older people, one needs to interact with older people frequently during the design/research process. The chapter has suggested that traditional forms of research need modification of the pattern of interaction between researcher and subject in order to achieve improved access to information. Examples of such modification that worked well in this research have been discussed. It has also been suggested that where the designer or researcher is considerably younger than the group to be researched there are a number of difficulties in communicating and working with older people that may be insufficiently appreciated by the younger person but which can be surmounted by adopting different forms of study design. In the chapter that follows we will look at the remarkably similar approaches to research on older people that have emerged from the work of Newell's team at the University of Dundee.

Chapter 9 Comparisons with the UTOPIA Approaches

9.1 Design for Dynamic Diversity and User Sensitive Inclusive Design

This section examines the methodology that has come from the work of the UTOPIA project led by Newell with a team centered at Dundee University. UTOPIA stands for "Usable Technology for Older People, Inclusive and Appropriate". The correspondence of the UTOPIA approach and my own work is of interest since while my own approach was developed independently there are considerable similarities between the two approaches and these similarities provide for a degree of mutual support between the two. The main themes of their work will be outlined in this section and then, in the following section, a comparison will be made with the approach that has been used in my own research.

There are an increasing number of web and interface design guidelines for including the needs of older and disabled users within mainstream products. These approaches come under names such as "universal design", "design for all", "accessible design", and "inclusive design". However, as Eisma, et al. (2003) note, there are relatively few guidelines for the successful involvement of older users in the development of systems for their use.

User Sensitive Inclusive Design as described by Newell and Gregor (2000), is a methodology aimed specifically at describing how to usefully include older and disabled people in research product development intended to meet their needs. User Sensitive Inclusive Design has numerous parallels to the methodological approach developed for, and used in, my own research. User Sensitive Inclusive Design (USID) was developed to provide a methodology that supports the Design for Dynamic Diversity (D3) paradigm described by Gregor and Newell (2001). In the D3 paradigm the concern is to develop systems that are appropriate for users whose abilities are different from those of the mainstream population and from each other (hence Diversity) and whose abilities are subject to change in both the users' development over their lifespan but also in their daily good and worse times, (hence Dynamic). Gregor and Newell (2001) and Newell and

Gregor (2002) describe Design for Dynamic Diversity (D3) as a more feasible approach to the concerns of universal usability. In these papers, although they acknowledge the usefulness of wide access to computing services by most of the disabled population, they see a need to relax the absolutism implied by the strict definition of universal usability. Hence D3 is offered as an alternative to the initial universal usability argument proposed by Schneiderman (2000) that every application should be available to all users irrespective of age or disability. This attitude is captured in the slogan, "Anyone, anywhere, at any time" but not, perhaps, realized in practice. Newell and Gregor argue that, in the approach identified under the name of Design for Dynamic Diversity, not only should some activities be seen as inappropriate for some users but also a conflict should be acknowledged in that features imposed on a design to adequately compensate for particular aspects of one sort of disability may restrict the usefulness of the design for users without disability or with different disabilities. Hence under D3 it is not proposed that all designs should suit all users, however there is the hope that when designing for disability there should be some level of acceptance of the resulting products by the general population, (except for designs aimed at extreme disability). It is also intended that some of the insights gained in developing products for older or disabled users can be used to alter mainstream applications so as to increase the range of users that they address.

The User Sensitive Inclusive Design methodology developed by Newell and co-workers at the University of Dundee is aimed at supporting the development of systems under the D3 approach. Although the first published description of the methodology is in Newell and Gregor (2000), the methodology draws on a considerable period of experience in working with disabled people in the research done at Dundee on development of assistive systems. Newell himself traces it back to a keynote speech given in 1993, (Newell 1993), where he agued that the full diversity of the whole user population should be taken into account when undertaking interface design. USID is seen by Newell and Gregor as a necessary adaptation of User Centered Design (UCD) that is required to cope with the characteristics of older and disabled people. In Newell and Gregor's view, UCD assumes relatively homogenous standard users with shared needs, similar abilities, competent communication skills and the ability to undertake informed consent. These standard users are assumed to adequately represent the general user population which is seen as being similarly homogenous.

In contrast USID is aimed at approaching users for whom there is a much wider range of characteristics and abilities. This is not simply a population with a broader distribution around a central tendency, rather it is a population containing many diverse clusters whose characteristics are different in kind from those of other clusters. Because of this USID needs to cope with the probability that any particular user sample is likely to be unrepresentative. Again because of the diversity of sources of impairments, USID, unlike UCD, needs to consider that designs that accommodate the needs of a sub-group of users (one form of disability), may in fact increase the level of difficulty for other sub-groups of the intended user population (those with different disabilities and needs).

USID should probably not be seen as a fixed definition of an appropriate methodology but rather as an evolving statement of the ways in which the workers at Dundee and those associated with them are finding ways to usefully capture the realities of the older and disabled people who are the focus and the intended primary beneficiaries of their research. Thus the UTOPIA project is both offered as an example of USID and also provides an ongoing enquiry into refining the methodology needed to work with older people, see Dickenson et al. (2002).

One of the key features of USID is that the relationship of test subject with researcher and designer is seen as problematic.

a. The users are very different from the researchers so that the researcher's own experiences as a user give a poor model for understanding the old or disabled user's needs, experiences and issues.
b. This leads to a much increased need for observation of the intended users, by the researcher, in the context within which they will eventually use the system.
c. The user is not always an adequate source of information on their own needs and abilities, it becomes necessary to incorporate expertise on aging or disability into the research team. However the inclusion of disability specialists does not diminish the importance of the information provided by the older participants, it supplements it and assists in interpreting it.
d. The users may in fact have levels of diminished competence where they have difficulty offering informed consent or adequately expressing or conceptualizing their needs.

There are several key ways in which USID seeks to resolve the problems noted in the preceding bullet points. Firstly the usual formal distance between the researcher and the test subject is reduced. Selected user representatives are formally recruited as research team members and at the same time there is a considerable effort to use methods that provide insights into the context of the lives of the older people who are potential users of the proposed systems. Thus while questionnaires may be used, Goodman et al. (2003), who work with Newell, point out the value of the extra information available if the questionnaires are completed face to face and if comments and discussion are encouraged to capture the wider issues raised by the questions. Researchers working at Dundee and in co-operation with Dundee use a variety of methods that allow observation of the unplanned. Focus groups and discussion are encouraged, visiting and observing older users in their homes or at older person's centers is seen as necessary and informal "hands on" sessions where groups of older users are encouraged to explore new technology are found to be useful. In general there is a concern in USID with a high level of personal contact with the older or disabled people who participate in the research. Note however this emphasis on involving the older or disabled users occurs for specific phases of the research such as needs elaboration or product refinement, in other phases, such as code development, older users are unlikely to be involved.

Although this leads to less formal and less quantified results there is a strong argument made by the researchers in the emerging USID tradition that the richness, and capability to surprise, of the information gained in this way makes this reduced rigor an acceptable payoff in the short term. There is a statement in Eisma et al. (2003) to the effect that the approach is concerned with allowing the chance for older people to provide answers to questions the researchers did not know should be asked. This is in complete agreement with the approach I have taken. Eisma et al. (2003) also propose a concept "mutual inspiration" where the older people who take part in testing, discussion and "hands on" sessions are inspired with new understanding of the opportunities that potential and existing systems can offer them as well as gaining an understanding of the nature and needs of the design process to which they are contributing. At the same time the researchers are inspired to frame more accurate research questions and design solutions by a fuller, more accurate and empathic understanding of the users' lives and needs. Note that Eisma et al. (2003) make the point that sessions involving groups of older participants can be socially rewarding, and are part of positioning older users so that they are less in awe of the researchers or designers, this facilitates fuller discussion. Eisma et al. also suggest that one of many payoffs from combining observation of older people actually using systems with their verbal reports of their use and capabilities is that they found that verbal reports often did not correspond to what was actually observed. This could involve observation showing unreported difficulties but could also involve older users displaying greater enjoyment and involvement than they had predicted.

Explicit in these papers is a level of personal involvement in the lives of the older participants, a building of trust and of understanding. Newell and Gregor note that the close ties between researchers and the research participants creates a need in USID for careful management of the relationship. In particular they insist on clear separation between the roles of researcher and usability participant although they do select some carefully chosen disabled people for formal membership of their research teams where they are able to provide a "test pilot" role that gives quick feedback on feasibility during system development as well as informed comment on research and development proposals. Newell and his research team also insist that the researchers are responsible for driving the direction of the research, they do not accept the position of some members of the Participant Action Research school that the crucial choices should be driven by the aged or disabled users to avoid any suggestion of patronizing the people the research is aimed at assisting. Another area that Newell and co-workers note needs care is in the management of the expectations of test users of successful assistive designs. For a variety of reasons ranging from cost to the availability of adequate technical support it is unlikely that test systems will continue to be available after the project is concluded and this can be very disappointing for test users if the system has proved beneficial. This is especially so given the deliberately personal nature of the relationship between researcher and participant encouraged by the USID approach. Newell notes the responsibility of the research team to make it very clear to test participants what the duration of system availability will be. This issue is of particular importance to Newell and co-workers since they have maintained an interest in "blue sky" research where the approaches they use are not limited by the availability of currently available affordable technology. Newell argues that to constrict research into what is currently practical and easily affordable represents a crippling of the long term potential to assist older people.

Newell and Gregor note that they do not reject formal, experimental approaches but that they wish to see a synthesis of the strengths of both informal and formal investigation of the needs and solutions for older and disabled users. They note that one of the key aims of D3 and of USID is to provide motivation for change in the people who design commercial products for older users. To this end they propose that firstly USID should be seen as a mindset rather than a set of rules suitable for mechanical application to design issues. What they would like to create is a "culture change" within the developer community. Secondly they suggest that the way in which results are conveyed might be in the form of a story telling metaphor which, they argue, is better suited to convey the particular solutions developed for older and disabled users as exemplars of using the personal understanding of these users that underpins the USID mindset. To quote Newell and Gregor (2002), "The narrative methodology is designed to provide useful information to designers in a form that they will find easy to assimilate and act on". Similarly Zajicek (2003), in discussing the use of a pattern approach to offering guidelines when developing for older users, is concerned with the need to make the reasoning and experience on which design principles are based, accessible to designers through the inclusion of pattern examples. More recently the UTOPIA project has made some videos that use actors to portray older people and the problems they bring to computer use. This emerged from the experience of the UTOPIA team with the Portal project where industry designers with a background in UCD signally failed to come to terms with the needs of older users from verbal descriptions of their issues presented by experienced academics. Until confronted with older people attempting to use computers, experienced industry designers persisted in designing for conceptual users who were much closer to the designers own abilities than the reality of older people, see Eisma et al. (2004).

9.2 A comparison of methodological approaches

This section is aimed at examining the way in which the methodology developed for the current research echoes and diverges from the approaches developed by Newell's team at Dundee.

9.2.1 The range of older users addressed

In Gregor and Newell's (2001) description of Design for Dynamic Diversity (D3) they look at the range of users who are targeted as consisting of people who fit the criteria in Table 9.1.

Table 9.1. The range of abilities targeted in Design for Dynamic Diversity

1. Able, but with some diminished capabilities
2. Frail, where reduction in capabilities noticeably limits what they can do
3. Disabled, with severely limited capabilities in some areas

My own research looks at designing for a slightly more limited group of older people indicated as classes 2,3 and 4 in the following list. Some of Newell's category 3 would fall into my category five and be outside my target population and some of Newell's category 1 would fall into my (excluded) category 1 and some into my (included) category 2. As Newell (2003) points out in practice these distinctions are somewhat arbitrary and there will be blurred cutoff points between my included categories and my excluded extremes. Newell also takes the position that even old, able users are in fact likely to have some age related restrictions but are at this point in their aging process able to compensate for them. Hence my findings can be seen as having some relevance to all of Newell's groups while the groupings I include or exclude primarily reflect my recruitment of participants.

Table 9.2 Range of users included and excluded in the current research

1. (Excluded) Old, able, users of mainstream applications
2. (Included) Old, slightly restricted, can use mainstream applications with some effort
3. (Included) Old, moderately restricted, mainstream applications require too much effort to achieve useful results

4. (Included) Old, moderately to noticeably restricted, cannot use mainstream applications
5. (Excluded) Old, very restricted, cannot use applications designed for moderately age restricted older people

9.2.2 Responses to the diversity of older users

Under a D3 model it is important to consider a mix of disabilities and a range of the severity of these disabilities, both within individuals and across the user group. In addition, Newell and his fellow workers use the word "Dynamic" to make the point that for any individual their capabilities will shift with time of day, with general health, with unexplained good and bad days and potentially with the progression (or remission) of the underlying conditions that cause the disabilities.

My work focuses on age as a source of various disabilities. I have made an arbitrary division into those older users who can cope well with mainstream software and those who have difficulty doing so. Newell et al. tend to argue for more of a continuum from able to moderately disabled, so they would argue that the older apparently able group do in fact have some reductions in ability due to aging. This implies that there is a case for altering mainstream design in ways that will improve the access of current older users and potentially increase the number of older users who can use mainstream products as well as extending the time during which older users can continue to make use of applications that they have learnt as younger people. I accept this argument and suggest that this means that there are two valid areas for research on user interface design for older users, one on desirable adaptations to aging within mainstream designs and the other on design for those older people who cannot use mainstream designs or are not comfortable with doing do. Although I have focused on the latter area I do not discount the usefulness of the former. I also see a considerable potential for cross fertilization between the two approaches.

Newell et al's statement of "Dynamic" diversity implies that individuals' capabilities are fluid and hence that the categories they use are heuristic rather than fixed. I did not originally incorporate the dynamic aspect of D3 into my methodology but I think it should be supported. Interestingly work reviewed by Monk (2005) on circadian rhythms suggests that there is a payoff from testing older people in the afternoons when they are at a generally lower level of ability than in the mornings and by accident much of the testing in my projects was done in the afternoons.

9.2.3 Adaptive software versus multi-compensating software

Gregor and Newell (2001) in their paper outlining D3 argue for the ability of the system to adapt to accommodate the user. I on the other hand note that older users tend to have difficulty finding out how to customize an application or remembering how to do so. I tend to consider choosing the level of the adaptations to a particular diminished capability such that an application is not irritating for users with minimal disadvantage in that area. Hence I have aimed to attempt designs that cope with a fairly wide range of age related disability with as little customization as possible. Thus for example I have tried to establish not simply a minimum font size for a suitable default font for older users but I have also tried to establish a maximum comfortable font size for older users with acute vision to check that they will be able to work with the suggested default font size in reasonable comfort.

I am not automatically against adaptive applications as such but rather my aim is for relatively quick and easy solutions to older people's current needs. I do however suggest a note of caution in avoiding adaptive software that noticeably alters the way in which an application functions, I believe that older users function best in an apparently unchanging system model and should not be exposed to what could be the equivalent of mode problems as adaptive software sets different levels of assistance.

9.2.4 The need to extend standard design methods

Newell sees USID as an extension to User Centered Design (UCD). The methodology used in my research began as an extension of Task Centered Design as defined by Cooper (1994) and Cooper and Reimann (2003), but it should be noted that Task Centered Design is in itself an extension of User Centered Design. Newell argues that the need for extending user centered design is based on the fact that the differences in the groups he is dealing with are too great to be accommodated by the assumptions of UCD. USID aims to accommodate a much greater variability of user characteristics and capabilities than current mainstream applications or the range of users considered in traditional user centered design. Although my work focuses on older people, rather than disability in general, I share with Newell the view that the older group in itself is highly variable and that methodology aimed at working with this group needs to be based on allowing for this variability in the techniques used.

Again because significant aspects of this diversity are dynamic, responding to changes in age related ability or to changes in context, a less formal and more extensive investigation of older people's use of artifacts that have been designed for them is demanded. Thus Newell's teams use projects that seek to evaluate realistic prototypes in the context of the potential older user's everyday lives. Again this matches the approach used by the current research where the aim has been for naturalistic investigation using realistic prototypes rather than the laboratory based usability sessions initially using low fidelity prototypes that typifies more conventional User Centered Design.

9.2.5 Responding to the variability of older people

As noted older people form a highly diverse group. One of the issues that Newell highlights in this respect is the fact that working with a highly variable population needs additional concern about the way in which participants are recruited. Where User Centered Design tends to assume fairly homogeneous users, who can be readily sampled, working with older or disabled people means that the population variability makes obtaining truly representative samples very difficult. I have covered my approach to the issue of recruitment in Hawthorn (2001) and in Chapter 8 on how to work with older users. I have specifically wanted to avoid recruiting confident older computer users, although exploring their strengths and weaknesses could be valuable in research with a different focus. I have looked for people who are showing age related problems and so I have tended to recruit people who have tried and failed at other approaches to performing computer related tasks or learning. I suggest measures like this are needed so that sample bias can be actively countered given that the people who volunteer as research subjects tend to be unrepresentative of the general population. The FileTutor study still showed a tendency to draw in volunteers who were better educated and had higher social status, but this study also illustrated the benefits of getting non-traditional volunteers who are less cognitively able, less self confident, and presumably more representative of the general older population.

9.2.6 Stance with respect to Universal Design

USID offers a relaxation of the aims of Universal Design as given by Schneiderman (2000) and others, suggesting that truly universal design may be such a difficult target that it would prevent progress on effective but separate design for disabled users. I tend to go further arguing that there is a case that effective design for those older people who cannot cope with mainstream designs may be inherently unattractive to younger users. My position is that designing for a range that includes fully able users is a very much a secondary consideration and as such is much less important than effective design for older users who fall outside the mainstream. As I have argued in the discussion of the SeniorMail project (Chapter 6), some of the aspects of good design for older people actually conflict with the standard tools used by interface designers to provide rapid access to a large feature set. Where younger users want access to more features and to make use of more densely presented information, I suggest that they will be frustrated by systems intended specifically for older users. I do not claim that it is necessarily impossible to design applications that satisfy both able mainstream users and older (less able) users but I do argue that this is more difficult and that it should not be used as a reason for delaying the rapid design of systems specifically aimed at older people. In a similar vein, arguing against using the ideal of Universal Usability as a reason for not attempting less than universal designs, Newell quotes Watson-Watt, the British inventor of radar, to the effect that, "the excellent is the enemy of the good".

Some proponents of Universal Design argue that having systems that are specifically designed for older people are stigmatizing and so should be avoided. Some older people may object to using applications that are publicly acknowledged as being for older users, however the older New Zealand people I talked with were rather derisive about attempts to sanitize old age or to go to extremes of tact regarding the disabilities old age brings. What they wanted were things they could use. There may be a genuine cultural difference with the older American population or it might even be that concerns as to politically acceptable expression may have isolated Universal Design advocates from what older Americans actually want.

Newell and Gregor (2000) make the point that there will be situations where "design for all" is simply not appropriate, their example is that one should not promote a right to car driving for the blind. They also make the point that there will be situations where design for one type of disability can actually make the design harder to use for people with a different type of disability. To provide an example, very large fonts for the partially sighted will mean that blind people need to traverse larger areas to explore the information on a screen while people with poor concentration, reduced effective visual field or impaired short term memory may find the greater spatial distances between the concepts presented make relating the concepts harder.

9.2.7 Role of older people in research

In USID Newell at al. examine the desirable roles of disabled people in project development. Newell argues that there are very important benefits from gaining wide ranging input from the target user group. Newell's team has found that observation and discussion are much more productive than are questionnaires and surveys, a view that I support. We also agree on the importance of meeting the older people in context, so that home visits and observation of older people in environments that they would normally use become important.

Newell (2003) notes a concern within one school of the participant design movement that argues that the designer should be subordinate to the disabled people. This in theory allows the disabled person to maintain an equitable power relationship, in this view they should dominate decisions about things they will eventually be the users of. Newell fairly bluntly rejects this, arguing that at times disabled people lack the breadth of knowledge or even competence that would allow them to see the potential of what might be created for them. After trying to elicit ideas for email design from older people I agree with Newell on the researcher shaping the overall direction of the design project. The older people tend to have too little understanding of the possibilities available in potential designs to be able to direct the decisions that form a new design. The role for older participants in my own research that has been found to be more appropriate, is to respond to concrete examples of design possibilities rather than to initiate them. This is not to say that issues of power are irrelevant in working with disabled or older users. I have explicitly opted for working with groups of older users in order to provide settings that empower the older participants with respect to the researcher and the UTOPIA team also makes extensive use of groups in product evaluation.

9.2.8 Role of older "in house" testers

It is interesting that in the UTOPIA project a few carefully chosen disabled people are in paid roles as project consultants and they make initial usability assessments before the version of a product is tried with disabled users who are strictly in the role of testers, not project members. This closely parallels the way in which I used a few selected older people to get quick initial feedback and then proceeded to get usability information from a wider group. Both the UTOPIA team and I have found this to be an excellent way of bridging the considerable gap between sympathetic but able researcher and the disabled target audience. There are so many design decisions in the course of a project that the availability of quick feedback is essential and this becomes more important when the difference between designer and user increases as is the case with both aging and disability. This "concentrated investigation with small groups of extreme users" is also strongly supported by Gheerawo and Lebbon (2002) who argue for becoming a trusted part of the user's life with whom the user can have very frank discussions of their needs, difficulties and aspirations. Gheerawo and Lebbon also argue for the inclusion of an empathic dimension to the researcher's relationship with the users. They argue that this can "open up a creative space" that will facilitate innovation and I tend to agree. In a similar vein Eisma et al. (2003) suggest a concept of "mutual inspiration" for deepening the relationship between designers and older people and hence increasing the value and depth of the resulting communication.

Newell made a much clearer distinction than I did between disabled consultants who were formally part of the organization and test participants whose involvement was restricted to aspects of providing information about their lives and testing designs. As noted above I had two late middle aged volunteers who provided substantial immediate input but I also tended to form longer term relationships with usability test participants who were interested in the projects and insightful. In the case of SeniorMail, a relatively few people became long term users though this raises problems in terms of providing sufficient long term support.

9.2.9 Role of experts and supporters of older users in research

Newell also argues that there should be contribution from the people supporting the target disabled group including clinicians, care givers and disability experts. The aim is to increase the expertise in understanding the conditions under which older or disabled people operate. In setting out the principles of USID, Newell and Gregor (2000) do not explicitly make the case for a strong reliance on the literature on cognitive and physical aging while I tend to see it as a keystone of my approach. However they do argue for a clear knowledge of the characteristics of the user group and they do employ experts in disability as part of the research teams. Further if one examines work by members of Newell's team, one finds examples of penetrating analysis of the implications of the literature on cognitive and physical aging, see for example Carmichael (1999) in the first chapters of his style guide for interactive TV design for older people.

Newell makes the point that experts in disability are likely to resist research directions that challenge the current orthodoxy of the area and this limits the freedom to make useful innovations, and hence at times experts must be overridden. A point that Newell makes strongly is that overall control of the direction of the research and the shape of products produced in the course of the research should remain with the HCI researchers. To this end Newell makes the point that the clinicians involved in the UTOPIA team need to be aware of and to accept such a research focus.

After trying to elicit ideas for email design from both older people, their family supporters and from rest home care givers who assisted older residents make emails, I agree with Newell on the researcher shaping the overall direction of the project. The older people tend to have too little understanding of the possibilities, family members often appear to want the older people to perform like themselves and care givers can have difficulty seeing the possibilities of independent action by older people. I have dealt mainly with independently living older people so I have not looked for input from official care givers or clinicians but I have no doubt that this would be valuable as the level of disability one is designing for increases. What I have done is emphasis the role of family supporters as both a source of information and as people who can benefit from design that considers the role that they play in an older person's software use. However I am willing to override some of the prescriptions of family supporters, just as Newell has at times overridden the views of the clinicians in his projects. Supporters of older users, in my experience, as well as being helpful, can adopt one of two non-productive roles in suggesting what is needed in a design for the older people they support. They are either too limiting on the potential of the older users, "Father could never handle that" or what they want is in effect a clone of the systems that they themselves use and they appear to be projecting their own likes and wants onto the older person.

9.2.10 The appropriate research focus

Newell argues for a focus on a long term perspective on the future needs of the elderly rather than looking to a short term product perspective. He argues that the project should remain research focused and not lose that focus to aim simply for constructing assistive devices. I do not disagree but I do suggest that there is, as well, a place for examining what can be done to improve current mainstream applications for older users using simple off the shelf technology.

I have had a dual focus in my research, aiming to expand and understand principles of design for older users at the same time as constructing software that was of immediate use and could be made available as commercial products. This gave me ready co-operation from older people who needed easier software and gave a stronger test of my designs, however it also stretched me in that coding for a robust application involved considerable time that was not directly related to my research aims. I tend to look more to an understanding that will support short term product development though, as I point out, I see my emphasis on the way my recommendations are grounded in the literature of aging as a way of relating my recommendations to future generations of older users who will have more initial computer knowledge, but similar patterns of aging.

Both Newell and I are concerned that a methodology for working with an impaired group should set out a proper way of relating to members of this group. This is discussed in more detail in Chapter 8 on how to work with older people. For the present is worth noting that Newell and I independently decided that it is inappropriate to treat the older people involved as subjects, the term "participants" seems to better capture the desirable relationship.

9.3 Conclusions

In short two sets of researchers have independently developed very similar ways of developing products for people who because of age or disability are unable to use mainstream products. The degree of correspondence between the two approaches is striking. Representatives of the disadvantaged groups become key players in the design team and provide frequent and ongoing evaluation as product features are developed. Expertise in the nature of the disabilities catered for is also incorporated into the design team. Evaluation of products focuses on informal observation and placing the product evaluation in the context of groups of older people working in their own environments. The design effort aims to inclusively meet the needs of a variety of types and levels of disability. There is a tendency to take a pragmatic approach to providing software that works rather than achieving universal design. The needs of the disabled users are evaluated informally and face to face allowing for the emergence of unexpected issues and clearer communication. Finally the key source of initial designs comes from the researchers, not from suggestions by the disabled participants who are seen as lacking sufficient design expertise to create initial designs but as being very capable in making suggestions about what does and does not work.

This close correspondence between two approaches developed without reference to each other on opposite sides of the globe and the degree of design success that both approaches have achieved, offers useful support for the overall approach.

Chapter 10 Conclusions

10.1 Introduction

This thesis has examined ways of designing user interfaces that suit older people. In the course of this research three applications (two interactive tutorials and an email system) have been built that older people report as being unusually suited to them as older people. Testing has shown that older people who have had little success with standard approaches to learning computer skills or emailing have succeeded in using these systems. It would be nice if we could then conclude that if an interface designer does A, B and C, they will then obtain effective applications for older users. However what emerges from the study is that successful interface design for older people depends on consideration of a number of issues that are not entirely simple to incorporate into interface design. This concluding chapter will provide an overview of the issues that the research found to be relevant, it will note how identification of these issues was arrived at, and will point to the ways that responses to these issues were used to create interfaces that suited older people.

The chapter will begin with an overview of the conclusions reached in this research. The question of the relevance of the findings for the current and future older generations will be considered. It will then proceed to look at the way each of the aspects of the research contributes to these conclusions. The role of the literature survey as a resource for designers will be discussed. The way in which the Dual Task pilot study and the experience of observing the Unitec classes for older people shaped a re-direction of the thesis will be reviewed. Then the chapter will look at the contributions of each of the three interface design case studies that provided successful examples of design for older users. After exploring the contributions of the WinTutor, FileTutor and SeniorMail studies this chapter will then look at the derivation of the research methodology with a view to making the thinking behind the choice of methodology accessible to other workers in this area so that they can make informed decisions as to which aspects may suit their own research. From here the chapter briefly looks at the concerns that need to be addressed when working with older people in such a way that they make useful (and ethical) contributions to a design project. Having noted that the designer needs the competencies in relating to older people that are explored in Chapter 8 the conclusions chapter moves on to examine the relationship between the thesis and the similar theoretical perspective developed at Dundee. The chapter has then reached a position where it is possible to look at the extent to which the thesis has achieved its aims. The final sections of this chapter look at possible directions for future research and attempts to sum up the overall thrust of the thesis.

10.2 Overview of the conclusions.

There are areas of the aging process that give rise to concerns about the ability of older users to use software that is designed for the mainstream population. With the expansion of the older section of the population and the expansion of the role of computing in society the problem of poor design for older people takes on particular relevance. By creating interface designs that take account of age related changes in vision, motor control, memory, attention, intelligence and learning abilities it is possible to improve the performance of older users well beyond the performance seen when these same users attempt to use standard software. However the creation of such age appropriate designs is not a simple matter of translating a fixed set of age based guidelines into interface practice. Rather the degree of difference between young or even middle aged designers is such that it becomes essential to incorporate older people into the design process from the beginning and to obtain frequent feedback from them to guide the design. In doing so the designer needs to adapt and alter practices that suit younger people involved in participant design, useful and ethical interaction with older people is not something that can be taken for granted but becomes another skill that designers in this area should acquire. In addition designers aiming at older people need a background of increased understanding of the aging process. With this combined knowledge base and skill set, the thesis has shown that it is possible to construct useful and successful software for older people that older people appreciate and benefit from.

The thesis documents a shift in attitude with the experience gained over several projects where products were developed for older people. At the start of the research my expectation was that from the literature survey and some experimental work the research could produce a set of strong recommendations for designing for older people.

With experience my emphasis changed from a view of design for older people as something that could be expressed in terms of rule based guidelines, to a view of design for older people as a process that involved older people within each design, that used knowledge of aging and previous examples of design for older people as resources rather than rules and which altered the traditional skills and role of the designer.

An overview of the issues that are seen as relevant to designing for older people is given in the following list. These points come from a variety of sources and do not originate solely with my research, but what my research has done is to find a variety of techniques for incorporating these points into both the interface designs produced and into the process of interface design for older people.

1. Older people are subject to a wide range of age related effects. Each change due to age represents a departure from what a designer could reasonably assume about the capabilities of people of similar age to the designer.
2. Older people are not uniform in the effects of aging. People of similar ages will have widely varying types and degrees of age related disability and the extent to which individuals are affected by age will vary over both the long and the short term.
3. Any interface design for older users should be restricted and simplified so as to fall within the perceptual, manipulative and cognitive capabilities of as wide range of older users as possible.
4. There are significant gaps between a younger designer’s assumptions about people, even older people, and the reality of the actual limitations of older people. It seems that these gaps are difficult for younger designers to adapt to except by exposure to older people.
5. Older people from the current older generation who learnt computing skills as older adults are likely to have unexpected (to a younger designer) gaps in their computing skills and knowledge.
6. Part of achieving suitable restriction and simplification comes from working with older people as part of the design team.
7. Older people form a different culture and it is not simple for younger designers to communicate well across the cultural gap.

8. Older people are slower to learn and more likely to forget during extended periods of learning.
9. Older people have generally fewer needs that they wish to meet by using computer systems, they are likely to be less frequent and less intensive computer users than younger users, this in turn impacts the frequency of opportunities they have for cementing learning.

10.3 Relevance

Part of the special relevance of the needs of older people attempting to use computers is that they represent a group whose vulnerability is exposed through the convergence of two major trends. The rate of demographic change towards an older population is at a rate and a level not experienced since the Black Death in Europe. At the same time we are at the beginning of a change in the way that information is used and disseminated through society that is akin to the magnitude of the eventual impact of Gutenberg's printing press. As with literacy given the existence of printing, we can expect that the skills of computer literacy will move from being desirable to being assumed and necessary for adequate participation in what our society will become. The current generation of older users faces special problems caused by the need to learn basic computing skills and concepts while old. Despite the Flynn effect, and somewhat better medical treatment of aging, future older generations will still face problems due to declining abilities. As social security systems struggle to cope with the demographic shift, older people are likely to need to engage in employment for longer in order to maintain sufficient income and that employment will increasingly require computer skill, again applications that are usable for older users will ease this situation. The current thesis is aimed at a Windows application style of interaction whereas much of the emphasis of HCI research has shifted to Web and mobile design. However with increasing bandwidth and the rise of web services, the more fully featured style of interaction available in Windows applications seems likely to return to relevance, especially where meaningful employment tasks are involved.

It was pointed out in the introduction that the aim of the thesis is relevant to older people over a time scale beyond the current older generation. There will continue to be a gap between applications that suit younger users and applications that suit older users. The next generation of older users who come to old age with existing computer skills will still suffer from the perceptual, manipulative and cognitive declines of age, forms of interface design that lessen the effect of these age related effects will be relevant to their needs. In addition they will be vulnerable to technological shifts that erode the relevance of the computer knowledge they learnt when younger. The findings on the narrow ranges within which expertise is maintained in old age and the findings on the role of crystallized rather than fluid intelligence in older people's performance suggest that future generations of older people will still not cope well with changes in what is expected in terms of computer knowledge.

Although we are moving into an age where the next wave of retirees will include many computer literate people, the new recruits to the older generation will not all posses computer skills and the computer skills they do possess may be relatively narrow and work related. It seems reasonable to suggest that the less educated among the people who will soon be retiring will include numbers of people with minimal computer skill so that for some time to come the older generation as a whole will have a majority of people who do not possess adequate (or in some cases, any) computer skills and yet may be forced to try to come to terms with computers because of the increasing advantages of computer based interaction with the world. The findings on intelligence and age link the extent of previous education with ability to maintain intellectual functioning into old age. This suggests that if computer use becomes important as a way of obtaining access to services for a wider section of the population, then this potentially exposes an older less educated section of the population to requirements which they may find difficult.

10.4 The contributions from the literature survey

The literature survey documents a wide range of effects of aging that can be argued to be likely to have implications for interface design for older people. Another way of looking at this is to see each of the differences that aging makes between younger and older people as another break in the in-built assumptions of (younger) designers that they are designing for someone who is generally similar to themselves. As it stands the literature review has identified over one hundred and fifty such departures from similarity between the younger designer and older users. This is before gaps in older people's specific computing or operating system knowledge are considered. It should also be remembered that the literature survey is not exhaustive given the volume of current research on aging. In addition, research on aging is continuing to produce new findings at a considerable pace.

It is also the case that these findings do not apply to all older people equally, the older population is far more diverse than the populations from younger age groups. This means that a designer is going to be performing a balancing act in which features in an application intended to cope with one form of aging disability may be strongly relevant for only a section of the product's target group, may be mildly beneficial for other potential users and may be irrelevant or an active disadvantage for others in the target group whose individual pattern of aging does not include the particular effect of aging at issue. It is even the case that individuals vary in the degree to which they are age impaired over the course of the day.

On the face of it design for older users is an apparently impossible task. It also raises the question of why users of WinTutor, FileTutor, SeniorMail and even the test software constructed for the Dual Task study stated that they found the software particularly easy to use and well suited to themselves as older people and that they wished that other software could be like this. All these designs were designed with extensive input from older people, but why should the relatively few older people providing the input give rise to software designs that were widely accepted by older people? Several possibilities exist but this is an area where further research could be highly productive. There may be a core group of age related disabilities that are more likely in many aged individuals. There may also be a situation where age related disability on these core problems is widespread in most aged individuals but that this is masked by the adaptations to aging that people learn to make as they age. In this view the older population may be more uniform than is currently thought. What is not uniform is the breakdown of the ability to cope with disability that occurs as various forms of disability worsen or as the conditions being coped with, such as the complexity of a problem, become more difficult. The assumption in relating this view to interface design for older people is that maintaining adaptations for age related problems takes effort and that where an application design does something simple such as providing large fonts, the people who benefit include those older people who are apparently coping well with normal sized lettering. This is highly speculative and the eventual answer may be quite different, but the question exists as to why an apparently wide range of older people appreciate the application designs that have resulted from this research where the designs are made up of features that accommodate specific age related difficulties that are not apparently major difficulties for the test subjects?

Another issue raised by the literature survey is the difficulty of obtaining experimentally verified confirmation of the implications that have been drawn. We have some one hundred and fifty age related effects, they are general findings saying such things, as older people find greater difficulties with motor control. They do not easily translate into findings on specific interface skills and features such as difficultly positioning a cursor in small text or the inadvisability of using Windows style menus with a broad structure of sub-menus. Even where we have research that is directly related to interface features, such as a finding that older people read more slowly when reading colored text compared with black text on a white background, Charness (1988), we can guess that colored text requires more effort for the older person to read but we do not know the range of conditions under which this is true. It appears from the fonts used in WinTutor and FileTutor that older people cope well with colored text if the font size is large, the color is relatively dark (navy and maroon were used) and there is a high level of contrast between letter color and background but this is impression, not an established finding. The problem is that given the vast range of aging effects and the potential subtleties of the implications that can be drawn from them there will never be enough time to experimentally verify the full range of interface adaptations for aging.

Given the range of aging effects, even if interface design for older people was suddenly and improbably given NASA levels of funding, if what resulted was a mass of interface rules, there would be so many rules and the rules would be so detailed as to overwhelm any real and human designer. To allow real products with appropriate interface design for older users to emerge in a reasonable time frame there simply has to be some use of design work based on impressions of what works well for older users. What I suggest is that the role of the literature on aging and the implications that have been drawn from it in this thesis is to provide a framework for considering possible problems, checking that proposed solutions are reasonable and, importantly, for interpreting observations on older people's problems and successes with interface features. As such the information on aging provided here does not function independently but as part of a design process that depends on closely working with older people. Interface designers require a way of coming to terms with the breadth of the findings on aging, what has been shown in this research is that combining a general knowledge of aging with the close involvement of older people in design development allows this.

10.5 The Dual Task Pilot Study Contributions

One of the interesting questions about the dual task study is why the findings were negative. We know that older people have difficulty in managing dual task situations, there is no reason to suppose that such difficulties will not be present when older people manage an interface task and a substantive task at the same time. We know from the work on automated responses in older people that such responses are more difficult to form when old and so older people are more likely to need to pay conscious attention to the steps involved in many interface tasks. The handwritten notes, giving step by step instructions on how to do computing tasks, that are found around older people's computers, are no accident. However in the dual task study a deliberately difficult interface did not lead to poorer substantive task performance. Are some forms of task pairing such as vision and comprehension more resistant to dual task effects or do dual task effects depend on fine details of such things as timing, or are some as yet unconsidered effects in play? At some stage in the future understanding more about whether and when interface tasks compete with substantive tasks seems likely to allow improvements in interfaces for older people.

The focus groups that formed part of the dual task study indicated that there was considerable information to be gained about older people and computing from interaction with them outside the setting of a laboratory study. The dual task study also opened the issue of what did ethical treatment of older volunteers consisted of? The standard ethical guidelines for younger people indicated that research was ethical if it did not cause any physical harm, therefore sitting in front of a computer trying tasks and failing on some of them was physically harmless and thus if the study gave the subjects suitable compensation and offered a chance for useful knowledge it was ethical. It became apparent that guidelines of this sort are not suited to older volunteers. Because of older people's tendency to self stereotype they were likely to generalize the experience of failure to conclusions about their computer competency and to thus view themselves as less worthwhile. It was also noticeable that failing on the comprehension tasks surprised the older people and distressed them by presenting a more negative view of how intellectually able they were. Without some sensitivity to issues of aging and self identity, researchers new to the field and non-specialized ethics committees are unlikely to pick up these issues. This is not to rule out laboratory studies with older people, including those that use computer displays for presenting tasks, but it does raise serious questions about studies of older people which are designed to lead to task failure on tasks that are important to the older volunteers' self concept. In this context it should be noted that there is no evidence that de-briefing older people after such experiences undoes the effect.

The dual task study also raised the issue of whether laboratory studies of older people would lead to the older people performing with realistic levels of engagement and motivation. Obviously if we are trying to obtain information relevant to older people's computer use outside the laboratory we would like levels of performance that are similar to those the older people apply to their own private computer use. What was found in the dual task study was that the older people tended to disengage under three conditions; if the experimental trials went on for too long, if they were distressed by failure and if they did not see the tasks as interesting and relevant to themselves.

Again the dual task study gave a first indication of the usefulness of social interaction and the use of small groups in working with older people. In the focus groups and in the refreshment breaks it was evident that getting together with other older people was in itself rewarding. It seemed that focus groups with older people who had shared a common recent experience were relatively easy to manage, some of the issues other authors noted as difficulties in using focus groups with older people such as insensitivity to what other people were saying were observed but not frequent and did not cause major problems. My interpretation was that the common shared experience in the group members' recent past (taking part in the dual task study) gave the group enough common ground to improve the group's functioning.

Obtaining basic personal information at the start of the dual task study drew attention to the way that asking for volunteers for a research project was leading to a sample that appeared to be considerably better educated and to have had higher status previous careers than the general older population. This raised the issue of sample bias for later consideration.

10.6 The WinTutor Study Contributions

With hindsight, studying the difficulties faced by older beginners in the Unitec teaching observations, was an excellent contribution to the overall research. As was made clear in the chapter on the WinTutor project, the decision to develop a tutorial for older beginners arose from a personal response to the unhappiness that was observed when older people tried to take classes intended for young and middle aged people. However the experience of designing the tutorial with the in-house testers led to an appreciation of the extent of the difference between older beginners and the users a designer might expect. One shot learning was almost non-existent, learning could take weeks or months and some older people appeared to be likely to remain as perpetual novices. Apparently elementary skills and concepts were missing, a designer could in fact assume that if something was completely obvious and basic then some of the older target group would not have learnt about it. Some older people appeared to proceed by using a few rote rules, sometimes learnt but often written on pieces of paper so that carrying out a computer task at home involved stops to find the right bit of paper and further work in trying to remember what their instructions to themselves meant. The older people seemed likely to learn at a concrete level and to be slow to form underlying concepts that allowed them to generalize learning to somewhat similar interface features and to different settings. Although the older beginners did learn from WinTutor and from the intervention tutorial they were slow to apply their skills to other applications and there were frequent cases of fragile learning. It appears that in order to make a design widely available to older people, a designer needs to design in a way that makes the design usable by beginners and does not make the assumption that all of those beginners will change status to become experienced users. A designer should assume that partial skill sets will continue to typify some of today's older users. It also seems likely that later generations of older users will have partial skill sets for computing paradigms that emerge after they have reached old age. How to anticipate and to accommodate a partial skill set will continue to be a valuable ability for designers aiming at older users. As an extension to this it seems valuable for any designer for older people to gain face to face experience with older beginners.

The WinTutor study identified a set of difficulties and needed skills that apply to the current older generation's beginners. It also included training features that seem appropriate for older people such as reasonably entertaining hands on activities, designing activities so beginners could achieve a high level of success and having very easy and consistent ways of restarting exercises.

The WinTutor study suffers from its lack of formal evaluation, but if the continuing use of the product by SeniorNet and the more formally evaluated success of the similar FileTutor tutorial are accepted as evidence, it seems as if WinTutor provides a suitable method of training older people in computer skills. I am cautious about evaluating this as general support for interactive tutorials as a method of teaching older people. It is my position that, in this research, interactive tutorials have been shown to be a format for teaching that can suitably contain solutions to the problems that older people have been observed to have with standard training formats designed for younger people. Interactive tutorials can offer easy solutions to providing hands on active learning and to integrating instructions with the hands on activity and to providing a format that suits small group and self paced learning. On the evidence presented in this research, this does not rule out other training formats as containers for such solutions, nor does it suggest that interactive tutorials are automatically a good idea for training older users. Rather the conclusion from the two studies involving interactive tutorials is that the success of these designs comes from carefully evaluating the problems that older people have with needed concepts and skills and then formulating interventions that aim to build knowledge towards providing the needed concepts and skills in a carefully built sequence where each step provides the needed knowledge and practical hands on experience for subsequent steps. It is also concluded that in order to effectively provide such step by step progress, the content, activities and the presentation need to be developed in close cooperation with inexperienced older people working as part of the development team.

In addition to being a training program, WinTutor is an example of an application that was designed to be used by older beginners. As such it provides other designers with an example of a program that older beginners found easy to work with. It makes use of a variety of recommendations from other authors and from the literature survey and while the study design is unable to offer experimental support for individual interface features, it does appear that the combined design features used in WinTutor led to an application that older beginners use well.

10.7 The FileTutor Study Contributions

One of the aims of the FileTutor study was to provide retrospective support for the WinTutor study. An interactive tutorial that was very similar to the interactive tutorial used in WinTutor was given more formal evaluation and proved to be effective in training older people on computer skills. It was noticeable that as the amount of conceptual material increased the interactive tutorial format was stretched. The older students' memory and comprehension issues meant that they struggled to relate a textual screen introducing concepts to a succeeding screen where the concepts were put into practice. The older students needed more assistance from the tutor and more encouragement to persist with the tutorial in the sections that had higher levels of cognitive content. After they had persisted they saw the tutorial as very helpful but, particularly for complex material, interactive tutorials may be better used in conjunction with support from a tutor. There is also the possibility that interactive tutorial design could be improved by including skilled teachers of older students on the development team.

With those provisos the FileTutor project demonstrated that it is possible to use appropriate interface design for older people, combined with appropriate interaction with older people, to improve training for older people to the point where the older people succeed in spite of being previously unable to gain adequate understanding on other forms of training. This is an important finding in the area of computing and older users. It offers a research based finding to counter views of how limited older people will be in their computer use, it also offers an alternative approach to creating interface designs specifically for older users. If there are situations where it is not immediately practical to redesign software to suit older users, or where the job demands are irreducibly complex, it seems that specialized training that takes account of older people's abilities can allow them to succeed in using applications that would be impossible or difficult to learn without such training. My personal view is that it is more desirable to produce versions of applications where the interface is designed specifically to be accessible by older people, if however this does not happen, for whatever reason, one should not write off the possibility of training older people to use software designed for younger people. The reservations are threefold. Firstly a training approach should not be used as an excuse for not making suitable software for older people. Secondly that providing appropriate training and training materials such as FileTutor is itself a large task. Finally the FileTutor project does not tell us where the training approach will break down as the target application's complexity and prevalence of age unfriendly features increase.

The FileTutor project provided a number of specific recommendations for making interactive tutorials suit older learners. These recommendations will not be repeated here in the conclusions but they are seen as being worth studying by any person intending to create such a tutorial. In addition the FileTutor project demonstrated that Carroll's work on restricting initial training to a minimal set of core application features and providing hands on experience with these features is suited to older learners as well as the younger learners that his team worked with.

It should also be noted that the FileTutor project provided a second demonstration of a successful interface arising from a development process that relied on the input of the older in-house testers. Two other themes started to emerge in the course of the FileTutor project that would be extended in the SeniorMail project that followed and would form part of the overall set of ideas on productive work with older people that the thesis contributes. The first was the idea of obtaining design input from older people by having them interact with a high fidelity working prototype that was suitable to their needs as older users. As reported in Chapter 5 the in-house testers worked with each individual screen of the FileTutor and WinTutor tutorials. These screens were presented as code based prototypes, the in-house testers were observed trying to use them and comments were collected. New screen versions were then produced and the cycle continued until the issues raised by the in-house testers had been resolved. By the time the usability testing was done FileTutor was a relatively well working program that had been repeatedly altered until it answered the needs of the in-house testers and the problems found by observing the in-house testers try and work with, and understand, files and folders. It was apparent from the responses of the usability testers that they had feared yet another computer program that they would struggle with and that finding a program that was generally suited to them as older users was both novel and welcome.

The other emerging theme was the use of group work in product evaluation and in eliciting comments about usability. It may be remembered that the FileTutor usability testing was done with small groups where although each person had their own computer running FileTutor there were other older people using FileTutor sitting alongside and the researcher allowed the test participants to interact with each other and discuss what they were doing, provided they brought usability problems to the researcher's attention. What I was doing here was modeling the situation in which FileTutor was intended to be used, the SeniorNet classes for older people. What emerged was that this was an effective way of finding usability problems. Given an initial credible prototype where the frequency of problems was low a single researcher could record and discus the issues found. What also emerged was generally an atmosphere of pleased, interested and lively engagement with the product and the other participants. This was an extraordinary contrast to the bored and sometimes distressed task compliance found in the Dual Task study as well as to the uncommunicative misery of the older adults failing to learn in the Unitec teaching environment. It was also observed that the participants in the FileTutor testing did not defer to the researcher/designer in the way that had been found in the Dual Task study. Remember that I, as designer, was conducting prolonged evaluations of the product that I had designed. Being human, in a few cases I slipped into trying to justify my design choices, to get sharp reminders in the form of, "Oh I didn't like that either". This is not to say that the relationship with the researcher was adversarial, it was much more that the participants had bought into the idea of contributing to improving the product and that they accepted the idea that their difficulties were valid data and that the researcher/designer was one member of a team trying to achieve improvements. My personal response was that I was challenged by, and I intensely enjoyed, most of the testing sessions.

Two other possibilities emerge from the FileTutor study. Firstly given that this tutorial format appears suited to older users it should be possible and useful to include such tutorials, alongside or embedded within, applications that are aimed at older users. In fact the SeniorMail email application did have an embedded tutorial that in effect provided Carroll's concept of minimal instruction for the SeniorMail system. This was used in training some of the long term users of the system in conjunction with a tutor and appears to be helpful but has not been extensively evaluated.

As a second approach the format used in FileTutor could well be used for either applications that older people use infrequently or for older users whose aging process is such that they struggle to remember sets of procedures. In a sense this is a way of modeling the working environment that older people were observed to repeatedly create for themselves. When I visited older computer users I made it a point to observe the computing environment they used. An almost universal feature was that they relied on hand written notes giving the steps for all but the most common tasks. The conclusion is that older people do not hold a mental working version of the procedural steps of infrequently performed computer tasks and that it is probably unrealistic to expect them to do so. Suppose the older user needs to copy a file or do a backup. An application similar to the second menu screen on FileTutor could present a set of buttons giving choices of typical file management actions. The user chooses [Copy a file] and then goes to a screen that provides step by step notes of how to carry out the procedure together with an embedded tool for doing the task, very similar in appearance and concept to the screen in FileTutor where a learner practices the file copying exercise. The differences from the FileTutor concept are that the application is intended for actual work, rather than learning and the embedded tool for file management in this case does not need to be a reproduction of a standard tool such as Windows Explorer but could be a file management tool specifically designed to suit older users. It might be possible to allow the older user to divert into a refresher course on some aspect of file management if they required but the main thrust of the application would be to allow the user to carry out basic file management tasks with clear step by step procedural notes positioned alongside the task. Although the example I use here is for file management the basic concept could well apply to any computer based job that older users need assistance with and where they are unable to retain the procedures needed between uses. The assumption here is that there are computer tasks where older people will choose to trade off the fastest way of performing the task for a longer winded approach that leads to eventual success. My position here is that this is conceptually different from a wizard in that the application provides an overview of the whole task and that the user can use the tool with as much or as little reference to the notes as they choose.

10.8 The SeniorMail Study Contributions

The point has been made that the interactive tutorials developed in the earlier studies are applications and that they require the design of a large number of screens that suit older people. However the task being accomplished by these applications is an internally focused learning task and the system model of each tutorial is relatively simple. The SeniorMail project allowed the research to move to considering whether the design process that had been developed for creating the interactive tutorials would work for an application with an exterior focus on a real world task and a more complex system model. The SeniorMail project took the themes related to design for aging that had emerged in the development of the interactive tutorials and put these themes in the context of development that was clearly application development and was for a moderately complex application. In-house testing using older people who were part of the design team, use of awareness of the effects of aging to inform design, and use of groups of interacting older people in order to test prototypes were all aspects of the earlier design studies. Bringing these themes to a different type of design gave not only a chance to suggest their relevance to application design for older people in general, but also gave a chance to refine the techniques involved as the new design setting exposed new requirements. Hence these earlier themes have been expanded to include firmer support for such aspects as the need for an initial credible prototype, the desirability of code based prototypes as distinct from standard practice, the development of "Computerware" parties to create a socially rewarding and supportive group environment for software exploration and testing, and the provision of alternative design fragments to allow older testers to critique designs without being seen as criticizing the designer and to see more of the variations that design changes allow. These techniques are seen as a significant contribution of the SeniorMail research, they provided an ongoing flow of responses and comments from older people that had a major impact on shaping and improving the SeniorMail design. They significantly increased my own understanding of the human reality behind the term “aging”. These techniques offer methods that can be applied by future designers for older people with useful payoffs for their own projects. The actual details of the techniques will not be repeated here as they are discussed in some depth in Chapter 6 on the SeniorMail project and explored further in Chapter 8 on working with older people.

The report of the SeniorMail project also contributes a number of examples of how design details were arrived at using multiple aspects of the information on the effects of aging further combined with observation. The study design contrasts the overall design of SeniorMail with the other email designs that the older participants used (effectively MSOE) so it is not equipped to make strong findings at the level of the individual features incorporated in the design. However descriptions of the considerations that went into such design features as the modified tool-tips used in SeniorMail are seen as useful to future designers, not as rules that are to be followed, but as exemplars of ways of considering design problems and solutions that are capable of linking what is observed with multiple aspects of aging. Some of the design decisions that are detailed in Appendix E are likely to be useful in future projects. For example if lists of instructions are used, then numbering them, simplifying the wording and making each point in the list deal with only a single simple step is a useful approach. However the support for its usefulness comes from unstructured observation, conversation with older users and apparent congruence with aspects of aging covered in the literature survey. Given the design of the SeniorMail study it may well be that some of the adaptations to aging used in SeniorMail and reported in Appendix E make much less of an impact on the overall design success than others, the success of SeniorMail is support for the overall design and not for every feature of the design, except to the extent that it can be argued that no feature that remained in the design after testing provoked strong difficulties or complaint from the older users. The reader should be aware that it is not known which of the adaptations to aging found in the designs are most or least relevant in SeniorMail or will be most important in future designs.

The SeniorMail project also highlights the tension between designs for older users and designs for the general computer using population. It was noted that the design techniques used in SeniorMail frequently involved dropping techniques used by designers for younger users that allowed applications to present a high number of features and ready access to these features. Examples would be the decisions to use full screen windows, to avoid Windows style menus, to increase font and button size, to limit the number of toolbar options, to restrict the navigation model and so forth. In order to make the SeniorMail design work for older people, dropping as many email features as possible was an essential prerequisite. The SeniorMail design would not be possible if it tried to incorporate an extended feature set without hiding the extra features as sub-levels of the program along the lines of the [Options] button on the main menu. What has been demonstrated is a way of making a useful and usable basic application. It has been shown that with such an application older people can achieve email tasks they want to achieve whereas they could not achieve those tasks with MSOE. What has not been shown is a technique or a set of techniques that allow a designer to make all of a fully featured modern application available to older people. The core enabler of the approach used is to carefully scrutinize the requirements in the light of what older people actually want and do and to then ruthlessly simplify the feature set offered by the application. This means that the approach used here to make a suitable application for older people is not scalable to complex, highly featured applications.

The trial of SeniorMail with the set of middle aged users that is reported in Chapter 6 was interesting. Older users were generally delighted by SeniorMail, it appeared to be a breakthrough in their experience of applications and their enthusiasm was readily apparent. The middle aged, computer and email experienced users were simply not excited by SeniorMail, yes it worked, yes they could use it, but so what? The older users came from a perspective that what they had previously tried did not allow them as older users to complete basic tasks, an application that did allow this and did not involve stress and frequent errors was a revelation to them. The middle aged users on the other hand took for granted that if something called itself an email application one would be able to achieve basic email tasks on it. What they looked for was the ability to use features that they used and valued in other email applications. When they did not find this in SeniorMail they concluded that it would not be suitable for them. As noted in Chapter 6, the relatively small sample, of 15 middle aged users, showed very little overlap in what they regarded as desirable extensions to the basic feature set. In essence the argument is that what middle aged or younger users want collectively is a fairly feature rich application. The approach used in designing SeniorMail will not extend to this.

This observation was extended at the end of Chapter 6 to consider the question of the Universal Usability movement's concern with full accessibility for all, regardless of age or disability. The argument was made that fully featured applications would be too complex and require too many difficult interface features to be accessible to many older people, nor would the extra features provided necessarily be desired by this older group. The further point was made that it is inequitable to delay older people's access to a basic and workable emailer or other application on the basis that a fully accessible, fully featured version is the desirable starting point. It was noted that there was interest in providing fully featured applications that provided a senior friendly skin with a simplified interface and minimum features. I suggest that the desirability of this approach and its difference from providing older people with usable but "dumbed down" applications is moot if the older people do not venture beyond the skin provided for them. What may be more important is the issue of extensible applications or skins that allow an older user to learn on a basic feature set and then to incorporate some extra features later as desired in such a way that the extra features conform to the gestalt of the initial application. This would be in accordance with the earlier finding as to the suitability of minimal applications for learning on where the WinTutor study extended Carroll's findings to older learners. SeniorMail has attempted this with its provision of categories for saved email and its use of a navigation bar but these features have not been tested with older users, so their utility for older people is yet to be demonstrated.

10.9 The Derivation of the Methodology

This section is a deliberately warts and all description of the way in which the methodology emerged. It is argued that the final methodology is suited to the study aims and it may well be a methodological approach that other researchers in the area could adapt. My concern in describing the reasoning (and difficulties) behind the development of the methodology is to assist any further researchers who adopt it to make their own informed decisions about how fully they use it and what adaptations they might wish to make.

The research methodology had initially been assumed to be a non-issue in the overall research. Research on older people proceeded by way of well constructed experiments and there was little to question by way of wider methodological issues. Methodology therefore was going to be an issue of experimental design, establishing the protocols for carrying out the experimental work and deciding on the appropriate forms of statistical analysis. With hindsight this ignored the extent to which working in an applied area differs from pure research. Because the Dual Task pilot study occurred in conjunction with my observations of teaching at Unitec, I looked not only at the issue of the failure of the study to support the dual task hypothesis but also at issues of the appropriate and ethical treatment of the older subjects, their levels of enjoyment and their motivation to contribute realistic levels of performance. There was also the issue of how much information the Dual Task pilot contributed in comparison with observation of older people in the Unitec setting and in the focus groups following the Dual task sessions and the question of which types of information were more appropriate to the aims of the study in establishing relevant guidelines for interface designers wishing to create software that older people could use well.

I was fortunate in that my background included, as well as a Masters in Information Systems, six additional Masters papers in Sociology with a focus on research methods in the social sciences. This prepared me to consider approaches outside those of hard science. The key question was - how to carry out research that met the thesis aims. It was apparent that the area of applied knowledge of aging was at a level that could be described as pre-scientific. This was true of knowledge about older people's computer use in particular. The implication was that hypothesis testing as such was premature but that observation and description of what was observed would be appropriate. It was also apparent that observation of older people led to new information. However observation and analysis of those observations did not offer a way of describing how to design for older people, nor did they offer a way of testing the value of such a description if it should emerge. The methodology would need to include examination of attempts to construct interfaces that suited older people.

The success of the rapid intervention tutorial created in response to analyzing the problems observed in the Unitec courses showed that the knowledge gained from observation of older people's problems in a computer use situation could guide successful interface design. The way that I drew on my reading from the literature review in designing the rapid intervention tutorial seemed to indicate that the information contained in the research literature on aging was relevant to informing the designer as they moved from observation of older people's problems to design responses to those observations. What was problematic was that this design was an informal and intuitive process that was hard to describe in a way that would assist other designers.

It would be nice to report that the obvious concept of carrying out repeated case studies was initially a deliberate choice. In fact the first case study, the WinTutor study was carried out as a holding action. I had tried to find a way of framing a form of experimental research that met the objections raised by the Dual Task study, I could not find one, I was, simply, stuck. To engage in useful activity during this phase it seemed useful to create an opportunity to find out more about older users and I had some hopes that this might give me some insight with framing my overall research. What emerged was the WinTutor project and the realization that I was engaging in a design process that seemed to be sufficiently powerful to produce highly appropriate software for older people. In contrast with the process that drove the rapid intervention tutorial, the design process for WinTutor was much more deliberate and allowed time to reflect on how the design choices fitted the findings of the literature review. The design process also included the in-house testers for the first time and it was very clear that the step by step feedback that they provided made a critical difference. It was at this stage that the next major decision in framing the research methodology emerged, that the overall study would consist of repeated case studies of interface design for older users. Again the WinTutor study drove an expansion of the scope of the material covered by the research. Where previously the methodology had been concerned with the relationship between the effects of aging and the interface features that older people could cope with easily, it now became apparent that a designer would also benefit from understanding the likely weaknesses in computing knowledge that typified the older population and including adaptations to such weaknesses both into design and into the designers understanding of the difference between the target group and the designer. So the methodology expanded to include a study of such differences.

With the FileTutor study the obvious shifts were to a methodology that made more systematic use of the case study approach, the use of evaluation by older people who had previously failed to master the area and skill being addressed by the software in evaluation so as to provide a quasi experimental check that the design was in fact better for older people than standard approaches and the use of group activity in the evaluation of the software. The FileTutor study also included the use of in-house testers as part of the development process and returned to a useful aspect of the Dual Task pilot by including focus group discussion so that the older participants in the usability testing could provide a wider picture of their relationship to computing as older people, and so that they could comment on their experiences with the product in a way that allowed information to be obtained that the researcher did not expect or prepare for in the study design. What was also occurring in the context of the FileTutor study was that the design process was becoming seen as a core part of the design principles so that the methodology extended from looking at questions and justifying answers based on, “What features work for older people?” to “How should one work with older people so as to obtain features that work for them?” Another aspect of the methodology that was brought into consideration in the work during the FileTutor study, and particularly during the evaluation phase was the issue of how best to work with the older participants. This was prompted by the obvious contrasts between the happiness and motivation of the FileTutor evaluators and the disengagement and unhappiness of the Dual Task subjects. Thus the case studies expanded to include reflection on how the older people were treated during my work with them and what the results were from the different aspects of my relationships with the older participants. One of the concerns that became part of the methodology was the question of altering power relationships between the older participants and the researcher in such a way that the older people obtained more ethical treatment and the researcher obtained less censored and more realistic responses.

The SeniorMail study was in effect a relatively full realization of the design approach and of the research methodology. The SeniorMail study continued the replication of design cases over different areas of interface design that the research methodology required in order to strengthen the arguments being supported. The study also expanded the role of exploring the context within which older people contributed well to the development of the interface. This led to the use of the “Computerware parties” as a productive tool for managing power issues in the relationship between researcher/designer and older participants as well as a way for the researcher to enter into the culture of the older people who were participating. The pattern of obtaining wider information about older people and computing was continued in focus group discussions within the “Computerware parties” but was also used in the requirements gathering phase with discussions with resthome dwellers and supporters of older users. The results gave continued support for incorporating information on older people from a wide range of sources.

With this background the role of Chapter 7, where the research methodology is described, is not to describe a research methodology that was adopted entire at the start of the overall study but to detail the research methodology that had emerged as a productive way of working during the course of the study, to examine the ways in which the techniques employed can be seen as legitimate borrowings from a variety of research traditions and to make a case for the validity of the methodology used.

10.10 Considerations in working with older people

As will be evident the underlying definition of the guidelines for designing for older users had evolved during the course of the research from “What interface features are suited to older people in the light of the literature review on aging?” to “What design process is useful for designing for older people is such a way that knowledge of aging <u>and</u> experience with older people contribute effectively to designs that are suited to older people?” As a part of this shift it was apparent that one of the key demands of a successful inclusion of older people in the design process was attention to how they were treated within that process. So rather unexpectedly in terms of the initial framing of the thesis, one of the skills that will be useful for designers is the ability to reflect on how one’s interaction with older participants is proceeding and the ability to make improvements to the interaction. Chapter 8 is thus still clearly aimed at using the research done during the thesis in order to contribute to the useful skills and knowledge of designers who are aiming at products for older people.

The areas of concern that are addressed in Chapter 8 cover the following areas; a brief overview of the interface design process for older users, appropriate ways of working with older people, specific techniques for developing applications with older people and ethical considerations with older people.

Under the heading of appropriate ways of working with older people Chapter 8 gives detailed consideration of the following issues, illustrated by experience gained in the course of the thesis research.

- Working with older people as if they came from a separate culture.
- Issues of establishing a framework where the older people see themselves as respected.
- Questions of the balance of power between researcher and older participants.
- Concerns about communication styles used.
- The problems in building time constraints into work with older people.
- Appropriate techniques of information gathering.
- Care of older participants.
- Approaches to sampling when acquiring groups of older participants.

In describing detailed techniques for including older people in application design Chapter 8 examines suggestions for managing the roles of older people in project development under the following headings and again gives examples of experiences from the three cases of interface design in the thesis research.

- Needs analysis
- Creating an initial credible prototype
- Prototyping
- Usability test cycles

The final main section of Chapter 8 explores the ethical issues that can arise during work with older people or indeed any other underprivileged or disabled group. Here more attention is paid to the writings of researchers such as Levy, Steele and Alm but again there is material showing how some of the concerns raised by these writers were experienced during the thesis research and some of the ways in which these concerns were addressed.

Without attention to these issues, simply involving older people in the design process would not have produced the degree of understanding of older people's needs and concerns that underlay the three successful design studies. It is acknowledged that working effectively with older people involves a relatively large skill set and one that may not be part of a typical designer's armory. However the point was made that older people are experienced in making allowances for the lack of skill younger people often display, so that the designer needs to show well intentioned and thoughtful interaction with older people rather than perfection.

10.11 The Relationship of the Thesis Research with the Dundee Research

The thesis has basically advanced the position that because of the gap between the capabilities, experiences and situation of the designer and the capabilities, experiences and situations of older people the designer needs to include older people within the design team. The thesis has also advanced the argument that design for older people is not a case for a design for a fixed set of age related disabilities but design that must work for a range of people who each have individual variations of the combination of losses that aging brings. In the thesis, design for old age is seen as requiring the designer to consider a range of age related effects but also to consider the designer's own relationship to the older people that they work with. Very similar themes are central to the position taken by Newell and co workers in relation to the research undertaken at the University of Dundee related to design for both older people and for people with disabilities. There are differences, Newell and co-workers have been more concerned with the effect of understanding good design for lowered ability on the usability of systems for the general population and in particular the relationship of techniques for reducing the effects of disability on designing systems for use by people from the normal population working in extreme circumstances where such things as environmental difficulties (noise, light etc.), protective clothing or speed of important input, challenge the user's ability to cope. My own work has a basic focus on assisting current older users and has not looked for wider implications. While my work looks at designing for variability in the types and levels of age related disability in the target population, Newell's group makes the correct and additional point that individuals will also vary over a range of timespans covering different levels of need for assistance over hours, months and years.

Despite the differences, when it comes to a practical view of how to work with and for older people the two approaches are very similar. The interesting point is that both approaches have been developed quite independently until 2003 when Alan Newell contacted me after the publication of a paper on SeniorMail. At this point I had completed the three design case studies using and simultaneously developing the methodology as described in the thesis. The extent of the similarities of the two approaches, coupled with their independent derivation and given the clear demonstration of successful products achieved using this design approach provides strong support for the overall approach.

10.12 Has the research achieved its aims?

In one sense it can be argued that the research has clearly achieved the aim of setting out and justifying guidelines for other designers interested in creating interface designs for older people. It has been shown that products can be created using the guidelines that are both usable by older people and are in fact enthusiastically received by them. The thesis in fact goes further by presenting the guidelines in a context of how they were arrived at, so that future designers can reflect on the differences between the design situation within which they are working and the design situations that existed in the case studies used in the thesis. This should have the advantage of allowing informed departure from the guidelines as the circumstances in which they are applied change.

In another sense we will not know if the research has achieved its aims until the findings are used and critiqued by other designers for older users. Personal communications from other researchers who have undertaken design projects for older users, (Aula, Dickinson and Newell) have been positive. When these researchers have seen parts of the overall research they have responded that the findings are in accord with what their experience has shown to be useful in design for older people.

However I am somewhat pessimistic. To quote Newell, “Making accessible interfaces for older people is a unique but many-faceted challenge”. This nicely encapsulates my own view on what I have discovered during this research. The problem is that meeting this unique and many faceted challenge is going to place considerable demands on designers, demands that their training and previous experience will not have prepared them for. Designers working in industry will be under pressure to produce results within a limited timeframe and a limited budget. Adapting design processes to fit older in-house testers who have a finite amount of time and effort that they can reasonably devote to product development per day will not sit easily within such constraints. There are further pressures that will be felt when trying to apply the approach in an industry setting. Retraining the designers themselves in skills of working with older non-computer literate people and gaining a background knowledge of aging takes time and access to providers of such training. Working with code based high fidelity prototypes runs counter to received wisdom in HCI and slows the development pace while increasing development costs and personnel. Further designing by reducing features and discounting appearance to achieve usability runs counter to most of a designer’s experience of what really matters if a designer is to be noticed, respected and promoted. Design for older users may also be hard to defend to a management concerned about budgets and marketers concerned about salability, what is being produced is (hopefully) impressive in terms of its usability but may be visually ordinary. Finally it is not known how great a market exists for products that older people can use. This is something of a chicken and egg situation, at present the Pew reports show that older people remain by far the smallest segment of the computer and internet using population and within that population the older group makes far less intensive use of almost all categories of computer use. Further the initial impressive growth rate of this group has flattened. The bulk of older people are unlikely to move to being frequent computer users until there are suitable products for the less able among them. But until there are a large number of older users who do not like standard available products (a contradiction in itself) there is a limited market for developing products that are suited to age affected older people.

There have been moves to force industry to move towards accessible web sites and products by legislation. However Kelly et al. (2005) among others argue that trying to enforce compliance with accessibility criteria is not a good way to provide older people with usable web sites and applications. Kelly et al. make the point that a system can fully comply with official usability guidelines but still be unusable, giving the example of providing an auditory rendition of a large table, where the spoken list of numbers is impossible to remember or extract relationships from, but is none the less officially accessible. Given this, when industry seeks inexpensive compliance with existing legislation, this is unlikely to radically improve the situation of older and disabled users.

10.13 Future directions for research

Ironically, having spent a rather long time exploring exactly what is needed in designing interfaces for older people and arriving at a description of a relatively slow and intensive process, I suggest that one of the urgent needs in future research is to explore ways of doing quick and dirty design for older people. It would be useful to know how much can be achieved with a relatively few rules and limited exposure to older people, if there is a form of design for older people that can fit more easily within industry development budgets it would be desirable to identify it. As always the aim is to increase the number of people who can make use of applications and web sites rather than to promote strictly ideal design for older people.

Given the difficulties identified in getting industry based designers to adopt the approaches to design for older people, the thesis advocates that is there a place for academic expertise in design for older people to be contracted out to industry. The UTOPIA team at Dundee has made a beginning on looking at this and found that such collaboration was demanding. One of the key issues they identify is convincing industry designers of the quantum leap between the usual people they design for and the reality of older computer novices. Further research on industry / academic collaboration is obviously desirable and this might include further attention to and identification of the factors that make such collaboration difficult.

A related issue lies in identifying what designers currently consider when asked to make designs suitable for older people, are there identifiable misconceptions in the design community that are sufficiently common to be worth developing material specifically to address re-education on these issues? Again the Dundee team has started to look at the use of videos with actors portraying older users, extending this to see how such videos impact the work of actual industry based designers will be difficult but looks to be worthwhile. A related issue is the question of how to make academic findings in the area available to industry. As Dray (2004) points out this is a more general issue where entrenched barriers and differences in perception of what is important, make fruitful communication between academics and industry difficult. Zaijcek (2003) looked at using pattern language for making her work on design for older people available to other designers, the problem here is that it is not certain that designers will be willing to make the effort of working through the rather lengthy format of patterns, especially if as is contended in this thesis, there are a very large number of patterns that are relevant to design for older people. Fisk et al. (2004) in their book “Designing for Older Adults” have taken the radical step (for academics) of writing in a much less academic style and deliberately avoiding endless referencing of the findings they use to make their case. The considerable combined authority of the authors makes this a valid approach. My reading of the book is that it should be readable for non-academic designers but feedback from actual non-academic designers would be useful. This thesis itself attempts to use a style that is accessible to non academics but I have a suspicion that few non-academics will ever read it while the style will be off-putting to a number of academic readers. One of the possibilities that could be of interest is to research suitable formats for design workshops for industry in this area. With the event of the web we appear to have a further decline in the influence of academic HCI as more web designers have career paths that do not include academic instruction in computing or in interface design. If there is going to be good design available for older people, academics will need to reach out, possibly by way of making exemplars of good design for older people available together with clear discussion of why the designs were developed in the manner chosen.

A more theoretical issue that is relevant to the work in this thesis is the question of how much disability is present in apparently well functioning members of the older population. The case studies in the research for the thesis made extensive use of input from the in-house testers. Neither of the in-house testers was apparently age impaired though as mentioned there was persistent difficulty in learning computer skills and concepts and for one of the people a degree of difficulty focusing clearly at the distance involved with computer screens. Nor did the extended testing group of older people used in the SeniorMail project cover examples of significant disability over all forms of age related disability. Why then should their input contribute to designs that older, demonstratably age impaired users were enthusiastic about? Salthouse (1996) and Newell and Gregor (2002) have considered the possibility that apparently well functioning older people do in fact have age related impairment but that under normal circumstances they make successful compensation for their problems. What we tend to think of as the problems of older people are not the onset of age related effects but the onset of the points at which the ability to compensate for age related effects starts to break down. Under this hypothesis, one of the reasons that apparently well functioning older people appreciate well designed software for older users is that they are freed from the effort needed to compensate for aspects of their own aging. It seems useful to see how far this can be confirmed and whether there are aspects of people's compensation for age related effects that can be identified and used to improve design for older people. It also seems useful to explore the related sampling issue of what extra benefits come to a design project if the older people who are recruited for the project come from groups who are more representative of the general older status population than the usually high status and well educated volunteers for research.

Another theoretical issue has already been mentioned in that it seems that older computer users should show some aspects of the general difficulties with dual task performance that have been shown to occur with age. While the Dual Task pilot study did not support this, it does not suggest any convincing reason why the effect should not have been observed and if dual task issues of cognitive resource scarcity do affect how older people benefit from an interface it will be worth while to understand how.

More specifically feature oriented areas for research include looking at how to make visual search easier for older users, suitable icon design for older users and the effective use of senior friendly skins for applications. New interfaces such as virtual reality and force feedback will provide new sets of challenges to older people whose sense of balance is less effective or whose motor control and proprioception (self awareness of body position) is aging. Even simple changes such as the touch mice and glossy screens on newer laptops are areas that may or may not suit older users and could benefit from research. To an extent all the recommendations on the design features that were found to be useful for older users contained in Appendix E can be seen as hypotheses about appropriate design for older users that are awaiting testing. This would include such things as establishing suitable parameters for animation that suits older people.

It was noted at the end of Chapter 5 on the FileTutor design study, that the format used in FileTutor for training older people in the use of the training wheels version of Windows Explorer could be adopted to provide a way of encapsulating an application within sets of notes to guide older users through seldom needed tasks. My observations are that current older users not only have difficulty remembering how to perform tasks but that the low intensity of their computer use means that the problems with remembering tasks are accentuated by having far fewer opportunities to practice tasks in real life than younger, more computer involved, users. Related enquiries could look at the content of the notes that older people currently write to themselves as reminders of how to carry out even basic tasks. In effect what is proposed here is that the equivalent of these notes are embedded with the application, I am reasonably confident that the current scrabbling in boxes, drawers and cubby holes in order to find a note written on scrap paper months ago is not a useful contribution to older people's application use but more seriously older people have stated that they find it important to write the notes on procedure themselves, it needs to be known if this is an important objection to the proposed style of application. Another related issue here is the use of wizards by older people. Here we have an application format that already provides guidance in following the steps in a procedure, is this more suitable than the proposed extension of the FileTutor format? Are there problems that older people find with wizards as they are presently presented and are there ways of addressing such problems?

The thesis has expressed a concern that those working on interface design may conclude that the current problems with older users may become less significant at a more computer experienced generation retires. Rather than take this on faith it seems worthwhile looking at the computing skills in the general middle aged population. How many of this group do in fact possess competent computer skills, how are computer skills distributed with education and income and thus what are the implications for the next older generations? It may be in fact that the numbers of older people for whom usable computer software becomes an important issue will actually grow as inadequately computer experienced people reach retirement age while at the same time the social isolation of being outside the computer literate group increases. Data is needed.

10.14 The overall thrust of the thesis

To sum up the thesis has created and repeatedly demonstrated a design process for creating user interfaces that suit older users. The thesis documents the process and discusses the changes to practice that a designer using the process can expect to make. The thesis has also provided resources to back the design process in the form of; 1.) a survey of the relevant effects of aging and a consideration of its implications. 2.) exemplars of the design process in the form of detailed descriptions of three working products resulting from the design process and discussion of how these products evolved, and 3.) consideration of the issues that designers should be aware of and sensitive to when working with older people within the design process.

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Appendix A Demographic shifts towards an older population

The data presented here is for the United States, U.S. Census Bureau (2004). US data may in fact show a less rapid move to an aging population than Europe or Japan. This is because of the high level of immigration from south of the US border and the high birth rate of the US Hispanic population mean that there is more replacement of younger population groups than in Europe or Japan. None the less the trend is stark. The data can be seen in summary in the following figure A.1. Supporting detail is then supplied in figures A.2 to A6 and tables A.1 and A.2.

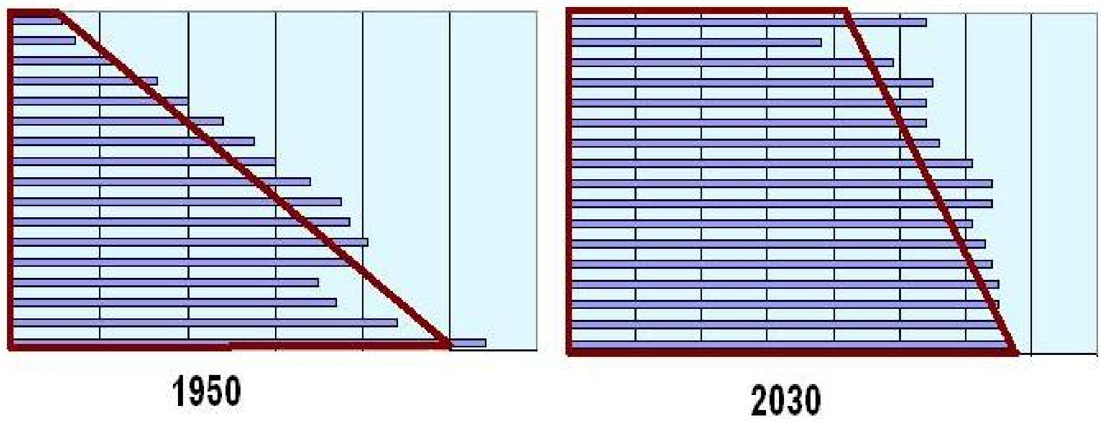

Figure A.1 Contrast in population structure from 1950 to 2030

In Figure E.1 the top band represents the 80+ age group, the bands then descend in 5 year age groupings to age 0 to 4 at the bottom. What is made very obvious in this figure is that there is a very rapid shift occurring from a triangular population structure with a relatively small proportion of the population over 60 (12.1% in 1950) to a population structure that is more nearly rectangular and having a substantial proportion of the population over 60 (a forecast 25% in 2030). In fact a full 30% of the population is predicted to be over 55 years of age in 2030 so the number of people who may benefit from software that includes adaptations to the effects of aging can be expected to be substantial.

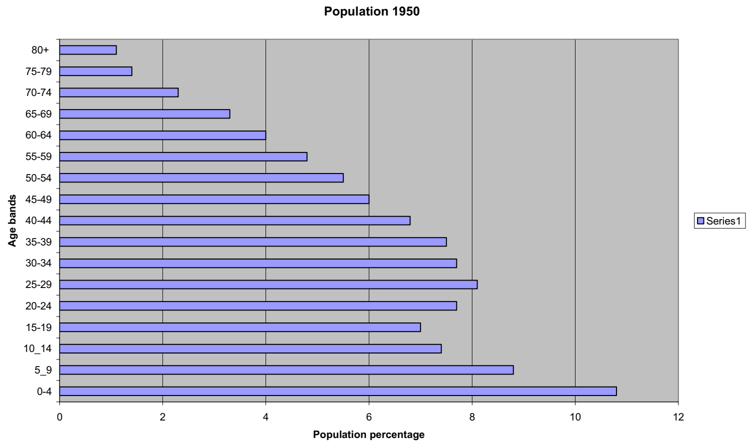

Figure A.2. Percentage of population by age bands for US population 1950

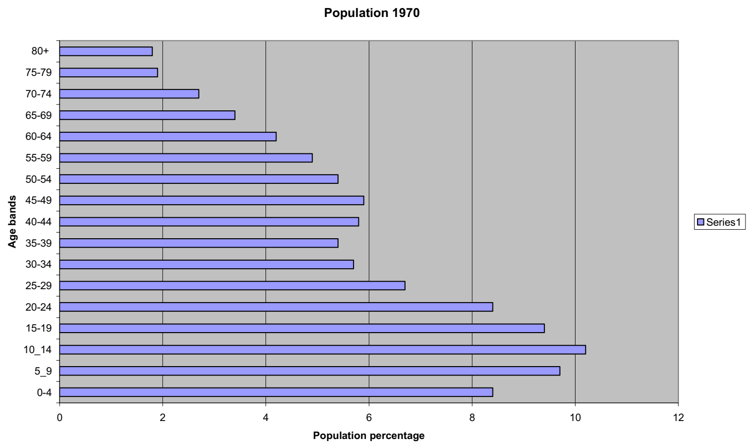

Figure A.3. Percentage of population by age bands for US population 1970

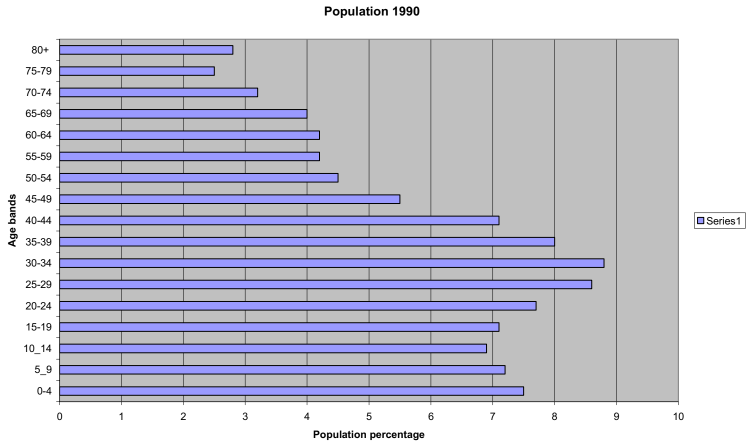

Figure A.4. Percentage of population by age bands for US population 1990

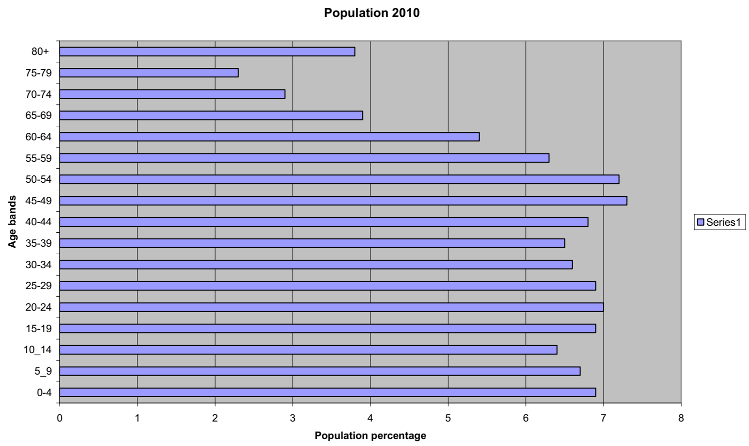

Figure A.5. Percentage of population by age bands for US population 2010

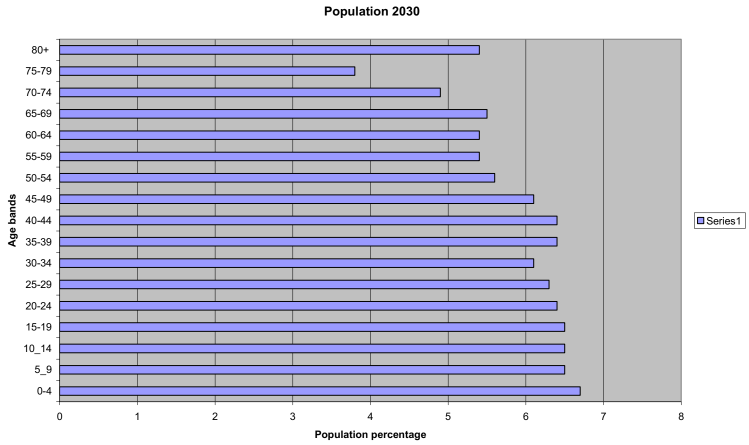

Figure A.6. Percentage of population by age bands for US population 2030

Table A.1 United States Percentage of population in age band by year 1950 - 2030

Year		1950	1960	1970	1980	1990	2000	2010	2020	2030
0-4		10.8	11.3	8.4	7.2	7.5	6.8	6.9	6.8	6.7
5-9		8.8	10.4	9.7	7.3	7.2	7.3	6.7	6.7	6.5
10-14		7.4	9.4	10.2	8.0	6.9	7.3	6.4	6.5	6.5
15-19		7.0	7.4	9.4	9.3	7.1	7.2	6.9	6.4	6.5
20-24		7.7	6.2	8.4	9.5	7.7	6.8	7.0	6.2	6.4
25-29		8.1	6.1	6.7	8.7	8.6	6.8	6.9	6.7	6.3
30-34		7.7	6.6	5.7	7.8	8.8	7.3	6.6	6.8	6.1
35-39		7.5	6.9	5.4	6.2	8.0	8.0	6.5	6.6	6.4
40-44		6.8	6.5	5.8	5.2	7.1	8.0	6.8	6.2	6.4
45-49		6.0	6.0	5.9	4.9	5.5	7.2	7.3	6.0	6.1
50-54		5.5	5.3	5.4	5.1	4.5	6.3	7.2	6.2	5.6
55-59		4.8	4.7	4.9	5.1	4.2	4.8	6.3	6.5	5.4
60-64		4.0	4.0	4.2	4.5	4.2	3.8	5.4	6.2	5.4
65-69		3.3	3.5	3.4	3.9	4.0	3.4	3.9	5.2	5.5
70-74		2.3	2.6	2.7	3.0	3.2	3.1	2.9	4.2	4.9
75-79		1.4	1.7	1.9	2.1	2.5	2.6	2.3	2.8	3.8
80+		1.1	1.4	1.8	2.3	2.8	3.3	3.8	4.0	5.4

Table A.2. United States Percentage of population in combined age bands by year 1950 - 2030

55 – 79		15.8	16.5	17.1	18.6	18.1	17.7	20.8	24.9	25
60 – 79		11	11.8	12.2	13.5	13.9	12.9	14.5	18.4	19.6
55+		16.9	17.9	18.9	20.9	20.9	21	24.6	28.9	30.4
60*		12.1	13.2	14	15.8	16.7	16.2	18.3	22.4	25

Source: U.S. Census Bureau (2004), International Data Base.
http://www.census.gov/cgi-bin/ipc/idbpyrs.pl?cty=US&out=y&ymax=250

accessed November 2005

Appendix B Test protocol used in evaluating the FileTutor study

The following one sheet set of tasks was used to see if the older participants in the FileTutor study could apply the skills learnt to the real world environment outside of file tutor. Subjects worked individually without assisting each other or using notes.

10.15 A check on your file and folder skills

1. Put your name here: ______________________________________

Tick the following jobs off as you complete them.

2. [ ] Start the real Windows Explorer

3. [ ] There is a folder called "**C:\Bills Stuff"** on your computer. Use Windows Explorer to help you draw a map (on paper) of the tree of folders that branches out from **Bill's Stuff**. Use the back of this page, just draw the folders, do not worry about the files.

4. [ ] There are three letters like **"letter to Sally and John 1.txt"** numbered 1, 2, 3. Use Windows Explorer to find the one called
   "letter to Sally and John 3.txt"
   and open it, add another line of text with your name and then save it and close the Notepad window.

5. [ ] Use Windows Explorer to copy a file called "**letter to Sally and John 2.txt**" from the folder called "**C:\Bills Stuff\Family**" to the folder called "**C:\Bills Stuff\Family\Sally and John**"

6. [ ] Use Windows Explorer to make some new folders called “**Bowls**” and “**House**” that are connected to the **“C:\Bills Stuff”** folder

7. [ ] Use Windows Explorer to move files from the “**C:\Bills Stuff\All sorts”** folder to folders that suit the topics. For example the letters about bowls should be moved to the “**Bowls**” folder

8. Show Dan the final result.

Participants were provided with a small folder tree on the C: drive of the computer that they were using. This folder tree had the following form.

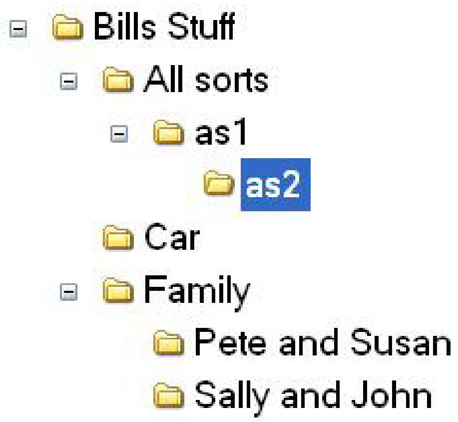

Figure B.1 Bill's Stuff folder and sub-folders.

Appendix C Test protocol used in evaluating the SeniorMail study

The SeniorMail program was put into practice mode. This allows the simulated reception of first three emails and then a forth email in response to two clicks of the [Check for emails] button. It also allows the user to write dummy emails and send them although no actual emails are transmitted to the ISP.

The following set of scenarios was used with this practice mode setting of SeniorMail. Older users after a short introduction to SeniorMail were observed one on one carrying out the following tasks.

SeniorMail scenarios

1. Find out if there is any new mail

2. Read each of the 3 new messages

    Bob and Mary Shaw - poem suitable for later forwarding
    Jenny Wilson - thankyou for dinner
    Peter Mason - you left a pullover

3. Save the address of Bob and Mary Shaw to your address book

4. Send an email to Ann Smith (Ann is in your Address book) just saying
   "Hi Ann - I will come over tomorrow at 2.30"

5. Find the email from Peter Mason and reply to it saying
   "Thanks, we will pick it up next time we are round'

6. You have a snail-mail letter from a friend Kay Davies in which she says

    "Doug, my son has just set up email for me on my computer, my email address is kaydavies@hotmail.com can you send me an email so I can send you one back"

Send her an email and save her email address while you are doing so.

7. Find and delete the email from Jenny Wilson

8. Find out if any more inwards mail has arrived while you were doing all this

   There should be 1 new msg from Sally Marsh with an attachment

9. The new message that has come in has a picture sent with it, have a look at the picture then reply to Sally Marsh saying "I liked the birthday card"

10. Pretend that you can't remember if you told Ann Smith the time you were coming over, find the copy of the email you sent to her and check what you said.

11. You want to find a poem that someone sent you several months ago. You have forgotten a lot of the details but you do remember that it contains a line mentioning the High Pyrenees. You decide to use the [Find] option on the main menu and search for any emails that contain the word Pyrenees.

12. You decide that you want to pass on the verse that came in the email from Bob and Mary Shaw to a friend called David Kelly who is in your address book. Find the email from Bob and Mary Shaw and forward it to David Kelly.

13. Use the "Write a new email" button on the main menu and send an email to Sue Travis (she is in your address book) with a picture of a flying pig that you will find in a folder called "My Pictures" when you look at the "Add attachments" tab when you are writing an email.

Questions for people taking part in the study on older people and email

1. Name:____

2. Year of birth: ____________________

3. What best describes your education?

   School Cert UE Some tertiary Bachelors degree Higher degree
   Comment:____

4. What has been (or is) your occupation or main occupations?

5. How do you rate your health?

   Poor health 1 2 3 4 5 Good health

6. Do you wear glasses or contact lenses at the computer?

   Yes / No

7. When you look at the computer screen how clear are the details? (with glasses / lenses if you use them)

   Very blurred 1 2 3 4 5 Perfect

8. How would you describe your typing skill?

   Hunt and peck 1 2 3 4 5 Expert

9. How easy do you find using the mouse?

A struggle	1	2	3	4	5	Easy

10. How frustrating do you find computers to use?

Very frustrating	1	2	3	4	5	Easy

11. Do you like using computers?

Really dislike	1	2	3	4	5	Like a lot

12. Why did you get your first personal computer?

13. Was you first computer bought new, bought second-hand, got for you by family, etc?

14. Which of theses ways were important as you learnt your computer skills?

1 not important – 5 very important

[ ] Self taught
[ ] Books
[ ] SeniorNet classes
[ ] Friends and family
[ ] Work
[ ] Other ______________________________

15. How many years or months have you been using computers?

16. How many years or months have you been using Windows?

17. How many hours a week do you use a computer?

18. How many times a week do you use email?

19. How many times a week do you use the World Wide Web?

20. The most common things I do on my computer are:-

21. Give a list of other things you would like to use your computer for in the future.

22. What has stopped you doing these things so far?

23. What are the most frequent problems you find with using a computer?

24. What do you see as the important issues for older computer users? (good as well as bad)

Appendix D Summary of age related problems

This appendix provides a summary of the age related changes reported in the literature survey from Chapter 2 that are potentially of relevance to an interface designer.

D.1 Changes in Vision for older people

D.2.1 Size and contrast

- Harder to focus at short distances
- Less ability to detect fine detail such as small print. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer color discrimination and detection especially in short wave lengths (blue-green)

D.2.1 Searching

- Visual search becomes harder
- Useful field of view declines
- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Older people are less able to filter out irrelevant items
- Less ability to tell if similar objects are the same or different
- Visual search is improved by consistent positioning
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space

D.2.1 Speed of perception

- Reading is slower
- Slower to recognize items but this effect is reduced for familiar items
- Ability to detect small movements declines

- Poorer estimates of speed and time of arrival
- It becomes difficult to read moving text
- Ability to detect flicker declines

D.2.1 Lighting and illumination

- More disrupted by glare
- Slower to adapt to changes in illumination

D.2.1 Perception of 3 dimensional information

- Poorer depth perception and estimation
- Poorer perception of 3 dimensional information

D.2 Changes in Speech and Hearing for older people

D.2.1 Speech

- Less distinct pronunciation with age
- More pauses and fillers such as “um”, “err”
- Harder to produce the exact word for precise requirements
- More tip of the tongue episodes where a familiar word cannot be found

D.2.2 Hearing

- High pitched sounds harder to hear
- Some words are lost when listening to speech
- High pitched voices can be harder to understand
- Harder to work out the location of a sound
- Harder to make sense of speech when there is background noise or competing speech
- Less able to deal with fast speech
- May depend on extra information from lip movements to make sense of speech
- Slower to respond to sound cues

D.3 Changes in Motor control for older people

- Response times are slower
- Movement is slower
- There is less control of speed, direction and force
- There are more small movements in a larger movement
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets
- Skilled movement such as typing by experts can be maintained but appears to require more plan ahead strategies
- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk
- Coordinated movement is harder
- There are more involuntary movements
- Less accuracy in knowing one's own body position
- Poorer balance and more need for visual input to maintain balance
- Possibly less touch sensitivity

D.4 Changes in Memory in older people

D.4.1 Short term memory

- The ability to make use of information in short term memory declines
- Older people are slower to recall information from working memory
- One effect of reduced short term memory is in problems with text comprehension, especially for longer or more complex passages

D.4.2 Recognition and Recall from long term memory

- Deliberate recall of previously encountered material becomes harder with age
- Recognition of previously encountered items is not greatly affected if the items are simple
- Older people are likely to use inadequate strategies for learning new material so that it can be retrieved
- Structuring of memories may be worse in less educated older people

- Problems in using context to prompt recall memory as distinct from recognition
- Less ability to inhibit irrelevant memories
- Attempts to recall information are more affected by anxiety

D.4.3 Specialized forms of long term memory

- Spelling of unusually structured words becomes poorer
- Memory for how to do relatively simple things remains
- Skilled motor performance requires practice to retain
- There can be problems in remembering if a job has been done or is still to do
- There is poorer memory of spatial information and other non-verbal information
- There is poorer memory for where information was found (source memory)
- It becomes harder to remember to do jobs at some later point in time (remembering to remember or prospective memory)

D.5 Changes in Attention in older people

D.7.3 Attention and vigilance

- There are some problems with maintaining focused performance over time but this appears to depend on the type of task

D.7.3 Selective attention

- Poorer ability to inhibit responses to irrelevant items
- Less ability to control an activity with a top-down plan of action

D.7.3 Dual task performance

- Less able to do multiple tasks at once if the tasks are complex
- Problems in dual task situations may paradoxically show on the task that takes less concentration
- Anxiety reduces dual task performance

D.7.3 Automated responses

- New automatic responses are hard to form for older people

- Existing automatic responses are harder to suppress if necessary due to changed circumstances

D.6 Changes in Cognitive performance in older people

- Reasoning ability declines
- Speed of mental processing slows
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- When faced with problems older people rely more on existing knowledge and are less able to work out new solutions, (crystallized versus fluid intelligence).
- The performance of older experts is maintained at levels similar to younger experts but this depends on high levels of practice and does not translate into general ability in areas that relate to the expertise
- Older people are slower and less able at decision making
- While decline is relatively slow if one follows the same individuals over time the gap between today's younger people and older people is wider than the gap between today's older people as they were when young and as they are now. This is due to a well established but not fully explained improvement by each generation in test performance, (the Flynn effect).
- Losses of types of mental functioning are not uniform, they vary widely between older individuals
- Losses of cognitive performance tend to be correlated with losses in visual performance
- Older people adopt a more conservative strategy with regard to risk taking
- Ability to work with spatial problems declines

D.7 Changes in Learning in older people

D.7.3 Difficulties

- Learning takes more effort and takes longer

- Older people can be overwhelmed by younger instructors who go too fast, present too many ideas and tend to be impatient with the slow and uncertain progress typifying older people.
- Older people's learning can be disrupted by the provision of too much information
- Learning may be limited to a minimum or inadequate skill set in some older people
- Older people are likely to blame themselves for learning difficulties
- Where older people see themselves in negative age stereotyped terms this further impairs their ability to perform

D.7.3 Content

- Older people can learn a wide range of new skills
- Older people benefit from learning on a simplified model before using the more complex real world tool
- Older people benefit from a focus on learning a minimum of essential concepts and techniques
- Older people benefit from learning skills as a set of concrete procedures
- Older people benefit from actually performing skills as they learn
- Older people may benefit from simple background information that places their learning in context but they are disadvantaged by a focus on conceptual material
- Learning techniques such as ways of associating new items with categories in order to assist remembering can show continued benefit over years, but older people need encouragement to adopt such techniques

D.7.3 Format

- The speed with which individual older people learn varies widely
- Older people benefit from self paced learning
- There may be a long period during which learnt items are easily forgotten and need to be relearned more than once
- Older people appear to benefit from learning in small (2 – 4) groups rather than individually or in large groups

- There appears to be a benefit in having either an instructor from the same (older) age group or an instructor who has adjusted their style to accommodate older learners

Appendix E Detailed design examples from WinTutor, FileTutor and SeniorMail

This section provides a bullet pointed list of the design recommendations that have been developed from the experience of developing the WinTutor, FileTutor and SeniorMail systems. One of the issues in designing for older users is that the specific design recommendations for a particular application can be related to the effects of age related disabilities with hindsight but are not necessarily predictable in advance. One of the aims of this thesis is to provide not simply a description of how to design for older users but also a feel for the level of detail at which specific design decisions are made. So the rationale for including these descriptions of a wide variety of low level design decisions that are often specific to SeniorMail rather than more generally part of design for older users is to convey something of the feel involved in the process of designing for this group. Design for older users is often a matter of minutiae where different combinations of ideas about older people's needs come into play.
Application design recommendations

Vision

- Blocks of text are easier to read if surrounded by white space and older people benefit from this. However this means that standard multi-line text boxes need a border added at the left and this border needs to preserve the behavior of multi-line text boxes where dragging to the left of a line selects the text in that line. The assumption is that older people will have more trouble adapting to minor inconsistencies in the system model such a whitespace (the left hand border) that behaves differently from other whitespace.
- Blocks of text appear to benefit from a larger font size than short captions, for blocks of text give the user the ability to simply adjust the font to size 16 and to set the font to bold.
- Some older users find bold text an advantage, some do not
- Hints or bubble help should be in a readable font, be simply written and be timed so that there is long enough for older users to read them given slower reading speed and poorer performance under time pressure. However as older users are less able to inhibit distracting information and they are likely to move the mouse

comparatively slowly they may be distracted if hints pop up while they are slowly moving the mouse to a different intended target. Hence - do not have the hint pop up too quickly. And again avoid covering up useful screen information with the hint, remember that older people make less sense of what they see when they can only see part of something.

- Older users were often observed to use the mouse cursor as a pointer to assist them while reading blocks of text. Therefore hints should not be shown in response to a mouse over on blocks of text.
- Use larger than normal icons and keep icon designs distinctive and simple, do not rely on minor changes in color or detail to distinguish icons. As a counter example the Windows Desktop method for showing a selected icon selects the icon's caption and makes the icon's colors much duller and hence harder to distinguish from each other. This makes the icon harder to interpret and on returning to the Desktop makes the supposedly highlighted icon harder to find for older users because it is both duller than the competing icons and it no longer looks like the icon they initially searched for.
- Do not expect many older people to turn on accessibility features such as altering the basic font size, their computer knowledge is usually not up to this, nor is the computer knowledge of the supporters of older users interviewed for this study.
- One consequence of the frequently poor typing skills of older users is that they look at the keyboard instead of the screen while typing and this makes it possible for them to miss that they are not typing within the input area that they intended to type into.
- Using full screen designs with plain backgrounds and no graphics unless the graphics are really relevant to understanding how to use the application is part of the more general rule of avoiding distracting background material.

Visual Search and Reduced effective field of view

- Expect older users to fail to find important screen features that you consider obvious. Older users can be surprisingly blind to parts of the screen away from the areas they usually look at.
- Try and put controls very close to the effects they produce. This helps assist with the reduced effective field of view of some older people.

- Status bar information at the bottom of the screen is likely to be missed by too many older people for it to be useful given their restricted effective field of view.
- When you ask older users to look for the right action, restrict the number of choices because older people are poorer at searching long lists. Ask your older users what features are actually going to be used by your target group.
- Put choices in a list or along a row, avoid two dimensional arrays or random patterns of choices. Older people perform better on searches of short, one dimensional arrays.
- Aim for consistent positioning of controls in each part of your application. Older people are better at searching when there is consistent positioning of search targets.
- "Flat" buttons that only take on the appearance of buttons on a mouse over appear to give older people a less useful cue when they are thinking, "I need to find and click the [Something] button". They also seem to worry older users as they change appearance, where a designer might expect them to welcome confirmation that they were on target. The response I observed was along the lines of "Why has it done that?" rather than "Oh good I have got there". In addition flat toolbar style buttons that only show as a button when the mouse moves over them give a smaller visual target.
- Menus in typical Windows programs offer too many choices for easy searching by older users, keep to very simple menus or avoid menus. Older people are particularly disrupted by large numbers of irrelevant items when searching.
- Older people were observed frequently losing the cursor when it was over a text background. Older people benefit from a larger and bolder cursor, especially over text. The cursors that older people seem to prefer have thicker lines as well as being larger.

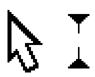

Figure E.1. Examples of enlarged bold cursors used in SeniorMail. The one on the left is the modified default cursor and the one on the right is the modified text cursor.

Manipulation

- Provide large targets. This includes larger buttons but also includes providing large fonts for entering and correcting text or when using listboxes and menus. It is not that older people are unable to capture small targets but that doing so requires concentrated effort that can distract them from the overall task.
- Some controls like radio buttons and check boxes visually imply a very small target area. Provide a larger target area by contrasting the control color with the background and possibly extending the active area at the front of the control with a label that shares the Click response with the radio button or check box.

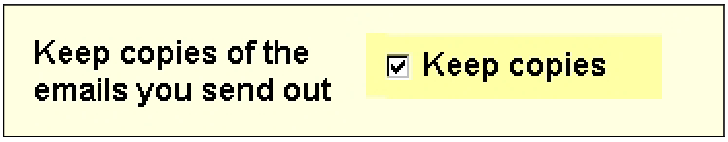

Figure E.2. Enlarging the target area for a checkbox, all the outlined area is clickable.

- Use open listboxes rather than drop down lists because of the small target size of the button that opens the list. It is also likely that some older users will not know the conventions behind the use of drop down listboxes.
- Use full screen windows and a few modal (stay on top) pop-up windows. Experience suggests that older users will be poor at window management tasks such as resizing, the window border is too small a target to acquire and the penalty for clicking off target can be severe, (the whole window vanishes!). Older users are generally in danger of unknowingly clicking on a background window (reduced accuracy in clicking on very small targets) and then being mystified by the fact that the window on which they were working has vanished. Usually their limited knowledge of the application model makes it difficult to get back to a window that has been hidden when another window comes to the front.
- Be wary of requiring drag operations, provide an alternative or avoid drag and drop altogether, especially over long distances. Some older people have difficulty combining mouse movement with holding a button down, this results in inadvertent dropping before the target is reached. For some older people similar inadvertent dropping was seen due to involuntary clicks on the right mouse button while

dragging. Some older users have difficulty in coordinating the mouse position with the timing of the release of the mouse button so that the mouse may have moved off target again when the drop is attempted.

- Do not require double clicking - many older users either cannot do this or cannot do this reliably. Also be aware that repeated single clicks on the captions of some components like icons or list views and tree views can put the caption into edit mode. Older people who cause this effect by slow attempts at double clicking are likely to be bewildered by what they have done and unsure about how to get out of the new mode.
- The need for double clicking means that a desktop icon should not be the only way of making a program for older people available. The points that these icons can be made to respond to single clicks or show an Open option if right clicked are irrelevant as most older people and many of their supporters will be unaware of these alternatives.

Menus and Sub-menus

- Avoiding the use of standard Windows menus and making the home screen a menu of command buttons has two effects, it increases the ease with which some older users can get access to features and it provides the older user with a frequently visited visual map of the core features of the system.

Typing

- Typing remains a major stumbling block for some older users. SeniorMail has not attempted to provide a solution to this.
- Given the slow pace at which older people acquire and consolidate new skills, typing remains a hard task for many of these older struggling typists for years. Given their reduced effectiveness in visual search some older typists can be described as, "hunt, hunt, swear, hunt and peck", and they can be seen going through the same agonizing process for the next occurrence of a letter that they have found only a few seconds before.
- Typing by older users is frequently error prone. In SeniorMail a spelling checker that displayed errors with red wriggly underlines is used. This provides a pop up menu of choices for spelling correction that older users found useful. However it needs to be explained as even those older users in the sample who used MS Word did not know

the meaning of the red underlines or know functionality of this approach to spell checking.

- Problems such as typing mean that creating work is harder for older users and therefore losing what one has done is a bigger loss. Try and design so as to preserve older user's work despite possible errors.

Comprehension

- Reduced complexity is the main way of increasing comprehension.
- Keep the system model simple. There should be as few parts to the system as possible and each part should have a clearly designed task. The aim is to make it very easy for the older user to form a mental model of the application.
- It is possible to go some way towards sheltering older users from the complexities of the operating system and the file management system.
- Layers of options can serve to keep more complex options away from older novices but there is a tradeoff with ease of use for more experienced or more capable users.
- Some simple analogies may help rather than conceptual explanations. Do not rely on users absorbing explanations of the underlying concepts. Older users appear to spend a long time working at a procedural level. Trying to think of the explanation as well as remember the procedural steps may simply give the older person more information than is useful.
- On making an error, older people are likely to be less able to work out what has gone wrong and to recover from the problem. A lot of design work needs to go into designing out errors that show up in prototype testing.
- Older users trying to understand what to do can be very literal in their interpretation of instructions. As an example, an error message read, "Click on the line for an email and then click the [Open] button". The result was that older users attempted to click on the email line and the [Open] button while the modal message box was still displaying. Changing the message to the future tense improved this, "You will need to click on the line for an email and then click the [Open] button". Another approach could have been to change the error dialog box so that it was float on top but not modal so that the older user could in fact respond as instructed while the error message was still displayed.
- In a further example an email address pick list actually showed a list of names rather than email addresses, some older users therefore objected to calling this an

"address list". This was not pedantry, they were worried and a little stressed by the inconsistency. The pick list was renamed "Who is the email going to?".

- Older users may not anticipate the later consequences of actions that they take. As an example older people are more prone to replying to a whole mailing list rather than just the sender as their mental model of "reply" does not seem to easily accommodate that the reply will by default go to more people than the person they intend replying to. A solution in this case was to give a dialog identifying that they were responding to an email from a mailing list and asking if they wanted to reply to the sender (default) or the whole list.
- As another example SeniorMail made it safe to delete emails even if they were later found to be wanted. Deleting moved emails to a recently deleted list.
- Unexpected situations are likely to be interpreted as errors rather than predictable and reversible consequences of past actions. An example from SeniorMail is where a temporary category filter has been placed on an email list, the older user has then left the list, done some other work and later returned to the list. The response is not "Oh, I am only showing bridge club emails" but, "I have lost most of my emails". It was found to be better to turn off filtering when the user left the list so that they returned to an unfiltered list.
- A realistic stress factor when older people are responding to errors is the difficulty older people face in obtaining support. Supporters often live some distance away. Asking for support can be felt to be embarrassing in that it exposes the older user's lack of competence and that it places a further demand on one’s friends or relatives. Depending on the availability of visits from supporters there may be a delay of days or weeks during which the computer is inoperable. Support from computer suppliers is expensive and transporting the computer is a major physical effort coupled with uncertainty as to whether the older user can successfully reconnect the cabling.

Idiomatic knowledge

- Expect older users to have large gaps in their knowledge of basic idioms of the graphical user interface environment they are in. Examples I have met include; not realizing that one was expected to click [OK] to complete interaction with a dialog box, not knowing about column sorting by clicking column headers, not understanding tabbed pages, not understanding the implications of text being selected, not understanding the Windows task bar, not knowing about Alt-Tab form swapping between programs, not understanding windows management skills such as dragging a top most window to a different location by using the title bar and so on.

- A lot of design depends on users seeing a cue such as a button and jumping to the "obvious" conclusion that they should click it. We, as younger users, interpret the screen based on a wide knowledge of standard ways of doing things in our particular graphical user interface. However in designing for older users, expect older people to have a fragmentary knowledge of such standards.
- As an example about 20% of the older users I tested with the email system did not know that the intended response to a dialog box is to click [OK] after entering one's choices. All the other buttons in the email system had colored icons and I found that including similar icons on the [OK] and [Cancel] buttons led the older users to examine them as possible solutions for the next step to take. This may also relate to older user's need for a stronger stimulus if items are to be seen at the edges of the effective field of view and the fact that without knowledge of the standard model for a dialog box the older user was not getting a preparatory cue indicating where they should look for the next step.
- As another example I found older users consistently ignored or were puzzled by very simple tabbed pages with a single row of two or three tabs. See Figures 6.11, 6.12 and 6.13. The older users had very rapidly formed the habit of searching the toolbar for options and ignored the [Add attachments] tab immediately under the toolbar. The solution was to put an [Attach] button on the toolbar that had the effect of opening the [Add attachments] tab.
- As an aside on tabbed pages, they seem to illustrate the weak level at which some older users view the application as an integrated whole rather than as a set of loosely connected parts. Older users would go to a tabbed page in the Editor and successfully choose a file and add it to the email as an attachment. But when they returned to the other tabbed page in the editor where the message text was entered they asked why there was no attachment on the email, this in spite of the attachment tab caption having changed to show the number of attachments made. The solution was to show a prominent drop down list of the attachments that had been added to the email to provide confirmation that what they had done had actually altered the email as seen on the page where the email's text was shown. As

a younger designer my assumption was that conceptually the two tabbed pages should be seen as part of a whole, this did not happen for the older users I tested.

Figure E.3. The tabbed pages of the editor were not understood

Memory

- Radically simplifying the number of choices available reduces the amount to be remembered.
- Making the choices visible instead of hiding them in menus reduces the load of trying to remember where a feature is to be found. For example a row of large toolbar buttons at the top of each screen means that if an older user has forgotten what to do they simply look along the toolbar.
- Do not ask older users to remember material from one screen or page to another, for example in SeniorMail Help information displays in small float on top (non-modal) windows so that the older user can see the aspects of the application that the Help information is referring to and carry out the steps described in the Help. (Microsoft has started providing this form of "Tooltip" help but it would benefit from a larger font.)
- The numbered instruction style developed for the FileTutor tutorial to guide older people through a series of procedural steps without getting lost can be useful in designing Help information for Help systems
- Do not depend on older users remembering to do things. In the email example there is a reminder if an unsent email exists when the user decides to exit the program. There was also a decision not to automatically poll for new emails on the grounds that older people might forget that this kept their connection to the internet live and

thus leave the email program running with the possibility of higher connection charges than they expected.

Learning applications

- Expect older users to try and use applications without having put much time into learning them. Older users, like anyone else, want to get going quickly without a lot of preparation.
- Your applications for older people need to make more of the knowledge needed to run them, "knowledge in the world" rather than, "knowledge in the head".
- One of the areas in which what seems to a designer to be "knowledge in the world" is actually "knowledge in the head" for older users, is when labels and instructions use computer jargon.
- A major area in which older users fail to learn enough to work effectively is in learning to understand the file management system. Expect older users to struggle with file Open and Save dialogs, especially if they are asked to change folders. Also expect older users to have problems finding documents they have previously created. The effects can take a number of forms, I have met older users who basically put all their word processing in one enormous document, that was the one they knew how to find through the recently opened files list in the MS Word menu, so each new bit of writing went at the end of this single document. I have also met older users who put most of their documents onto the desktop with consequent problems with clutter. Other older users have everything in "My documents" but the folder is so full that it is very hard to search and too big to back up.
- Try and design applications for older users so that they minimize the amount of learning required. One technique is to divide the application so that some configuration tasks are off-loaded to the supporters of the older users.
- If older people learn one way of doing something at the start of using an application they will find it very difficult to switch to another more efficient method later. This means that the designer needs to be concerned with what methods for controlling the application get exposed first.
- Another aspect of this is that older people can be blind to things that conflict with their initial learning. Told initially that the functions they needed could be found on the toolbar buttons at the top, older users ignored clearly labeled buttons that were relevant to the task they were attempting and less than 4 cm from the toolbar.

- If there are three standard ways of doing a job then some of your older users will each know only one of these three and the one's that they know will be different. All standard approaches need to be supported. At the same time the older users I have worked with complained strongly if more than one way of doing something was included in the learning instructions. As an example of coping with this, in an email system for older users, when an email needs to be opened, the user clicks on the header line and then clicks on an [Open] button on the toolbar. This is the official instruction given to new learners. However double clicking and pressing the Enter key also open the email, it is simply that they will be used by people who expect these capabilities and will be ignored by other users. As another example I have made my email program available from the Start/Programs menu, from a desktop icon and from the Start/Run option.
- One of the things that older learners will have reliably learnt is that when they use the computer, things go wrong. I find that older users may need reassurance that an action has succeeded, for example a small message, "Please wait, saving the address", that appears and sits in mid screen for a second. Younger people tend to assume that if they clicked the [Save Address] button the address will have been saved. Note that I am not requiring the older users to respond to a message box by clicking an [OK] button, this in itself can be disruptive. Instead the message appears for long enough to be read and then vanishes of its own accord.
- Another thing that older people will have learnt is that Help systems do not give them what they are after. Expect many of your older users to avoid even attempting to find information in Help systems.

Interactive tutorial design for older learners

This section provides a bullet pointed list of the detailed design recommendations that have been developed from the experience of developing the FileTutor and WinTutor interactive tutorials.

Designing for the older user's background - Recommendations

- Provide a high level of success, many older users have previous experience of failure with a variety of learning approaches and this needs to be combated.
- Provide a safe environment for carrying out exercises where mistakes are non damaging and easy to recover from, by the very people who are most likely to

make those mistakes. This can involve providing an easy "Undo" feature and a safe practice area that will not affect the rest of the user's computing environment.

- Allow for self paced learning and the ability to repeat sections of the material. Also provide support for small group learning as a social activity rather than making learning purely machine focused. Make it easy to use tutorials for revision at home.
- The above points imply an easily understood architecture and simple navigation methods for moving around in the tutorial.
- Cater for a wide range of learning styles from highly verbal to largely activity based and from learning of procedural steps to a desire to understand the underlying model.

Visual design for older users - Recommendations

- Graphics should be relevant. They should also be clear, large featured and simple.
- Avoid any visual distractions in the form of purely decorative graphics, wallpaper or animation.
- Make graphic features involved in exercises easy to locate while retaining realism.
- Graphics may change in the course of an exercise or demonstration but this should either be step by step in response to the user's actions or in slowed animation.
- Particularly for older users visual feedback resulting from actions needs to occur close to the site of the action that causes the effect. Graphics should be placed close to any instructions that refer to the graphics.
- Older people can make use of some spatial metaphors but the designer should be careful to user test elements that depend on spatial understanding.
- Do not ask older users to rely on remembering graphic information between screens.

Text instruction format for older users - Recommendations

- The text format that worked in FileTutor matches recommendations by Morrell and Echt (1996, 1997) and Morrow and Leirer (1999). Text used was a dark Arial

12 - 14 point sans-serif font contrasting strongly with a very pale plain cream background chosen to reduce glare. White space was used to help keep items separate.

- Instruction content that worked in FileTutor matches recommendations by Morrell and Echt (1996, 1997) and Morrow and Leirer (1999). Sentence construction and language were kept simple, negatives were avoided, sentences and lines were kept short, instructions were phrased in an active voice.
- Morrow and Leirer (1999) note the advantages of lists for older people for such things as medication instructions, in FileTutor where older users are following sequences of multiple steps to carry out a procedure, numbered lists were found to be better.
- Inserting statements of what has been achieved up to this point may be useful as a way of helping older users understand what they are doing in long lists of procedural steps.
- Do not combine two or more procedures within one point in a list of instructions.
- Provide a consistent layout so that older students know where to expect instructions.
- Place instructions physically close to the point on the screen where they are to be applied.
- Test instructions carefully to remove ambiguity and avoid unexpected results.
- Use concrete examples and language together with supporting and relevant illustrations.
- Instructions that ask users to type some specified text should use a distinctive font to identify what is to be typed, not quotes.

Manipulative design for older users - Recommendations

- Keep the required manipulations simple.
- Provide large, easy to locate targets for manipulation.
- Reduce the need to scroll.
- Avoid requiring double clicks while allowing them for those older users who are comfortable doing so.
- Use of pop-up menus and right clicking is a satisfactory way of avoiding the problems some older users find with double clicking and / or with using main menus distant from the site of the intended action and results.

* Changes to improve manipulation should still maintain the basic behavior of the application being learnt.

Interactive graphics - Recommendations

* Using interactive graphics to integrate explanations, instructions and exercises within the same screen is an important way of designing to accommodate the reduced working memory of (some) older students
* Interaction with interactive graphics should be in terms of a series of exercises that actively develops the older students' skills and understanding.
* Older students benefit from having a working but simplified version of the application being learnt embedded in the interactive graphic.
* Interactive graphics should be driven in single steps by the student's actions with the aim of getting the student to actively explore the topic.
* Make the interactive exercises as quick and easy to perform as possible.

Menus and Sub-menus

* In line with Carroll's "training wheels" and "minimal manual" the menu structure used while older users are learning should be strongly simplified.

Typing

* Typing should be reduced where possible for older users. In particular the effort of typing may compete for cognitive resources and displace material in short term memory thus reducing the effectiveness of older learners.

Comprehension ,Memory and Learning - Recommendations

* Deal only with a core set of essential skills and concepts taking Carroll's "training wheels", "minimal manual" and "active learning" approaches throughout.
* Background material is important to a sub-group of older learners, this should be made available in a way that allows most learners to ignore it.
* Begin from a starting point that should be at simple revision level for most of the older users involved. Be prepared for gaps in understanding of very basic Windows skills.
* Introduce topics and concepts more slowly than for a younger audience, carefully building on a structured development of supporting concepts.

- Use an active approach to learning so that students put their new knowledge into effect as they acquire it. Do not assume that simply telling older users about a concept will allow them to integrate the concept into their mental model. Where possible provide explicit interactive exercises aimed at letting them check their understanding of the concept.
- Concepts and skills developed early in a tutorial should be reinforced and re-emphasized in later topics. Do not assume that because some skills have been covered previously, older students will be able to incorporate these skills into later exercises without further instruction.
- Having older students work with a consistent set of example material can aid building understanding
- The time frame in which (some) older users learn may be much, much longer than one would expect for younger students.

Designing Effective Interfaces for Older Users

A thesis

submitted in fulfillment of

the requirements for the degree

of

Doctor of Philosophy in Computer Science

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by

DAN HAWTHORN

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Abstract

The thesis examines the factors that need to be considered in order to undertake successful design of user interfaces for older users. The literature on aging is surveyed for age related changes that are of relevance to interface design. The findings from the literature review are extended and placed in a human context using observational studies of older people and their supporters as these older people attempted to learn about and use computers. These findings are then applied in three case studies of interface design and product development for older users. These case studies are reported and examined in depth. For each case study results are presented on the acceptance of the final product by older people. These results show that, for each case study, the interfaces used led to products that the older people evaluating them rated as unusually suitable to their needs as older users. The relationship between the case studies and the overall research aims is then examined in a discussion of the research methodology. In the case studies there is an evolving approach used in developing the interface designs. This approach includes intensive contribution by older people to the shaping of the interface design. This approach is analyzed and is presented as an approach to designing user interfaces for older people. It was found that a number of non-standard techniques were useful in order to maximize the benefit from the involvement of the older contributors and to ensure their ethical treatment. These techniques and the rationale behind them are described. Finally the interface design approach that emerged has strong links to the approach used by the UTOPIA team based at the university of Dundee. The extent to which the thesis provides support for the UTOPIA approach is discussed.

Dedication

I would like to dedicate this thesis to the individual aging of each and every one of us.

“I am entering a foreign country, one that will change me and eventually kill me. While I can still talk with you I would like to report back and tell you something of what I have found”

Acknowledgements

I would like to warmly thank the following people for contributions to my research and my work in completing the thesis. Without the support that they have generously given the thesis would not have been possible.

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Anna Dickenson and Alan Newell for showing a belief in the value and validity of the work I was doing at times when I was in despair.

The anonymous in-house testers and the other older people who made such important contributions to the understanding of older computer users, who cheerfully gave of their time and who candidly discussed the issues they faced as older people.

Jean Harding and Mary Ann Furda for putting up with my trials and tribulations over the course of writing up.

And finally to the many excellent people who gave me support and made allowances as the thesis took over my life.

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Chapter 1 Introduction

1.1 Designing software for older users

This thesis looks at the issues involved in designing software that older people can use effectively. This is an atypical thesis with a much broader scope and broader research aims than most PhD theses. In the period in which the thesis was done (1999-2002) there was virtually no extant literature on designing interfaces for older users. It was obvious that there would be a rapid shift to a much older population with a need to engage with computing. Further it was apparent that older people, particularly older people exposed to computer use for the first time, were finding computer use challenging to say the least. However the HCI community did not appear to be involving itself with this problem. On this basis it was decided that my research should take the form of crisis research where the aim was to open up the area over a broad scope rather than to provide exacting support for a single narrowly defined proposition. This implied using a greenfields approach to the issue of how to design user interfaces for older people rather than the more typical approach in PhD theses of deriving a relatively narrow research question from extant literature. The research aim (rather than research question) was to examine relevant issues for those who intend to design effective user interfaces for older people. The intention behind the aim is to provide a research based enquiry that opens up a new field and at the same time makes computer use more accessible for older people.

In another sense the thesis is an extended case study of the process of acquiring the skills and resources to carry out the design of software that older people can use effectively. The thesis examines the aspects of aging that make older people a distinctive group of users and reports on three studies of creating effective designs for older users that were carried out in the course of the research. This is followed by reflection on the research methodology that was developed in the course of these design studies and further reflection on the design approach itself.

Interface design for a distinct group follows the general directions set out in approaches such as User Centered Design and Task Centered Design. One acquires knowledge of what makes the group distinctive. One acquires knowledge of the tasks that need to be supported by the design and the context within which the design will be used. One then involves members of the group in prototyping and testing at various stages through the creation of the design and its implementation. However the details of the approach may need to be adapted if the group being designed for differs markedly from traditional users. This thesis will provide an examination of adaptations of the approach to interface design that assist in successful interface design for older people.

Design for older people certainly involves adapting designs to the limitations that age imposes. However the study suggests that there are considerable subtleties that are overlooked in a design mantra for older people of "big fonts, big targets and simple layout". There are a wide variety of ways in which age may affect older users in their interaction with an application. In addition there are difficulties within designers' likely assumptions about older users. Older users are both likely to be considerably less able than most designers expect while at the same time older users are likely to be able to carry out more computer based tasks than might be expected from a first acquaintance with their difficulties with computer use. The achievement of effectiveness in older people's computer usage depends on effective support from the interface design, but also on effective training.

The term "older users" represents a degree of lazy thinking. The reason for special approaches to design for some of the older population is that they are age affected, the aging process has reduced some of the abilities we assume in younger users. Some older users can be assumed to have few age reduced abilities well into their lives, the design issues described in this thesis are less relevant to these people. Although the thesis generally uses the less precise term "older users" the point that what is really meant is age affected users should be born in mind. The distinction is somewhat blurred however if, as seems likely, most older people have some age related effects even though they can compensate for a number of them in normal circumstances and so appear less affected by age.

One of the keys to designing for a distinctive group lies in acquiring a wide ranging knowledge of the characteristics of the group. The thesis makes a case that the literature on physical and cognitive aging contains a large body of information that is relevant to interface design for older people. Within the literature study the thesis will set out a summation of the implications of aging for those designing interfaces for older people and this is regarded as a useful resource. However the thesis will suggest that there is considerable value in extensive interaction with older people so as to force designers to confront the realities behind written descriptions of age related effects. Recent research by Newell et al. (2006) makes it clear that being told about the issues of aging does not prepare designers to make the paradigm shift needed in designing for older people. In that study Newell and co-workers found that experienced interface designers persistently discounted information they were given about older people's needs and issues. When these designers finally met with and observed older people working with computers they could fairly be described as stunned by the extent to which they would need to adapt their usual design practices to meet the older people's capabilities. Yet all the points that surprised the designers had been conveyed to them previously by people with extensive experience in design for older people. Thus design for older users requires a decided shift from design for users who are more like the designer. Interaction with older people is a way of achieving such a shift but as will be seen working with older people has its own special skills and sensitivities.

1.2 Relevance

Why is a study of interface design for older people relevant? There are two parts to an answer. The first is that with the demographic shift to an older population there are a considerable number of older people in the population and many of these people find computer use difficult. If interface designs that specifically address aspects of aging allow these people to use computers more effectively, then this clearly falls with in the aims of HCI in terms of studying and improving human-computer interaction. However the current older generation are largely people who have had no previous experience with computers and their struggles with computing are intertwined with the issues of learning computer skills as an older person.

The second aspect of relevance is to address the question of whether there is long term relevance for the study, given that future cohorts of older people will bring considerable experience of computing to their interaction with computers in their old age. We will now proceed to look in more detail at each of these concerns.

1.2.1 The demographic shift

It is now a commonplace that there is a higher proportion of older people in the population. This is due to a lowered death rate among the older section of the population and in many (but not all) western countries, reduced fertility among the younger section that is not fully compensated for by immigration rates. What may be less appreciated is that the scale and speed of this demographic shift is unprecedented.

The data presented here is for the United States, U.S. Census Bureau (2004). US data may in fact show a less rapid move to an aging population than Europe or Japan. This is both because of the high level of immigration from south of the US border and the high birth rate of the US Hispanic population. These factors mean that there is more replacement of younger population groups in the US than in Europe or Japan. None the less the trend is stark. The data can be seen in summary in the following figure 1.1. Supporting detail is supplied in Appendix A.

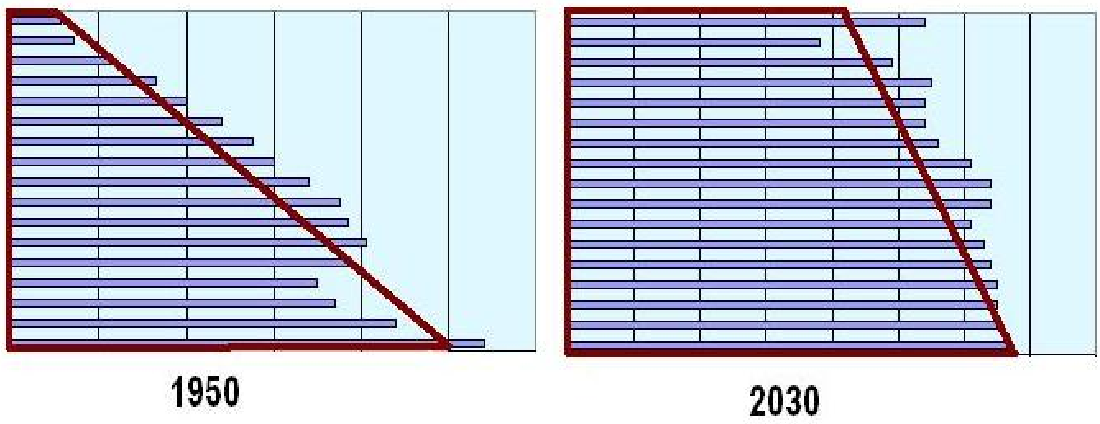

Figure 1.1 Contrast in US population structure from 1950 to 2030. Y axis gives 5 year age bands with 80+ grouped in the top band. X axis gives percentage contribution to the overall population.

In Figure 1.1 the top band represents the 80+ age group, the bands then descend in 5 year age groupings to age 0 to 4 at the bottom. The X axis gives the percentage that each band contributes to the overall population. What is made very obvious in this figure is that there is a very rapid shift occurring from a triangular population structure with a relatively small proportion of the population over 60 (12.1% in 1950), to a population structure that is more nearly rectangular and having a substantial proportion of the population over 60 (a forecast 25% in 2030). In fact a full 30% of the population is predicted to be over 55 years of age in 2030 so the number of people who may benefit from software that includes adaptations to the effects of aging can be expected to be substantial.

This in turn leads to problems with schemes for supporting older people in retirement caused by the increased number of older people combined with the reduced number of working age tax-payers available to support them. This is predicated to mean that there will be a need for older people to stay in some form of employment for longer, both in order to support themselves and because there are going to be fewer younger workers to replace them. In addition having fewer younger workers means that older people are likely to need to find ways of being less reliant on care givers and younger supporters.

1.2.2 The shift in the role of computing

The demographic shift has come at a time of major technological change, one aspect of which is the increased role of computers in work, communication and access to services. Some extent of computer fluency is becoming a requirement for full access to society. Already computer access can be a cheaper and faster way of accessing services such as banking. It is possible that the price and ease differential may increase to the point where not being able to use computer based services may leave people marginalized. It is also likely that if older people will need to have computer skills if they need to maintain themselves in employment within an increasingly computerized workforce.

1.2.3 Aging for a computer experienced population

The argument is sometimes made that this problem only exists for the current cohort of older people who entered old age without prior computer skills, further it is argued even this group is now on-line and so the issue of older people and computing is vanishing. There is limited direct evidence here but what is available is not reassuring. Firstly there is some evidence that after a very high rate of initial uptake, the rate at which older people are taking up computer use has leveled off and is now doing no more than keep up with new recruits to the older population and those older people who cease using computers, leaving around 80% of the older population as non-computer users, the figures are based on reports from the Pew institute, see Fox (2004). Again, examining the data provided in the Pew reports, in most categories of computer use older users remain the most infrequent and least sophisticated users as well as being the slowest group to adopt new trends.

In addition to this, computer use in the next cohort to become old, current 50 – 65 year olds has not been universal. There will be substantial groups of non computer users within this next older generation. Further there is some evidence that those in the 50 – 80 plus group who have learnt computing skills are on average more able than those who remain non-users. From this it could be argued that the problems facing older beginners may in fact be more severe in the next years than for the older people who adopted computing earlier. Again, where older people delay learning computer skills, the continuing effects of aging mean that the act of delay can make skill acquisition harder. On this basis there will remain a significant section of the older population who have the potential to benefit from gaining computer skills (and from software designed for their needs) but who will not find gaining such skills easy, who may indeed find the required learning harder than did those who went before them. The position of such people will not be helped by the assumption that the issue of computing for older people has been solved.

There is another strand to the counter argument, this suggests that the above is merely about timing. At some relatively near point in the future virtually all new recruits to the older population will have extensive computer experience and then surely the issue of special needs for computing for older people will vanish. Again I suggest that what little is known is not reassuring. One should firstly note that the Pew reports do not suggest that any current adult age group is completely computer literate. Findings on retention of expert behavior into old age from studies by Charness (1988) and Salthouse (1990) indicate that while skilled behavior is preserved into old age, particularly if practice in the behavior continues, there is virtually no generalization of the preserved abilities to presumably closely related abilities. Thus people may continue to practice as respected architects into their seventies but when tested on general problems involving spatial perception they do not perform better than the general older population. The implication is that we (the computer literate) will go into old age with a fairly specific set of computer concepts and skills but we will not find it easy to generalize those skills when the nature of computing undergoes a paradigm shift. It is worth noting that changes in the form of computing are a significant economic driver of the industry and that there is no indication that current changes such as the emergence of the web or the shift to portable and eventually ubiquitous computing represent any cessation of change in the industry. If, as we age, we find it increasingly difficult to adapt to changes, it may well be that in old age we will be most comfortable with the computing skills, concepts and tools we learnt in our mid 50s. Where these are no longer available we will perhaps be more similar to today's bewildered older novices than we might like to imagine. In this case the sections of the thesis on older people's issues in learning computer skills can be expected to retain an uncomfortable relevance.

There is also the point that overwhelmingly software and its interfaces come from designs that are produced by younger designers. The reality is that, unless forcibly restrained, designers will tend to design for people somewhat like themselves. This means that as we age we will be likely to meet software that assumes we can read 8 point fonts on colored backgrounds while dealing with fine manipulation and coping with memory demands that do not accommodate our likely reduction in short term memory capacity. Less rhetorically some of the difficulties that face older computer users come from normal aging. Although there may be some technical progress in alleviating some aspects of aging it is perhaps wise to assume that as those currently computer literate age they will be affected by much the same effects of aging as the current older generation in terms of things such as vision, manipulative skills and declines in aspects of cognitive capacity. Where such effects of aging conflict with the assumptions about ability that designers build into their interfaces, the new computer literate old will still face problems in coping with software. From this perspective those parts of the thesis that examine the ways in which software can be designed so as to make allowances for the effects of aging will also retain their relevance.

1.3 The history of the current research

My study of aging and its implications for interface design began in 1998 with a survey of the literature on physical and cognitive aging. This gave a view of the way in which the consequences of normal aging might be seen as indicators of characteristics of an older population that interface designers should be aware of and build into their designs. This led to two conference papers and a journal article, see Hawthorn (1998a, 1998b and 2000a). At this stage two strands of enquiry were pursued, I decided that the pure research perspective of the majority of the findings in the literature I had surveyed meant that there would be benefits from open ended observation of, and involvement with, older people who were using computers or trying to learn computing skills. This resulted in me observing as older people were taught computing in a variety of settings and also involved me in discussions with older computer users. At the same time I began a study that sought to explain the observed problems that older people had with software in terms of a dual task model where using cognitive resources for managing the interface of an application reduced the cognitive resources available for the older person to work with the substantive task that they were using the software as a tool to achieve. I designed a pilot study to test an experimental approach to studying the dual task hypothesis.

Thus at this stage I was involved in two simultaneous studies, one a fairly open ended observation-based study of older people and computing, the other a pilot for a traditional experimentally based test of a hypothesis. The results were striking. The observational study expanded to involve the construction of an interactive tutorial for introducing older people to very basic computer skills. Here the implications for design of the literature review of the effects of aging and my ongoing interaction with older people came together in a very successful design that is still in use today. Further the identification of the sorts of gaps in computing knowledge that affected older people and the extent to which such gaps seemed likely to persist provided valuable information for interface designers intending to work in this area. On the other hand the pilot study ended with no support for the dual task hypothesis in its simple form and with the recognition that treating the older volunteers in the study as experimental subjects had both distorted the level of realism and motivation obtained from them and had also exposed them to stresses that could be seen as unethical. The contrasting outcomes from the two studies led to a major change in the intended direction of the thesis.

The experimental approach was dropped for a variety of reasons. It was felt that the level of understanding of the effect of aging on computer use was too limited for the sort of hypothesis testing used in more mature areas of knowledge. It was also observed that a wealth of relevant knowledge came from working with older people during the process of interface design. In the process of working with older people to design interfaces that they could use, the older people expressed themselves to be well rewarded with their participation. This contrasted with the distress, disengagement and boredom shown in parts of the dual task study. The clinching argument came from considering the utility of hypotheses at the level of the dual task hypothesis if in fact the hypothesis had been sustained. What was found in constructing the interactive tutorial for older beginners was that a knowledge of the effects of aging (from the literature review) combined with frequent feedback from older people with an ongoing relationship to the design project gave a good basis for a designer to proceed with creating a successful product. In contrast a hypothesis such as the dual task hypothesis might be publishable if sustained, but was of less value in providing a designer with well targeted guidance. It was a reminder that the thesis was intended as an applied study and that the research techniques and outcomes should reflect this.

This change of direction saw the focus of the research shifting to case studies of design for older people based on both knowledge of the effects of aging and on encouraging considerable involvement from older people in developing the interface designs. A further interactive tutorial was constructed dealing with training older people in file management as a way of both checking the lessons learnt in the design of the interactive tutorial for beginners and of expanding the area of training to investigate the way in which training might be designed to allow older people to deal with software that was more complex and not specifically designed for older people. This file management tutorial was relevant to the thesis aims in several ways. For a start it considered the utility of an interface designer incorporating interactive training into their designs when the task involved areas of unavoidable complexity. It also looked at the possibility of designing training instead of redesigning a complex package thus giving an alternative strategy for allowing more effective software use by older people. Finally it provided another example of designing an application (the interactive tutorial itself) that older people could use easily. The completed tutorial was then tested with further groups of older volunteers and found to be highly effective both as usable software and as an effective training strategy.

This use of case studies in effective design was continued in the final study for the thesis. Here a reasonably full featured email system was constructed using the design approach that had been used for the two interactive tutorials. It was desired to retain the emphasis of the thesis on providing useful information for designers who were going to produce interfaces to be used by older people so the design focus was shifted to what was clearly application development without a training/tutorial focus. The system was evaluated with further older volunteers and was also put into long term use with a smaller group of older people. The results again support the idea that designing from a knowledge of the effects of aging coupled with the ongoing involvement of older people in the design process is a basis for a design process that results in products that are considerably better suited to older users than standard software.

There was then a nearly two year gap where illness resulted in very little progress with the thesis and writing up was not resumed until mid 2005. What has emerged from the writing up process is an examination of the research methodology and the design approach that evolved in the course of the research for the thesis and the positioning of these methodologies as important results of the overall research. The work on an appropriate design approach for working with older people in particular is seen as being important for designers intending to work with this target group. The thesis is less specific on specific design points such as, “use Arial 14 point font on a plain strongly contrasting background” since it was apparent that the sort of advice that was appropriate would vary strongly with different applications, consider for example Zaijchek’s (2003) work on telephone information systems for older people. Recommendations for specific aspects of design are given in each of the chapters discussing an interface design development case, other work on specific design recommendations is identified in the literature review and the general recommendations from all the design cases are collected in an appendix to the thesis. However the role of these recommendations is seen as illustrative of the way that the designer can proceed from knowledge of aging to techniques appropriate for a particular development rather than a prescription for designing for older people.

1.4 What is meant by “older” people

Throughout the thesis there is reference to older people and older computer users. This is a convenience but should not be taken as implying a uniform “older” group. Because of the diversity of their life experiences coupled with the highly variable way that individuals are affected by the onset and progression of aging, the “older” group is the least uniform of the developmental stages. From the point of view of an interface designer it is not age itself that is the problem but some of the effects of aging such as reduced vision, reduced manipulative ability and a variety of cognitive effects that lead to declines in memory, reasoning ability and speed of learning. Typically in this research the older people involved were aged between 65 and 85 but numerical age is relatively insignificant. What matters is the extent to which one or more effects of aging such as reduced vision, reduced manipulative ability and a variety of cognitive effects are present. Again this research is aimed at older people who have moderate levels of functioning, this is not an attempt to make computer use available for people suffering from extreme effects of aging. Age itself can be seen as a surrogate variable that is only loosely correlated with the effects of aging. We use “age” and “older” as terms for our own intellectual convenience but it is the (individually varied) effects of aging that are actually of importance.

For this reason the thesis has focused on a group of people within the older population, those older people who have difficulties in using standard software and standard forms of instruction in computer skills. The thesis takes it as a given that a large number of today’s older people have difficulty using the available software, see Czaja and Lee (2003). The thesis does not attempt to identify the prevalence of this group in the overall older population or to examine the frequency of the various forms of age related decline. The assumption is made that by selecting volunteers from people who self identify as having problems with software use due to the effects of their own aging, we have a group of people whose problems are relevant to the age related problems with computer use present in the wider older population.

Later chapters will look at the design implications of the diversity in the older population. Here it suffices to say that the design aim is not to make software that is usable for all older people, nor is the aim to cope with a clearly defined sub-group of older people who have a particular set of age related concerns. The aim of the thesis is to provide designers with resources and guidelines that will increase the number of older people who can make use of the interfaces they design. As part of this approach the designs developed and examined in the thesis take the stance that a particular form of age related disability may or may not be present in an individual who uses the software. What becomes important in designing for older people is that the software contains features that make it more usable for different individuals with a number of different expressions of age related decline. Such design needs to be done in such a way that design for any particular age related issue does not disadvantage those older users who do not suffer markedly from that particular aspect of aging.

1.5 Overview of the thesis

The structure of the thesis at a chapter level is given in this section and then the more detailed argument set out in the thesis chapters is examined in the following section. This first introductory chapter is followed by a second chapter containing a literature review, that looks at work on physical and cognitive aging where this has relevance to interface design as well as looking at work on interface design for older people. The third chapter reports on the pilot study for the intended experimental examination of the Dual task hypothesis. The fourth chapter reports on the experiences with older learners that led to constructing an interactive tutorial for older beginners and goes on to describe that tutorial. After this chapter five reports on the development, design and evaluation of a second interactive tutorial constructed to help older people learn file management skills. The sixth chapter reports on the development, design and evaluation of an email system for older people. The next chapters describe the research methodology (chapter 7) and the design approach (chapter 8) that emerged from the study. There are considerable parallels in the research and design approaches developed in this thesis with those developed in the UTOPIA project based at the University of Dundee and so chapter nine compares the two approaches. Finally conclusions from the overall research are presented in chapter 10.

1.6 The detailed structure of the thesis

This section will provide an introduction to the detailed argument laid out in the thesis. The aim is to provide the reader with sufficient information about the material covered in each chapter to allow the reader to form a picture of the way in which each chapter contributes to the overall argument of the thesis.

1.6.1 Chapter 2 - The literature review

The initial form of the literature review was driven by the relative lack of studies on interface design for older people that were available in 1997. This meant that the topic of design for older users was a relatively new topic and the usual approach of reviewing an existing body of relevant literature was not available. There was not only a lack of literature that was specifically linked to my chosen topic but I was also aware of my limited technical knowledge of the effects of aging. As I read in order to increase my knowledge of aging and how it could relate to interface design for older people it became apparent that this offered a useful and appropriate approach to a literature review. As the review itself makes clear, there are a very large number of effects due to aging that could cause problems when an older person interacts with software designed (by) and for younger people. The literature on cognitive and cognitive aging is largely based on studies that contrast the behavior of older groups with younger control groups on a wide variety of experimental tasks. Studies typically seek to establish differences in behavior on the experimental tasks and then infer, support for, and, counter arguments to, various theoretical explanations of the difference. This is a body of literature that is strongly concerned with the theoretical mechanisms of aging and much less concerned with applied research or with supporting application of any findings. However it also represents a potential treasure trove for the interface designer. Firstly there is the emphasis on establishing differences in ability and behavior between younger people and older groups. This is clearly one of the areas of knowledge that an interface designer should acquire when designing for any group that is significantly different from the designer and the sort of user that a designer might assume. A second feature of the literature on physical and cognitive aging is the breadth of aging effects that have been (and continue to be) studied. Thus work on vision and aging looks at far more than simply the size of recognizable targets. Some of the sub-topics cover changes to color perception with age, the effect of age on the width of the useful visual field, effects of low lighting and of off center location of targets, ways in which ability in visual search decreases with age and many others. A third benefit of using this literature as a resource is that there is experimental rigor in proving the existence of this wide variety of differences between young and old.

However there is a note of caution needed here as the findings in this literature are not specifically intended to support application of the findings or use by interface designers in particular. Not all findings are in agreement and it is possible that particular findings may be artifacts of the experimental conditions under which they were obtained and might be less apparent in older people’s behavior in real life situations. In addition the experimental conditions are created to examine and challenge specific theoretical issues, they provide tight control on variability, they are not designed to recreate the conditions faced by an elderly computer user in their home. It is usually sufficient for the hypotheses being tested in the original research to show that a difference exists between the young and old groups of subjects in the particular study, this does not translate into information about how widely an effect of aging is distributed in the population that an interface designer may be interested in, nor does the theoretical literature provide much guidance on the strength of various effects in the general older population.

There is a further problem in that the literature is not a source of guidance on how the findings should be translated into aspects of interface design for older people. If, for example, peripheral visual stimuli need to be stronger for older people to be aware of them, does the designer make them stronger, or design so as to place less reliance on peripheral vision? In taking either choice what trade-offs does the designer make that may impact on how the design affects some other aspect of aging? Again there are literally hundreds of old-young differences, which one’s are likely to impact a particular design? Further if there is a requirement that interface design recommendations for older people be subject to rigorous experimental verification, then the number of possible design implications from the literature on physical and cognitive aging, the number of possible interactions of such implications and the number of ways in which adaptations to the implications could be implemented lead rapidly into paralysis by analysis.

What I suggest is that providing consideration of the possible implications for interface designers in the findings of the literature on physical and cognitive aging provides designers with a useful resource but not a rulebook. The role of the literature review in this thesis is to assist in the understanding of the process of developing designs with the participation of older people. It is not intended to provide background for some hypothesis to be tested in the course of the thesis.

As time has gone by there are an increasing number of studies of specific aspects of useful design for older people. The literature review has expanded to include these studies but the material from the literature on physical and cognitive aging has not been correspondingly shrunk. It is my contention that awareness of this literature and a continuing process of updating one's knowledge in this area is a valuable resource for any designer involved with older people.

1.6.2 A pilot study – Chapter 3 and the Dual Task pilot study

Chapter 3 "The Dual Task pilot study" describes an attempt to operationalize a hypothesis that, if supported, would assist designers in incorporating the findings of the literature review into their designs. One of the concerns that occupied me after completing the first version of the literature review was how to test the effectiveness of the implications that I had drawn from it. As pointed out in the preceding section, there is such a richness of implications that an experimental study at the level of verifying individual recommendations or even many such studies would be beyond the resources of even a well funded research institute, let alone a single PhD student. None the less I was strongly influenced by the almost exclusively experimental format of the literature on physical and cognitive aging. How then could one proceed with an experimental study that supported designers using the design implications of the literature on physical and cognitive aging as a framework for better design? After some consideration it appeared possible that a way of linking the individual implications to an overall framework for assisting older users might lie in the studies looking at how older people performed in dual task situations. It had been established that as people became older they showed poorer performance on dual task performance than younger subjects. This was usually explained in terms of older people having a more limited cognitive capacity than younger people and hence if they performed two tasks simultaneously the cognitive resources needed for performing one task would reduce the cognitive resources required for performing the other task. Under this formulation one could suggest that handling the demands of the interface became one of two tasks the older user was engaged in, referred to in Chapter 3 as the interface task. The other task was whatever job had led the older user to use the software in the first place, for example, writing and sending an email, this latter task was designated the substantive task. The dual task hypothesis then stated that the demands of the interface task had the potential to compete for cognitive resources with the substantive task. Hence a designer should reduce the cognitive demands of the interface task by plugging in design features that reduced demands on the older users in accord with the suggestions from the literature review. This, it was argued, would allow the older user to devote more resources to the substantive task and promote more effective computer use by older people.

A basic experimental design was developed in which older subjects would perform a task under differing levels of both interface difficulty and task difficulty. Two variations of the experiment were designed so that the test of the hypothesis could be replicated under two different types of task and interface. A pilot study was organized using 12 older volunteers. The bulk of Chapter 3 is devoted to describing the method and the results. However the core contribution of chapter 3 is in its last few pages where the results and the rethinking of the thesis that they prompted are discussed. This is addressed in the next sub-section (1.6.3).

What emerged was a complete lack of support for the dual task hypothesis. This was unexpected and daunting. I had already established that a finite set of resources would not allow experimental verification of the individual usefulness of the recommendations from the literature survey. I found the dual task hypothesis appealing and hard to disbelieve. It appeared though that if it were true it did not operate on a simple level over long periods of software use but it still might operate at a second by second level within the loadings that interface and substantive tasks simultaneously placed on various subsystems such as memory, vision and manipulation. This was potentially interesting if substantiated but it did not offer ready guidance to designers unless they were willing to engage in a level of task analysis that would be unusual and demanding.

1.6.3 Changes to the research direction from the Dual Task study

In the discussion and conclusions at the end of Chapter 3 the groundwork is laid for a complete change in direction for the research underlying the thesis. The resulting new directions resulted in useful and productive research. The issues raised by rethinking my approach in the light of the failure of the pilot study to support the dual task hypothesis included a question of whether designers would be helped by the level of abstraction that is represented by overall hypotheses or would they be better served by a background understanding of the effects of aging at the level of concrete issues that could be countered by appropriate design features? The older subjects in the Dual Task pilot had also shown unexpected distress when the experimental tasks led to them failing to achieve, thus placing older participants in such situations was ethically questionable.

Again the focus groups' discussions of the subjects' experiences during the experiment and in their day to day efforts in computer use provided a wealth of relevant information that was not tapped by the experiment and its results. It seemed apparent that a wider and more human understanding of older users would yield useful information that was not available in the literature that had been reviewed. (In fact there is information in the literature on psychological and social aspects of aging that would be relevant and related to the stories told by the Dual Task subjects in the focus groups but extending the literature survey to this extent was impractical.) At the same time as the Dual Task study was occurring I was involved in observation of older people in a variety of contexts and the relevance of the material gained here reinforced my decision not to rely solely on an experimental approach and its implied distancing from the subjects so as to obtain objectivity.

It was apparent that the older people who volunteered as subjects in the Dual Task study were considerably better educated and had greater levels of career success than the general population. Thus another concern raised by the Dual Task study was the need for finding ways of recruiting older people that reduced the strength of the selection bias effect.

Another striking observation from the dual task study was the extent to which I failed to anticipate the level of task simplicity appropriate for the older subjects. This was in spite of having a sample of older people obviously skewed towards indications of previous high performance. I was unusually informed (for an interface designer) about the effects of aging and was, I considered, aware of the need of older users for cognitive simplicity. I had pre-tested the substantive tasks with middle aged people and was unprepared for the older subjects being uniformly unable to cope with the two harder levels of task complexity that had been only mildly difficult for my middle aged testers. This suggested that design for older users was not possible without the active involvement of older users in actively and frequently informing the designer of the way in which the performance of older users would differ from the designer's assumptions.

Other indications of the need for a change in approach included the problems found with obtaining realistic motivation from older subjects in carrying out the experimental tasks where these tasks were a) not particularly relevant or interesting to the older people involved and b) led to painful reflections by the older subjects on their conception of their own competence. In an early part of the Dual task study the older subjects were involved in finding preferred font styles and sizes. This was a task that they saw as relevant and potentially helpful to older computer users, it was also non-threatening, it did not involve failure in the sense that the later tasks in the study did, the older subjects participated enthusiastically in the font preference task. It seemed that older people needed to be studied working on tasks that they saw as relevant to themselves and to people like them if realistic levels of motivation were to be obtained.

As part of my concern with gaining a wide knowledge of older people and their involvement with computing I looked for opportunities to observe older people working with computers as well as discussing computer use with a variety of older people. One particular opportunity came when Unitec, a local polytechnic, started running training courses for older people. The intention was to generate revenue and to do this by recycling courses that were already in use for providing adults lacking computer experience with basic computer skills and word processing. There was no expectation that older people would need any special treatment, the designation of the courses as being “for older people” was simply to extend the range of potential customers. I found out about the first course after a tutor had been assigned and students had enrolled. The tutor had no special training in working with older people and their teaching experience included presentations to computer professionals. After discussion with the organizers and the tutor I attached myself to the class in a combined roll as an observer and as an assistant.

The experience was unpleasant for me and distressing for the older students. On the other hand it gave me a very valuable understanding of the difference between older novices and the younger students the course was designed for. It also highlighted the consequences of treating older people as if they were simply younger people to whom one spoke a bit more loudly and repeated things slightly more often. Little learning was achieved, the older students blamed themselves for this and the tutor, while polite and patient with the students in class, wondered privately if they were wasting their (the tutor’s) time as the older people were obviously incapable of learning. My self assigned role gave me a possibly more objective view of the specific problems that the older people faced and allowed me to spend time with the older students individually at their computers rather than being limited to a “front of the class” perspective of the situation. A range of issues related to aging emerged, none of which was effectively addressed. The class struggled to see material at the front of the room, they did not pick up idioms and simple skills at the speed expected by the tutor, they had difficulty finding features on the screens in front of them, they suffered navigation problems when using the software provided and did not learn quickly from their errors. They failed to understand concepts that the tutor felt would be self evident. The course was typing intensive, many in the class were extreme “hunt and peck” typists, often undergoing their first attempt at typing. They learnt at different speeds and they forgot much of the material taught on previous days. They showed total incomprehension of the technical information (such as binary storage) that the tutor believed needed to be included in the course in order to give people a “respectable” understanding of computers. The conclusion of the individuals in the first class was that they were “too old to learn computing” rather than that the class was not designed for older learners. It would have been highly unethical to have set this situation up deliberately. I remained in a role of assisting individual students and observing the class and did not make suggestions for changes to the tutor on the grounds that I would be more objective about suggesting better approaches if I did not intervene until the five sessions of the first course had been completed. (The exception was reconfiguring the tutor’s machine so that it displayed more legibly on the screen at the front of the class and doing similar reconfiguration so that the older students could see the fonts on their own screens.) Early intervention with limited information, while tempting, would have added a partisan flavor to my analysis of what was occurring.

Following the first course I did intervene and provided the course with a simple tutorial program that let the students practice the most obviously lacking skills separately from the MS Works program that was the software the course was intended to teach. This was useful but the course content remained much too wide for the student’s needs. Older people who are struggling with using a scroll bar or finding and clicking an [OK] button are not likely to benefit from attempts to teach them introductions to spreadsheets and desktop publishing. These courses thankfully died a natural death but I was struck by the range of difficulties that older people found with apparently elementary (to me) computing skills. I was also impressed at how much difference the crude intervention tutorial made to the ease with which the older students acquired these skills.

Practical experience in working with this new set of concerns and directions began to emerge in the WinTutor study described in Chapter 4 and outlined below.

1.6.4 Older beginners – Chapter 4 and the WinTutor study

Chapter 4 documents the development of a much fuller interactive tutorial for older beginners. I was interested in whether the approach used in the intervention tutorial for the older students in the Unitec classes could be used more widely in training older novices. I also wanted to continue to extend my experience of older people as they worked with computers. A possible way of combining these aims was to work with an organization that already specialized in training older people in computing use and see if an extended tutorial could be developed that would be adopted in courses that already had material designed for older beginners. I started discussions with SeniorNet (NZ) tutors and this ended in the design of WinTutor. This design is discussed in Chapter 4 and it has in fact proved very successful, becoming widely adopted by SeniorNet simply through word of mouth advertising.

There are some points that are worth noting here. Chapters 3 and 4 both discuss case studies of the development of interactive tutorials for older users. However it was not the intention to divert the thesis direction towards gerontological education. There are a number of advantages that come from working with interactive tutorial design for older users in an overall project aimed at effective interface design for older people. Firstly it appears that learning in many older people is slow and fragmentary. What the work on WinTutor (as an interactive tutorial for older novices) provided was understanding of which skills older people initially struggled to master and an indication of the gaps in knowledge that were likely to mean that older users broke the assumptions about pre-existing computing skills likely to be made by younger designers. Secondly an interactive tutorial is in fact an excellent exercise in appropriate design for older people. To an extent one theme of the thesis is the presentation of an ongoing case study of the process of one interface designer (the author) acquiring skills as an interface designer for older users. Creating WinTutor involved me in designing some 57 interactive screens that were each expected to be functional for older novices. So creating the WinTutor tutorial provided extensive practice and grounds for reflecting on what worked, and what did not, for older users, while drawing on the implications of aging as explored in the literature review. Thirdly there is a place for some understanding of appropriate training for older people in the armory of interface designers. One of the ways in which an application can be made more accessible to an intended older audience is to provide carefully designed training (suited to older users) as part of the application package. The analysis of the design features of WinTutor reported in Chapter 4 is useful material to that end.

One of the other features of the WinTutor design was the incorporation of two older novices into the design stages of the project. These people were consulted on a day by day basis as the design was developed and very obviously contributed strongly to the eventual success of the project. Older people in this role are referred to from here on as the "in-house testers". In-house testers were used in the next two design studies and one of the outcomes of the overall research was refinement of the way that the role of in-house testers could be handled. This is considered in more detail in section 1.6.8 describing Chapter 8 which deals with the skills needed in working with older people.

A weakness in the WinTutor project is that it was not originally intended as work to be written up. It was undertaken partly out of desire to make life easier for older people who were trying to learn computing skills, prompted by anger at what I had observed at Unitec. It was also motivated by a belief that it was desirable for a designer to get a more rounded and more human picture of older people than that which emerged from the descriptions of experimental work in the literature review. I had not intended to write this work up and was caught unprepared when it emerged as both a useful source of important information and as a highly successful case study in designing for older people. What was missing was a process for formally evaluating its usability with older people. The tutorial was released to the SeniorNet community and adopted by many branches to replace their previous teaching materials but in place of a description of success based on results from usability trials the WinTutor chapter has testimonials and continued sales figures. It was decided to rectify this lack in the next study.

1.6.5 Learning more complex applications – Chapter 5 and the FileTutor study

The next study in the research for this thesis was again based on the design of an interactive tutorial for older people. As noted above there was a desire to recapture the design success of the WinTutor project in a way that allowed more analysis of the factors leading to a successful design and more formal demonstration of the success of the design, if in fact it was successful. I had some concern that including a second interactive tutorial in the thesis would lead to the core design message behind my work being missed by readers who might see the work as just being about teaching older beginners, rather than maintaining a focus on appropriate design for older users. There were several responses to this incorporated in the research. It was decided that the thesis would include a third design project that was clearly an application design for older users after the second interactive tutorial was completed. It was also decided to shift the nature of the second interactive tutorial so as to extend the range of useful information (for interface designers) that could be extracted from the study. The previous arguments for viewing the construction of an interactive tutorial as excellent practice in designing multiple screens that needed to be workable for older users still applied.

The extended target for the new interactive tutorial project was to look at how somewhat experienced older computer users could be assisted with learning more complex computing skills and assisted in learning an application that challenged their ability as older users. The topic eventually chosen was Windows file management and the related application was Windows Explorer. The interactive tutorial product that came out of the design process was nicknamed FileTutor.

Although finding a way of training older people in file management under Windows was itself a useful achievement the reader is asked to bear in mind that this was a secondary aim in this project. The relevance of the FileTutor project to an interface designer for older users comes from the following argument. If older people are to use computer applications that are part of the computing mainstream and therefore accommodate younger users, older users will be asked to work with situations and information presentations that are not extremely simplified. One weapon in the interface designer’s set of tools is to design training programs for older people that allow them to develop the skills needed for working with software that they otherwise would be defeated by. What was examined in the FileTutor project was how to tackle training older people in levels of skill that were regarded by experienced teachers of older people as difficult to acquire. The result is an example of how to extend the range of software that older people can use and understand.

In designing the FileTutor interactive tutorial the same design process used with WinTutor was followed. As before I consulted widely with experienced SeniorNet tutors before starting the project in order to choose an appropriate topic. As before I worked with in-house testers who contributed to the day to day development of the design. Two differences in the process were that firstly I was consciously aiming for inclusion of the project in the thesis writeup and so I was more analytical about the successes and failures as individual screens were designed. The second difference was that an evaluation of the usability of the tutorial was undertaken at the end of the development. The form of this evaluation was quasi-experimental in that the older people recruited for the evaluation were recruited from people who had tried and failed to learn Windows file management by a variety of means. They used FileTutor to learn Windows file management and then, a day after training, completed an exercise outside the tutorial environment to see if they had in fact achieved useful skill levels.

There was also a change in the content of the tutorial. The WinTutor tutorial was aimed at simple skills that were general throughout computer use under the Windows operating system. The FileTutor tutorial also covered general skills and concepts, this time related to file management. However the FileTutor tutorial was also intended to be an example of training older people in the use of a moderately complex application, as stated above this would potentially extend the ability of designers to make widely used software available to older people.

To return to the issue of finding a way of training older people to use a complex application there had been interesting work done by John Carroll looking at how to improve the training of younger people so as to improve their eventual competence in mastering a complex application. Carroll et al.(1990) showed in a series of studies that ruthlessly simplifying the information initially presented to trainees so that they learnt a very restricted but core sub-set of application skills meant that over time their eventual performance was significantly better than the performance of students who were initially taught a wider set of application skills. In arguing for such restricted training approaches as “the minimal manual” and the “training wheels” version of an application (where many options were deliberately unavailable) Carroll made a case that initially restricting instruction to simple core information meant that the learner emerged with a more robust conceptual model of the application which then provided better support as the learner later proceeded to investigate further options on their own. This work had been done with young people as the subjects of the studies. It appeared to be of interest to see if the same effects would hold for older trainees.

Thus in order to see if Carroll's findings could be extended to older people the tutorial included a training wheels version of Windows Explorer specifically designed for older users and the evaluation of the usability of the tutorial included a section where the participants were asked to apply the skills they had learnt within the tutorial and the training wheels version of Windows Explorer to an exercise done with the real life version of Windows Explorer. The results supported the argument that an initial reduced instruction set as suggested by Carroll was appropriate for older trainees.

1.6.6 Application design for older users – Chapter 6 and the SeniorMail study

The last stage of the research for the thesis was aimed at clearly establishing the utility of the design approach that had emerged in the previous two design studies, to a relevant application for older users. An email application was chosen as the design target since this offered the chance to design a reasonably fully featured application that older people would see as relevant to their needs and interests. The system that eventuated was called SeniorMail. As in the previous two design studies, research was carried out to examine the context in which older people would be likely to use email and the likely needs of older users. Focus groups and discussions were carried out with older users and potential users of email in a variety of settings. Some older people were observed using standard email software, this gave useful insight into current difficulties. Focus groups were also used to get information from the supporters of older email users, this gave valuable additional information relevant to the design aims for an email application for older people.

In-house testers were again used as a core part of the development and they again gave rapid feedback, virtually on an as-required basis, influencing much of the design. There was, however, a worry that the in-house testers would become too familiar with the overall gestalt of the application as it emerged and so loose their quality as naïve users. Therefore the concept of in-house testing was extended to include groups of people who wanted to become users of the new email system as soon as the very early versions became functional. This gave the designer a further set of motivated testers who could be relied on to show an involved interest in how changes and developments would affect the usability of what would become “their” system. A number of observations were made as to what techniques led to useful prototyping and useful gathering of usability information. These observations and the implications for a design approach to be used when developing with older people are examined in Chapter 8.

At one level the aim of this design study was simply to provide an email system that older people found easier to use than standard email systems, in particular MS Outlook Express which was the system that I found older people attempting to use. At another level the design study was intended to support the case that usable design for older people could result from a design approach that combined sensitive use of older people in the development process with knowledge of many of the relevant effects of aging. To show success on either level there needs to be some form of evaluation of how well the system lets older people carry out emailing tasks. This evaluation was carried out with a group of 25 older users who were volunteers at a local Citizen’s Advice Bureau and found conventional email difficult to use. The results supported the argument that the SeniorMail design study had succeeded and these results are reported in Chapter 6. As this evaluation was carried out in a short time frame, under an hour per person, the chapter also notes the experience of a small group of long-term older users of the system who retained enthusiasm for it. However the chapter also reports the response of a group of middle aged users who, while they found the SeniorMail system easy to understand and use, did not want to adopt the system as it failed to provide sufficient features. This disparity between the feature sets likely to be used by older and younger users is seen as an important issue in the whole area of designing for older users.

Chapter 6 proceeds to describe the features of the SeniorMail system at some length and to examine how they have been derived from a consideration of the information from the literature review in combination with the feedback from the extended team of older testers. It is noted that the system makes use of the ideas developed in the previous study on training older people to use complex applications and in fact contains its own training wheels version within the application. This was used to train volunteers in how the system should be used when evaluating the usability of the system.

1.6.7 The research methodology – Chapter 7

Note that the research methodology emerges from reflection on what worked as a greenfields investigation was carried out, hence the unusual positioning of the research methodology chapter after the chapters describing the research. The research methodology is a product of the investigation, not a primary driver of it.

The opening sentence of this introductory chapter describes the aims of the thesis in the following terms, “This thesis looks at the issues involved in designing software that older people can use effectively”. As initially conceived this implied a framework of relatively traditional design guidelines; use big fonts, use simple layouts etc. As my research proceeded and as I reflected more on what was happening in the design studies this concept broadened. It became clear that the inclusion of older people in the design process was central to the success I was achieving. Slightly less obvious, but equally important, was the way in which the older participants were included and the relationship between the older people contributing to a design and the designer.

This process of reflection on what I was achieving led to two sets of understandings about the process I was engaged in and about the outcomes of the research. In the first place I had developed a structure for addressing the research aims of the thesis, this is described in the methodology chapter and will be outlined here. In the second place I had developed a useful body of experience in working enjoyably, ethically and productively with older people on interface designs. This is addressed in Chapter 8.

The methodology chapter opens by examining the lessons to be learnt from the Dual Task pilot study. As previously mentioned the failure of the Dual Task pilot study to support the dual task hypothesis and the distress and low motivation of the older subjects led to me rethinking the direction of my research. The arguments for this change of direction are examined here. The question then became if an experimental approach was not going to meet the aims of the research what methodology was in fact suitable? The chapter starts the process of addressing this question by restating the aims of the overall research as a way of focusing on the question of what methodology would be appropriate to meeting those aims.

Having spelt out the research aims, the chapter proceeds to look at a variety of candidate methodologies; quasi-experimental research, case studies, ethnographic approaches and action research. It is concluded that while elements of each of these approaches are useful in supporting the research aims, none in their basic form meets the specific needs of the research aims of the thesis. The research methodology that was eventually used is then described showing how it draws from the candidate methodologies that have been described.

The chapter next looks at the way in which the research incorporates the information from the literature on the effects of aging together with the observations made in the design studies and the supporting activity surrounding those studies. Finally the rationale of the format used within the design studies is examined in terms of the research methodology. It is argued that the development of a methodology for addressing the research questions of the thesis is one of the valuable outcomes of my research.

1.6.8 Working and designing with older users – Chapter 8

A further valuable outcome from the overall research is the experience in working productively with older people in creating designs for older users. This is reported in Chapter 8. The position taken is that while interaction with older people is a vital part of the design of artifacts for older people, constructive interaction with older people around technology issues is not obvious, simple or likely to be undertaken successfully on the basis of a designer's or supporter's usual patterns of interaction.

There was a further benefit for the overall research that arose from the WinTutor design. I had two close friends who were not computer literate, had tried to become so and had failed. They were in jobs that now required them to use computers in the near future. They knew of my interest in training older people and half jokingly suggested I train them. I blithely went to see them, expecting that a half hour clearing up misconceptions would have them on track and self supporting. What I discovered was a puzzling inability to learn that closely paralleled the problems I had been observing in the Unitec courses for older beginners. These people were intelligent, articulate, self aware, in their mid fifties and worked from home close to where I worked and could easily take short breaks during the day. They badly needed computer skills. After discussion we came to an agreement that they would help me field test the screens I was developing for WinTutor on a daily basis and that as they did so I would assist in their learning of computer skills. In effect they became in-house testers for the project and surrogate older users. The concern that they might not really represent older users was reduced in so far as they showed some of the same behaviors predicted from the literature survey and seen in the Unitec classes. In addition the eventual product, WinTutor, which obviously owed a great deal to the in-house testers, was found to be very effective with much older people.

This in-house testing agreement became a very useful and mutually rewarding arrangement. The in-house testers ended up with the skills they needed. I ended up with an insight into how transformative it was for me to have immediate responses to my design ideas from older learners. As a computer experienced designer I could not shake enough of my preconceptions about what should be obvious. I repeatedly produced initial designs that met with incomprehension and frustration from my in-house testers. This could arise from either my way of presenting computer concepts or from my interface designs. There was another benefit in the relationship. These were old friends, they did not treat me as an unapproachable authority figure, they were volubly cheerful in pointing out my and my program's failings. This was a vital contrast to the deference shown the tutor in the Unitec classes. As we built up experience in working together I came to increasingly value their insights into what was lacking in a prototype screen, they on their part came to see that their suggestions were resulting in useful changes and that some of the problems they found with gaining computing skills were not ingrained (and blameworthy) aspects of who they were but were amenable to well designed training. This experience became the prototype of the format of including older people as participants in the design process that was used and refined in the FileTutor and SeniorMail studies. This design process is discussed in Chapter 8. It also became an independently developed way of working with older people that strongly matches the UTOPIA model and hence adds some support to that model, especially given the success in developing useful applications for older people that has come from the use of my approach. This is discussed in Chapter 9.

Chapter 8 starts by giving a bulleted outline of the approach to doing interface design with older people and then moves to considering typical problems in working with older people. It looks at the gap created by the differing experience of (younger) designer and older person. It looks at the issues related to the lack of respect accorded to older people in our society. One of the problems here is that older people may well “buy into” a view of age as implying that they are insufficiently competent to tackle modern technology such as computing. In a related issue older people are likely to defer to those they see as more authoritative and this is likely to include the interface designer or developer. The problem here is that this undermines the communication of problems the older person experiences with a design and communication of ideas the older person may have for improving a design. The chapter notes that there are stereotypical and unproductive patterns that younger people fall into when trying to communicate with older people, the use of so called “elder speak”.

In the light of these concerns the chapter considers how a researcher or designer should care for the older people who are part of the designer’s team and design resources. After summarizing the set of issues to be dealt with the chapter provides extended coverage of each issue in turn. The chapter looks at issues such as older people’s need to avoid being subjected to time restricted tasks if realistic optimum behavior is to be obtained. Variations on standard information gathering techniques are considered so that interviews and questionnaires are less likely to create miscommunication due to the older people’s lack of familiarity with apparently common technical terms and potentially due to power imbalance between researcher/designer and the older person. The problem of selective sampling is also addressed.

The chapter then turns to specific techniques that were found to be useful in my experience of developing designs with older people. Variations on needs analysis when addressing an older target group are considered. Initial concerns in creating the basic designs are discussed. This includes discussion of the argument that low fidelity prototypes are less appropriate for older users. It also examines the creation and maintenance of a good working relationship with in-house older testers. Usability test cycles involving older people are considered and the value of establishing a pool of long term testers is looked at.

One of the problems in working with older people is that the potential power imbalance between researcher/designer, as well as older people’s tendency towards deference and politeness can mean that older people are not well protected from unethical treatment. Nor is it always immediately apparent what constitutes unethical treatment of older people. Therefore the chapter concludes by devoting a section to considerations of how to achieve ethical treatment of older volunteers.

1.6.9 Parallels with the UTOPIA approach – Chapter 9

The approach to research design and to productive and ethical work with older people has strong parallels with the important approach to research on the design of technical assistance for older people that has been developed by the UTOPIA team centered on the University of Dundee and headed by Alan Newell. This is interesting and important since my own work was done without my being aware of the UTOPIA research. The network of citations I pursued in largely American journals did not reach widely into English and European work. In an ideal world I should have been aware of Newell's team and their work in considering dynamic diversity and inclusive design at the beginnings of my own research. I would then have been in a position to build my work within the framework of the considerable insights that they provided on working for and with older people. However by proceeding independently of Newell's team and yet coming to very similar positions on research and design approach it can be claimed that I have contributed to strengthening the case for both positions.

In this light Chapter 9 provides a detailed examination of the stance involved in Newell and his co-workers' position statements on dynamic diversity, inclusive design and appropriate ways of working with older people and makes a point by point examination of the similarities and differences with the approach I have developed. A very high degree of agreement between the two approaches is demonstrated and the chapter concludes that my own work can justifiably be seen as an independent verification of the UTOPIA approach all the more so in that both approaches have led to successful product development for older people.

1.6.10 Conclusions – Chapter 10

The thesis concludes with an examination of how the various studies have built towards the development of a design approach for working closely with older people as part of designing products for older people. In the course of this review of what the thesis has achieved the twin themes are the way in which insights during the research have contributed to the design approach and the way in which the results of testing the design cases with older users has provided support for the design approach. Inevitably a wide ranging thesis of this nature raises numerous questions and so the conclusions chapter also considers areas for further research that appear relevant in the light of the current work.

1.6.11 The appendices

There are five appendices that either provide further information related to the study or are intended to provide useful summaries of information contained in the study as resources for designers intending to work in this area.

Appendix A gives further information on the demographic shifts as developed countries move to a population with a higher percentage of older people.

Appendix B provides the test protocol used for evaluating the FileTutor Study.

Appendix C provides the test protocol used for evaluating the SeniorMail Study.

Appendix D provides a summary of the changes that occur during aging and appear relevant to the concerns of an interface designer. In effect this is intended to give a reader easy access to the main findings of Chapter 2 but shorn of the discussion and citation of the research studies on which Chapter 2 is based.

Appendix E also provides a summary, this time of the age related interface features that were implemented in the three designs used in the case studies. The aim here is not primarily to provide a designer with a set of firm guidelines for dealing with interface design for older people, in different designs different approaches may be appropriate. The concern here is to gather together the design features from the three successful design studies as a set of examples that may help future designers to consider how to proceed from a knowledge of the effects of aging and a design problem so as to work with older people towards a successful design.

1.7 The Contributions of the Thesis

The thesis has taken a significant problem on a world scale and has applied a greenfields approach to it resulting in a wide ranging body of useful work and resources for approaching the area of interface design for older people. At the time the thesis was done (1998-2002) the HCI community did not appear to be involving itself with a vital problem. See Czaja (1998), Hawthorn (1998a) and Czaja and Lee (2003) for backing for this contention. There was limited published research on the issue but it was obvious that there would be a rapid shift to a much older population with a need to engage with computing. Hence the thesis was conceived in terms of crisis research where the aim was to open up the area over a broad scope rather than to provide exacting support for a single narrowly defined proposition.

Accordingly the contributions of the thesis cover a broader scope than would normally be expected for a PhD thesis. The contributions can be considered under several headings; opening up a new area of interface design, providing resources for designers for older users, providing an approach to be used when designing for older users, findings on training for older users that are relevant to designing for older users, support and extension of other worker's findings and finally a contribution to research methodology.

Opening up a new area

1. The thesis research has helped open up a new and important area in which there was little extant work at the time of the research. (This contribution was achieved by publishing the work as it was done at the times when it was relevant so the contribution is ascribed to the research rather than to the thesis.)

Providing resources for designers for older users

2. The thesis provides a useful resource sumarizing the potential impact of aging effects on the interface design needs of older users. This has been done by an extended examination of, and reflection on, the interface design implications of the literature on physical and cognitive aging.
3. The thesis provides a picture of the elderly novice that should assist designers in this area.

4. The thesis provides three exemplars of designing effective interfaces for older users, giving information on the design considerations involved, the design approach and the level of effectiveness achieved. This is important because there are few, if any, examples of application design for older users that have progressed beyond the prototype stage. It is also important in that Newell's team found that designers appeared to be at a loss as to how to proceed when they were exposed to the actuality of older users.

Providing an approach to be used when designing for older users

5. The thesis suggests an extension of traditional user centered interface design that can be adopted when working with older people. The value of this extended approach is supported by the success of the designs described in the case studies.
6. Based on reflections on what worked and what did not in the author's own experience as an interface designer for older users, the thesis gives a set of strategies for managing the relationship between younger designers/researchers and older participants.
7. The thesis explores the role of the designer as an outsider to the culture of the elderly and ways of working that accommodate to this. In effect the thesis contributes to an understanding of the needs of applied ethnography when working with an older target group.
8. The thesis demonstrates the usefulness of high levels of participation by older people in interface design for this group and relates this to the differences between (young) designers and the target older population.
9. The thesis develops a picture of just how broad is the range of issues that can usefully be considered in designing for older users.

Findings on training for older users

10. The thesis demonstrates the value of appropriately designed interactive tutorials in assisting older people to learn computer skills and applications. Further the thesis provides guidance on features that contribute to appropriate design of interactive tutorials. I see this as a finding of considerable importance to people who are trying to integrate older people into a workforce. It also breaks new

ground in that it suggests an alternative approach to the current favorite of accessible design.

Support and extension of other workers' findings

11. The thesis extends Carol's findings on the use of "minimal manuals" and "training wheels" versions of an application to the teaching of older users. (This is relevant to designers for older users since the complexity allowable in an age appropriate design can be increased by providing inbuilt, age appropriate interactive tutorials.)
12. The thesis has provided independent support for the UTOPIA approach.

Contribution to research methodology

13. The thesis has developed an eclectic and wide ranging research approach that allowed the range of contributions given above from a greenfields beginning.

The thesis provides a comprehensive survey of the research literature on aging covering the abilities of older people that are relevant to interface design. This picture of aging is extended and enriched by reporting experience with older people in a variety of computer related contexts. By reporting observation of, and interaction with, older people, the thesis establishes a picture of the current target group for those wishing to design for older computer users. The thesis then provides the reader with three case studies of design for older people carried out as part of the research. These designs are shown to be successful in terms of older users being able to use them where they have not been able to use standard forms of training and applications in the same areas. The designs are described in some detail and the rationale behind the designs is examined so that a designer is provided with examples of converting from academic knowledge of aging to workable designs for older people.

In the course of selecting areas for the interface design cases used, the thesis looks at two examples of interactive tutorials aimed at training older users. Not only did these tutorials provide the author with extensive experience in design for older people that strengthens the basis from which the information in the thesis is presented, but the work on interactive tutorials opens up two areas of older people's learning of computer skills that are of importance for a designer. Firstly the WinTutor tutorial looks at the sorts of gaps that are likely to occur in older novices' skill sets and makes the point that some older users are likely to remain at novice status, a fact that designers need to allow for if they are going to target a wide range of older users. Secondly the FileTutor case study makes the point that with appropriate training older people may be able to work with some software that is not only poorly designed for older users, but that they have previously failed to learn while using standard approaches to learning designed for the younger population. This is important given the tendency of both managers and older people themselves to write off their ability to master computing skills. The two case studies on interactive tutorials also contribute useful ideas and working demonstrations both on overall design for older people and on the suitable design of interactive tutorials for older people.

The third case study covers developing an email application that older people have been shown to find highly useable. This study showed that the techniques used in the tutorial development could be extended to developing a more typical application with a moderately complex feature set and system structure. It also provided a third replication of the general design approach so that the reader is provided with more than one example in which this approach has been found to work.

In the course of designing the interactive tutorials the importance of working with older people in an appropriate manner became increasingly obvious. Use of contributions from older people became central to the design approach. It is argued that designers inevitably design from a perspective of users somewhat like themselves, but that this assumption is invalid in the case of older people because of the extent of the difference that aging creates between designer and target audience. This difference and the resulting gap between designer and target audience is extended in the case of the current older generation with their generally minimal computer skills. What the thesis has argued strongly is that bridging this gap demands working with older people as part of the design team, rather than the designer working in isolation merely using guidelines about the needs of older users. What the thesis also argues is that for a younger technically knowledgeable person to work on interface design with representative older users is not a simple undertaking. It requires a new set of skills in working with older people. Since considerations of how to work with older people as distinct from what to provide for them, may not be central to the thinking of a designer new to this area the thesis provides a careful analysis of the issues to consider in working with older people and enabling them to make useful contributions to the ongoing design process.

Overall one of the key contributions of the thesis is to show that the knowledge required for successful interface design for older people is multifaceted and covers fields that may not be initially thought of as part of a designer's brief and skill set.

Chapter 2 Design Implications of Physical and Cognitive Aging

2.1 INTRODUCTION

This chapter of the thesis provides a survey of the literature on physical and cognitive aspects of aging and considers the implications of these effects of aging on interface design. In the original versions of this chapter, published in 1998 and 2000, there was almost no extant literature that specifically addressed interface design for older computer users see Czaja (1998), Hawthorn (1998a) and Czaja and Lee (2003). In the absence of an extant literature the decision was made to ground the thesis in the existing (and wide) literature on the effects of aging. The situation has now changed and there are now a number of publications in the area of interface design for older computer users. However since details of interface design are dependant on the particular computing environment the users face, any particular recommendation about such things as mouse use can become less relevant as the technology changes. What is less subject to change is the nature of human aging, although here too better understanding of the aging process is leading to lessening of the severity of the effects of aging. It still seems that there is a case for maintaining the original focus and considering the most obviously relevant effects of aging, discussing the possible implications of these effects for interface design and incorporating the newer findings on suitable design for older people within this discussion. One of the other points that will be brought home by maintaining a focus on the effects of aging rather than research specifically on interface design for older people is the sheer breadth of the changes that aging involves and hence the range of aging effects that may prove of relevance to a designer.

Another way of looking at this is to see each of the differences that aging makes between younger and older people as a break in the in-built assumptions of (younger) designers that they are designing for someone who is generally similar to themselves. Hence these age related differences are areas that require deliberate consideration by designers if they are to design effectively for a group so unlike themselves.

The chapter will use the structure outlined in Table 2.1 below.

Table 2.1 Organization of the literature survey chapter

1. Introduction
2. Methodological issues in aging research
3. Problems with interpretation of Research on Aging
4. General aspects of aging, slowing and recruitment
5. Vision and Aging
6. Speech, Hearing and Aging
7. Motor control and Aging
8. Memory and Aging
9. Attention and Aging
10. Cognitive ability and Aging
11. Learning, Training and Aging
12. Conclusions

The next sections of this chapter (2.2 through to 2.4) look at some of the methodological issues and some of the problems with interpretation and application of the studies in the remaining sections. The aim is to make it easier for a reader without a background in this area to be aware of the limitations in interpreting and applying this research.

The chapter then looks at the main areas in which relevant effects occur, giving a brief survey of findings and then considering the possible implications and relevant findings from research on interface design for older people. In these sections that describe specific effects of aging (sections 2.5 through to 2.11), the sections will each be split into a general discussion of the findings within this area of aging, followed by a bullet point summary of the main findings, followed in turn by a discussion of the way in which these findings may have implications for interface design for older users. Thus in each of these sections the material will be structured in the following manner:

- 2.5 Vision and Aging
  - 2.5.1 Studies of vision and aging
    - Review of findings on vision and aging

Summary of age related changes in vision

2.5.2 Possible effects of age related changes in vision on interface design

Vision and Text - relevant changes

Vision and Text - design suggestions

Vision and glare - relevant changes

Vision and glare - design suggestions

…etc

Reviews of the changes that aging makes to the human factors impacting design can be found in Scheiber (2003), Klein (2003), Morrell et al. (2001), Hawthorn (2000) and Carmichael (1999). Well written guides to general design for older people including interface design can be found in Charness and Schaie (2003) and Fisk et al. (2004).

2.2 Methodological issues in aging research

As Rybash et al. (1995) point out studies on aging are particularly subject to confounding effects. This section of the chapter looks at methodological issues in aging research which mean that it is difficult to make authoritative research based statements about aging. The studies which will be cited in later sections of this chapter are part of a lively debate as to what exactly does happen to human abilities with age. The points in this section on cohort versus longitudinal studies and on controls needed in experimental studies on aging, as well as the points made in Section 2.3 on factors to consider in interpreting research findings on aging are useful in interpreting the sections surveying the general research on aging.

2.2.1 Cohorts vs. longitudinal studies

Most studies of ability and aging are cross-sectional, comparing two or more age groups at one point in time. As well as age, each group reflects the shared history of the group and hence the changing patterns of the society. What appears to be an effect due to aging may, on closer examination, be due to the increased years of education for each generation this century, due to changing patterns of mental and physical activity in work or leisure, due to changes in nutrition or to some other factor. A cross-sectional study showing decreasing performance with age on some cognitive task may show no such effect when the level of education of the subjects is controlled for. Rybash et al. (1995) and Permutter and Hall (1985) argue that for studies of aging and memory or cognitive performance, control for educational level is virtually mandatory.

Longitudinal studies attempt to counter the problems of cross sectional studies by following the performance of the same set of individuals over time. There are fewer longitudinal studies due to the extent of time and commitment required. Longitudinal studies of ability and aging tend to show smaller effects due to aging than cross sectional studies, Rybash et al. (1995). However part of this tendency may come from methodological problems in the longitudinal approach. Following the same set of individuals over time has two effects, the subjects are being trained in test taking and the study deals with those subjects who remain in the study. A problem is that elderly individuals with impaired cognition may be more likely to drop out.

Rybash et al. (1995) state that the problems of longitudinal research tend to overstate the ability of the older groups while cross-sectional studies are more likely to exaggerate the decline in function with age. However, even this may be questionable since the typical control for cross sectional studies is in terms of number of years of education and over this century prolonged education has changed from an elite pursuit to a mass movement. Groups of widely differing ages with the same years of education may have had quite different initial abilities. Rabbitt et al. (2004) looked at the effects of correcting longitudinal results for practice effects and for dropout effects. They conclude that interpretations of longitudinal studies of cognitive aging are misleading unless effects of practice and selective drop-out are considered. When results were adjusted for practice and drop-out effects they revealed accelerating declines in fluid intelligence and cumulative learning, linear declines in verbal free recall, and no substantial change in vocabulary. Socioeconomic status and basal levels of general fluid ability did not affect rates of decline. After further adjustment for demographics, variability between individuals was seen to increase as the sample aged.

As Charness (1988) points out, the methodological problems which beset the field occur because chronological age is a surrogate variable for a number of poorly understood determining variables which form the biological basis of aging. The manifestations of biological aging are further modified by the nature of individual adaptation to these changes. Individual adaptation in turn reflects the individual's history, part of which is common to a cohort. With cross-sectional groups selected for participation in some activity, such as computer users or marathon runners, one is looking at a selection effect where those who remain in the older group are those who are able to, or chose to do so. The older group is in effect a group of survivors, therefore examining their performance understates the problems of aging individuals who fail to remain within the group. If we wish to understand the impact of age on interface design it may be worthwhile to design studies which examine the reasons for which individuals avoid, reduce or move away from computer use.

2.2.2 Controls needed in experimental studies of aging and computer use

We next look at some of the controls required if we are to design studies of computer use and aging. There are some controls that are standard in studies on aging such as controlling for health, medication and eyesight. Salthouse (1996) states that controlling for the general slowing of response time found in older people is required in any study that wishes to make findings on response times for specific abilities. Otherwise as Salthouse (p40-41) points out the apparent link between age and an ability using response time as the measure is open to the interpretation that any effect shown is simply due to the general slowing of processing speed found in older people. Work by Gilbert and Rogers' (1996) makes it clear that training effects persist for longer in old people, older people take considerably longer to reach asymptotic performance indicating that training has been completed. Studies seeking to eliminate training effects should be designed to allow for this.

When we look for controls more specifically related to computing rather than aging we meet the question of levels of expertise. People who have areas of expertise seem to maintain performance in these areas as they age but to show declines typical of the general population in areas unrelated to their expertise. See for example Charness (1988) on aging and chess playing. Computer users cover a wide range from novice to intermittent user to expert and it is worth considering if the level of skill and experience affects performance as users age. While length of experience with computers is relevant it seems probable that several other factors will affect results. In particular controls should be established for the type and variety of experience and for frequency of computing use. It seems reasonable that any proposed study of computer use and aging should consider the subjects' depth of computing background which provides the basis for abstraction and expertise. Researchers should also consider how closely the subject's computing background matches any test environment. Are subjects experienced for example with a command line or a WIMP/GUI environment?

Charness (1998) points out that in their unpublished studies of older adults performing word processing tasks, that breadth of computer experience was an important mediator of age effects on performance. Because of this Charness suggests cohort effects are probably the most relevant issue for understanding future age effects for computing. Future cohorts of old adults will surely have had a great deal of experience with computers (though they may have even greater problems with obsolescence of knowledge if they don't stay engaged). So current research may lie within a relatively narrow window in time where older adults are particularly disadvantaged in using computers. However full breadth of experience with computers lies in the realms of computer expertise and expert users will probably be a small subset of all users even decades from now.

In common with other studies of the effects of aging on skilled performance, the older groups actively involved in computing are likely to be unrepresentative of the general population due to self selection, those who meet significant age-related problems are more likely to withdraw from the pool of computer users. It might be worthwhile to select subjects on a basis unrelated to computing such as membership of service clubs so that the study can sample responses from non computer users. Such studies could then, as suggested above, examine the reasons for which individuals avoid, reduce or move away from computer use.

2.3 Problems with interpretation of Research on Aging

2.3.1 Individual Variability

Results on aging tend to be expressed in terms of average declines for the age group and variances. This is misleading where older populations consist of sub-groups with disabilities on different abilities rather than distributions showing a strong central tendency about the mean. It is worth remembering a comment by Oldaker (1992) that old people are among the most stereotyped groups in our society and yet in fact show the greatest internal variation of almost any group. In any aging population many of the individuals will show declines on a few specific abilities, but on different sets of abilities in each case. Spirduso and MacRae (1990) point out that descriptions of average behavior become less accurate as the age of the group being described increases. Heart conditions, poor eyesight, reduced memory, stiffness and all the other manifestations of aging do not advance uniformly throughout the population but apply apparently at random to individuals who retain good functioning over many of their other abilities. Statistics of central tendencies do a poor job of reporting this. See for example the study by Schaie (1990) reported later in this chapter which shows this pattern for individual differences over different types of mental ability. The effects of age are highly idiosyncratic and the average picture may in some cases be false for many of an aged sample.

Decline in finger-tapping speed (Dixon et al. 1993) is an example of such an average finding. To establish the relevance of slowed finger-tapping for interface design it may be important to know whether this is a widespread moderate decline among the aged group or whether the average decline for the group represents near normal performance for most and seriously impaired performance for a few. As the aged are likely to have more health problems we can also find mixtures of performance patterns for health reasons. For our finger-tapping example this might be a general slowing of neurological function overlaid by a significant subgroup suffering from the onset of arthritis and possibly other groups in which finger-tapping is slowed for other causes. Our final concern is for interface design that makes reasonable performance possible for a wide cross section of the population despite the uneven distribution of problems such as finger-tapping speed.

2.3.2 Plasticity

Plasticity is a term used to refer to changes in performance in the face of practice, training or disuse. This is another potential problem in interpreting apparently authoritative statements of decline in specific abilities with age. The impaired performance of older people can show marked improvement with practice or decline with disuse. A general statement about decline in finger-tapping ability based on apparently competent research results has an air of authority but it does not in fact tell us the extent to which older adults can expect to retain or regain finger-tapping ability if this action is important to them, as in for example double clicking or typing.

Krampe and Ericsson (1996) emphasize the importance of recent practice in maintaining skills for older pianists. Also see Salthouse (1984) for work on the retention of expert typing skills. Presentation of results in the face of plasticity is something of a balancing act. The bald statement that an ability declines by x percent between the years of 30 and 60 can cement a self fulfilling expectation of such a decline into the minds of doctors, employers and the aging themselves. On the other hand in a wide-ranging review qualifying every observation with cautions about plasticity becomes repetitive and distracting. It should also be borne in mind that the underlying causes of decline in performance with aging can potentially be compensated for with new discoveries in drug treatments, training methods or general care of ourselves. Normal aging is a dubious concept. We tend to accept it for intellectual and statistical convenience.

2.3.3 Ecological validity

Much of the research knowledge on the psychological effects of aging is based on extending standard psychological tests to aged groups, see Rybash (1995), Birren and Birren(1990). Though these tests are traditional in psychometric literature they present subjects with atypical, simplified, stand-alone tasks in an unfamiliar environment. It is not certain how far one can generalize findings based on tasks such as figure rotation or list memorization to performance on real life tasks where the task is familiar, done repeatedly and done within a supporting and meaningful context in which the person may well have a different level of motivation. If we accept that there are changes in ability with age the questions become; how strongly such changes are manifest within the work and home environment, how well individuals are able to adapt their behavior to compensate for such changes and how the environment might be made more supportive of such adaptation. However see Diehl et al. (1995) for studies showing good correlation between lab tests and some everyday tasks.

2.3.4 Interconnection of effects

Considerable work is done in pure research on aging to separate the effects due to different aspects of aging. One of the issues in theoretical aging research is to tease apart the separate contributions of physical and neural aspects of aging. Thus in studying aging and vision there is an effort to understand the contributions of deteriorations of physical structures in the eye and to distinguish this from possible impairment in the brain's ascending visual pathway, which in turn should be distinguished from visual effects due to declines in higher cognitive function involved in interpretation and ascribing meaning to visual stimuli. However when we consider the application of findings on aging and vision we return to a situation where all the interconnections between the various levels at which aging can apply to vision are present concurrently. There needs to be some caution in applying findings that arise in the course of pure research aimed at clarifying a hypothesis about aging to the much less controlled situation of an older person in front of their computer where many effects can come into play at once.

2.4 General aspects of aging: cognitive processing and recruitment

2.4.1 Reductions in cognitive speed and cognitive capacity

Reductions in processing speed are the most widely established finding in research on aging. Salthouse (1996, 2004) has shown that the cognitive factor of processing speed accounts for a significant amount of the variance in almost all measures of aged performance. There has been debate as to the cause, with discussion of reduced efficiency in neural transmission and consideration of the costs of re-routing neural signals through an age damaged network.

What is important from the perspective of an interface designer is that older people can be expected to take longer in actions that require cognitive processing. The extension to this is that most human activities of interest to a designer do require cognitive processing so that cognitive slowing effects can be expected to show up in areas of activity that may initially appear to be physical such as vision, hearing and motor control. Note, though, that recent work challenges the idea that cognitive slowing is global and offers instead that view that cognitive slowing is task dependant, see Ratcliff et al. (2003) and Thapar et al. (2003).

It is also argued that aging is associated with declines in cognitive capacity, see Salthouse (2004). However it should be noted that it can be hard to give precise definitions of an overall concept of cognitive capacity as distinct from capacity in specific functions such as short term memory span, see Wenger and Gibson (2004).

2.4.2 Recruitment

Increases in the areas of the brain activated while undertaking a particular task are typically seen in brain imaging studies comparing older people with younger people. This is assumed to indicate compensation for diffuse neuron loss in aging. One view, the recruitment hypothesis, posits that diffuse neuron loss in aging is associated with transient (i.e., task demand associated) use of additional circuits to aid performance. Another view, reorganization, posits that neural decline in aging prompts the consistent use of alternative brain circuitry as a means of compensation for failing circuitry. Nielson et al. (2002) suggest that recruitment and reorganization may be better seen as aspects of the same thing and in this chapter evidence of greater brain activation by older people will be referred to as recruitment. Wu et al. (2005) point out that since recruitment means integrating the activity of larger areas of the brain, task performance that relies on recruitment is less effective. Hence recruitment may be an aspect of the general finding of cognitive slowing noted above. Recruitment is not universal in older people, Cabeza et al. (2002) carried out a brain imaging study that compared young adults with low performing and high performing older adults. Interestingly the low performing older adults showed similar activation patterns to the young adults with no evidence of recruitment. The high performing older adults activated extra areas of the brain in addition to the areas activated by the younger adults. There are possible implications from this. If as seems increasingly likely, recruitment is not organized on the fly but requires reorganization of brain function over time, then older adults maintaining intellectual activities are more likely to accompany this by recruiting additional areas to assist them in their pursuits in spite of generalized neuronal decline. This offers the possibility of a mechanism underlying the “use it or lose it” maxim for successful aging.

2.5 Vision and Aging

2.5.1 Studies of Vision and Aging

Progressive visual impairment is one of the more clear-cut areas of decline in performance with aging. See Kline and Scialfa (1996) for a recent review. Fozard et al. (1977) suggest that aging affects vision at two levels. One level of changes becomes apparent between 35 and 45 though actual decline may have started much earlier. This level is largely the result of reductions in the eye's ability to accommodate to near focus and reductions in the amount of light transmitted to the retina. Effects from this level of changes include the need for reading glasses in one’s forties, increased sensitivity to glare, reduced sensitivity to color and the emergence of problems with depth perception. These problems continue and worsen in later years but a second level of changes becomes noticeable between 55 and 65. These changes reflect changes in the retina and the nervous system and include reduced visual field, problems with dim lighting and reduced ability to detect flicker.

Somewhat more than 10% of elderly suffer from seriously impaired sight due to one of three degenerative diseases; glaucoma, cataracts and macular degeneration. The presence of these diseases increases sharply in extreme old age. Desai et al. (2001) report that half of those over 65 have sufficient opacity of the lens to meet the formal definition of a cateract condition. At the other end of visual ability about 10% of elderly above 80 retain 20-20 vision, Rybash et al. (1995). The remainder of elderly adults show various levels of non pathological decline both in the ability to perceive visual sensation and in the way in which these sensations are processed. However not only does vision generally decline with increasing age but the visual defects of advanced age are less likely to be able to be satisfactorily corrected with prescription lenses. The level of such intractable visual defect is reported to be around 14 percent of people in the 70-79 age group but increases to over 30% of those over 85.

Near vision

The most widely noticed problem is the reduced ability to adapt the lens of the eye sufficiently to allow focus at short distances, a problem which emerges in the early forties and is compensated for with reading glasses. The eye also becomes slower to adjust to shifts in focal depth. These problems arise because of increased stiffness of the lens and some atrophy of the muscles responsible for adjusting lens curvature, see Kuwabara (1975).

Visual acuity

Visual acuity declines, this is the ability to detect fine detail as measured by letter recognition on the familiar optician's or Snellen chart. The pupil becomes smaller with age (this increases focusing power but decreases the use of available light.) In addition the lens yellows letting less light through to the retina, the effect of these changes on visual acuity can be partly compensated for by increasing the available light. Pollack and Atkeson (1978) point out that the decline in visual acuity after age 50 is much greater than would be predicted purely from the changes to pupil size and lens yellowing. However other retinal changes occur, Fozard et al. (1977) report on metabolic changes in the retina with age and Schieber (1992) reports that there is a substantial decrease with age in the number of cone’s in the fovea at the center of the retina and suggests that this contributes to loss of visual acuity. Weale (1975) provides an extended exploration of possible reasons. There is a peak of visual acuity between 15 and 20 years followed by a steady decline to age 60 with a slight acceleration in decline after age 60, Richards (1977). Gittings and Fozard (1986) report that with corrective lenses a majority of individuals retain 20/40 vision into their 80s. However Salthouse et al. (1996) show that there is still a decline in corrected visual acuity with age. Rybash et al. (1995) point out that measures of visual acuity are taken under fixed conditions providing strongly illuminated stimuli and hence may overestimate subject's ability to make visual discrimination under more usual conditions. Kline and Scialfa (1996) p32 cite findings indicating that the reduction in acuity with age significantly worsens in dim light even among older subjects who were visually equivalent to younger subjects in well-lit conditions. See also Haegerstrom-Portnoy et al. (1999) who confirm this and note that this can be extended to low contrast visual stimuli. From this report high contrast acuity is reasonably well maintained on average, even into very old ages High contrast acuity is reasonably well maintained on average, even into very old ages. Standard visual acuity testing, Haegerstrom-Portnoy et al. found, underestimates the degree of vision function loss suffered by many older individuals under the non-optimal viewing conditions encountered in daily life. All spatial vision functions show a similar rate of decline with age of the population, but the age at which decline begins varies among different measures. West et al. (2002) report that the failure rate for all vision functions and physical performance measures increased exponentially with age. Standard high-contrast visual acuity and standard visual field tests showed the lowest failure rates. Nonstandard vision tests that could be more representative of actual living situations showed much higher failure rates. Poor performance on many individual vision functions was significantly associated with particular individual measures of physical performance in activities of everyday living. Kline and Scialfa (1996) cite numerous recent studies which indicate that some of the decline in vision associated with aging is due to decline in functioning of both neural pathways and cortical functioning. Salthouse et al. (1996) support this by showing in three studies that the relation of impairment in corrected vision to age occurs via a factor related to cognitive functioning rather than directly with age.

Contrast sensitivity

Contrast sensitivity is measured by the ability of individuals to detect differences in illumination levels usually in lines forming gratings of differing fineness. This has been argued to provide a more sensitive and realistic measure of visual ability. Owsley et al. (1983) reported a significant decline in contrast sensitivity comparing 50 year olds to 20 year olds and the decline increases again by age 80. Kline and Scialfa (1996) provide references to a number of later findings confirming and extending this. Age-related losses are not as great for wide gratings which Kline and Scialfa suggest test real life abilities similar to detecting a truck in fog.

Glare sensitivity and dark adaptation

There is also increased sensitivity to glare with age. Glare results in the older lens scattering significant amounts of light onto areas of the retina that are away from the line of the incoming light, resulting in a “veiling luminance” over the back of the eye decreasing the contrast available for images, reported in Shieber (2003). This means that where strong lighting is used because of its generally beneficial effect on older people’s visual acuity, the lighting needs to be arranged with care so as to minimize glare. Schieber (1994) found that after exposure to 10 seconds glare older subjects took around 2 seconds to detect a low contrast stimulus that they could comfortably detect under normal conditions. Middle aged subjects took about 1.2 seconds to recover while young subjects took around .98 seconds. Schieber's concern is with loss of contact with oncoming vehicles at night but there could be interface implications for older users in both increased sensitivity to environmental glare and difficulty with marked contrasts in screen lighting levels between successive screens.

Glare problems are distinct from the problems older people experience with dark adaptation. The overall reduction of light to the retina and possibly changes in retinal metabolism reported by Fozard et al. (1977) mean that the eye is slower to adapt to dim conditions and the level of dark adaptation achieved decreases, Domey et al. (1960). Older people are slower to recover losses in visual sensitivity after being exposed to glare from sources such as oncoming car headlights.

Color discrimination and detection

There is a decline in color recognition under normal lighting starting at age 20 and becoming marked by age 70. The loss of ability to distinguish colors is particularly concentrated in the shorter blue green wave lengths. Helve and Krause. (1972), Lakowski (1973). Color recognition in dim light is worse for older people and particularly so for short wavelength light partly because of the differential filtering on blue/green hues of the yellowing older lens.

Critical flicker frequency

There is a decline in the frequency at which subjects can detect flickering as opposed to reporting a steady light, known as the Critical Flicker Frequency declines, see McFarland et al. (1958). A related phenomenon also reported by Mcfarland et al. is persistence, the sensation of continued presence of the stimulus after presentation of the stimulus has ceased.

Motion detection and estimation

Older people appear to be less able to detect minimal motion by objects they are observing and may give more cautious estimates of speed of real life objects Kline and Scialfa (1996).

Depth perception

The ability of older people to make accurate estimates of depth declines. According to Bell et al. (1972) there is only a slight decline up to 40 years but after this there is rapid decline in depth perception through to age 70 which corresponds to the oldest subjects in the group studied. Gittings and Fozard (1986) found little evidence of decline with age in the threshold at which people can detect depth differences. However this is not inconsistent with reports such as that of Wright and Wormald (1992) showing an increasing frequency for older people of failing to notice depth differences.

Useful-field-of-view

The effective visual field becomes smaller with age. This means that peripheral stimuli must be stronger and/or closer to the center of the visual field to be detected, Cerella (1985). Ball et al. (1993) found that a composite measure that they term Useful-field-of-view (UFOV) had a strong relationship to driver history of crashes in the previous five years. UFOV measures the percentage reduction in the useful visual field. It depends on at least three measures; duration of target presentation, competing levels of task demand from a peripheral target location task and a central target identification task, and the salience of the peripheral target. The UFOV declines with age. However linear modeling showed that other measures including chronological age, cognitive status and visual sensory function had minimal predictive ability on crash history. Visual acuity shows greater declines with age in the peripheral visual field. Critical flicker frequency also appears to decline more sharply in the peripheral visual field, Casson et al. (1993).

Pattern recognition and identification of differences

The overall processing of visual information and the recognition of patterns appear to be slower with age Kline and Szafran (1975), Fozard et al. (1977). There are declines in several of a person's abilities to make sense of what is seen. The ability to recognize figures that are embedded within other figures is reduced, Capitani (1988). There is a decline in the ability to recognize objects that are fragmented or incomplete, Salthouse and Prill (1988), Frazier and Hoyer (1992).

Older adults are slower to identify whether two objects are the same or are different. While younger subjects were faster on a comparison task if there was a match (the two stimuli were the same), older people were equally slow on match and mismatch decisions and slower overall. Older subjects showed a greater benefit from redundant information. Gottlob (in press). However findings by Ratcliff et al. (2003) and Thapar et al. (2003) indicate that speed differences in identifying differences may be task dependant. Over two sessions older people remained slower than younger people and less accurate in identifying whether two letters were the same or different. However when the task was switched to identifying whether two patches were of the same or different brightness older people became as fast and as accurate as younger subjects by their second session.

Visual Search

Older people do not perform as well on location tasks when trying to locate a target figure in a field of distractors Plude and Hoyer (1986) or on visual search tasks when trying to check if a figure is present amidst distractors, Madden and Plude (1993). Hommel et al. (2004) found that older people had worse performance on visual search tasks involving search for a feature or for a conjunction of features. The performance of the older group was particularly impaired on target-absent trials and with increasing numbers of distractors.

However on filtering tasks where the subject must identify a figure that is always in the same location with or without distractors there is little or no difference due to age, Farkas and Hoyer (1980). This is extended by Carlson et al. (1995) who showed that in visual search of text, consistent target location not only eliminated age-related effects due to neutral distractors (shown as xxxx) but also nearly eliminated effects for meaningful distractors. Without consistent target location there were effects from both the presence of distractors and from the meaningfulness of the distractors. Age differences in visual search are also dependent on how visually distinct the target is from its background, Plude and Doussard-Roosevelt (1989). Older people appear to benefit more than younger people when presented with advance cues indicating the future location of a visual search target, Kline and Scialfa (1996). However older people appear to learn visual searches at the level of the specific targets presented and unlike young people they do not show transfer of learning to new searches where the specific examples have changed but the catagories have not, Fisk et al. (1997). This is consistent with Underwood et al. (2005) who found little evidence of an age-related decline in the search of a simulated traffic scene when detecting traffic hazards. Traffic hazards are presumably well learnt categories of targets.

Effective visual search requires that saccades (eye movements) be accompanied by remapping of the visual environment such that previously visited positions are not revisited (inhibition of return) and items classified as irrelevant get less visual attention (inhibitory tagging). Langley et al. (2005) suggest that age deficits in inhibition are selective, for example when they looked at visual search in older adults they found no deficit in inhibition of return to positions previously visited but inhibitory tagging of objects that had been previously searched was found to be absent in older people but not in the younger subjects.

In consistent mapping the categories of the target and distractor sets do not overlap while in varied mapping the target and the distractor items are randomly chosen from the same category of items over successive trials. Search through a menu of fonts is an example of a varied mapping visual search. Fisk et al. (1990) confirmed other studies reporting that older people perform worse on both types of visual search, corresponding to a higher intercept for older groups on a plot of response time against number of items searched. Fisk et al. then looked at the slope of response time against number of items. In the consistent mapping condition they found that for older people, the time to respond increased moderately with the number of items being searched, for younger people response time did not change with the size of the search item set. The interpretation was that younger people unitize the display, treating it as a single perceptual item whereas older people do not. For varied mapping the slope of response time against number of search items was large and similar for both groups. Fisk et al. further reported that over both types of search, subjects instructed to respond only if a target item was missing took longer than subjects instructed to respond only if a target item was present. Positive search has clearer end points. Anandam (1994) confirmed that younger subjects after visual search training did not show a display size effect (unitization) whereas older subjects did show a display size effect. However when Anandam restricted the area of visual search to the central 2 degrees of the display older subjects also showed evidence of unitization.

Ho et al. (2001) observed older and younger subjects searching for traffic signs embedded in road scenes previously classed as cluttered or uncluttered. Both groups were less efficient at searching the cluttered scenes. Although the older group made more errors and took longer there was no interaction between age and clutter. Ho et al. found that clutter as such did not appear to specifically worsen visual search for the older group. However later studies have found that older people perform more poorly when searching cluttered scenes. Grahame et al. (2004) performed a study in which eye movements, reaction time and errors were used to analyze performance in a search of web pages for links. It was found that older adults showed additional benefits from increased link size, while they were disproportionately affected by increased numbers of non target links and by the degree of clutter on the page. McPhee et al. (2004) looked at older and younger adults searching for traffic signs in digitally altered traffic scenes in which the level of clutter was varied. Searching was carried out under either single-task or dual-task conditions. The older adults were less accurate overall. This age effect was worsened by high-clutter scenes. The older adults were slower to decide that a target sign was not present. In the divided-attention condition, older adults exhibited longer eye fixations as well as showing a reduction in recognition memory for the content of the secondary task.

Vision in everyday living

Kosnik et al. (1988) found in a large survey of adults from 18 to 100 years of age that older participants reported five areas of concern where visual ability affected everyday functioning; Visual processing speed - the speed needed to read a passage or recognize an object. Lighting - trouble seeing at dusk or sorting dim colors. Near vision - trouble reading small print. Dynamic vision - ability to read moving type. Visual search - eg. difficulty locating products on supermarket shelves.

Summary of findings about vision and aging

Size and contrast

- Harder to focus at short distances
- Less ability to detect fine detail such as small print. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer color discrimination and detection especially in short wave lengths (blue-green)

Searching

- Visual search becomes harder
- Useful-field-of-view declines

- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Older people are less able to filter out irrelevant items
- Less ability to tell if similar objects are the same or different
- Visual search is improved by consistent positioning
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space

Speed of perception

- Reading is slower
- Slower to recognize items but this effect is reduced for familiar items
- Ability to detect small movements declines
- Poorer estimates of speed and time of arrival
- It becomes difficult to read moving text
- Ability to detect flicker declines

Lighting and illumination

- More disrupted by glare
- Slower to adapt to changes in illumination

Perception of 3 dimensional information

- Poorer depth perception and estimation
- Poorer perception of 3 dimensional information

2.5.2 Possible effects of age-related changes in vision on interface design

The possible effects of changes to vision are extensive and suitable adaptations will vary for individuals. Note that the finding by Salthouse et al. (1996) on decline in visual acuity with age <u>after</u> allowing for individuals' use of corrective lenses means that we can expect some level of visual problem to be widespread. In addition tri-focals or graduated lenses are expensive, not all older users will be able to afford them or will be able to learn to use them satisfactorily. We can thus expect that some older users will be perpetually squinting at fuzzy screens, which is tiring and may increase the cognitive effort needed to follow text.

The high level of variability of vision in older people as well as in other indicators of performance means that applications should probably give users greater control over the appearance of the application. Klein (2003) notes that in any interface aimed at older users care should be taken to allow for the variability shown by older people, rather than a “one size fits all” approach Klein suggests that older people need to be able to adjust fonts and other visual aspects of displays to suit their individual needs. This however can run into a catch 22 situation for users with very poor sight where the task of customizing the application is also dependent on the persons' visual abilities. There is however a problem in whether older users will have sufficient knowledge to make such adjustments.

Vision and Text – relevant changes

- Harder to focus at short distances
- Less ability to detect fine detail such as small print. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer color discrimination and detection especially in short wave lengths (blue-green)
- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Reading is slower
- It becomes difficult to read moving text

Vision and Text – design suggestions

The obvious starting point is to use large fonts. Schieber (2003) and Fisk et al. (2004) suggest fonts of at least 12 point. Morrell and Echt (1997) suggested that older adults will benefit from san-serif fonts (with a specific recommendation for Helvetica) that are in the 12 - 14 point range and of medium to bold weight.

The choice of font should be one that is simple, easily recognized and does not rely on fine detail. When saying easily recognized I am arguing for a font that gets full benefit from peoples life-time exposure to text and so lies within the reader’s learnt expectations of what letters "should" look like. Older people with imperfect vision should find it easier to recognize highly familiar lettering. This reasoning is consistent with the recommendations of other authors that fancy fonts, italic text and ALL CAPS should be avoided. My preference is to use sans-serif fonts in particular Arial for screen displays. I argue that given the lower resolution of screen displays compared to paper, serifs (the small lines at the bottoms of letters) are not well displayed and become distracting detail. However for printed text there is an argument that serifs help the reader scan along lines of text.

Such text should be displayed so that it contrasts strongly with the background. Remember that Charness (1988) found reading slowed for older adults if the text was colored indicating increased cognitive load. Strictly this should translate into a recommendation for using black text on a white background. It is not clear from the literature how far a designer can go from this standard while maintaining older people's performance. White backgrounds may accentuate glare problems so the possibility of pale off-white shades should be considered. Plain backgrounds are essential, older people struggle to make sense of text on any patterned background.

Focusing is improved when pupil size reduces and this can be achieved by a well lit, but glare free, environment and reasonably bright displays. In addition the focusing problems of older people are for short distances, or, when using corrective lenses, for distances between reading distance and long sight. One set of solutions to these focusing distance problems lies in altering the size and position of the screen. Larger screens can be used and placed further away and high enough to be in the long distance field of bifocals (with an appropriate increase in font size). Alternatively smaller screens such as laptops can be placed closer and lower down so that they are in the range of the short distance field of bi-focals.

Morrell and Echt also recommend short line lengths and left justified text. These recommendations were for printed text but it appears that they hold for on-screen displays. In general older people should not be asked to read large blocks of text on-screen.

As vision declines the obvious strategy of increasing font size for captions and general text runs into two problems; limited screen size prevents unlimited font size increases, while the presumed difficulty of older people in integrating complex information from multiple sources limits the extent to which an application can be split into simpler, large font, sub-screens. In addition narrowing of the visual field with age reduces peripheral vision and may make it more difficult for older people to integrate widely spaced parts of a screen. This could possibly affect the ability of older users to benefit from status bar information. This may also affect older people’s use of multiple or very large screens as these become more common. An additional effect may hold with large fonts for screen displays of text where the reduced amount of text entering peripheral vision is likely to interfere with an individual's pre-processing of text and will therefore interfere with the flow of comprehension in reading. This effect can be observed when normally sighted adults attempt to use large print books for the poorly sighted.

Problems with recognition of embedded and overlapping figures may translate into a need to provide slightly greater separation between lines of text and to make greater use of white space in the areas surrounding text such as framing and margins.

Text in itself provides a complex background and it may be useful to ask if older users are likely to have target acquisition problems when locating the typical carats currently used in word processing applications. This could be made more difficult if the blink rate for a carat gets close to the lowered critical flicker frequency for older adults. If so, how should the insertion point carat be customized? A slow blinking red carat for example?

Older users should not be asked to work with displays that show moving text. Because of issues with focusing and slowness of adapting to working at differing focal lengths older people will find difficulty in working with a combination of on-screen and printed materials.

Vision and glare, brightness adaptation and environment – relevant changes

- More disrupted by glare
- Slower to adapt to changes in illumination

Vision and glare, brightness adaptation and environment – design suggestions

Screens should not produce rapid sequences of bright followed by dim displays since accommodation to brightness is slower as people age. Fisk et al. (2004) suggest older users will be better served by LCD screens because of the increased display brightness and hence contrast that they offer over CRT screens.

Reduction in the ability of one's eyes to accommodate quickly to changes in focal distance can be expected to make it harder for older users to work from a mix of paper and screen documents. This may already be reflected in the development of tri-focal and multi-focal glasses. Designers of work environments might usefully consider allowing greater choice in distance from the screen to allow for poorer near sight adaptation and the provision of diffuse back lighting which increases visual acuity by reducing pupil size. Klein (2003) suggests that the majority of older people will have difficulty in focusing on objects at an intermediate distance (60 – 100cm) such as automobile dashboards or computer monitors. Klein suggests that particular care should be given to the visual design of such objects.

Older people may have more difficulty with viewing LCD screens at an angle since the visual display quality declines, however Charness (1998) points out that this is less true now that active matrix screens have become more common. As sharing screens is relevant to sharing of information and training it is worth asking if this might also apply to CRT displays where, as the viewing angle changes, standard cues such as letter proportions and spacing are distorted. It is possible that older people are, on average, less comfortable with prolonged use of VDU displays and should incorporate more breaks from screen use in their work schedules.

Vision and graphics – relevant changes

- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Poorer color discrimination and detection especially in short wave lengths (blue-green)
- Useful-field-of-view declines
- Less ability to tell if similar objects are the same or different
- Harder to focus at short distances

- Less ability to detect fine detail. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer depth perception and estimation
- Poorer perception of 3 dimensional information
- Slower to recognize items but this effect is reduced for familiar items
- Ability to detect small movements declines

Vision and graphics – design suggestions

The basic response to the changes above is to design graphics for older people that are simple, do not involve subtle shading or detail and are reasonably compact so that all the important elements can be encompassed in the older adult's reduced useful-field-of-view. Older adults should not be asked to make sense of details using blue-green shadings and should not be asked to detect small differences. The reported problems with depth perception in older people may affect the suitability of 3D graphical information. Kline and Scialfa (1996) recommend that 3D displays provide additional cues such as grid lines that reduce the dependence on pure depth perception but a simpler approach is to ask if 3D graphics are needed or simply regarded by the designer as decorative.

When it comes to animated graphics for older people the changes above imply that older people will be better able to make sense of animated material if the animation is relatively slow and the elements involved are familiar. Again making sense of an animation should not depend on distinguishing small differences or details or movements.

Older users are going to be less able to detect color and contrast differences that are taken for granted by younger users (and designers) as suitable cues for indicating important differences. Becker and Nowak (2003) describe various tools for adapting web site design to suit older users and one of the tools described - The Aging Vision Simulator tool available at http://cob.fit.edu/facultysites/abecker/Accessibility/OlderVision/ColorandAging/OlderVision.html) allows a designer to simulate the effects of the older person's less vivid rendering of color.

Another way that designers can simulate some of the effects of older users' visual problems is to simulate loss of fine detail. Graphics can be subjected to the Gaussian blur test used by Schieber (1998) to examine the legibility of road signs. Those graphics that remain distinguishable when tested under severe blurring are presumably going to remain distinctive and therefore learnable when used by older users with poor sight.

Vision and screen layout – relevant changes

- Useful-field-of-view declines
- Visual search becomes harder
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space
- Visual search is improved by consistent positioning and advance cues
- Older people are less able to filter out irrelevant items
- Ability to detect small movements declines

Vision and screen layout – design suggestions

In general the aim should be for simplicity of layout, Aula and Käki (2005) showed that a simpler visual layout improved older people's performance in a redesign of the Google display of search results. The changes they made emphasized using fewer elements, better grouping of elements and the removal of irrelevant items. Older users may be expected to be more dependent on consistency and simplicity of layout for locating target areas of a form and less able to cope with complex and overlapping or embedded designs. In particular young users appear to appreciate visually complex, if irrelevant, backgrounds while older users are distracted by them.

Since older people in Western cultures still follow the top-down and left right pattern of eye movement typical of Western reading this should decide the basic flow of attention that a screen layout is designed for. The decline in the useful-field-of-view implies that items that follow each other in terms of task flow should be kept closer together than one might need to do for younger users. If a related item is too far away from an older user's current focus it simply may not be seen, or alternatively the search to find it may be disruptive of the older user's overall task focus.

Older users' lack of awareness of visual items that younger users will notice and use, applies particularly to designs that require older users to scroll. Older people are less likely to scroll and more likely to have problems with scrolling. Designing screens and web pages to eliminate scrolling is an ideal but if this is not done then older people appear to have more problems with horizontal scrolling than with vertical scrolling.

The vulnerability of older people to clutter means that screens designed for older people should be drastically simper than screens for younger users. This together with the need to use larger fonts is one of several reasons why effective design for older users will restrict the number of options that can be made available and the amount of material that can be presented on a single screen. Older people's problems with filtering out irrelevant items may be particularly acute when animation or flashing or moving text is present. Animation should be presented so it does not compete with other activities and flashing and moving text should not be used.

The fact that search for items is faster when older people are provided with advance cues may translate into support for the standard practice of a layout that has clear conceptual groupings for task elements. The use made of consistent positioning by older users in achieving faster search results supports consistent positioning of similar elements over all the screens in an application. This is likely to be aided by consistent task flow through the various screens.

Screen changes which indicate completion of a task will need to be both obvious enough to attract notice but not such as to affect the consistency of the older person's model of what is being presented. The reduced ability of older people to detect minimal movement implies that small changes should not be indicated purely by analog indicators such as gauges or sliders. The need for more time to absorb information and slower processing in general may impact on any designs where the time of display is under program rather than user control, the old are unlikely candidates for space invader games or rapidly flashed information.

One of the implicit recommendations in the preceding material is to greatly reduce the need for older users to search for items on any screen. However some searching is always going to be required so it should be made as easy as possible.

Vision and searching – relevant changes

- Visual search becomes harder
- Useful-field-of-view declines
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space
- Visual search is improved by consistent positioning

Vision and searching – design suggestions

The first option is to eliminate visual searches or substitute simpler searches for more complex one's. Where search is required it should take place in limited area or if it is over a large area there should be organizing principles that effectively make the search area a set of several small areas. Search fields should be static and consistent. There should be as few items as possible within a search field and there should not be any irrelevant graphics. Where graphic items are used as search items they should be clearly distinguishable. It seems likely that searching a line of search items is going to be easier than searching a two dimensional array of search items. Searches should preferably be designed so that they have obvious end points, If I am searching for C then A B C D E and A B D E both assist with the search but S W A G B does not. Older users should not be asked to perform searches under limited time conditions.

The findings on visual search support current design practices for simple consistent screen layouts with clearly defined features. They may also offer support for full screen designs rather than designs involving overlapping or tiled forms. However in some situations, such as searching for information on the Web, the user is faced with a wide variety of layouts, this may reduce efficiency for older users. Note a review by Kelley and Charness (1995) which finds that, in several studies, older people's success in learning a new application is correlated with their scores on spatial ability, again this seems an argument for keeping the layouts to be learnt, very simple.

The findings on visual search indicate that while younger users learn to treat the search list as a unit thus reducing cognitive load this “unitization” does not happen for older users and so we can expect visual searches to remain sources of cognitive effort for older users Fisk et al.’s 1997 finding that older people learn visual searches at a specific word level rather than a semantic category level appears to indicate that older people will be more disrupted by version changes which make minor, semantically consistent changes to such things as menu contents. Menus with typically small type and large numbers of competing choices and large collections of icons with the need to search over a wider area than the effective visual field of older people both seem likely to challenge the ability of older people to perform effective visual searches. As noted later menus also lead to motor control issues.

The findings cited by Kline and Scialfa on the involvement of higher cognitive processes in visual processing and its decline with age could indicate that older people may be more sensitive to cognitive load due to poorly designed visual displays. Hence a poor visual design could lead to greater reductions for older users in their ability to cope with the underlying task. This is interesting but remains to be researched. However note that Chadwick-Dias et al. (2003) did not find that text size affected older people’s performance on a simulated web site, while Fukuda and Bubb (2003) found that older people showed significant slowing as measured by eye fixations when font or search target shrank below a size corresponding to fonts below 10 point, (these are below the sizes tested by Chadwick-Dias et al.)

2.6 Speech, Hearing and Aging

2.6.1 Studies of Speech, Hearing and Aging

Speech

Speech becomes less distinct with age, possibly due to reduced motor control of tongue and lips, possibly due to impaired ability to hear and correct one’self or to compare one’self to others. In addition a proportion of the elderly have speech impairment due to strokes. Speech slows with age both from the insertion of more and longer pauses into spoken material and due to word lengthening, Balota and Duchek (1988). The ability to produce words which correspond precisely to experimenter defined constraints declines and the time taken to produce words to precise requirements increases with age, Mackay and Abrams (1996). Older adults speak less fluently with more evidence of language planning deficits such as false starts, hesitations and filled pauses such as um and er or word repetitions, Kemper(1992). They are also more subject to tip of the tongue episodes where a familiar, but infrequently used, word eludes the speaker, Burke et al. (1991), Burke and Shafto (2003).

Hearing

Overall hearing declines with age, about 20% of those between 45 to 54 have some hearing impairment, this rises to 75% for those between 75 and 79 years of age, Fozard (1990). Rybash et al. (1995) quote estimates that 15% of the US population over 65 is legally deaf. About 9% of middle aged adults and 11% of adults between 65 and 74 suffer from tinnitus or ringing in the ears, Rockstein and Sussman (1979). Hearing loss due to aging appears to be from both physical changes to the inner ear such as the loss of hair cells within the inner ear but there is also evidence for neurological changes, this distinction is important in that physical changes in the ear could be compensated for by interventions that improve the available signal, while neurological effects suggest interventions based on training, Shieber (2003). Given that prolonged exposure to noise at 75 decibels (vacuum cleaner) can cause damage to the hair cells within the ear and consequent hearing loss and that workplace regulations have at least until recently allowed levels up to 90 decibels (lawn mower), a significant proportion of hearing loss in Western societies must be considered as due to environmental noise damage rather than due to normal aging. Recent concerns about localized noise levels in headphone's for young music listeners suggests that hearing problems are likely to persist in society even with reform of industrial legislation.

There is usually a loss in the ability to detect tone's over all frequencies but particularly for high pitched sounds. The selective loss of high pitched tone's is termed presbycusis. This is detectable in laboratory tests from age 25 but significant loss is fairly common by age 50 particularly in men, Rockstein and Sussman (1979), Schieber (1992). It has also been reported that older people are less able to discriminate between similar sounds that differ in intensity and /or frequency, He et al. (1998). Older people are also poorer at judging time intervals of sounds and this is worse if the sounds are part of a more complex aural sequence.

Since some consonants in English are high pitched (such as f, s, t, z,), selective loss of high frequencies (presbycusis) means that parts of speech are not heard and the impaired listener needs to guess at meanings. Older individuals may find female voices harder to follow than male voices because of the overall higher pitch. Feldman and Reger (1967) reported that by age 80 people may miss 25% of the words in a conversation.

Older adults also show reduced ability to localize sound and this is more pronounced in individuals with presbycusis or poor speech discrimination, Kline and Scialfa (1996), Shieber (2003). There are problems for older people when dealing with background noise as evidenced by the typical complaint about being unable to follow conversations in noisy groups of people. This may be partly due to physical changes which reduce the ability to attribute direction to sound, see Corso (1977) but is also consistent with many reports of difficulties with selective attention in older subjects. Tun et al. (2002) found that older adults were more impaired than young adults in extracting information from speech given the presence of competing spoken material in the background. Since the younger subjects were more able to recognize words from the distracting stream of speech this implies that the older adults' difficulties can be interpreted in terms of reduced ability to direct attention and inhibit attention to competing material.

Corso also reports that sentences which are meaningful under test conditions are lost when words within the sentences overlap or are interrupted and that, for older people, the ability to obtain meaning from spoken information declines under conditions of stress. Kline and Scialfa (1996) report that older people make more use of contextual clues to identify speech than do younger groups.

Another contributing factor is thought to be the general slowing of processing experienced with age. Calearo and Lazzaroni (1957) found that young adults could understand virtually all of conversation speeded up to 350 words per minute especially if the speeded conversation was somewhat louder. In contrast older people managed to pick up only 45% of the content of such speeded conversation no matter how loudly it was spoken. (Normal speech runs at about 150 words per minute.) Looking at mild speech compression, DeGroot and Schwab (1993) found that older users on an audio menu and instruction system took more time, made more errors on the subsequent tasks that the system had given them instructions for and were less satisfied. Gordon-Salant and Fitzgibbons (2001) confirm that time compressed speech is generally difficult for older listeners. By examining different forms of time compression Gordon-Salant and Fitzgibbons found evidence that the problems of older listeners in recognizing time-compressed speech are associated with difficulty in processing the brief, limited acoustic cues for consonants that are inherent in rapid speech.

Older adults appear to react more slowly to pure tone's, even when their ability to detect the tone is similar to that of younger adults. Rees and Botinwinick (1971) suggest that this is due to a general caution on the part of older adults which affects reporting of signal detection, as one gets older one is more likely to report a maybe as a no rather than as a yes.

Summary of findings about aging and speech and hearing

Changes in speech for older people

- Less distinct pronunciation with age
- More pauses and fillers such as “um”, “err”
- Harder to produce the exact word for precise requirements
- More tip of the tongue episodes where a familiar word cannot be found

Changes in hearing for older people

- High pitched sounds harder to hear
- Some words are lost when listening to speech
- High pitched voices can be harder to understand
- Harder to work out the location of a sound
- Harder to make sense of speech when there is background noise or competing speech
- Less able to deal with fast speech
- May depend on extra information from lip movements to make sense of speech

- Slower to respond to sound cues

2.6.2 Possible Effects of Age-related Changes in Speech and Hearing on Interface Design

Speech

At first glance speech offers an attractive alternative to forms of input that some older people have problems with such as typing and mouse input.

Speech and using spoken input – relevant changes

- Less distinct pronunciation with age
- More pauses and fillers such as “um”, “err”
- Harder to produce the exact word for precise requirements
- More tip of the tongue episodes where a familiar word cannot be found

Speech and using spoken input – design suggestions

Many older people face major problems with learning to type so the use of voice recognition as an alternative form of input is appealing. However it is not certain that speech recognition software will be easier for older people, see Kalasky (1999) . In part speech recognition relies on the user observing errors and correcting them which will bring into play difficulties older people face in visual search, sustained attention and motor control. Speech recognition software may also need to cope with slower speech from older users, more hesitations, interruptions and filled pauses as well as more audible breathing. There is the problem with reduced articulation among some elderly as well as the disrupted speech of stroke victims. Czaja and co-workers are currently starting work on this problem. It can be expected that some older people will have less control over their speech production, see Morris and Brown (1994), Ryan and Burk (1974), and so may be less able to adapt to the sensitivities of speech recognition software. It seems reasonable that elderly people are more subject to respiratory infection and so have more periods during which their voice is significantly different from the voice the interface is adapted to. It may also be that extended periods of more precise speech are difficult for some elderly people. Finally the willingness of older people to take the time needed for training speech recognition systems is not known, nor is it known whether training times will be longer for older people.

Speech as a control mode for interfaces may meet problems when used by the elderly. In the light of the material on difficulty in speech planning, word retrieval and conforming to a precise vocabulary, use of a verbal command language is likely to be more difficult. On the other hand, Vercruyssen (1996) notes that where single word responses are used to replace manual responses, the age difference in response time found with manual responses disappears.

If elderly people use computers in the same environment as users who use a speech interface there may be problems for the older users because of their lower capacity to filter out distracting noise so that the problem of shared work spaces with a speech interface becomes more acute when older users are involved.

Hearing

Hearing is less relevant to current interfaces but problems with hearing among the older population may affect attempts to design speech based interfaces that compensate for problems with sight or with lack of keyboard skills.

Hearing and detecting sound alerts – relevant changes

- High pitched sounds harder to hear
- Harder to work out the location of a sound
- Slower to respond to sound cues

Hearing and detecting sound alerts – design suggestions

Older adults miss attention getting sounds with peaks over 2500Hz. Commercially available telephone bells and smoke alarms tend to have intensity peaks around 4000Hz which is effective for younger users but these sounds are missed by older users, Berkowitz and Casali (1990), Huey et al. (1994). To design ringers and alarms which are suitable for older users these authors found that the sounds need an intensity peak in the 500-1000Hz range. This means that computer interfaces that use sound to get the users attention will need to use lower frequency sounds for older users. Huey et al. found that a beep that swept a range of frequencies including the 500-1000 range was reasonably effective. This could be transferred into applications that use sound cues to alert users to events so that the sweeping of a frequency range could be used to replace standard sounds. It would be useful to know how well sounds provided by current operating systems fit within these recommendations

If at some later stage binaural sound is used to indicate to users where sound is coming from on a display designers should be prepared for this to be less effective for older people. Although reports presented in Shieber (2003) suggest that older people's problems with localizing sound are worse for low pitched sounds there are problems with using high pitched sounds to aid in localization given the reduced ability to hear high pitched sounds particularly for older men. Older people may be less able to use binaural sound to locate where information is coming from if sound from computer speakers is used to indicate position or it is important to distinguish which of several people are speaking in a video clip. Kline and Sciafla (1997) suggest that performance on localization tasks can be improved by increasing the duration of the sounds involved. It might be useful here to combine sound information with redundant visual information confirming the area to which attention should be directed.

Hearing and understanding spoken output – relevant changes

- High pitched sounds harder to hear
- Some words are lost when listening to speech
- High pitched voices can be harder to understand
- Harder to make sense of speech when there is background noise or competing speech
- Less able to deal with fast speech
- May depend on extra information from lip movements to make sense of speech

Hearing and understanding spoken output – design suggestions

Recorded voice should make use of speakers with low pitched voices. Computer generated speech as output for older people needs to accommodate the likelihood of hearing loss affecting the ability to hear high pitched tone's and the ability to distinguish speech from background noises. Designs which allow for the use of headphone's may be useful.

Smither (1992, 1993) found poorer performance for older adults with remembering and understanding computer generated speech and attributed this to short term memory demands. He found older subjects showed poorer memory for numbers given via synthesized speech and that this effect did not diminish over 78 trials. It has also been claimed that part of the understanding of speech shown by elderly people may in fact be due to unconscious lip reading and hence designers could find that speech from a mechanical source was less intelligible for that reason. Czaja (1996) suggests that the meaning of verbal content may be better communicated to older people if the visual cues used in communication are also made available.

In general a note of caution may be needed in considering the utility of audible material for improving older people's performance. Shieber (2003) notes that while older people "can successfully employ higher order cognitive mechanisms to compensate for age related loss in sensory (hearing) function…what remains to be established is the attentional cost of such compensatory processes". Given that spoken input gives the recipient little control over the flow of new information and given older people's problems with short term memory it seems likely that unless spoken information is carefully designed, useful information in earlier parts of a message risks being "overwritten" by later parts of the message. Zajicek and Morrissey (2001), note that the performance of older people in using spoken information is improved by making certain that messages have a short and simple structure.

Archer, et al. (1996) found for young users that adding voice to text did not improve comprehension but slowed performance while adding text to voice did lead to improvement. However this applied to blocks of text for young adults with adequate eyesight. Older people might benefit more from the availability of a speech option. On the other hand the slowness of speech compared to reading and the lack of user control over the delivery may lead to problems in remembering content since older people are more likely to suffer from interference effects where a stream of facts makes it hard to remember earlier information. There is also the characteristic of spoken information that it does not remain physically present so that going back to refresh one's understanding of some point depends on working memory rather than eye movement.

One can speculate on interfaces where the current fly-over help could be optionally replaced by voice to give brief names or explanations of buttons and other features. Are older partially sighted users able to use spatial / iconic clues to organize and retain the memory of what a button is for provided a verbal explanation is available if needed? It is possible that interfaces of this sort could extend the number of years during which users were able to make use of applications.

2.7 Motor control and Aging

2.7.1 Studies of Motor control and Aging

Ketcham and Stelmach (2004) and Vercruyssen (1996) provide wide- ranging reviews of this area. Vercruyssen states that 70% of Americans over 65 have some degree of restriction of activities due to problems with general mobility ranging from mild arthritis to stroke damage. Reginster (2002) has found around 80% of adult Americans over 65 have some arthritic restriction of movement. With age comes slowing of response times on motor tasks as well as loss of muscle strength and endurance. Control of fine movement declines for older people. Older people show lower peak speeds within a movement, they have reduced ability to control the amount of force applied and the structure of sub-movements within an overall movement changes from that of younger people. Vercruyssen (1996) notes that a number of explanations have been advanced for loss of motor skill and for problems with control of fine movement with age, among them being loss of controlling muscle and neuron groups, reduced ability to inhibit interference from neural noise and a cautious approach to speed-accuracy trade-offs that develops with age, however Vercruyssen does not regard any one explanation as sufficient by itself.

Slowing of movement response

There is general agreement that slowing of response times is common over a range of activities among older people and that this is due to a common factor, presumably reflecting cortical function, see Salthouse (1996). Such overall slowing certainly applies to movement response times for older people with the slowing being more pronounced if the action is more complex and the number of possible choices increases, Goggin and Stelmach (1990), Light and Spirduso (1990), Fozard et al. (1994), Melis et al. (2002).

This slowing can be seen as a result of slowing in two aspects of movement with older people taking longer to pre-plan the movement and then taking longer to carry it out.

Training can provide some improvement in response times. There is little evidence for age-related decline on simple discrete actions which can be planned in advance, Welford(1977), or on real-life, well practiced non-laboratory tasks, Salthouse (1984). Bosman (1996) confirmed Salthouse's 1984 finding that older skilled typists maintained their speed by scanning further ahead than younger typists. However Bosman also found that response time contributed to the speed of older skilled typists. Bosman showed that skill may at times overcome age effects on finger speed but that this was dependant on the context within which finger speed was being measured. Skilled older typists appeared to have faster reaction times than unskilled older typists only on typical typing movements, not on non-standard finger + keyboard movements. Compared with skilled younger typists, skilled older typists appear to be slower in activating plans to translate input into keystokes but to be as fast in executing those keystrokes once the plan is activated. Low skilled older typists appear to be slower than similar younger typists in both planning and executing keystrokes. There is likely to be slowing as a task becomes more complex, Spirduso (1995), or as demands for repetitive speed increase. Dixon et al. (1993) report decline in finger-tapping speed but this is modified by the extent of recent practice, see Krampe and Ericsson (1996). The degree of choice required also affects response time and highly predictable responses may show little age differential.

Changes in movement structure

Older people are generally slower and more cautious when executing movements. They are widely found to be slower in point to point tasks Ketcham et al. (2002). Slowing is also found on a range of other movement tasks as reported by Ketcham and Stelmach (2004), with the extent of slowing increasing with task complexity. With respect to Fitt's law Ketcham et al. (2002) found that slowness of movement was more affected by distance traveled to the target and less so by alterations in the size of the target. For other work on aging and Fitt's law see Brogmas (1991).

A movement can be broken down into sub-components and it is now possible to track such sub-components. Typically one sees an initial first phase consisting of acceleration and then deceleration which takes the subject close to the target. This is followed by secondary correcting movements until the target is acquired. When older people's results from such studies are compared with results for younger people the major differences that stand out are that; 1) younger people produce higher peak speeds, 2) that younger people cover more of the distance between starting point and target in the first movement phase and 3) the acceleration and deceleration within the first movement phase are symmetrical for younger people while for older people acceleration is of relatively short duration followed by a longer deceleration phase, see Figure 2.1

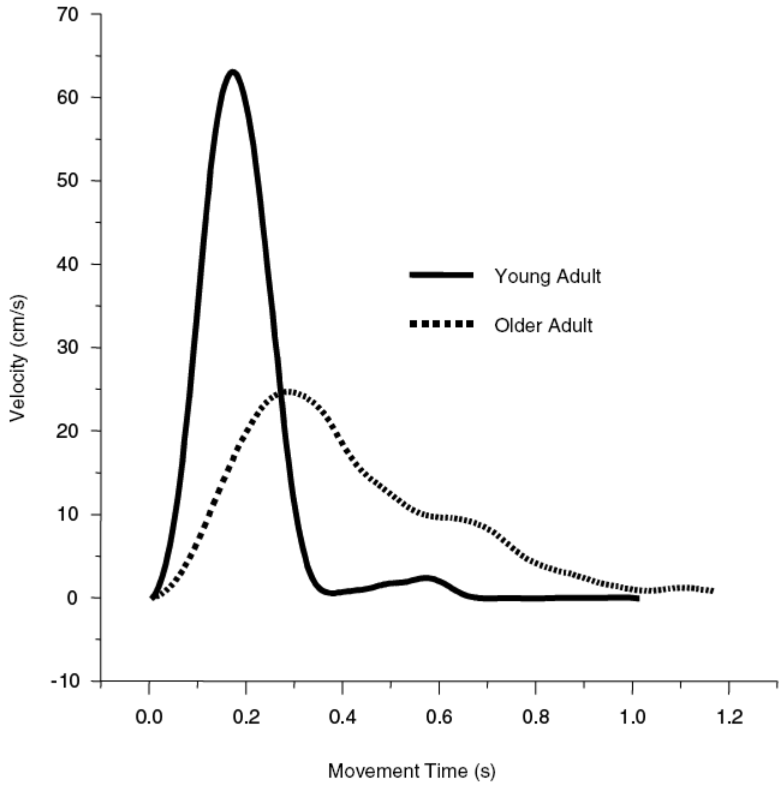

Figure 2.1 Example velocity profiles for an older and a young adult on a point-
to-point aiming task. adapted from Ketcham et al. (2002, p. 56).

From the point of view of an interface designer it is of interest to consider how these differences might change if the older adult is performing a well practiced task. The results from training studies using blocks of repeated trials showed that while older adults did improve overall times this improvement came from the secondary phase of the movement. Training did not help older adults increase the closeness to target achieved in the primary phase of the movement.

Changes in movement control

Walker et al. (1997) confirmed earlier studies showing that older people made more sub movements and were slower in capturing a target with a mouse. Both old and young made more sub-movements as distance increased and as width decreased but there was also a significant interaction between age and distance with the number of sub-movements increasing more strongly with distance for the older group. Vercruyssen's 1996 review also reports that older people may have difficulty in receiving new information during the execution of movements. It seems possible that this corresponds to a greater need for more involvement of higher cortical functions in responding to feedback from movement and planning and controlling subsequent movement.

In general, Ketcham and Stelmach (2004) report that older adults show less accuracy and fine control in executing movements. In point to point movement as discussed above the secondary phase of movement is likely to consist of a number of sub-movements as the older person makes several corrections to direction as they near the target. Not only is the primary movement likely to end further from the target for older people but in addition the trajectory of the primary movement, its peak speed, duration, acceleration to deceleration ratio and the location of the end point is likely to be more variable over repeated trials, Cooke et al. (1989). This has the result that the secondary sub-movements start from different places and so need more attention to result in ending at the target. This is compounded by older people’s slower perceptual speed so that the process of obtaining feedback as the secondary movement proceeds is itself slower. In other words given reduced perceptual speed it is possible for older people to outrun their ability to provide feedback on the progress of a movement.

Ketcham and Stelmach (2004) cite a number of studies that show that older adults have a bias for accuracy over speed. In the study by Walker et al. (1997) subjects were tested under a variety of rules that imposed either a penalty for error or no penalty for error. Older people were more cautious / error aversive in their movement strategies, younger people changed their movement strategy according to the penalty for error while the older group adopted a consistent error avoidance strategy independent of the penalty level. In trials where there was no penalty for error and subjects were asked to make a single movement towards a target as fast as possible younger people were able to move and accelerate the mouse faster than the older group. The inaccuracy (distance from target) of these fast movements climbed more sharply with peak acceleration for the older group which Walker et al. see as consistent with the theory that older people experience more noise in the signals they use for muscle control. Older people in the no-penalty-maximum-speed condition were in fact able to exceed the speeds used by young people in the penalty-for-error-speed-chosen-by-subject condition. However when there was a penalty for error the older group chose to use slower mouse movements. Walker et al. see older subjects producing a movement strategy that compensates to an extent for both their reduced ability to produce acceleration force without noise and their slower perceptual speed. This strategy is seen as successful in that the overall increase in response time is less than would be expected from a linear combination of the observed effects for maximum force, perceptual speed and increased sub-movement. Ketcham and Stelmach (2004) suggest that there is a common sense explanation for such findings. If an older adult has learnt by experience that the results of trying to close directly with a target are unpredictable, so that in reaching for a glass one may in fact knock it over in some attempts, a more workable strategy is to deliberately undershoot and then apply caution in the final approach. Part of what we may be seeing is older people's implementation of a compensatory strategy for having less control over movement.

Other changes in movement

Force production - Older adults are reported as having less ability to control and modulate the forces they apply, Siedler and Stelmach (1996). Older people have poorer control over force production with reduced maximum available force, more variability in the amount of force produced in repeated trials and are also slower to exert peak force. As control over force production contributes to arm and other body movement this carries part of the explanation for the overall reduction in precise and controlled movement described in the preceding section.

Coordination - Older people show reduced ability to coordinate multiple parts of movements such as the arm extension and finger opening and closing that make up a reach and grasp task, see Wishart et al. (2000) and Ketcham et al. (2001). If older adults attempt to increase the speed of tasks such as drawing, handwriting or tracking, performance starts breaking down at lowers speeds than is the case for younger people. Older adults show poorer performance when asked to track a target, Jagacinski et al. (1995). Charness and Bosman (1990) report that older adults have some problems with cursor positioning if the target is the size of letters or spaces in text and they note that this is in accord with a study by Welford (1977) which recommended adding an age correction factor to Fitts' law governing target acquisition. As the number of joint sections increases the difficulty older people find with smooth coordination increases. There is also difficulty in coordinating activities between both hands, particularly as the complexity of the activity increases, Wishart et al. (2000). Light and Spirduso (1990) looking at young, middle aged and older groups found that as well as general slowing of movement response time with age there was also an interaction with the complexity of the response with age. Single digit movement was faster than two-digit movement which in turn was faster than similar movement involving digits on both hands. Sensitivity to movement complexity increased with age. I have not found reports of unintended finger movements during arm movement being more common in older people. However I observe this in myself and in some of the older people I have worked with. This problem could be seen as either difficulty in inhibiting actions or as part of difficulty in coordination arm and finger movements. The consequences are unintended mouse actions; drags may be interrupted by unintended pressure on the right mouse button, clicks may be made while the mouse is being moved and drops may occur at unintended places.

Proprioception is the term for a person’s awareness of body position in relation to their surroundings. Ketcham and Stelmach (2004) have reported studies indicating that older people are less accurate in reporting body position in relation to surroundings and in relation to other parts of the body. This appears to be due to reductions in the effectiveness of sensors in the joints and limbs. Vercruyssen (1996) reports that older adults require more time to verify the accuracy of their movements and slow more following an error than do young subjects. In the study by Walker et al. (1997), both older and younger people took more time to verify that they had captured the target as target size decreased but this effect was stronger for the older group. Older people are less able to maintain balance and are more dependant for visual input in order to maintain balance, Woollacott (1993). Ketcham and Stelmach (2004) note P79 that “during quiet stance, disturbances in incoming information greatly affect postural stability in older adults whereas young adults can quickly and effectively recover from such disturbances”.

Touch sensitivity is an area where there is conflicting evidence but it appears that there is a degree of loss of sensitivity to light pressure on the palms evident in the sixties (Kenshalo 1977) and there is a loss of sensitivity to vibration in feet and hands but this is much more evident in the feet and seems to involve only response to high frequency vibrations, Skre (1972), Verillo (1980). Stuart et al. (2003) found that vibration sensitivity was preserved at the fingertips. Specifically they tested the palmar surface of the end of the middle finger and found that this site showed no significant decline in sensitivity to sine wave vibrations even for a group aged 70 – 90. However arm, shoulder and face sites did show sensitivity declines.

Summary of findings about aging and motor control

- Response times are slower
- Movement is slower
- There is less control of speed, direction and force
- There are more small movements in a larger movement
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets
- Older people are slower to recognize that they have captured a target
- Skilled movement such as typing by experts can be maintained but appears to require more plan ahead strategies
- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk
- Coordinated movement is harder
- There are more involuntary movements
- Less accuracy in knowing one’s own body position
- Poorer balance and more need for visual input to maintain balance
- Possibly less touch sensitivity

2.7.2 Possible Effects of Age-related Changes in Movement Control on Interface Design

Motor performance appears to decline with age and it seems relevant to ask what should be done to revise the interface standards for such things as minimum acceptable button size and timing or elimination of double clicks.

Movement Control and target size – relevant changes

- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets
- There are more involuntary movements
- Less accuracy in knowing one's own body position

Movement Control and target size – design suggestions

Users should be provided with larger targets. This covers a wide range of features including the following. Larger buttons allow older users to click buttons while diverting less attention to controlling the movement. Targets should be clearly separated so that the consequences of overshooting and clicking off target are reduced. Larger fonts in drop down menus will mean that each line becomes a more easily captured target. Older people are likely to experience small target problems at the level of inserting, selecting and correcting text in textboxes at typical fonts used for younger people. Aula and Käki (2005) showed that part of the improvement of older people's performance resulting from a redesign of the Google display of search results came from increasing the size of the text used in the textbox in which the search terms are entered.

Movement Control and mouse skills – relevant changes

- There are more involuntary movements
- Less accuracy in knowing one's own body position
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets

Movement Control and mouse skills – design suggestions

Many older users show sub-optimal mouse skills. Designers should not require older users to double click or to perform drag operations. As always this is not to imply that no older users can perform these operations but that the percentage of older users able to use an interface will increase if these recommendations are followed. The presence of involuntary finger movements in some older people means that clicks and drops may occur without the older person intending such action or at times being aware of doing so. One area in which this becomes apparent is in older users faced with multiple overlapping windows where clicks outside the window boundary can lead to the older user being perplexed as to why a window has vanished and unsure as to how to recover from this. Applications that use full screen designs avoid difficulties of this nature.

Because of problems with inhibition of motor noise older people may have more problems with basic mouse action such as holding the mouse still while clicking or controlling dragging on scrollbars. Fine control of movement is difficult for older users and should be avoided. Pointing devices such as button mice and touch pads which depend on fine control of movement may be difficult for older users to manage. Problems with tracking and with responding to new information presented during movements may cause problems for older people scrolling or using drawing tools in addition to problems related to drag and drop actions.

Movement Control and other aspects of design – relevant changes

- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk
- Coordinated movement is harder
- Response times are slower
- Movement is slower
- There is less control of speed, direction and force
- There are more small movements in a larger movement
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- Older people are slower to recognize that they have captured a target
- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk

- Coordinated movement is harder

Movement Control and other aspects of design – design suggestions

Menus and scrollbars

Menus are an area in which the mouse skills required can be difficult for older users to manage. Here the problems arise from the need for precision in capturing one of several closely positioned targets and, where sub-menus are involved, from the need to follow precise paths or to move quickly in order to move from the main menu item to the sub-menu, Rogers and Fisk (2000) suggest that menus are not suitable in designs for older people. Another problem related to older users' movement control arises with scrollbars which Morrell et al. (2003) notes are a frequent source of disadvantage for older users. The problems here are partly lack of knowledge by older users of the conceptual model of scrollbars but there are also problems in coordinating mouse movement with visual information from the text being scrolled as well as problems with unintended drops of the slider and clicks on the scrollbar.

Timing of motor tasks

It is worth considering the timing of complex physical tasks, do they occur in the midst of other cognitive activity such as composing a letter or do they occur after creative effort has paused? For example scrolling or control-S to save during work have more potential to disrupt cognition in older users, compared with clicking a minute exit button after work has ended despite the greater difficulty of capturing the small target.

Layout

It appears that layout should accommodate the finding of slower, more deliberate movement by older people but it is a matter for research as to how this can best be achieved. In general layout should limit the amount of movement required as well the amount of fine control needed. Thus buttons should be large enough and sufficiently separated that older users do not click unintended buttons. Problems with target size may arise in designs that use controls where the target area is particularly small such as radio and option buttons.

Where very large screens are used or multiple screens joined to make a large virtual screen this will either require more mouse movement to get to distant targets or higher gearing between mouse movement and screen movement, either may affect older users.

Providing redundant information

Given that older people are slower to acknowledge target capture, will they be assisted by redundant information such as a flat button becoming three dimensional when captured or by sound cues? Gottlob (in press) showed adults benefiting from simple redundancy, Jagacinski et al. (1992) showed that while older adults were not as good at a tracking task as younger adults both groups improved to the same extent when an audible tone was provided that gave (redundant) information about position or speed. Jagacinski et al.'s work is probably not support for general use of redundant cues as the effectiveness of the auditory information varied quite specifically with gender and the type of information carried. Female subjects benefited more from velocity information and male subjects benefited more from position information. Again when observing older people in the SeniorMail study there were specific problems with such things as flat buttons since the older people relied on the traditional appearance of a Windows button to assist their search. There may also be a resource competition effect when the redundant information is using the visual channel (showing a change in button appearance) while that channel is also engaged in mouse control. Finally there may be a problem in making use of redundant information about target capture as older people are slower to respond to new input while performing movement tasks.

Typing and Handwriting

Loss of strength and endurance may affect prolonged typing or indicate more care with keyboard design and work procedures designed to avoid occupational overuse syndrome. Typing will slow with age but the findings on retention of learning of sequences of body movements suggest that if previously learned the skill will remain usable, this is confirmed by work on older expert typists, Salthouse (1984), Bosman (1996). What is not certain is how much of a barrier a need to learn to type is for older novice users. It is important to consider how easily older people learn new motor sequences in general and how well they handle learning sequences that conflict with previously well-established sequences. It should also be noted that age has an effect on the speed, sustainability and legibility of handwriting and that this may make the use of a pen based interface more difficult.

New interfaces

These suggestions are supported by two small studies by Charness et al. (1995) in which a mouse was compared to firstly cursor keys and secondly a light pen. The light pen was significantly easier to use than the mouse, cursor keys were hardest to use. Older users showed less difference from young performance with the light pen. Greater difficulty with stimulus response incompatibility for older adults might suggest that a mouse, which maps a horizontal response to a vertical stimulus, may be more difficult for older adults than a touch screen. With a light pen one points directly at what one sees, with the other forms one points to an imagined map of the screen and confirms success by looking at the mouse cursor. Extra cognition seems to be required and the feedback is more indirect. Charness et al. (1995) suggest these points as the basis for the superiority they found for the light pen over the mouse as a pointing device for older users. The differences found are marked but Charness et al. note that the study numbers are small and it is not clear how the extra strain in holding a light pen to the screen would affect prolonged use.

The findings on reduced touch sensitivity and ability to modulate response force with age could have implications for feedback mechanisms such as data gloves. Again Buxton (1996) found that using a mouse in each hand for control of drawing sequences in a designer's drawing tool gave more appropriate ability to express the designer's intentions. However this may be difficult for older people. In general new interfaces and interface tools are more likely to exploit motor skills available to younger users.

2.8 Memory and Aging

2.8.1 Studies of Memory and Aging

Education is one of the few times in life where people actually engage in list learning, the favorite task of memory research, This poses some questions about the real life applicability of research findings on memory. There is general support for memory becoming less effective with age, but the extent of decline varies with the area of memory researched. Memory is a complex phenomenon and researchers have approached memory in a number of different ways over the last three decades. Smith (1996) distinguishes between resource theories, structural theories and stage theories of memory. Resource theories look at the amount of support the environment offers to a memory task and the amount of processing an individual must contribute to the task as well as reduction in processing quality due to age. Structural theories divide memory tasks by time over which memory is required and broad categories of remembering being undertaken. The understanding here is that differing brain mechanisms support each type of structural memory. Stage theories have looked for explanations of memory problems in aging within the presumed stages of encoding, storing and then retrieving memory. There are findings from all these approaches that are relevant to interface design for older people.

Resource theories

Resource theories of memory cover a number of apparently competing explanations for poorer memory performance with aging. Craik (1994) has used level of environmental support versus amount of deliberate processing required to explain the lack of age-related decline in recognition tasks compared with the marked age-related impairment on recall tasks. Implicit memory is involved in tasks where there is no conscious attempt to remember but it can be shown that prior exposure to items improves performance. An example might be filling in the blanks on the words res_u_ce and con_r_te . Here implicit memory leads to the first word being more readily filled in since it has been primed (that is, it was encountered earlier in the text) while the second word was not. Explicit memory on the other hand involves deliberate processing by the individual in an attempt to remember. Jacoby et al. (1993) suggest that most memory tasks are able to be influenced by both familiarity leading to priming and deliberate remembering. However Jacoby et al. found that the implicit component of remembering was not affected by age while deliberate remembering was poorer for older subjects. The context in which an item is encountered while being memorized is important as a cue to later remembering. Older adults appear to have problems in making use of contextual cues if either the context is only loosely related to the target item or there is competing cognitive load during the memory task, Craik and Jennings (1992), Park et al. (1990). Smith (1996) interprets these findings in terms of the older subjects being at a disadvantage to the extent that deliberate processing is required to integrate context and the information to be retrieved. Hasher and Zacks (1988) see the available resources for memory tasks in older people being affected by reduced ability of the elderly to inhibit thoughts which are irrelevant to the task. Resource theories overlap with structural theories in the areas of working memory and perceptual speed that are considered below.

Stage theories of memory

Stage theories of memory consider the stages of encoding, storing and then retrieving memory. There is no support for any difference between young adults and healthy older adults in the way that information is stored in memory or for actual losses of stored material, Light (1990). Rather the problems faced by older adults from the perspective of stage theories of memory lie in the strategies used for encoding and retrieval of memories. It has been shown that older adults tend not to adopt strategies for organizing material to be remembered unless prompted to do so, Ratner et. al. (1987). However if adults are provided with semantic categories to organize learning and are again provided with semantic categories to aid recall the differences between young, middle aged and elderly essentially vanish, Smith (1977), Craik et al. (1987). It was suggested by Perlmutter and Mitchell (1982) that the encoding abilities of young and old do not in fact differ, they claim that what does differ is the spontaneous use of complex encoding strategies by older groups. See also the work by Baltes et al. cited below in the section on training. It is argued that there is little if any decay in the storage of long term memory but that the age-related deficits found are due to problems with recall and to problems with older people using less than optional strategies for organizing or encoding new information so as to facilitate later recall. Springer et al. (2005) using brain imaging found that higher levels of education altered the areas that older people recruited to deal with memory encoding and retrieval and that this corresponded with better performance by these better educated older people.

Touron and Hertzog (2004) looked at older and younger adults performing a noun-pair task. Even when the noun-pair list was learnt in advance older adults were slower to switch to a catagory-based retrieval strategy despite comparable noun-pair knowledge. Young and older adults reported comparable confidence ratings for the accuracy of each memory probe response. However, older adults reported lower confidence in their overall ability to use the category based memory retrieval strategy, which correlated with avoidance of the category based retrieval strategy.

Structural theories

Research based on structural theories of memory tends to see memory as comprising a number of distinct abilities that are brought into play in different tasks. The main distinction is between short term memory, defined as a system for storing and using memory for very recent events (under 60 seconds), and long term memory which as its name suggests is involved in the storage of information over longer periods of time, up to and including the individual's lifetime.

Short term memory is a system for storing information of immediate concern. Within the short term memory system **primary memory** is used to hold the events of the immediate past as well as information just recently retrieved from long term memory. Primary memory is limited in capacity and information stored in primary memory is lost rapidly over time unless it is transferred to long term memory. **Working memory** combined with **executive** control provides a system for temporarily manipulating the information contained in primary memory, see Baddeley (1989).

Long term memory is involved in information storage for periods longer than 60 seconds. Long term memory involves several components, **episodic memory** for specific events, **procedural memory** for holding knowledge of the way in which tasks are carried out and **semantic memory** which holds information about meaning of the components of one's world. Normal aging (excluding pathological conditions such as Altzheimer's disease), produces differing degrees of impairment on the different forms of memory. Different brain sites appear to be involved in different memory tasks, Rybash (1994).

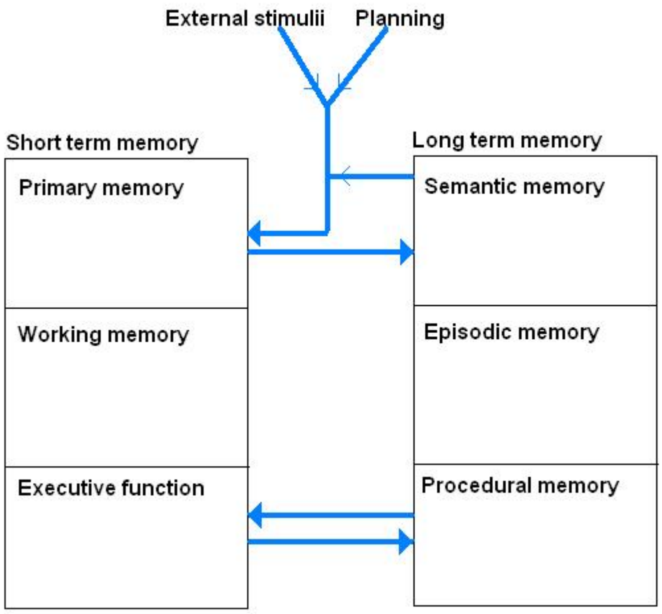

Figure 2.2 Short Term and Long Term Memory: adapted from Schieber (2003)

The short term memory system

Primary memory

Research on short term memory shows only a slight decline in the number of items which can be held in primary memory, an average of around 6.5 items can be held from the 20s through to the 50s but this then drops to around 5.5 for the 60s and 70s, Botwinick and Storandt (1974). Even this may be a cohort effect since Dobbs and Rule (1990) showed that primary memory span was correlated with education level rather than age and general education levels have increased over the last century . We can in general rule out extreme declines in primary memory with normal aging.

Working memory

Tests of working memory show that there is a decline in the ability to engage in processing of the content of short term memory as distinct from simple recall, Salthouse(1994). Dobbs and Rule in the study quoted above found that age significantly affected the ability of subjects who heard a new digit every 2 seconds to answer questions such as "What was the number two back from the one you just heard?". Haarmann et al. (2005) report that older adults have less success in maintaining context awareness on a short term memory task such as responding to the presentation of a target letter but only if it is preceded by a letter denoting a response context. Thus subjects might be asked to respond each time they heard an X in a series of letters but only if the X was preceded by an A. Bopp and Verhaeghen (2005) performed a meta-analysis of findings on different verbal span tasks related to primary and working memory. They found that there are age differences in all verbal span tasks with the size of the age related deficits being greater for working memory span than short-term memory storage span.

Older people are observed to have problems in text comprehension. Light (1990) reviewed and analyzed work in this area, looking at the interrelations between aging, working memory limits, memory for information and verbal ability. Light examines and then rejects claims that verbal ability at the single word level accounts for the observed results. She suggests that the key issue lies in working memory reduction in old age. Light states that this means that it is harder to place later passages in a text in the context of earlier one’s where this is needed to understand the later passages. This effect according to Light, is self amplifying, since points that are not understood are harder to remember, both in working memory and in long term recall of the substance of a text.

Executive function and working memory

Salthouse and Babcock (1991) split the effects on working memory into processing and storage components and found that the declines in working memory with age were attributable to the processing component. Howard and Howard (1996) suggest that we will see few effects with age where tasks impose little load on working memory but that as tasks become demanding age-related problems will appear.

The general slowing of cognitive processing with age also shows up in search speed when scanning primary memory, Fisk and Rogers (1991), with both middle aged and older adults taking more time to process each item in primary memory. Studies requiring mental rotation of figures also indicate that processing of visual information in working memory slows with age, Hoyer and Rybash (1992). However slowing of search speeds for short term memory appears to be reversible with training, Salthouse and Somberg (1982) found that after 40 sessions the relation between response time and the size of the set of items held in short term memory had become comparable for young and elderly adults. However an age difference remained in the overall time needed to perform the task. Training can actually increase the gap between young and old in some memory tasks in spite of improving performance for the older group, as younger groups can show more benefit from training, see Baltes and Kliegl (1992).

Salthouse (1996) in a meta-analysis examines ten studies as part of a growing body of evidence pointing to the relation between memory and age being largely mediated by speed of processing. In these studies when the variance due to processing speed is controlled for, the relation between age and memory is markedly reduced. In this 1996 survey Salthouse found evidence for a general factor based on processing speed which contributes to the variance of a wide range of performance measures. This general speed of processing factor in turn is strongly related to age but after controlling for the general speed factor there is little relation between Salthouse's varied performance measures and age. Salthouse strongly recommends that future studies proposing a specific age effect on any timed aspect of behavior should control for processing speed.

Long term memory

Long term memory shows different results with age depending on the tasks involved. Recognition tasks are those where a mix of previously presented and new stimuli are presented and the subject identifies which stimuli have been seen previously. Recall memory tasks involve the subject remembering previously presented items without the environmental prompting provided in recognition memory. According to Howard and Howard (1996) findings of age-related deficits in recall of episodic and procedural information are common but there is generally little age-related decline in semantic or recognition memory until extreme old age.

While studies typically show little if any decline in the ability to perform on simple recognition tasks there are significant age related declines in the ability to recall information, Rybash et al. (1995). This is subject to the complexity of the memory tasks. When learning material contained in stories, interviews or text, age-related declines are also found in recognition tasks, Hultsch et al. (1991), Hertzog and Rogers (1989) and Stine and Wingfield (1987).

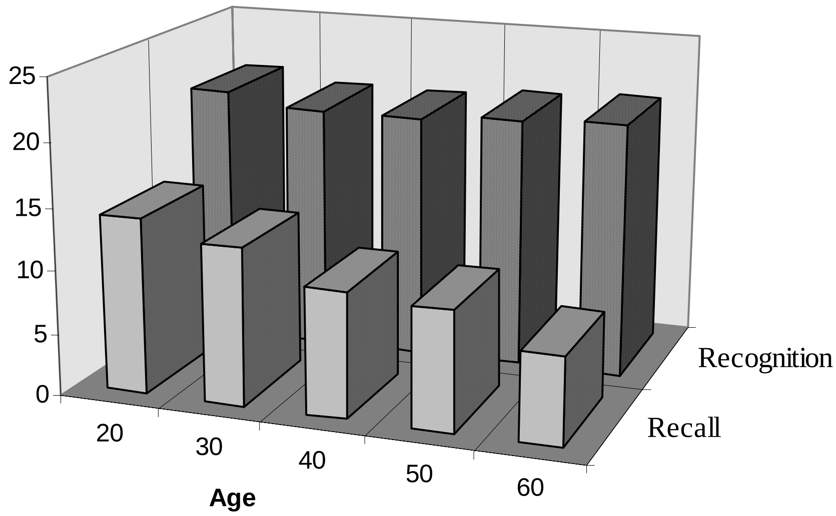

Figure 2.3 Items remembered on recall versus recognition tests with age. Adapted from Rybash et al. 1995. The lack of age-recognition effects may only hold for simple list learning.

An age related decline in the ability to spell words correctly has been shown by several studies, Stuart-Hamilton & Rabbitt (1997), MacKay and Abrams (1998), Burke and Shafto (2003). Typically the words that older people cease to spell effectively are those with a spelling that differs from their pronunciation. The misspellings of both young and older adults usually matched the correct pronunciation (e.g., calender instead of calendar, spontanious instead of spontaneous).

May et al. (2005) tested young and older adults for memory retrieval at the time of day that corresponded with their peak arousal as well as at an off peak time. Memory responses for explicit attempts at recall were better at the time of peak arousal in each group. Interestingly the effects of time of testing on implicit memory were opposite with best performance in implicit stem completion and category generation tasks occurring at the time of off-peak testing.

Procedural Memory - memory for actions

Nilsson (2003) in a review of memory and aging reports that procedural memory generally shows little change across the adult life span but that an age related deficit is revealed with some of the tasks used to assess procedural memory. The findings on skilled performance cited in the section on expertise indicate that procedural memory for motor control tasks requires continued practice if skill is to be maintained.

However, while established procedural memories are reasonably preserved, forming new procedural memories may be more difficult in old age. There is evidence for older people having greater difficulty in remembering which actions they have performed when the actions consist of a set of complex activities. Earles and Coon (1994) provide an example where the activities to be remembered were a set of psychometric tests performed earlier. However Smith (1996) suggests that there are mixed findings as to the ability of older adults to remember which actions they had performed from sets of simple physical actions. Kausler (1994) found that all the studies reporting non-significant differences gave results in the direction of increased difficulty for remembering actions by older adults. Kausler suggests that performing a physical action automatically encodes it and that this explains why there are smaller age differences when recalling which physical actions have taken place than when recalling verbal materials.

Spatial memory and non-verbal memory

Older adults appear to perform worse on tasks which require remembering spatial location, for example which quadrant a word appeared in, Denny et al. (1992) or replacing items in a model, Cherry et al. (1993). Smith and Park (1990) summarized the previous decade of spatial memory studies and found that 12 of 14 studies showed age differences. Gilbert and Rodgers (1999) found that older adults were slower to master a spatial mental model and fewer of the older adults achieved mastery (62% vs 91% for younger adults). Once the older adults had mastered the mental model they made equally effective use of it except for tasks that placed a load on working memory.

Older adults tend to have poorer memory for non verbal items such as faces Crooke and Larrabee (1992) or map routes, Lipman and Caplan (1992). However Park et al. (1990) confirmed her earlier work showing that memory for complex scenes was equivalent in young and old, it appears though that this depends on the consistency of the internal support provided by the interrelated elements of the scenes, Frieske and Park (1993).

Source memory

Source memory is the ability to remember where information was previously encountered as distinct from the remembered information itself. Shimamura and Squire (1991) argue that source memory is a separate system from memory for facts. According to Dywan and Jacoby (1990) source memory shows a decline in accuracy with age. This is confirmed by Simons et al. (2004) who found that age-related deficits were observed on both specific- and partial-source recollection but that there did not appear to be a difference between the age related effects on the two forms of source recognition. Cabeza et al. (2002) compared older adults who were rated as low performing on cognitive measures with high performing older adults and with young adults. Subjects were compared on tasks involving recall and source memory identification of recently studied words. Young adults showed a pattern of activating the right side of the pre-frontal cortex. Low performing older adults showed a similar limited pattern of brain activation to young adults. However high performing older adults engaged areas on both sides of the pre-frontal cortex. The authors suggest that the observed difference is consistent with the idea that high performing older adults recruit extra cognitive capacity to compensate for neural impairment while low performing older adults remain with the patterns of activation used when they were younger.

Anxiety and age stereotyping

Li et al. (2004) found that anxiety worsened performance on episodic and source memory for older subjects but not for younger subjects. In work by Hess et al. (2004) older but not younger people showed altered performance on memory tasks when exposed to implicit versus explicit priming with stereotypes related to aging. Implicit priming with positive stereotypes led to improved memory recall while implicit priming with negative stereotypes led to decreased recall. When explicit priming was used there was an effect due to the strength of the stereotypes. With exposure to subtle stereotypes older people showed little effect but blatant stereotype exposure led to decreased performance irrespective of whether the primes were positive or negative stereotypes. Chasteen et al. (2005) also found that being negatively stereotyped influenced older subjects in a way that increased age differences in memory performance. In addition it was found that that the effects on performance from negative stereotyping were not easily reduced by reframing the task instructions.

Prospective memory

Prospective memory is the ability to remember to remember, to remind one'self to keep appointments, take out the rubbish or take one's medicine. Prospective memory is reduced in elderly people. Einstein and McDaniel (1990) found no problems with older subjects' prospective memory on a simple task where they had to press a key each time they saw a target word during the performance of other tasks. When the prospective task was made more complex such as having several target words to respond to, Einstein et al. (1992) or seeing a beard while looking at pictures, Maylor (1993) then age differences appeared. Age differences are also seen with tasks which require subjects to perform an action every so many minutes without providing reminders, McDaniel and Einstein (1993). Salthouse et al. (2004) looked at performance on four prospective memory tasks and found age related declines for prospective memory. Salthouse et al. analyzed the relationship of prospective memory to other measures and found evidence that there was evidence for prospective memory existing as a valid independent construct after allowing for the fact that prospective memory was correlated with cognitive abilities, such as executive functioning, fluid intelligence, episodic memory, and perceptual speed. Prospective memory was only weakly related to self-ratings of memory and to personality traits.

Einstein et al. (1998) looked at prospective memory in a specifically computer based situation. Subjects did 11 tasks each 3 min long on a computer. They were told to press the F1 key at some stage at least 30 seconds after the start of each task. In one condition the subjects had a reminder note "Remember to press the key" taped to the keyboard. In addition half the tasks were presented under divided attention conditions. Subjects were young - ~20 vs old ~70. Errors could consist of repetition or omission. Subjects were questioned as to whether they had pressed F1 after each trial. Older subjects performed worse than younger subjects. This was most pronounced in the divided attention condition where repetition errors were higher in the older group in earlier trials while omission errors were higher in the older group in later trials. Einstein et al. suggest that older people in later trials may have difficulty in remembering whether a key press had been made in the current or a previous trial. In earlier trials the effect could be due to slower learning by the older adults. The presence of a cue had a paradoxical effect, it gave slightly worse performance overall, this was particularly so for omission errors in the older group in later trials.

McDaniel et al. (2003) confirmed earlier studies showing that when execution of retrieved intentions must be briefly delayed, older adults display deficits in performing those intentions. McDaniel et al. interpret their findings as suggesting that age compromises maintenance of information in awareness. Consequently, when forced to delay execution of retrieved intentions, older adults may rely more on plan reformulation and subsequent retrieval of the intention from long-term memory at the end of the delay.

Memory Training

It may be that, without intervention, older adults persist with encoding and recall strategies that they used and found adequate when young but which are no longer adequate given an aging brain. A study of learning practice effects by Gilbert and Rogers (1996) is of interest because it demonstrates training effects on response time persisting over a very large number of trials. Gilbert and Rogers found that older subjects in a group provided with 960 practice trials maintained an advantage over a control group of the same age which did not undertake practice trials. This advantage was maintained over the next 3600 trials in the study. In younger subjects practice did not provide a long lasting advantage, both younger groups rapidly reached asymptotic performance. This indicates the very long period during which older subjects' response times continue to fall with increased task experience.

Morrell and Echt (1997) suggest that for older but not younger groups learning of procedures given in text is poorer when the text is presented accompanied by superfluous graphic material. However Morrell and Echt also note that where including graphics reduces cognitive load there is a positive effect on accurate learning.

Baltes and Kliegel (1992) put groups of young and old adults through 35 training sessions over 16 months using a method of learning to associate items to be remembered with familiar images from the subject’s life. Both young and old groups in the Baltes and Kliegel study showed ability to improve their test scores with this method. However the young group showed much greater benefit from training and the separation between the groups increased over the training period. Kliegel et al. (2003) looked at inhibition efficiency, memory span and the way that participants structured the material learnt. All these factors contributed to the observed poorer performance of the older group. There was a notable contribution from the subjects’ quality of structuring the learnt material by categories. Kliegel et al. emphasize the importance of teaching strategies for organizing learning material in the context of cognitive training for the elderly.

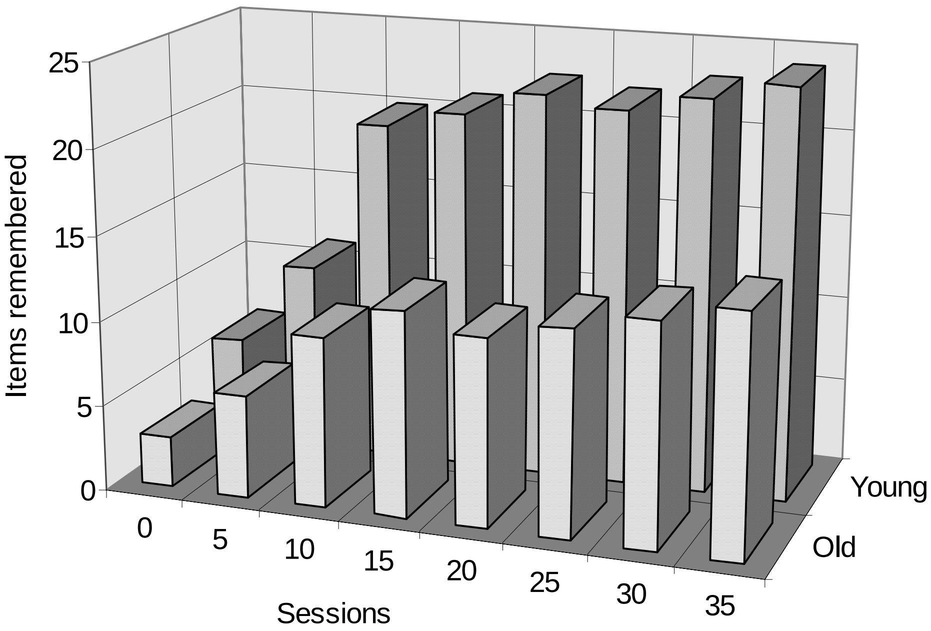

Figure 2.4 Younger subjects benefit more from memory training than older subjects. Adapted from Baltes and Kliegl (1992)

Summary of findings about aging and memory

Short term memory

- The ability to make use of information in short term memory declines
- Older people are slower to recall information from working memory
- One effect of reduced short term memory is in problems with text comprehension, especially for longer or more complex passages

Recognition and Recall from long term memory

- Deliberate recall of previously encountered material becomes harder with age
- Recognition of previously encountered items is not greatly affected if the items are simple
- Older people are likely to use inadequate strategies for learning new material so that it can be retrieved
- Structuring of memories may be worse in less educated older people
- Problems in using context to prompt recall memory as distinct from recognition
- Less ability to inhibit irrelevant memories
- Attempts to recall information are more affected by anxiety

Specialized forms of long term memory

- Spelling of unusually structured words becomes poorer
- Memory for how to do relatively simple things remains
- Skilled motor performance requires practice to retain
- There can be problems in remembering if a job has been done or is still to do
- There is poorer memory of spatial information and other non-verbal information
- There is poorer memory for where information was found (source memory)
- It becomes harder to remember to do jobs at some later point in time (remembering to remember or prospective memory)

2.8.2 Possible Effects of Age-related Changes in Memory on Interface Design

Memory is an essential tool for acting in the human world and for working with human artifacts. Older people will in general work within an application under the burden of reduced memory function. There are a variety of ways an application designer can attempt to assist older users to compensate for this but the core message is that if your users have poor memory then give them less to remember. Simplicity is the central design approach for coping with poorer memory.

Memory, Learning and Cognitive Ability have pervasive and interwoven effects on application use by older people. As such they are harder to discuss separately and harder to make specific design recommendations with respect to particular aspects of computer use.

Learning is covered later in this chapter but for now it is enough to say that partly because of issues with memory older people will be slower to learn, will require more repetitions to learn, will forget more details for a longer period. For this and other reasons a designer should expect some of their older users to attempt to use an application with a more partial knowledge of the application than would be expected of younger users. It is my impression that some older users will retain the status of "perpetual newbies" over a year or several years. One of the design challenges in designing for older people is to design applications for users who may not remember the basics, "Well I have done that, now what do I do?....Oh you want me to click that button with OK on it?"

In younger people cognitive function provides an alternative to memory, if one has forgotten how to do something then it is often possible to use a variety of models of the situation (a task model, an application model and an environment model) to work out what should be done. However because of a degree of decline in cognitive function older people are likely to be less able to construct new solutions in this manner.

One aspect of designing for people who forget, or do not learn, basic application details and interaction idioms is that a younger designer uses these details with little conscious thought. Older users with minimal knowledge and limited capacity to acquire it break a younger designer's fundamental assumptions about what can be assumed of the users they are designing for. Because of the younger designer's unconscious mastery of such detail (and similar easy mastery by the younger users that the designer may have experience with), the designer's assumptions about basic skills and basic knowledge are usually taken for granted. Meeting users who break these assumptions, and carefully designing within the limitations of such users rather than rejecting them, can be a rude shock.

Short term memory – relevant changes

- The ability to make use of information in short term memory declines
- Older people are slower to recall information from working memory

- One effect of reduced short term memory is in problems with text comprehension, especially for longer or more complex passages

Short term memory – design suggestions

If we look at the general roles of memory in computer use we can see that short term and working memory are crucial for detailed control of interaction and for placing action or interpretation of one part of an application into the context of actions or interpretations made in some other part of the application. We can speculate that since older people have more difficulty processing information in working memory this should affect computer use. The role of the application should be to minimize the load placed on working memory and to make it possible for a user to conveniently off load and later recover some of the contents of working memory.

This should also be important where physical slowness or perceptual difficulty means that it takes an older adult longer to complete a task with a consequently increased likelihood of information being lost from short term or working memory. The implication is that older people in particular will benefit from simplicity of interface design both where this reduces cognitive complexity and where the time and number of items that need to be remembered is reduced. We can ask if older Web users are more affected by delays in displaying web pages where they need to relate information obtained from several pages.

It is worth considering if older peoples' problems with text comprehension on paper documents become greater when text is available via a word processor on a VDU display. It seems likely that where scrolling is involved, requiring extra manipulation via a word processor to view the text will create task interference and hence extra cognitive load. Charness (1998) suggests that the visual unavailability of text that has scrolled out of view will mean more bridging is required in memory to relate sections of text when working with long documents in VDU displays. “You can't make return saccades to disambiguate text when its scrolls out of view.”

Long term memory, Recognition and Recall – relevant changes

- Deliberate recall of previously encountered material becomes harder with age

- Recognition of previously encountered items is not greatly affected if the items are simple
- Older people are likely to use inadequate strategies for learning new material so that it can be retrieved
- Structuring of memories may be worse in less educated older people
- Problems in using context to prompt recall memory as distinct from recognition
- Less ability to inhibit irrelevant memories
- Attempts to recall information are more affected by anxiety

Long term memory, Recognition and Recall – design suggestions

Remembering how to use an application

Older users can be expected to remember fewer ways of activating features of an application. This means that older users are likely to have to search for the tools that they want to use instead of remembering where to find them. It is also likely that older users will have a less detailed knowledge of what a particular tool does. A design response to this is to have fewer tools (or features) and to provide very obvious visual cues that make it easy to find ways of activating the required tools. The tools themselves should be suitable for using with a limited knowledge of the tool's function.

Longer term memory has numerous roles; remembering actions or interpretations made in some other part of a complex document in the current or a previous session, remembering how to use the program, remembering external data or events which are relevant to the current session and remembering information acquired during the session after the session has ended. The research findings suggest that while long term memory itself is not impaired with age older adults may suffer from problems with strategies for organizing newly acquired material or for retrieval. Here the role of the application may be to indicate useful ways of organizing material and to provide suitable cues for retrieval.

The relevance of source memory here would seem to be in remembering how or where one previously obtained information about a complex and infrequently performed task. Source identification tasks with a computer interface would seem to be mixes of 1. motor tasks – what mouse targets or keystrokes combinations were needed in the past to get to application options, 2. purer source tasks - who told me that, which book, which chapter and 3. verbal memory tasks - what key word will get to this task in the Help system's search engine.

We can expect older users to remember fewer shortcuts, icons and idioms. The design response is to make less use of such items, trying to make an application whose ease of use does not depend on the user finding clever ways of doing things. Older users can be expected to have greater reliance on knowledge in the world so designs should provide clear visible affordances such that older users will both find and correctly interpret them. This may translate into well captioned links and buttons rather than icons and pictorial toolbar style buttons. It also would support a design approach where the information about what to do next appears close to the position at which an older user completes the previous action. It is likely that caution needs to be taken when adding graphic material to ensure its simplicity and relevance, both of which should enhance an older user's ability to remember the relevance of the graphic.

Kelley and Charness (1995) suggest that function keys may be too demanding for older users since they require recall rather than recognition. Menus which provide cues depending on recognition would appear to be appropriate for older users except for the problems noted earlier related to motor control and to visual search. Kelley and Charness see the status of icons as intermediate between menus and function keys. However older people may be more sensitive to proliferation of low quality icons. Common warning symbols had varying levels of recognition for both young (< 40) and old. For a few symbols such as Explosive, Hot, Moving rollers older adults were much less likely to recognise the symbol that younger adults. For other symbols older adults typically showed a slightly smaller (non-significant) recognition rate. (eg Flammable 91% vs 98%), Mayer and Laux (1989). In 1989 both groups had zero recognition of the biohazard symbol. The study was extended to see what actions subjects reported that they would take in response to encountering a warning symbol. Subjects chose from a check list of appropriate actions. Older users were much less likely to check behaviors such as not smoking near an object marked with a Flammable symbol, (17% to 95%) so the authors raise a concern about the ability of older adults to link appropriate behavior to graphic symbols.

As Fisk et al. (2004) point out, paradoxically in some parts of their computer use older people will be more dependant on “knowledge in the head” where they will expect conformance with those conventions that they do know. The examples provided by Fisk et al. include using an upward move or rotating to the right to increase a value, the point made by Fisk et al. is that where the conventions that older people do remember are broken by a design older people will have fewer resources available to discover the new behavior required, in addition older people tend to be more upset and disrupted by what they see as error or inconsistencies.

Obtaining and transferring information

Memory and in particular short term memory is relevant where users are involved in obtaining and transferring information. The situations vary; understanding parts of a document or sentence in relation to other passages or other documents, reading Help documentation, working between a paper source and the screen, cutting and pasting and remembering the content of the passage cut in the course of transferring to the place where pasting will occur, noting and remembering relevant information in a document, re-reading information, making sense of text and diagrams.

In following on-screen instructions a user is engaged in remembering position while making saccades to the area where the information will be applied and back to the information source. This may involve more returns to the source list for older users with their poorer working memory. Design choices to assist could involve making the list items short and clearly written but could also involve making the position in the list easier to remember by numbering the list or by having a position pointer that is moved when a part of a task is completed. Similarly when making estimates from an on-screen graph short term memory is involved in part of the control of saccades from the axes to intersections of values on the graph. As another example it can be shown that performance can be improved for younger users by providing grids and smart graphs that provide mouse over information as the mouse moves over the graph, see for example Hawthorn (1996), similar techniques could reduce the short term memory demands on older users.

It is not always clear how findings on memory should be applied. As an example Fozard (2003) takes issue with asking older people to enter long sequences from credit cards when entering security codes. What I have observed is that in fact older people seem to cope reasonably well given that the codes are usually broken into 4 or 5 digit blocks, at the bottom end of Millers limit of 7+-2 for primary memory. Where memory problems come into play in this example is that older people may not have learnt that the entered code should be devoid of spaces and the lack of spaces in the entered text may make checking harder as one has to remember the segment and relocate a position in a long string. What would help here in my view is that the application should deal with the spaces without generating an error. A possible further refinement is the approach taken when entering authorization codes for installing applications. In this scheme, not only are the numbers grouped but each group of numbers has its own box and the focus shifts automatically as a box is filled.

[1234]   [5678]   [   ]   is easier for people with limited short term memory than
12345678____

With some documents the designer has control over the content and the display. Thus a Help document might follow the recommendations for text understandability for older people given earlier and it might also be displayed within the application in a format where the user can still see the application screen the older user is obtaining help for, so that the older user does not have to remember details from either a paper manual or full screen Help while transferring their attention to the application screen where help is needed. Keeping documents short so that a user does not have to scroll is another design response, the aim being to avoid requiring the user to hold off screen information in short term memory. Another response could be to make it easy to print any text, including error messages. Automatic error message logging could again assist older people, provided that they understood that the message had in fact been stored.

For other documents however the designer provides the container within which they are displayed but does not control the content. It could be of interest to consider if improved tools can be constructed to assist older readers to find and or highlight passages of interest, but such tools themselves imply more tools to be found and skills to be remembered so may not lead to improvements over the wider group of older users.

Although healthy older adults appear to retain most semantic memory the designer should be aware of the possibility that some aspects of long term memory for rules and meaning will fail. An example is the increasing frequency of spelling difficulties with age. Spelling correctly is part of self presentation and hence part of maintaining an older person's self respect. Thus the provision of easily usable spell checking in applications such as email where an older person's writing will be seen by others is a useful step. Such spell checking needs to actively point out errors rather than expect the older person to remember to spell check. The wriggly red underline available in Microsoft Word is an example of this.

Specialized forms of long term memory – relevant changes

- Spelling of unusually structured words becomes poorer
- Memory for how to do relatively simple things remains
- Skilled motor performance requires practice to retain
- There can be problems in remembering if a job has been done or is still to do
- There is poorer memory of spatial information and other non-verbal information
- There is poorer memory for where information was found (source memory)
- It becomes harder to remember to do jobs at some later point in time (remembering to remember or prospective memory)

Specialized forms of long term memory – design suggestions

Remembering where one has been and where to go

In web sites older users have been shown to be poorer at navigating, see Mead et al. (1997). This seems likely to be general, applying to application navigation as well. Navigation skills include holding an overall model of the site or application, holding knowledge of specific locations for finding particular facts or tools, remembering where in the site or application one is currently located and understanding how to move to other parts of the structure.

Ways of reducing memory demands on older users as they navigate may include the following. Making the application structure as simple as possible. Holt (2000) has shown that older web site users are definitely helped by appropriately designed site maps. So application designers could consider providing the equivalent of a site map. One way of doing this may be to make the home base of an application into a set of command buttons that take a user to each of the other parts of an application, with a provision for a sort of sub-menuing where some buttons may take the user to a further screen of navigation buttons. In effect the main screen(s) of an application become a permanently open menu, this reduces the older user's need to remember what options are located in what parts of a menu and to combine searching with mouse manipulation. It may also assist by providing the older user with repeated views of what is effectively a site map (and hence repeated learning opportunities for absorbing the application model). In translating the site map concept to applications it may be useful to clearly identify the destinations available with the tasks to be achieved by going to each destination.

Another way of assisting navigation is to enforce a simple navigation model where progress is essentially linear, either proceeding away from the main menu to options or proceeding back to the main menu. This can be accompanied by consistent location of the buttons or links for achieving relevant navigation tasks, particularly the buttons or links for returning to the main menu. Pages and screens can be captioned in such a way as to make it clear how the page or screen fits into the overall site.

Remembering what has been done and remembering what needs to be done

Older user's problems with remembering if they have completed particular actions and with remembering to remember to carry out actions in the future should be considered by designers. To an extent existing designs already accommodate some aspects of remembering to remember such as asking users if they want to save changes before exiting. However other common prospective memory situations do not allow the application to understand a user's likely intention, for example in the matter of attaching a file to an email before sending it. It becomes a matter of interest in working with older users to identify tasks where users either repeat already completed sub-tasks or fail to carry out sub-tasks and to experiment to find if there are changes to structure or cuing within an application that make such lapses less likely.

2.9 Attention and Aging

2.9.1 Studies of Attention and Aging

Simplistically, attention is the ability to focus on elements needed for the performance of a task. Plude and Hoyer (1985) defined attention in terms of the capacity or energy to support cognitive processing. Shieber (2003) notes that a key characteristic of attention is that it represents a limited human capacity, our ability to coordinate tasks with our awareness of environmental input and stored information can be overloaded. Within the overall topic of attention there are five traditional research concerns; **sustained attention** – maintaining attention over time, **selective attention** – maintaining a focus on relevant aspects of incoming information, **divided attention** – maintaining attentional focus on more than one task simultaneously, the **span of attention** – the spread of information that can be attended to, and **automatic response** – where well learned behavior can proceed without attentional control. There are numerous findings of age-related decrements in performance on a variety of attention-related tasks, including sustained attention, selective attention, and inhibition tasks, Armstrong (1997), Chao and Knight (1997).

Attention, sustained performance and vigilance

Vercruyssen (1996) states that older adults have problems maintaining attention over long periods of time. This is indicated by the increased frequency of gaps in performance in older subjects who are asked to perform response time trials for periods over 10 minutes. Vercruyssen suggests (p66) that tasks requiring rapid or continuous scanning are particularly fatiguing for older adults. However note findings cited by Kline and Scialfa (1996), p37 in the same handbook, that reported no age difference in a vigilance task involving detecting infrequent double jumps on a chronometer display over very long time intervals. Berardi et al. (2001) also found no age related differences in sustained attention. But when Mani et al. (2005) used the continuous performance test to measure sustained attention, they found evidence for age-related differences in performance, particularly for deficits in selective response inhibition.

Deaton and Parasuraman (1988) found differing effects for cognitive versus sensory vigilance tasks. The tasks involved detecting episodes where a pair of numbers were odd and even (cognitive) or different in size (sensory). For young and old vigilance dropped more over time on sensory tasks. Old subjects showed poorer hit rates when cognitive events were presented rapidly (40/min) and had more false alarms on the sensory task. Deaton and Parasuraman found that older users were best at a slowly presented (15/min) cognitive vigilance task though they see older users as less suited for vigilance tasks overall. Interestingly older users gave the cognitive task a higher rating on a subjective workload scale than the sensory task. As the authors point out this means that subjective ratings could lead to a designer picking the type of vigilance task older people are worst at.

Selective attention

In selective attention tasks the subject must extract relevant information from distracting detail, here there is agreement in the literature that the ability to pay attention to relevant information in the presence of distracting information declines with age, Connelly and Hasher (1993), Kotary and Hoyer (1995). In a series of papers dating from 1988, Hasher, Zacks and co-workers have argued that this is because older adults are less able to inhibit response to the presence of distractor items, see Kane et al. (1995) for a summary.

The Stroop interference effect is found where incompatibility between stimulus and response slows response time, for example in identifying the color in which a target word is displayed where the word might be RED and the color in which it is displayed was in fact green. In such cases people have to inhibit the initial well learnt response to the meaning of the word before they can produce the desired response, “Green”. This demonstrates difficulty in inhibiting strongly learnt associations. Vercruyssen (1996) reports that the Stroop effect is accentuated with age. That the Stroop effect is more pronounced in older adults is possibly due to declines in inhibitory control with aging.

Nielson et al. (2002) showed that older adults activate additional brain areas to those activated by younger subjects when engaged in tasks that require inhibitory control. In spite of this older adults achieve poorer levels of success on tasks requiring inhibitory control. Langenecker et al. (2004) using functional magnetic resonance imaging found older adults were slower and made more errors during the interference condition of a Stroop test. The imaging results indicated that the older adults activated more parts of the frontal brain areas in performing the task, thus offering support for the recruitment hypothesis.

Top-down modulation is a cognitive control mechanism that supports both attention and memory by the suppression and enhancement of sensory processing in accordance with task goals. The distinction between bottom-up and top-down forms of attentional control is important in current theories of visual search performance. An example of bottom-up attention is the involuntary orienting to a target item distinguished from nontarget (distractor) items on the basis of local distinctiveness of its display properties (e.g., a red target letter among gray distractor letters). In top-down processing, in contrast, search is driven more by the observer’s knowledge and goals than by the properties of the display. Most forms of visual search represent the combined influences of bottom-up and top-down attentional control.

Top-down modulation has been reported to be less efficient in older people. Gazzaley et al. (2005) used functional magnetic resonance imaging to investigate the effect of normal aging on top-down modulation. Their findings emphasize a defect in older people’s ability to suppress irrelevant information. They found that older adults had much less brain activation when they needed to engage in the suppression of cortical activity associated with task-irrelevant material while activation for task-relevant activity was preserved. This supports the role of decrements in inhibition in older people’s poorer performance with selective attention. A singleton is a search item that is the only distinctive item in a collection of search items by virtue of being the only colored item or by some other distinguishing feature. Madden et al. (2004) compared younger (19–27 years of age) and older (60–82 years of age) adults performing a letter search task in which a color singleton was either noninformative (baseline condition) or highly informative (guided condition) regarding target location. The guided condition provides an example of top-down modulation and under this condition both age groups exhibited a substantial decrease in response time (RT) to singleton targets, relative to the baseline condition, as well as an increase in RT to nonsingleton targets. Madden et al. conclude that under conditions that equate the physical structure of individual displays, top-down attentional guidance can be at least as effective for older adults as for younger adults.

Divided attention and dual task performance

There is agreement on the effect of age on the ability to maintain divided attention where the subject must pay attention to more than one task at the same time. Researchers such as Hartley (1992) and McDowd and Craik (1988) have reported declines in performance with age on divided attention tasks. However divided attention problems with age appear to occur only in complex tasks rather than simple or nearly automatic tasks. There is an argument that the apparent attention deficit may be a result of overall task complexity rather than due to divided attention as such, (McDowd and Craik 1988 , Salthouse and Somberg 1982). Holtzer et al. (2004) found that age increased the performance problems found where the degree of temporal overlap was increased between competing tasks in a dual task situation. This effect was reduced but still present when the dual tasks represented different modalities.

Hogan (2003) examined whether higher levels of anxiety are associated with poorer cognitive performance in older adults. Looking at selective and divided attention tasks it was found that higher anxiety was associated with poorer divided attention performance in older, but not younger, adults.

Korteling (1994), in an interesting paper, showed that old people initially performed as well as a younger group on familiar dual tasks in a driving simulator. The dual task involved was to keep to the center of the road while maintaining a set following distance from a vehicle ahead. However when gas pedal polarity was reversed so that faster became up, the older group had trouble, not with the following task involving the gas pedal but with the steering task. Kortelling interprets this to mean that while coping with the reversed gas pedal was possible, to do so markedly reduced the cognitive resources available for the second task.

Wikman and Summala (2005) had subjects perform a visual search task on a display unit within a car while driving. The older group spent longer looking at the in-car display, they traveled a longer distance with eyes away from the road and showed a larger lateral displacement of the car in relation to the road. The number of long (>2 sec) glances was larger among the elderly group. The difference between the older and younger subjects was larger when the subjects needed to press a key on the display (motor response) than when a verbal response was required. The authors conclude that even by the age of 65 to 70 years, older drivers have difficulties in time-sharing in highway driving.

Morrow and Leirer [77] reviewed studies of pilot performance. Older pilots were similar to younger pilots in response time on simulator tests except for "high workload conditions" such as a landing involving cross winds and turbulence. Older pilots made more mistakes in responding to and feeding back air traffic control communications in flight simulator tests and this effect worsened when the messages were made more complex. Age had more impact on communication tasks than on routine maneuvers. This is of potential interest to those looking at co-operative environments. It may be that older users have less ability to cope with the communication load and demands on working memory expected in a co-operative environment.

Automatic responses

While most activity requires attention to support it, some activities that are well learnt appear to shift to a different category of performance where the behavior is in essence automated, that is it does not require conscious control and attention for the behavior to be carried out. Activity of this sort is referred to as automated responses, automatic responses, automatic attention responses and similar terms. Testing for the presence of automatic responses can involve showing that the supposedly automated behavior does not contribute to extra load in dual task situations – thus demonstrating that the task does not make extra demands for attention and control. Alternately testing for automatic responses can involve putting a person in a situation where the stimulus that normally provokes the automated response is presented but the older person is required to produce a different response and inhibit the automatic response. An automatic response can be shown to be more difficult to inhibit than a non-automatic response that is under conscious control. Automatic responses are important in that they are seen as reducing the cognitive load associated with task performance.

While it seems that automatic responses that have been established while young persist into older individuals there is concern as to the ability of older individuals to establish new automated responses. Work by Plude and Hoyer (1981) and Fisk and Rogers (1991) supports the argument that there are reductions in the capacity of older individuals to direct attention to support complex tasks but that this does not apply to tasks, which, through training, have become automated. A group of studies done by Rogers, Fisk and co-workers concluded that most older adults may be unable to form an automated attention response (AAR), see Rogers, Fisk et al. (1994). Gilbert and Rogers (1996) report a study confirming this. In this study during extensive practice (3840 trials), words from some categories always served as targets in a visual search task while words from other categories always served as distractors. The test for the formation of an automated attention response occurred after the practice period in a new set of trials where the target categories now served as distractors and the distractor categories now served as targets. Under the new conditions, for the younger group, response times increased indicating that interference from an automated attention response to the previous target categories had formed during training. Most of the older group (16 out of 24) did not show this effect and this is seen as consistent with other reports that older adults do not form automated attention responses. The suggestion taken from this is that, while older adults may be more flexible in learning new sets of associations, what they do learn remains attention demanding.

However recent work by Wu et al. (2004, 2005) suggests that older people can in fact form automated responses, at least in sequences of motor actions. Using brain imaging Wu et al. found that older subjects took longer to achieve automatic responses and that they recruited greater areas of the brain to achieve these responses. These effects were increased by the complexity of the movement sequence being learnt. Wu et al. suggest that these extensively greater activated brain regions indicate that the strategy aged subjects use for execution of automatic movements is obviously less efficient. They appear to require more brain activity to compensate for the greater difficulty they have in performing automatically at the same level as young subjects. This appears to be the main reason why aged subjects have more difficulty in achieving automaticity.

Where older adults do possess automated responses a study by Rogers and Fisk (1991) found that these automated responses led to higher levels of disruption for an older group on tasks that made the automated response inappropriate. On the other hand Kelley (1996) showed that for subjects trained on an experimental word processor, young expert users (20 - 35) showed more disruption than older expert users (50 - 65) when learning a version which contained a non standard sequence of actions for selecting and changing an object. This is consistent with the older subjects not automating their learning over the course of Kelly's experiment and thus having a lower barrier to conscious control of the learnt behavior.

Summary of findings about aging and attention

Attention and vigilance

- There are some problems with maintaining focused performance over time but this appears to depend on the type of task

Selective attention

- Poorer ability to inhibit responses to irrelevant items
- Less ability to control an activity with a top-down plan of action

Dual task performance

- Less able to do multiple tasks at once if the tasks are complex
- Problems in dual task situations may paradoxically show on the task that takes less concentration
- Anxiety reduces dual task performance

Automated responses

- New automatic responses are hard to form for older people
- Existing automatic responses are harder to suppress if necessary due to changed circumstances

2.9.2 Possible Effects of Age-related Changes in Attention on Interface Design

Attention and vigilance – relevant changes

- There are some problems with maintaining focused performance over time but this appears to depend on the type of task

Attention and vigilance – design suggestions

If applications need to involve older people in vigilance or monitoring tasks this should raise a note of caution in the designer's mind. Obviously it is preferable if the application can perform the monitoring but if older humans must be involved the question becomes one of careful usability testing. From the findings so far we know that poorer performance on monitoring tasks by older people is possible but we do not know under what conditions, so it is left to the designer to see if the particular application that they are working on triggers vigilance difficulties for older users.

It also seems possible that older people, or at least some older people, may be more easily distracted while in the middle of long computer tasks. This might mean that older people would benefit from information that re-establishes where they were in a task. The challenge is to create such features without creating extra tools for older people to learn, the answer might lie in simple solutions such as re-finding one's position in a long text passage through an insertion point that becomes more distinctive over time if the screen is unattended.

Selective attention – relevant changes

- Poorer ability to inhibit responses to irrelevant items
- Less ability to control an activity with a top-down plan of action

Selective attention – design suggestions

Older people will be more easily distracted by features that are not relevant to the task they are engaged in. The design response is again to simplify and to remove irrelevant features. Obvious distractions such as graphics that are not required for the task, animation, flashing parts of a screen or moving text are easy to identify and remove if a designer is willing to think in terms of usability rather than appearance. A problem remains in that what older people find distracting may fall below the distraction thresholds of younger designers. What a younger designer may find comfortable to live with might reduce the ability of some older people to use the intended design. Once again there is a case for careful testing and discussion with older people as part of design. Another issue is with control over the on-screen environment. If an application for older people uses screens that are not full screen there is a potential for distracting displays to exist in the background that are from other applications of from a browser. Since some older people have limited understanding of windows management they will not be able to re-arrange the task window to hide the distraction, nor should they be required to do so. Designing applications for older people with full screen windows rather than overlapping windows gives a designer appropriate control over the environment in which the older users will work.

However even with carefully designed simplicity as a user works through the sequence of a task, at any point in time some of the elements of a screen will be immediately relevant, other elements will provide confirmation of completion of previous parts of a task and some elements will become relevant in later parts of the task. Older people's problems with selective attention, possibly combined with a narrower effective field of view and a poorer mental model of the application mean that the designer may need to give more care to providing interface elements for guiding older people through a task sequence than would be the case for younger people. This might be achieved by careful layout where the design elements to be used in the next sub-task are always close to the end point of the previous sub-task. More active solutions such as graying out areas of a screen that are not immediately relevant, may meet problems from older users' lack of knowledge of conventions such as graying out unavailable features and older users problems with reading greyed text given its lack of contrast with the background.

Attention and Dual task performance – relevant changes

- Less able to do multiple tasks at once if the tasks are complex
- Problems in dual task situations may paradoxically show on the task that takes less concentration
- Anxiety reduces dual task performance

Attention and Dual task performance – design suggestions

Divided attention in dual task situations seems applicable to many application tasks. Consider word processing where attention must be split between composing the document and manipulating the interface. It is convenient to refer to the composition task as the substantive task, this is what the user came to the computer to achieve. The other task is the interface task and this can be seen as potentially competing for the older user’s attentional and cognitive resources with the substantive task. Interface designers can perhaps ignore the theoretical distinction between divided attention over multiple tasks and overall task complexity and concentrate on reducing the effort and attentional resources required by the interface.

A similar issue exists here as for the preceding section on selective attention. A young designer is not in a position to easily decide what makes an interface resource hungry for older users. Given poorer vision, less idiomatic computing knowledge, less motor control and a more limited application model, older users will devote resources to aspects of an interface that a younger designer is likely to find make minimal demands for attention. The solution is again to obtain the participation of older people in design so that the designer’s perspective is modified.

The issue raised by Korteling (1994) is that under dual task situations the impaired performance that occurs when one task becomes harder may show on the concurrent task, not the task with increased difficulty, as the older person diverts resources to the more difficult task. This has serious implications for testing new interface features with older people, we should be concerned not simply that older people can use a new feature but that they can maintain task performance on the substantive task while using a new interface feature.

Attention and Automated responses – relevant changes

- New automatic responses are hard to form for older people
- Existing automatic responses are harder to suppress if necessary due to changed circumstances

Attention and Automated responses – design suggestions

The problems with forming automated responses are potentially very important. Automated responses are a key method by which users reduce the cognitive load of an application. From the work by Rogers, Fisk et al. (1994) and Wu et al. (2004, 2005) we can expect that older people will not form automated responses quickly and that comparatively simple actions for controlling the interface will remain attention demanding for much longer in older adults than in younger adults. It is not certain that automated responses are entirely an all or nothing aspect of brain function and the possibility still exists that older users may offload some of the attentional demand of interface features that they have first encountered in old age by a form of partially automated response.

For older experienced software users one might expect that previously acquired automated responses would seriously interfere with learning new applications which required conflicting responses. However Kelley's (1996) results cited above either conflict with this or suggest that we need to be cautious about assuming that older experts have in fact automated their responses simply because we have classified them as expert. Lassiter et al.'s 1996 paper also indicates that we may need to consider when skills were acquired if we want to interpret the effect of well learnt skills on aging and performance. Kortelling’s (1994) findings also suggest that the problems emerging from alteration of established tasks may appear in concurrent or underlying tasks rather than the behavior directly affected by the new task. The implication is that older users may be observed to cope with a new interface feature but will in fact have a significant reduction in the cognitive capacity available for other tasks.

2.10 Cognitive ability and Aging

2.10.1 Studies of Intelligence and Aging

There are considerable problems with even the definition of intelligence. Some authorities argue for a single generalized factor while others argue for multiple mental abilities each involving some distinct areas of the brain. Measurement is also a matter of difficulty, the initial thrust of intelligence testing was to look at the rate of individual development relative to the average so as to identify individuals who could benefit from special assistance. Work with adults, aimed at studying intelligence changes with age, needs to work with raw scores on adult intelligence tests rather than with the traditional approach of adjusting scores for age group to obtain an intelligence quotient. Modern adult intelligence tests consist of batteries of subtests each covering different aspects of mental ability.

A large scale cross sectional study by Schaie and Willis (1993) provides detail of the sorts of declines in mental ability found with age. In this study four sets of abilities;

inductive reasoning, spatial orientation, perceptual speed and associative memory showed a similar pattern of a performance plateau extending to about 40 years of age followed by a steep and relatively steady decline of the order of about 30% by age 90. (Associative memory is the ability to recall relevant information through associations with information presented in a problem.)

Two other abilities; verbal ability and numeric ability showed a different pattern with age - a performance plateau or even slight gains over the period up to the mid 60s and then a decline of about 10 - 20% by age 90. To avoid confusing overlap these two patterns are illustrated by data only for inductive reasoning and numeric ability in the graph in Figure 2.5

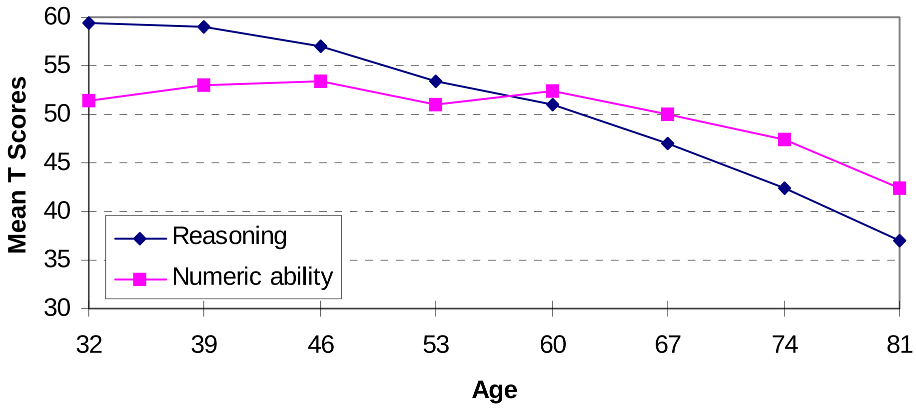

Figure 2.5 Decline in reasoning and numeric ability with age - cross sectional data adapted from Schaie and Willis (1993)

The cross sectional data are alarming, the onset of senility appears rapid and inevitable. It should be noted that the charts present the data with a cutoff value of 30 on the Y axis which accentuates the apparent decline. More importantly it has become clear from repeated comparisons of cross sectional and longitudinal data that cross sectional data do not give a valid picture of the progress of intellectual functioning in individuals over time. The key set of longitudinal studies is the Seattle Study started in 1956 by Schaie, see Schaie (1996) for a review. The reports arising from this and other longitudinal studies give a different picture in which performance on various mental abilities is maintained or even displays gains until around 55 and then shows some decline from this age. The data is displayed in the graphs below where composite longitudinal data based on combining the shifts in abilities within cohorts over 7 year periods is contrasted to the cross sectional data from the 1977 test period of the study

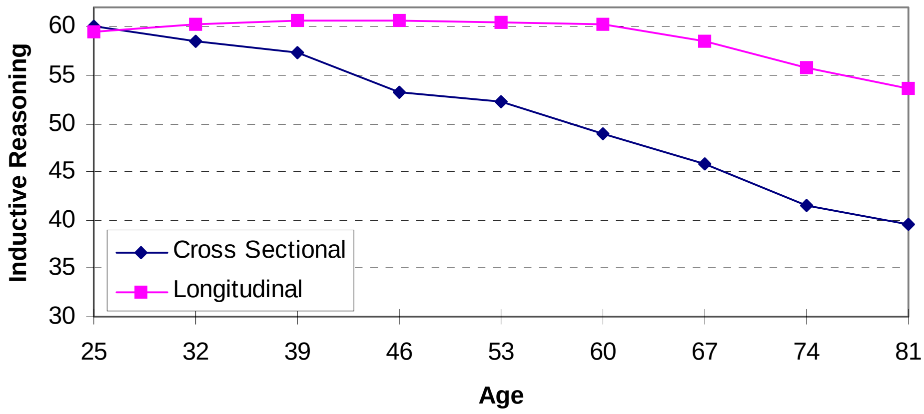

Figure 2.6 Reasoning - cross-sectional versus longitudinal scores. Adapted from Schaie (1985, 1996)

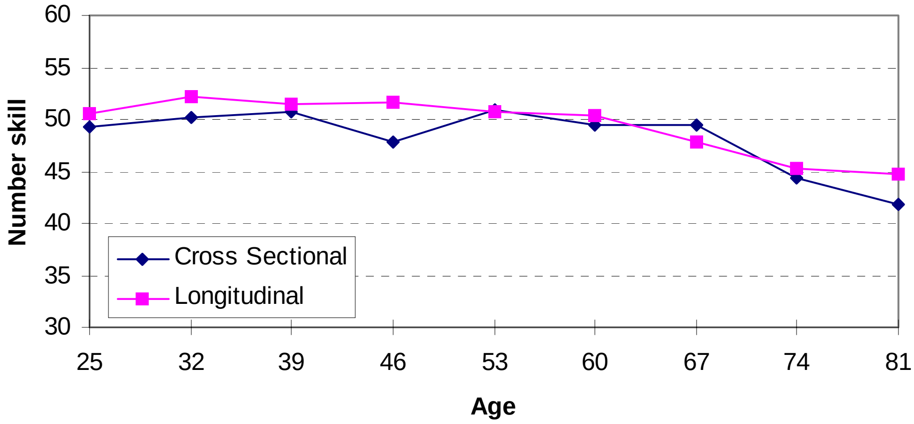

Figure 2.7 Number tests - cross-sectional versus longitudinal scores. Adapted from Schaie (1985, 1996)

Schaie (1996) confirmed his earlier findings when analyzing later results from the Seattle study. In essence longitudinal scores on verbal meaning, spatial orientation and inductive reasoning improve from a baseline figure at 25, peak sometime in the 40s and 50s and do not decline to baseline levels until the mid 60s or early 70s. A pattern of accelerating decline shows in the late 70s and 80s. A different pattern shows for longitudinal scores on measures of numeric ability and verbal fluency where decline starts in the 30s. Schaie suggests that longitudinal change over short periods is minimal in normal individuals and that major decline in intellectual abilities is limited to late old age and probably mainly in abilities which were not central to the individual's life experience.

The longitudinal decline, based on composite data, shows *individuals* maintaining the ability they had in their 20s until their mid 60s. However Charness (1998) notes that as Schaie adds more measurement occasions, decline is detected at earlier ages. Charness suggests this is probably due to the greater power to detect change as longitudinal age ranges approach cross-sectional study ranges. The cross-sectional data show that today's older age groups do not score as well as today's younger age groups and that the difference between them is significant and increases as the ages compared become more different. This demonstrates the Flynn effect, a well documented increase in the ability to score on intelligence tests for each generation this century, see Heylighen (2000).

Perceptual speed

Longitudinal scores on measures of perceptual speed taken in the more recent test periods of the Seattle study show a markedly different pattern to measures of intellectual function. Perceptual speed showed an almost linear drop in perceptual speed from age 25 leading to about 1/3 reduction by age 88. Lindenberger, Mayr and Kliegl (1993) found that there was little direct relationship between age and measures of intelligence. In an analysis using latent variables they found that age related to speed and speed in turn related to the measures of intelligence, *even though these measures of intelligence did not depend on speed of completion*. This extends the numerous studies by Salthouse showing that the relation between aging and a number of cognitive measures depends on the relation between aging and perceptual speed, see Salthouse (1996) for a review. Birren has maintained since 1951 that speed is an important factor in intellectual performance and that if a person is unable to think quickly then they are unable to think well, Birren and Fisher (1992).

Schaie reports in his 1996 review that age of peak performance and age of onset of decline appears to be occurring later in life when cross sectional figures for performance by each age group are contrasted between 1970 and 1991. Schaie found that each succeeding generation showed increased scores on measures of verbal meaning, inductive reasoning and spatial orientation. (In contrast there is a striking decline in numeric ability which appears for Seattle residents to have peaked for those born in 1924 and declined fairly steadily for those born in later years.) Rybash et al. (1995) suggest that to explain improved performance in successive birth cohorts we should look at increased years of formal education, a greater cognitive orientation in work tasks and improvements in treatment of disease.

Selective drop out of impaired individuals will boost results in longitudinal studies, see Rabbitt et al. (2004) but the difference between cross-sectional and longitudinal studies also reflects the point that social changes over this century have boosted the ability of succeeding cohorts to obtain results on IQ tests. The increase is of the order of three IQ points per decade, this increase has been found for virtually every type of intelligence test in a wide range of countries. The effect is actually stronger on non-verbal tests. This effect, known as the Flynn effect, is supported by a number of studies, see Heylighen (2000) for a review. One consequence of the Flynn effect is to strengthen the difference between younger people's view of average performance and older people's actual attainment. Heylighen notes that older people who were rated as high performing early in the 20th century (on the Raven progressive matrices test) would now be rated as below average in performance.

Schaie reported in a 1990 analysis that individuals exhibited very variable patterns of decline when he looked at longitudinal results over differing mental abilities.

Table 2.2. Percent of individuals showing decline over time on specific mental abilities

Mental Ability	Age 53 - 60	Age 60 - 67	Age 67 - 74	Age 74 - 81
Verbal meaning	15	25	27	36
Spatial orientation	21	27	30	33
Inductive reasoning	14	26	24	28
Number	17	26	26	32
Word fluency	24	28	27	37

Table 2.3. Percent of individuals showing decline over time by number of abilities impaired

No. of Abilities	Age 53 - 60	Age 60 - 67	Age 67 - 74	Age 74 - 81
0	41	27	24	15
1	35	35	38	37
2	17	22	22	25
3	5	10	11	14
4	1	5	4	6
5	< 1	< 1	1	2

The point made clearly in the two preceding tables is that decline for an individual is likely to be on two or fewer abilities. Which abilities are affected and which are unimpaired appears to be almost random, though which abilities are preserved may be affected by an individual's career choices, activities and interests. This is not a population for which concentrating on one or two specific problem areas will provide a widely applicable solution. Schaie (1996) and Baltes (1993) make the point that ability loss is likely to be shown only in situations which are complex and challenging enough to require activation of an individual's reserve capacities. Most normal and routine activity is likely to be largely unaffected by the losses of aging. However where individuals do show declines on intellectual functioning they may simultaneously be disadvantaged by declines in perception. As part of the Maastricht Aging Study, Valentijn et al. (2005) looked at the relationship between perception and cognitive functioning. Acuity measures in both visual and auditory perception were strongly correlated with a number of measures of cognitive functioning and this finding held for both cross-sectional and a longitudinal data.

Crystallized intelligence and fluid intelligence

A different approach first developed by Horn (1970) attempts to divide intelligence into crystallized intelligence and fluid intelligence. Crystallized intelligence corresponds to performance based on life experience and cultural knowledge held in long term memory. Fluid intelligence on the other hand, measures skills of perception and abstract reasoning that are not directly incorporated in experience but are more directly related to the integrity of the central nervous system. Fluid intelligence is thought to be more important in novel task performance while crystallized intelligence is related to achievement on well practiced and familiar tasks.

Studies by Horn (1970, 1982) and Horn and Donaldson (1976) show that there are gains on crystallized intelligence up to the sixties which tend to compensate for the losses shown on measures of fluid intelligence so that overall intellectual performance declines only slightly. This can be seen as compatible with views held by Dittman-Kohli and Baltes (1988) suggesting that practical and social intelligence increases with age and that these aspects of functioning are not well measured by traditional IQ tests. This gets some support from Cornelius and Caspi (1987) who found measures of practical problem solving and verbal meaning increased with age while a letter series test showed scores peaking at about 40 and then declining. Beier and Ackerman (2005) examined the role of prior knowledge, fluid intelligence, and crystallized intelligence in a task involving learning new information. It was found that all three factors contributed to learning. Beier and Ackerman argue that this provides a more optimistic perspective on the relationship between aging and learning than that offered by theories that focus only on the role of fluid abilities in learning.

Expertise

There is a general belief that once the current generation of older users who have to learn computing skills in old age are replaced by future generations of older people then the difficulties with older users will become unimportant. As part of examining this it is useful to examine other areas where skill is maintained into old age. Studies by Salthouse (1984) on typists and by Clancy and Hoyer (1994) on medical technologists showed that experts retained high levels of performance in skills specific to their area of expertise while showing normal declines in areas such as figure identification and reaction time which might be argued to underlie their specific skills. Salthouse’s work also showed that, for expert older typists, the maintenance of typing skill depended on developing compensating strategies for reduced speed and reaction time. The older typists planned keystrokes further ahead than younger skilled typists. Szylk et al. (1995) looked at driving performance with age. They found that older adults drove more slowly and made more eye movements, compensatory actions which translated into a lower real world accident rate for the older drivers in spite of the younger groups' faster responses. It is of interest that the older adults showed poorer driving in a simulator in contrast to their real world performance. Does this suggest that older adults did not adapt as well to a generally familiar task (driving) in a new setting (the simulator)? If this interpretation is valid it reinforces concern for the adaptability of older adults.

Masunaga and Horn (2001) looked at Go players and found that expertise (in Go) related working memory and expertise (in Go) related deductive reasoning were independent of general fluid reasoning and general short-term working memory measures. While, overall, players showed a decline in the expertise related measures with age this did not show for the more expert players and decline appeared to be reduced by intensive practice.

Lindenberger et al. (1992) and Salthouse et al. (1990) found that older experts in architecture and graphic design showed significant declines on measures of general visual thinking and imagery. Bosman (1996) found that skilled typing in old age translated into faster responses only on finger movements that specifically matched standard typing keystrokes. On non practiced movements such as responding with a Z or a / when the fingers started at rest on either the Z or / keys older skilled typists did not have an advantage over older low skilled typists. It seems that expert performance is maintained only over narrowly specific areas as skilled people age.

Docampo Rama et al. (2001) have made the interesting suggestion that there is in fact another aspect to the ease with which people model the concepts underlying skilled performance. Docampo Rama et al. showed that it is possible to disentangle general effects of aging from and effect due to a generational shift. In Docampo Rama et al.'s work suggests that those who grew up before 1960 had a world view that was shaped by interacting with electro-mechanical devices (basically an off/on style of interaction) while the different forms of interfaces associated with electronic devices such as sliders led to a world view that was easier to adapt to graphical user interfaces for those who grew up after 1960. Thus major shifts in technology paradigms after a person matures may be more difficult for that person to adapt to, at least on initial exposure to examples of the new paradigm.

Decision making and information seeking

Ronnlund et al. (2005), note that there is a relative lack of studies addressing issues concerning decision making in older adults in general. We do know that older people have problems in understanding complex text, see Light (1990). They also appear to do less well in extracting information from complex data, for example see Chadwick-Dias et al. (2003) on older adults' ability to cope with large tables of data. Thus older adults may have poorer resources with which to begin decision making. There is also some evidence of generally poorer decision making in older people as the following research indicates.

Decision making can be slower in older adults. This may not simply be due to differences in processing speed or cognitive capacity. Ratcliff et al. (2001) identified two other comparisons between the decision making of older adults and young adults. First, the older adults set more conservative criteria than the young adults, accumulating more information before making a response. Second, the non-decisional components (encoding and response execution) of processing were slower for the older adults. Deakin et al. (2004) looked at a computerized gambling task and found that aging was associated with longer deliberation times, poorer decision making and reduced risk taking. Lemaire et al. (2004) had young and older adults estimate values for 2-by-2-digit multiplication problems under varying conditions of speed and accuracy emphasis. It was found that as well as being slower and less accurate, older adults chose estimation strategies less adaptively than young adults.

Mell et al. (2005), note that flexible learning of stimulus-reward associations, when required by situational context, is essential for everyday behavior but may be more difficult for older adults. The task studied required learning and reversing associations between actions and their outcomes as the context changed. Older participants had more difficulty with this than a younger group. They collected fewer points, needed more trials to reach the learning criterion, and completed less blocks successfully compared to young adults.

Mead et al. (1996) looked at on-line library catalog use by older and younger groups of roughly equal levels of education and found that the older users had a range of problems formulating command line queries. Problems included wrong search catagories, missing commands and errors when attempting use of logical AND or ALL. Notably older users not only made more initial errors but were significantly poorer in recovering from them. In a later study Mead et al. compared users by age and by degree of computer experience. Previous findings were generally confirmed. In addition computer experience made little difference for younger users (but the range of experience was from low to high). Older people with low computer experience showed somewhat poorer performance than young people with low computer experience but the most disadvantaged group were older people with no computer experience. Despite a prior training session on use of the library catalog older people with no computer experience had a much poorer success rate, completed fewer searches, often avoided the slightly more complex tasks, took up to 5 hours to attempt 10 searches and showed poorer understanding of the underlying basis of the search. This was in spite of the older subjects being more educated than the general older population. It was pointed out that older library users are in fact less likely to make use of computerized catalogs and the authors suggest that current library search designs significantly disadvantage older users.

Zaphiris et al. (2003) looked at various ways of linking pages into a tree. They examined different depths of link structure and they examined different ways of presenting the links. They found that both older and younger groups preferred broad shallow trees. While older adults were slower and more error prone, the rate at which difficulty increased as depth of structure increased was similar to the rate of increase for the younger group. However when the authors looked at different ways of presenting the tree structure they found striking contrasts between young and old. The two forms of presentation consisted of an expandable view of the tree structure and a non-expandable view of the tree structure. In the expandable sets of links the view was such that any set of branches could be expanded or compressed so that clicking on a link resulted in a new page showing the same tree but with a different section expanded. In the non-expandable links clicking on a link would show a new page displaying only the links that branched from the previous link. In the expandable condition shown on the left in Figure 2.8 the expanded tree always fitted onto the page without scrolling so that scrolling problems cannot be used to account for the age related differences.

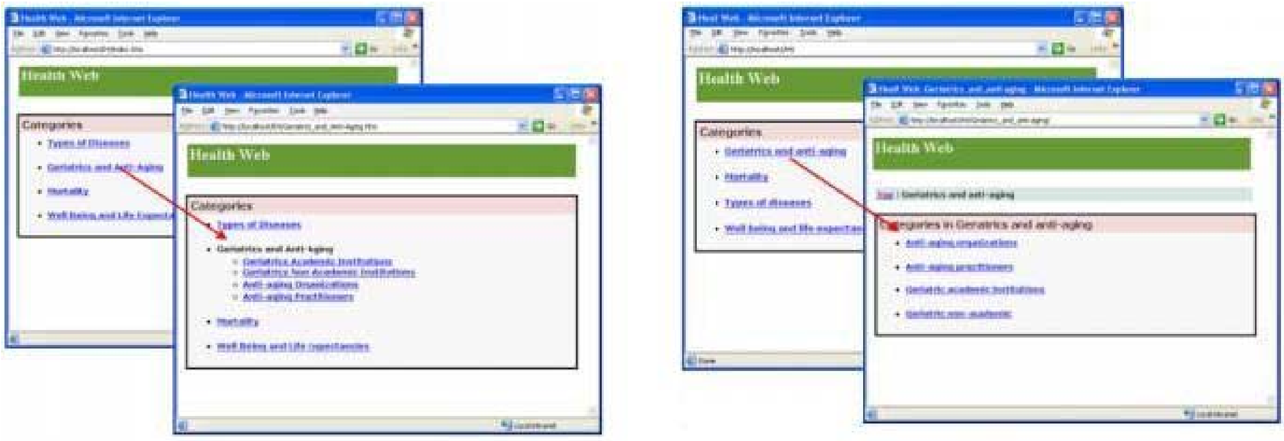

Figure 2.8 Examples of Expandable (on left) and Non-expandable views of a tree of links, adapted from Zaphiris et al. (2003).

Older adults showed greater loss of orientation when working with expandable sets of links than when working with non-expandable links in order to navigate a tree structure. The difference between young and old with depth of structure was markedly worse when using expandable links. Older participants preferred the non-expandable hierarchies, whereas their younger counterparts preferred the expandable hierarchies.

Training and plasticity

Baltes in a 1987 paper introduced the idea of plasticity of adult intellectual development where training or life experiences can enhance test performance. A number of papers have supported this concept but it is not clear to what extent this represents generalizeable enhancement of life skills beyond test taking. See Baltes (1993) for a review. There is however general consensus that adults are able to benefit from education and training well into old age. Studies on improving cognitive performance by training have showed that 5 hours of training can significantly improve test scores over a range of cognitive abilities; see Baltes and Willis (1982) and Schaie and Willis (1986). More impressively two follow-up studies have shown that the effects of such 5-hour training show up in significantly lower levels of decline over a seven-year period, Willis and Nesselroade (1990), Willis and Schaie (1994). Schaie sums up the findings with the statement “It seems likely that periodic reactivation of specific mental skills is likely to reduce the magnitude of intellectual decline in community dwelling persons" Schaie (1996, p280).

There is also a suggestion from explanations of cohort effects that longer periods of earlier education and training facilitate later ability to learn as well as general retention of cognitive ability. Schaie (1989) found that high levels of education predicted that individuals would show slower rates of intellectual decline. Dutta (1992) and others cited in Schaie (1996) provide evidence that high job status and work complexity indicate a likelihood of maintaining cognitive functioning into old age. However it appears to be education, not initial ability that is in effect here. Rabbitt et al. (2003) cast some doubt on the claim that people with higher intelligence in youth maintain better intellectual functioning in old age. Scores on a vocabulary test were found to be stable with aging while measures of fluid intelligence declined sharply over the period 42 - 92. Further, in younger people, the verbal scores were found to be closely correlated with scores on fluid intelligence. Rabbitt et al. therefore used the verbal scores in their older subjects to estimate the fluid intelligence that these older people had possessed when they were young. When the rate of decline in fluid intelligence was then calculated the rate of estimated decline did not vary according to initial levels of intelligence.

Summary of findings about aging and cognitive performance

- Reasoning ability declines
- Speed of mental processing slows
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- Older people are slower and less able at decision making
- When faced with problems older people rely more on existing knowledge and are less able to work out new solutions, (crystallized versus fluid intelligence).
- The performance of older experts is maintained at levels similar to younger experts but this depends on high levels of practice and does not translate into general ability in areas that relate to the expertise
- While intellectual decline is relatively slow if one follows the same individuals over time, the gap between today's younger people and older people is wider than the gap between today's older people as they were when young and as they

are now. This is due to a well established but not fully explained improvement by each generation in test performance, (the Flynn effect).

- Losses of types of mental functioning are not uniform, they vary widely between older individuals
- Older people adopt a more conservative strategy with regard to risk taking
- Ability to work with spatial problems declines

2.10.2 Possible Effects of Age-related Changes in Intelligence on Interface Design

Simpler conceptual modeling – relevant changes

- Reasoning ability declines, older people are poorer at making inferences
- Older people have poorer comprehension of complex information
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- Older people are slower and less able at decision making
- When faced with problems older people rely more on existing knowledge and are less able to work out new solutions, (crystallized versus fluid intelligence).

Simpler conceptual modeling – design suggestions

Older people will create and use simpler system models so systems for older people should be such that they fit simple modeling. Remembering that older people find it harder to ignore irrelevant information, this will normally mean simpler versions of applications for older people with either less features or with some features suppressed. Instructions for older people will benefit from being short and simply expressed. As an extension to this, interaction design for older users should be such that it suits short, simple explanation. Fisk et al. (2004) suggest that one of the things that contributes to simplicity when trying to understand text (or applications) is the use of familiar terms and concepts. Because older people have problems with inference and do not benefit as much from associative memory, Fisk et al. (2004) suggest that designs for older people should explicitly spell out connections between features and actions that younger people might be expected to infer. We do not know if this means applications that display simple procedural instructions at the level of “Step 5 press the [OK] button” but the level of “knowledge in the world” and the presentation format of such information needed to extend the range of older people who can use applications would appear to be a useful area of investigation.

Older people will also have simpler models of the graphical user interface environment, the operating system and the machine. Since older people have problems with inference, applications should not depend on older people reasoning from knowledge that might be assumed to be standard (or even elementary) in these areas. In older users the knowledge may well be missing or incomplete but even if the knowledge is there it will be more difficult for older users to form correct inferences from such knowledge.

Older people may benefit from training on considerably simplified versions of applications where the initial system model learnt is correspondingly simple. The issues here are firstly, can an older person benefit from a training version of an application to form an adequate if simple model of the situation that the full application addresses, and secondly, can they apply such a model to guiding their interaction with the full application. This also raises the possibility of older people benefiting from multi layered application designs that allow users with limited needs to work with a simplified and reduced feature set, only adding additional features as required and making it easy to drop features that are difficult to use or understand.

By depending on experience (crystallized intelligence) rather than on new reasoning about situations (fluid intelligence) older people may maintain performance on applications or parts of applications that are the same as past applications they have used. However they may be unable to proceed where there are apparently small differences in the way of proceeding towards the same aim. Designers may need to be much more careful about maintaining interface consistency between versions of applications when designing for older people.

Older people may be less able to adapt to modal responses to commands where the response to a command varies with context. Hence design for older people should avoid results from responses that are situation dependant. If older people become stuck they will have less ability to work out what has gone wrong and how to recover from this. Older users will benefit from applications that protect them from errors and have error messages that clearly and simply explain how to correct a problem. Applications for older users should provide very simple procedures for undoing, trying again or for working out what should be done. Older people will need longer to respond to information. For older people all aspects of response to information presented by applications need to be user paced.

Older people are more likely to learn associations at a specific rather than general level. This means that aims such as saving, scrolling and so forth will be associated with the specific appearance of the controls used to make the action happen, similar aims but visually different controls are likely to require that they are learnt separately. Younger people may reduce cognitive load by seeing that a new control with a couple of arrowhead icons for moving through a set of pictures uses the general scrolling model. Older people fail to make such a generalization, will learn such a control separately and experience increased cognitive load. Where standard patterns of interaction exist, using the standard appearance for controls, not simply the concept behind the pattern, will assist those older users who know the pattern.

Decision making, Information gathering, Problem and information presentation – relevant changes

- Older people's declines in cognitive function are likely to show under novel situations and conditions of increased cognitive load, although older people's performance may be well preserved in familiar activities.
- Older people adopt a more conservative strategy with regard to risk taking
- Ability to work with spatial problems declines
- Speed of mental processing slows
- Reasoning ability declines, older people are poorer at making inferences
- Older people have poorer comprehension of complex information
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- Older people are slower and less able at decision making

Decision making, Information gathering, Problem and information presentation – design suggestions

Tufte (1983) made the point that differences in the way that information is presented can make large differences in problem solving and interpretation of data, conversely poor presentation of information can create difficulties in achieving accurate understanding. It seems reasonable that older users will both benefit more by simple presentation of information and be more affected by information presentation that departs from simplicity. For example Chadwick-Dias et al. (2003) found that where web pages had large data tables, older users had significant difficulty accessing information and often could not move beyond that page while attempting to complete a task. However the actual form of information presentation that older people will find best in simplifying modeling of information is uncertain. Consider for example Zaphiris et al.'s work on extensible versus non-extensible views of tree data where showing the tree structure more fully, via the extensible view, led to poorer orientation by the older users, Zaphiris et al. (2003). We need to be aware that there may be a disproportionate pay-off from giving simple representation of data to older people but we should be very cautious about what such simple representations will consist of.

It is not clear how the findings that older people show declines on spatial ability should be interpreted by interface designers. The findings come mainly from experiments involving mental rotation of figures, not a common feature of interface designs. However it has also been found that spatial ability as measured by figure rotation tests correlates with the ability of older people to learn new applications. On the other hand it has been shown that older people can benefit from site maps which incorporate a form of spatial information. Fisk et al. (2004) suggest that spatial ability indicates the ability to infer extra information from the visual presentation. The implication for interface designers might then be to make the transition from visual representation to system model as simple as possible and to be particularly cautious in testing whether older users can benefit from spatial presentation and layout information. It may be that providing support in the area of spatial inference could provide assistance with the large table problems identified by Chadwick-Dias et al.

Cognitive performance gaps between young and old – relevant changes

- Older people's declines in cognitive function are likely to show under novel situations and conditions of increased cognitive load while older people's performance may be well preserved in familiar activities.
- While intellectual decline is relatively slow if one follows the same individuals over time, the gap between today's younger people and older people is wider than the gap between today's older people as they were when young and as they are now. This is due to a well established but not fully explained improvement by each generation in test performance, (the Flynn effect).
- The performance of older experts is maintained at levels similar to younger experts but this depends on high levels of practice and does not translate into general ability in areas that relate to the expertise
- Losses of types of mental functioning are not uniform, they vary widely between older individuals

Cognitive performance gaps between young and old – design suggestions

Examination of the longitudinal data on various aspects of intelligence implies that most individuals should maintain reasonable intellectual functioning until their mid sixties. Further only a small minority are likely to show impairment in multiple areas of mental functioning. Again impaired functioning should only be apparent in tasks whose difficulty challenges individual's cognitive reserves, routine tasks, including well-learned computing tasks, should be carried out with little decline in performance.

What is of concern is that younger designers may either attempt to model the likely performance of older users on their own performance or they may take evidence of older people functioning normally in familiar settings as evidence that the older people will be competent in the new circumstances into which the designers are about to thrust them. Neither assumption is likely to be helpful. The Flynn effect seems likely to increase the gap between younger designers and older users when it comes to intuition about what constitutes an easily solvable problem. What younger designers assume to be simple may be see as too difficult by older people. There is more need to check with actual older users when designing for older people than is the case when designing for younger people.

Older people may be seen as having a degree of expertise in everyday living. However it would be mistaken to take this as evidence of ability to cope in new areas or even areas seemingly related to existing skills. The performance of older experts is maintained at levels similar to younger experts but this does not translate into general ability in areas that might be expected to relate to the skill set, visual thinking for example is not disproportionately preserved in older architects. Maintaining expertise in old age depends on high levels of practice. Masunaga and Horn's (2001) findings on Go players suggest that as well as needing practice, expertise is better maintained in those who enter old age with a very high level of expertise, moderate players show declines in skill with aging. It also seems that expertise in old age is best produced in a relatively narrow and highly familiar context, Szylk et al. (1995). This raises questions as to how well computing skills acquired by future generations of older computer users before they age, will assist their computing use in old age.

A variety of issues mean that the disadvantaged status of older computer users may ease but is unlikely to disappear. Masunaga and Horn's findings may indicate a reason for concern in that few older people will enter old age as highly expert computer users and with full or partial retirement the level of practice of their skills can be expected to reduce. Szylk et al.'s work and the lack of general preservation of ability in skill related areas suggests that skills are maintained with a very narrow focus indeed and that the paradigm shifts and feature changes that are an economic driver of the computing industry will erode the relevance of the computing skills that older people bring into old age. We know that driving skills decline with age, we would expect this to be much more pronounced if cars changed paradigms rapidly, the same seems likely for computing skills. It appears probable that future generations of older people will not have generalizable computing skills that will allow them to work well in new computing environments.

2.11 Learning, Training and Aging

2.11.1 Studies of learning and older people

Baldi (1997) has reviewed the literature on training older adults to use applications. The papers reviewed indicate that while older adults can learn applications it may take them twice as long to reach the same level as younger users. Older adults also needed more assistance during learning. Baldi also noted reports that prior experience with computers improved learning for older adults. What is not clear from the papers Baldi reviews is what happens to older learning as program complexity increases, some of the negative findings on successful learning involved Lotus 1-2-3. Bosman and Charness (1996) suggest that declining cognitive resources may hamper acquisition of new skills in older adults. It seems reasonable that this will depend on the complexity of the skill being learned. Kelley and Charness (1995) reviewed twelve studies in which older users were trained to use computer applications and found that in ten of the studies the older users had significantly greater difficulty in learning. It should be noted that these were older pre-Windows applications, the duration of training was short – less than a week and the subjects were computer novices. Czaja and Sharit (1993) found that the level of prior computer experience outweighed the effects of age when considering performance on training to use an application. It is also worth considering that older people have been shown to have a more negative bias in self evaluation and that they may further see learning computer skills as more challenging for the old in particular. Stresses caused by such expectations could impede learning, Baldi (1997).

Where learning is seen or experienced as difficult or unrewarding it would seem probable that learning is minimized so that a person learns a bare minimum for surviving in a particular computing environment. It may also be that minimizing learning is a strategy for reducing the complexity of the material older adults face when meeting new computer tasks. Once a method has been learned there may be resistance to abandoning it to learn a more efficient alternative. Given richly featured and evolving applications and operating systems this has potential implications for the efficiency of older users. Perlmutter and Mitchell (1982) suggested that some of older peoples' memory problems are due to differences in applying strategies for organizing material. It is worth asking if there are differences in the way older people organize information about richly featured applications and whether more effective patterns of organization can be offered. However Touron and Hertzog (2004) found that older people's belief that they would not be able to learn a system for improving memory by using categories meant that they avoided such learning when in fact they were able to benefit from it. We can ask if older people have less effective application models and is this subject to training effects? It may be worthwhile to consider if older users are more averse to making mistakes while learning applications, show less one-shot or incidental learning and possibly tend to learn on tasks which are important to them rather than tasks which are artificial. There is also a concern that, particularly for older adults, poor techniques included in early learning of an application are resistant to later changes.

Rogers et al. (1996) found that the best form of training out of a brief description, a text manual, a pictorial manual and an online tutorial was the on-line tutorial. Rogers et al. concluded that this was because the older adults benefited from repeated hands on experience with the component tasks of ATM use. Note however that Charness and Bosman (1990) looking at earlier studies of training mode and learning success with older computer users report that there is no clear indication of what training mode is best. However Charness and Kelley (1995) recommend self-paced learning using a minimal manual approach for older adults. They note that the studies they review on on-line tutorials found that this represented the least satisfactory form of training, possibly because of the lack of self pacing and the lack of opportunity to learn from mistakes. They also cite findings by Caplan and Schooler (1990) which indicate that while younger users may benefit from emphasizing the metaphor underlying an application older adults performed worse on training when the desktop metaphor was explained prior to training. In Baldi's 1997 review of training a number of studies report that the method of training affects the success of older learners of computer programs. However a rather wide variety of methods are reported as being better.

There is a tradition of research using contrasting tutorial designs for teaching older users to use computer applications, see Morrell and Echt (1996, 1997) and Kelley and Charness (1995) for reviews. Morrell and Echt (1996) point out the dominant research method is to contrast two different approaches for delivering the same content. There are at least two problems here. There is a question of the fit between the content of the tutorial and its delivery medium, would the same medium have performed differently in delivering different content specifically designed for the medium? There is also the question as to how representative the tutorial studied is in relation to best practice among tutorials of the same type. Debate about the best method for teaching older people may well be unproductive, a demonstration of older people succeeding well with one approach to acquiring complex computer skills does not rule out other approaches. Note that Morrell and Echt's reviews endeavor to extract underlying principles that could be generally useful in producing instructional material for older people, rather than arguing for a particular type of instructional approach.

It may also be that, as the supporting technology improves, different approaches may become more valuable. For example earlier studies of on-line tutorials such as Gist et al. (1988) found them to be a poor form of instruction for older people but later studies are more likely to support on-line tutorials, emphasizing the advantages of active performance of procedural steps by the learners, see Mead & Fisk (1998), Morrell, et al. (2000), Rogers, et al. (1996), Czaja & Lee (2001). Morrell et al. (2000) found that providing older learners with background conceptual information in addition to step by step instructions led to poorer performance both immediately after training and on retesting one week later. Morrell as well as Czaja and Lee (2001) and Rogers (2000) argue for providing the older user with active hands on learning. These studies used limited tutorials constructed purely for use in their experiments. However they give overall support for computer based training as a method of training older people in computer skills.

We can summarize the guidelines for instructional material and delivery for older people offered by Morrell and Echt (1996, 1997), Morrow and Leirer (1999), Morrell et al. (2000), Rogers (2000) and Willis (2004) as follows.

- Text formatting: Use a typeface with rounded distinctive sans-serif letters (e.g. Helvetica), use 12 to 14 point with strong contrast between letters and background, use short, left justified lines with a maximum of 65 characters per line, use white space to increase clarity.
- Instruction structure: Use lists in a standardized format, language structure and vocabulary should be kept simple, avoid the use of negatives, use an active rather than a passive voice.
- Provide an active learning situation and provide sufficient practice with task components. Ensure that the training environment is free from distractions.

- Content: Emphasize procedural steps and leave out background conceptual information, use concrete examples, some instructions should be accompanied by relevant simple illustrations since some information is not well conveyed in text, slowed animation may be useful. Training material should be well organized and important information should be highlighted.
- Ensure that help is available and easy to access
- Delivery: Allow extra time for training. Training should be self-paced and may work better in small groups
- Instructional materials for older learners should be designed so that attention can be focused on single areas, being mindful of older adult's issues with maintaining divided attention.
- General: Be aware of older peoples' problems with: reductions in working memory capacity, reductions in ability to deal with complexity, reduced color discrimination particularly in the blue green range.

What can be seen from this list is that the recommendations come from a wide range of areas related to the effects of aging on older people and techniques for addressing those effects. In fact training older people is another example of the general area of interaction design for older people. In particular training older people on computer skills and applications is going to involve computer based materials if not a full fledged interactive tutorial. From this it follows that the whole of the literature review thus far can be seen as having implications for the design of any computer based training material for older users and this includes the design of interactive tutorials. This considerably extends the number of considerations that are relevant to training older people in computer skills, we need to examine what we know of older people's learning and what we know of suitable application design for older people. In what follows we will look at implications from what is known of older people's learning and leave the issue of application design to what has already been covered in the earlier sections. However we need to acknowledge the insight of previous authors in taking recommendations not just from older people's learning patterns but also from older people's cognitive and perceptual abilities.

Summary of findings about aging and learning

Difficulties with learning

- Learning takes more effort and takes longer
- Older people can be overwhelmed by younger instructors who go too fast, present too many ideas and tend to be impatient with the slow and uncertain progress typifying older people.
- Older people's learning can be disrupted by the provision of too much information
- Learning may be limited to a minimum or inadequate skill set in some older people
- There may be a long period during which learnt items are easily forgotten and need to be relearned more than once
- Older people are likely to blame themselves for learning difficulties
- Where older people see themselves in negative age stereotyped terms this further impairs their ability to perform

Points with Implications for content

- Older people can learn a wide range of new skills
- Older people benefit from learning on a simplified model before using the more complex real world tool
- Older people benefit from a focus on learning a minimum of essential concepts and techniques
- Older people benefit from learning skills as a set of concrete procedures
- Older people benefit from actually performing skills as they learn
- Older people may benefit from simple background information that places their learning in context but they are disadvantaged by a focus on conceptual material
- Learning techniques such as ways of associating new items with categories in order to assist remembering can show continued benefit over years, but older people need encouragement to adopt such techniques

Points with implications for delivery format

- The speed with which individual older people learn varies widely
- Older people benefit from self paced learning

- Older people appear to benefit from learning in small (2 – 4) groups rather than individually or in large groups
- There appears to be a benefit in having either an instructor from the same (older) age group or an instructor who has adjusted their style to accommodate older learners

2.11.2 Implications for training older people to use applications

Difficulties with learning – relevant changes

- Learning takes more effort and takes longer
- Learning may be limited to a minimum or inadequate skill set in some older people
- There may be a long period during which learnt items are easily forgotten and need to be relearned more than once (fragile learning)
- Older people are likely to blame themselves for learning difficulties
- Where older people see themselves in negative age stereotyped terms this further impairs their ability to perform

Difficulties with learning – design suggestions

The point that learning in older people is initially fragile may imply that the instructional format should be such that older people can easily repeat sections of material, in fact a need to structure learning materials so that they can be used on demand over the period of weeks or months when previously learnt material is forgotten, re-learnt and forgotten again. It also seems likely to be useful to create a learning environment where success is easy to achieve and mistakes are easy to recover from in order to counter older learner's initial negative expectations. The point that some older people will only achieve limited learning may indicate that when deciding on instruction content the instructor should define what constitutes a survival skill set and this should be the first aim of a course for older people. However the variability of older people means that courses should allow those who are learning well to progress beyond this basic skill set.

Content of learning material – relevant changes

- Older people can learn a wide range of new skills

- Older people benefit from learning on a simplified model before using the more complex real world tool
- Older people's learning can be disrupted by the provision of too much information
- Older people benefit from a focus on learning a minimum of essential concepts and techniques
- Older people benefit from learning skills as a set of concrete procedures
- Older people benefit from actually performing skills as they learn
- Older people may benefit from simple background information that places their learning in context but they are disadvantaged by a focus on conceptual material
- Learning techniques such as ways of associating new items with categories in order to assist remembering can show continued benefit over years, but older people need encouragement to adopt such techniques

Content of learning material – design suggestions

The content of courses for older users should be rigorously simplified. Very simple conceptual background that is closely related to the skills being learnt may be helpful but more general conceptual information is likely to hinder learning. Overall courses should present a limited amount of material. Older learners will benefit from a focus on procedural steps rather than conceptual background. Active learning, where older people actually carry out the steps being learnt is important and there needs to be time for sufficient practice. The exercises that are chosen for practice should be appropriate to the current skill level and perceptual, motor and cognitive abilities of the older learners. It also seems reasonable that there should be only a little new material introduced at any one stage of a course and this implies careful sequencing of the skills taught so that earlier skills support the teaching of later skills. However this will not be simple to implement given that the skills learnt earlier will be subject to fragile learning.

Older people may benefit from being taught specific techniques for remembering as part of a course but remember that Kliegel et al. (2003) found that although older people benefited from using such techniques they were skeptical of their ability to benefit and were therefore less likely to use the techniques.

Learning and delivery format – relevant changes

- The speed with which individual older people learn varies widely
- Older people benefit from self paced learning
- Older people appear to benefit from learning in small (2 – 4) groups rather than individually or in large groups
- Older people can be overwhelmed by younger instructors who go too fast, present too many ideas and tend to be impatient with the slow and uncertain progress typifying older people.
- There appears to be a benefit in having either an instructor from the same (older) age group or an instructor who has adjusted their style to accommodate older learners

Learning and delivery format – design suggestions

It seems to be the case that older users learn well in small groups and that the group can provide a rewarding social context in which learning benefits. Note that this seems to depend on the class as a whole being well designed. Classes for older learners should be small, note that SeniorNet classes in New Zealand choose class sizes in the range of two to five students. The speed of instruction should be such that older learners are not hurried and this implies at least double the time taken for younger learners. However the variability of older people indicates that there is likely to be no ideal pace for a group, rather that self paced learning should be supported.

Given that older people need considerable support as they learn but that they learn at differing speeds there is going to be strain placed on an instructor. An overloaded instructor is at risk of triggering older people's views of themselves as poor learners, which can then be self-confirming. It becomes important to reduce the load on an instructor. Having only a very small number of students to teach is going to assist this. In addition it will be an advantage if the learning materials are such that they reduce the requirement for the instructor to be the main source of information, they allow older learners to proceed in a self paced manner with less instructor input and they allow other older people in the group to assist each other.

The claim is made by SeniorNet New Zealand that there is a benefit from having older instructors of a similar age to those being instructed. This has not been verified but seems reasonable, however I have met a few past students of SeniorNet computing courses who argued that their older instructor knew too much to be, "useful to beginners like us", so not all same age tutors are suitable. There has been research on ways in which younger people fall into counter-productive patterns when attempting to communicate with older people, this is explored in Chapter 8. What seems important is to have an instructor who has adjusted their expectations so as to be accepting of the likely initial level of knowledge displayed by older people, the slow speed at which they will be able to expand this knowledge and the inevitability of fragile learning in this group. It also seems important to have an instructor who does not trigger older users' negative self stereotypes and a suitable older instructor may have an advantage here.

2.12 Conclusions

The first point that arises from such a literature survey is the sheer breadth of aspects of aging that can affect older people as they try and use computer applications. Following from this is the difficulty of translating this information into terms that are relevant for interface design. The design considerations raised in this chapter are mainly inferred from findings on aging, only a few have been the subject of published interface design research. It is therefore unknown how well the suggestions made for responding to the effects of aging will translate into successful interface design for older people. It is apparent that rigorous research to substantiate or challenge these suggestions would take a very long time so we are cast back on Donald Norman's argument that establishing workable designs takes "approximate science". Even so there are so many suggestions that they are likely to overload any designer and it is uncertain in what design contexts they will be relevant or can be ignored or downgraded. In effect what has occupied the rest of this thesis is a search for ways of helping a designer come to terms with the abundance of possibly useful information about aging that has been uncovered here. In the next chapter we will discuss an attempt to provide a perspective for integrating this material through the concept of competition for the older person's cognitive resources between the user's substantive task and the tasks involved in manipulating and comprehending the interface. Following this we will look at using increased involvement with and understanding of actual older users as a resource to guide designers through the interface design process.

Chapter 3 The Dual Task Pilot Study

3.1 INTRODUCTION

This chapter of the thesis describes the first study done after completing the literature review. An experimental approach was used but showed unexpected difficulties. The key result was to prompt careful examination of the appropriateness of an experimental approach given the thesis aims. This led to a change in direction for the thesis. The concerns on which this change in direction are based are set out in the discussion and conclusions at the end of this chapter. This discussion on the change in direction gives the core of the effect of this study on the overall thesis.

The literature review was a strong influence on the intended style of the overall research. The literature reviewed came overwhelmingly from the discipline of cognitive psychology and the predominant method was experimental. This led to a presumption that an experimental approach would be the appropriate way of approaching the thesis research. The initial approach was to look for a set of hypotheses that would relate the overall effects of aging to a way in which the presumed poorer performance of older people on computing tasks could be moderated by interface factors. The hypotheses adopted centered on the concept of dual task performance. Older people had been shown to exhibit poorer performance in several dual task situations so it was of interest to see if this could provide a worthwhile model for the role of the user interface for older computer users. The assumption was that older computer users are in a dual task situation. The task that led the older user to use the computer (the substantive task) might be writing a letter. However actually using the computer called for simultaneous performance on the task of managing the user interface (the interface task). It seemed reasonable to propose that as the interface task increased in difficulty then performance on the substantive task would show the effects of competition for cognitive resources from the interface task. Given support for the dual task hypothesis it was then intended to study particular aspects of interface design to see how they contributed to the dual task difficulties. It was decided to carry out a pilot study to evaluate this approach. The result of the pilot study was a lack of support for the dual task hypothesis and the development of a very different view of how the research should proceed.

This chapter will describe the hypothesis developed, give details of the experimental method used and examine the results obtained from carrying out the pilot study. The dual task study actually consisted of three linked studies using the same set of volunteers. The first sub-study looked at font readability in order to establish baselines for manipulating the difficulty levels of the interfaces provided in the second sub-study. The second sub-study examined the older volunteer's ability to carry out a series of comprehension tasks provided in the format of a game while level of difficulty of substantive task and interface task were varied. The third sub-study provided a second look at comprehension tasks while level of difficulty of substantive task and interface task were varied. This second study was done within different context using a web based comprehension quiz. The method description and the results of each of these sub-studies will be presented separately with a discussion of the findings of each sub-study. The key to the importance of this chapter however lies in the closing pages where a general discussion of the results and problems of the pilot study examines their implications for the direction of the overall research.

3.2 Theoretical basis for the pilot study

The approach taken in this study is to consider the user's activity in terms of two tasks, coping with the interface of the application and carrying out the substantive task the application is designed for, writing a letter, sending an email, etc. It has been shown that older people have difficulty carrying out complex tasks or carrying out two tasks simultaneously, see Korteling (1994). People have a limited cognitive capacity and it seems reasonable that cognitive effort expended in coping with the interface should reduce the capacity available for dealing satisfactorily with the substantive task. On this basis a poor interface should reduce task performance, as discussed in Cooper and Reimann (2003). The next issue is whether interfaces which are acceptable for younger users are acceptable for older users, it is possible that an interface which is simple to use for younger people would cause significant difficulty for older people. In the near future older people will be disadvantaged if they cannot complete computerized versions of daily tasks such as banking. Worryingly Rogers et al. (1996) found that older adults generally made high levels of mistakes on a simulated Automatic Teller Machine (ATM) contradicting bank staff expectations that the use of ATMs was self evident. It was decided that it would be interesting to look at comprehension of material presented via a computer interface as a general task and to give the same comprehension task to users under different interface conditions. The interface conditions chosen for manipulation involved text appearance and display style. There has been some previous work on font preferences for older people. Morrell and Echt (1996) suggest that older adults will benefit from san-serif fonts (with a specific recommendation for Helvetica) that are in the 12 - 14 point range and of medium to bold weight. These recommendations are for printed text so it is of interest to see if they hold for on-screen displays. Discussion with older people indicated that some found large font books uncomfortable, possibly because the large font meant that there were fewer words in a given viewing angle and this reduced the amount of information available in the sub-conscious scan ahead activity supporting reading. It was therefore decided to include a test for the upper size limit at which participants found fonts comfortable.

I had observed older people with impaired vision caused by the onset of macular degeneration, both the style of text used and the background against which it was displayed were important to their being able to read successfully. It was therefore decided to compare comprehension when the interface used fonts that were easy to read versus fonts that users could read with difficulty. The expectation was that comprehension would drop as the text quality declined (and more effort had to be put into reading). There is agreement in the literature that the ability to pay attention to relevant information in the presence of distracting information declines with age, Connelly and Hasher (1993), Kotary and Hoyer (1995). One of the display conditions was therefore set to include distracting animated graphics. From the proposition that both the substantive task and coping with the interface compete for the user's limited cognitive capacity there was a further implication. There should be an interaction effect in that difficult comprehension tasks should be more affected by text formats that require greater effort to read information. It was desired to provide a degree of internal replication within the study so two different comprehension tasks were designed.

3.3 General Notes on Experimental Methods

The study was done as a pilot study for a planned larger study. 12 older volunteers each attended three sessions of two and a half hours. They ranged from 66 to 82 years old with a mean age of 76.2. Previous careers indicated considerable achievement, careers included manager, nurse, lecturer, doctor, etc. All volunteers were able to drive themselves, all were members of SeniorNet. All used Windows 95 or 98 and email. The number of years' experience with computers ranged from 1 to 35 years. All but one reported themselves to be in reasonable health and all wore spectacles when using a computer.

There were three software programs used in this study, one for studying font preferences and two for studying how well research participants could comprehend information given a variety of presentation formats. One of the comprehension programs was a text based game and the other comprehension program consisted of a quiz on articles presented in a Web page format. Participants attended the first two sessions in groups of two or three and worked with the experimental software. The final sessions ran focus groups for six participants at a time in which they discussed both their experiences in the experimental sessions and their overall experiences with computing as older people.

3.3.1 Note on analysis of results

Total numbers are small and since this was a pilot study there were some problems with time available and my administration. Three participants did not complete all parts of the Pen Game and Web Quiz studies so analysis using ANOVA was not attempted.

3.4 Font size and preference study

Part of the manipulation of interface task difficulty intended in the dual task study was the manipulation of the readability of information presented on screen. A small study of the readability of different fonts under different conditions was planned as part of the overall dual task study. The aim was firstly to obtain individual measures of acceptable and poor fonts for the volunteers involved in the dual task study that meant that individual baselines would be available in the later parts of the study. In addition there is a basic gap in the research literature, we do not know how the ability to cope with various text displays is distributed in older users. Hence a second aim was to use this study as a pilot for a study establishing the range of fonts and backgrounds that could be considered appropriate for older users.

3.4.1 Font size and preference study - method

Text was presented on a 14" SVGA color monitor using 800 x 600 resolution and the Windows small fonts setting. Participants adjusted chair and screen positions to suit their preferred working conditions. There were four subsections to the font size and preference study

Preferred size within a font – short text passages

Ten passages of the same small paragraph of text in a single font but at differing sizes were displayed simultaneously (Figure 3.1). Participants were asked to find the size at which they could barely read the text, the size at which the text was comfortable to read and the size at which the font became too large to read.

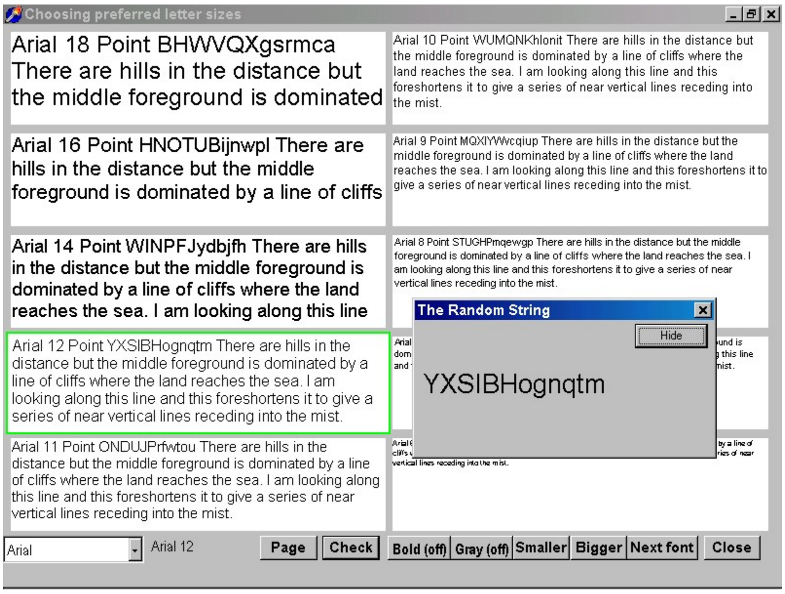

Figure 3.1 Preferred size within a font – short text passages - subjects choose three text sizes: as small as they could read, smallest comfortable and largest comfortable.

The subject was asked to read aloud the string of random letters at the top of each text block and the experimenter then displayed a larger version of the string to check it had been read accurately. To ensure that experimenter and subject both knew which block of text was being referred to, the block could be highlighted with a green outline by clicking on the block, (the Arial 12 point block is highlighted in the figure).This was repeated over a range of fonts. The fonts chosen represented three font families, sans-serif, serifed and a range of fancy fonts.

Preferred size within a font – long text passages

The fonts were also presented in displays that gave a full screen of text and the range of comfortable sizes was again found (Figure 3.2). Subjects choose text sizes that were as small as they could read, smallest comfortable and largest comfortable.

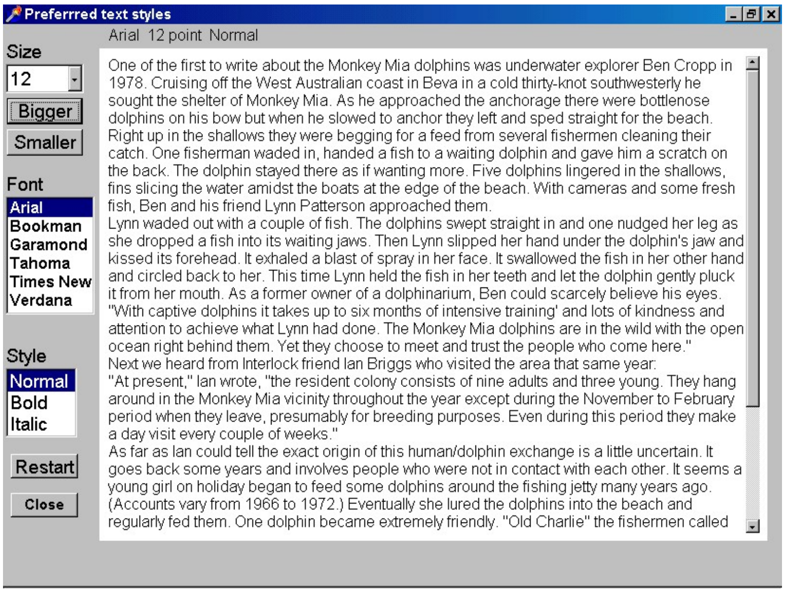

Figure 3.2 Preferred size within a font – long text passages

Font preference within font size

Ten passages of the same text at a single size but in differing fonts were displayed simultaneously (Figure 3.3). Participants were asked to rate the readability of each of the fonts on a five point scale: (excellent, good, fair, poor and horrible).

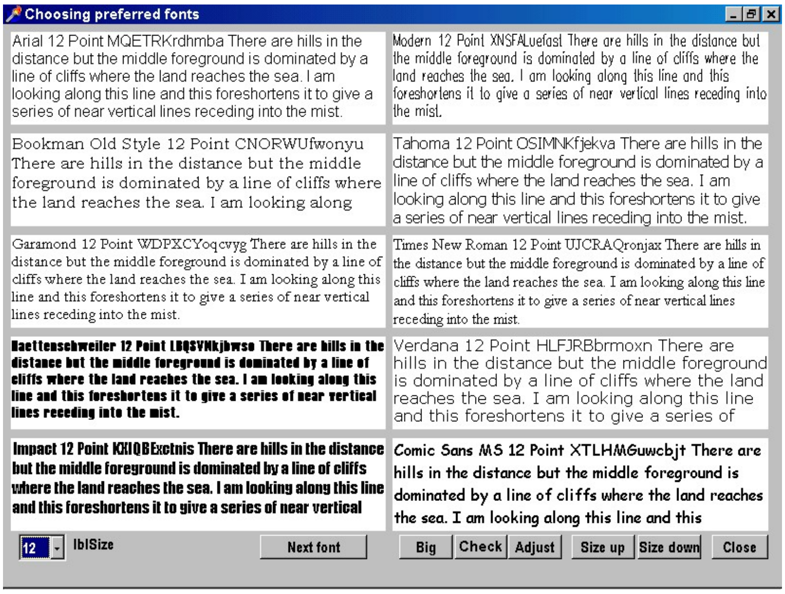

Figure 3.3 Font preference within font size

Effect of background on legibility

Text was shown with differing percentages of colored and graphic backgrounds and the effect of varying the intensity of the background was examined (Figures 3.4 and 3.5). Background effects were studied looking at a split screen where the subject could rate the relative readability of the two halves as background color and background illustrations were varied. Hue saturation and luminance could be altered and a background picture displayed at various percentages of full picture density.

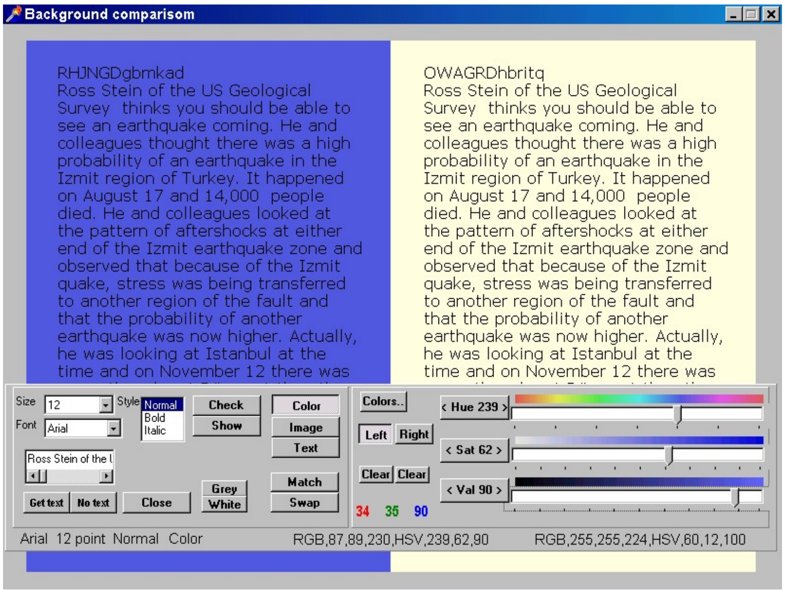

Figure 3.4 Effect of plain background on legibility

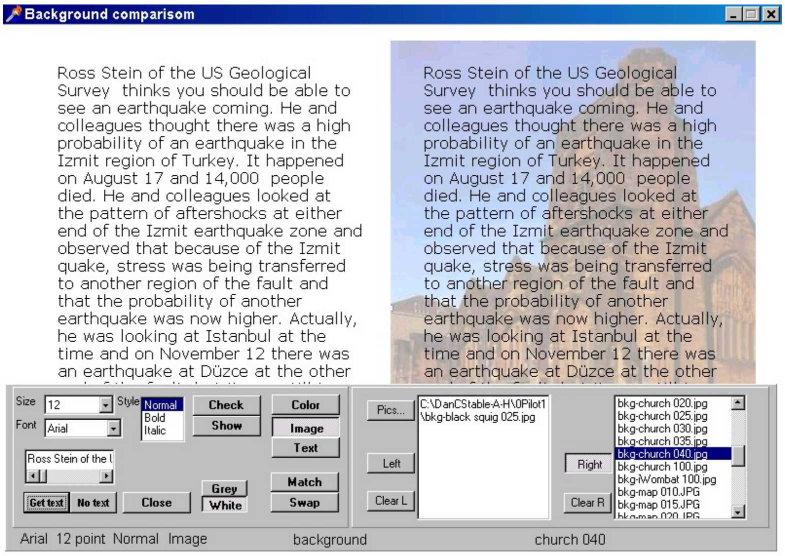

Figure 3.5 Effect of graphic background on legibility. Background effects showing a graphic background with a picture displayed at 40% of full density.

3.4.2 Font size and preference study - results

Table 3.1. Point size where font is just readable

Font>	Arial	Bookman	Garamond	Tahoma	Times New Roman	Verdana
Ave.	7.2	7.0	7.8	7.4	7.5	6.8
Range	6 - 8	6 - 8	6 - 10	7 - 9	6 - 9	6 - 7

With corrected vision all participants were able to read very small fonts.

Table 3.2. Point size at which text in this font becomes comfortable

Font>	Arial	Bookman	Garamond	Tahoma	Times New Roman	Verdana
Small paragraphs of text						
Ave.	9.1	9.3	10.4	9.4	9.9	8.8
Range	8 - 11	8 -11	7 - 12	8 - 11	8 - 11	7 - 10
Full screen of text						
Ave.	10.3	10.5	11.6	10.6	11.3	10.1
Range	9 - 13	9 - 13	8 - 14	8 - 14	8 - 16	8 - 14

It was notable that larger font sizes were preferred for big text displays.

Table 3.3. Point size at which text in this font ceases to be comfortable

Font>	Arial	Bookman	Garamond	Tahoma	Times New Roman	Verdana
Small paragraphs of text						
Ave.	13.6	14.0	15.3	13.1	13.9	13.4
Range	10 – 17	11 – 17	12 – 18	11 - 16	12 - 17	11 - 16
Full screen of text						
Ave.	14.7	16.0	15.9	13.7	14.1	14.6
Range	12 - 20	13 - 26	14 - 20	11 - 18	12 – 20	11 – 20

Only seven of the twelve participants reported a size at which reading was not comfortable but this was a different seven for small paragraphs and for full screen text displays.

Although some of the older adults could read text at remarkably small point sizes they were seen to strain when doing this. The comfortable size required was consistently larger when screenfulls of text were used than for small paragraphs. Comparing the top of the size ranges where comfortable reading begins with the bottom of the size ranges where comfortable reading ceases, there appears to be no font and size combination which completely suits all the older people in this group. However participants reported that comfort was more affected by undersize text than by oversize text. Therefore if it is not practical for users to adjust font sizes to suit, the best option seems to be 11 point fonts for small blocks of text and 12 – 13 point font where large amounts of reading is involved. However a warning may be seen in the ability of this group to read very small fonts. It seems likely that this group is not representative of older people as a whole and so larger font size recommendations may well emerge from a larger, more representative study.

Table 3.4. The readability ratings given to the different fonts at different font sizes

Size of font >	Just readable		Smallest comfortable		Largest comfortable	
Font	Ave.	Range	Ave.	Range	Ave.	Range
San serif fonts						
Arial	2.5	1 - 4	1.7	1 - 3	1.8	1 - 3
Tahoma	2.8	2 - 4	1.9	1 - 3	2.3	1 - 3
Verdana	1.5	1 - 2	1.3	1 - 2	1.7	1 - 3
Serifed fonts						
Bookman	2.8	1 - 4	1.5	1 - 3	1.6	1 - 3
Garamond	3.6	3 - 4	2.8	1 - 4	2.1	1 - 3
Times NR	2.7	2 - 4	2.2	1 – 3	1.9	1 - 3
Fancy fonts						
Comic Sans Serif	2.4	2 - 4	1.9	1 - 3	1.9	1 - 2
Haettenschweiler	5	5 - 5	4.0	3 - 5	4.2	3 - 5
Impact	3.5	2 - 5	3.8	3 - 5	3.8	3 - 5
Modern	4.6	4 - 5	3.9	3 - 5	3.2	2 - 4

The font preference figures in Table 4 are from a range of 1 (excellent) to 5 (horrible). The ratings could be interpreted in terms of a slight advantage for san serif fonts over serifed fonts with generally poor performance from fancy fonts. However another possible interpretation is that the fonts receiving the best ratings are those which emphasize well rounded, well spaced letters (Arial, Verdana, Bookman and Comic Sans Serif) and this overrides the sans serif, serif, fancy categories. When it comes to preference at small sizes the rounded fonts are highly preferred. (Verdana appears to be ahead but this can be considered an artifact of Verdana's larger characters at small point sizes.) In general the readability of all fonts improves as size increases.

Colored and Pictorial backgrounds

The older people in the study found that marked degrees of background color or anything except very, very faint background pictures interfered with their ability to read text. Blue hues, which are the darkest, were the worst performing backgrounds. It was noticeable however that the effect of background color and pictorial backgrounds decreased as the font size increased.

3.5 First Comprehension Study - the Pens game

As pointed out in the first sections of this chapter the two comprehension studies were intended to examine the issue of whether a dual task model explained the relationship of substantive task performance to interface difficulty. The hypothesis was that because of presumed competition for cognitive resources performance on the substantive task should decline as the difficulty of the interface task increased. As a way of providing an experimental setup that would allow the difficulty level of the interface task to be manipulated, software was constructed that allowed the volunteers to play a game based on combining information about 8 animals paired in 4 pens with a set of rules that stated which animals were safe to pen together and which were unsafe. Thus penning a cat and a rabbit together would result in one safe animal (the cat) and one unsafe animal (the rabbit). The volunteer's task was to provide a total for the number of safe animals out of 8 in each round of the game. In each round the pairings of the animals in the 4 cages was randomly altered. The substantive task could be made harder by varying the syntactical complexity of the way in which the information about the pairings was presented. As well as varying the difficulty of the substantive task, the experiment varied the presumed difficulty of the interface by altering the readability of the font used for presenting the information about the pairings.

The hypothesis under test was that given limited cognitive resources on the part of the older volunteers, interface difficulty should interact with substantive task difficulty. It was also expected that there should be main effects where time taken and accuracy were affected by both syntactical complexity and by interface difficulty.

3.5.1 First Comprehension Study - method

The substantive task is a “game” in which the participant is given a page with a set of rules stating which of nine common animals can safely be penned together and which would endanger other animals. The rules remained constant. The participant was presented with a text passage on screen describing how eight animals are put into four pens two at a time. The participant then pressed a key on the numeric keypad to record how many animals are safe according to the rules.

Interface difficulty

The software accepted as setup information three text styles chosen from the test subject's individual results from the preliminary font study and rated by the subject as excellent, fair and poor (but readable). The format of the text display was varied on each trial using the three fonts chosen at setup.

Task difficulty

Task difficulty was manipulated. Low task difficulty consisted of presenting the information as a list of four lines with a pen number and two animal names per lines with the pens given in order, see Figure 3.6. High task difficulty gave the same information but as a paragraph of eight sentences in random order, see Figure 3.7.

The software recorded the settings for each subject, the settings for each trial and the accuracy and time taken for each response.

A within subjects design was used, participants did 4 sets of 6 trials under the low task difficulty condition and 4 sets of 6 trials under the high task difficulty condition. Within each set participants met two trials under each of the excellent, fair and poor readability conditions. The accuracy and time for each trial was recorded. Participants practiced for 20 minutes beforehand, results of the practice tests were discarded.

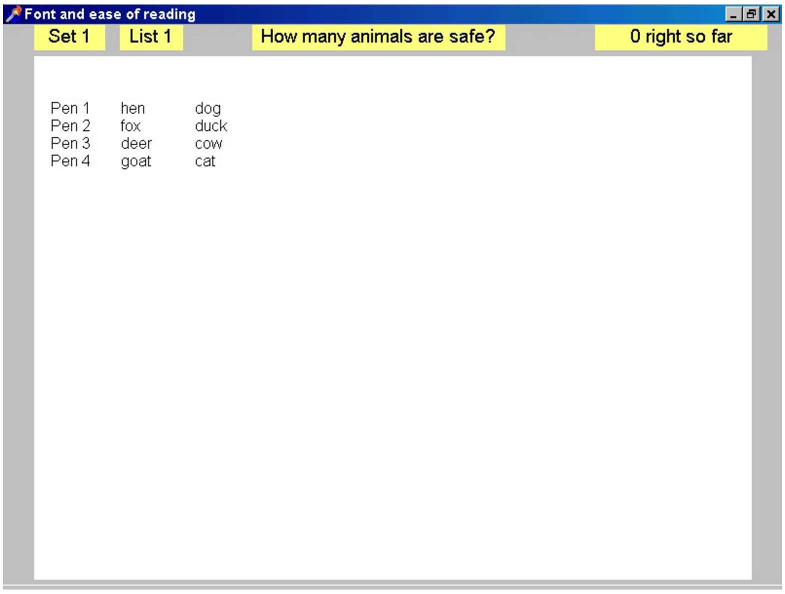

Figure 3.6 Pens game low task difficulty and high readability

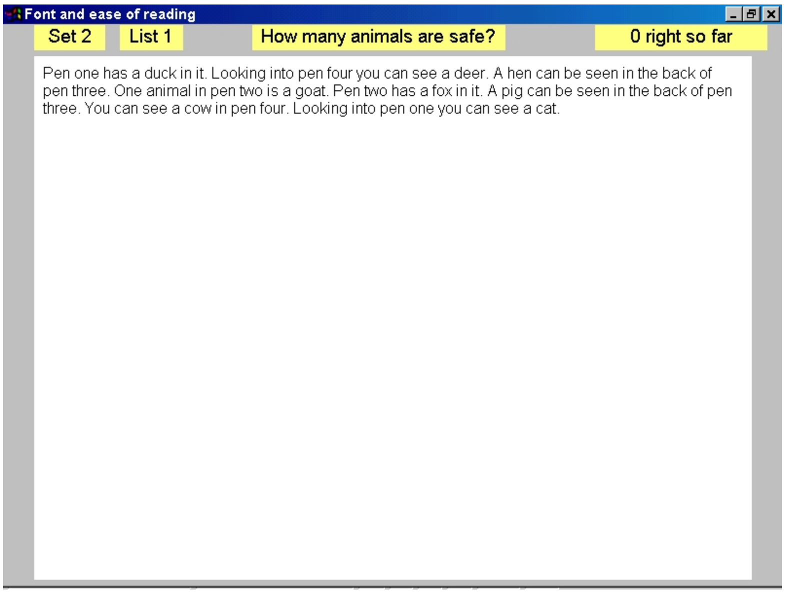

Figure 3.7 Pens game high task difficulty and high readability

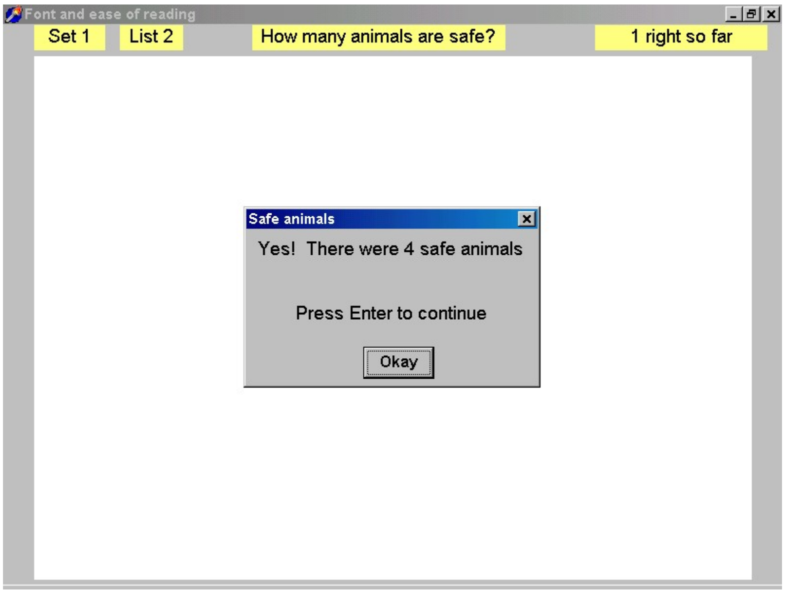

Figure 3.8 Pens game - the subject was given results after each trial

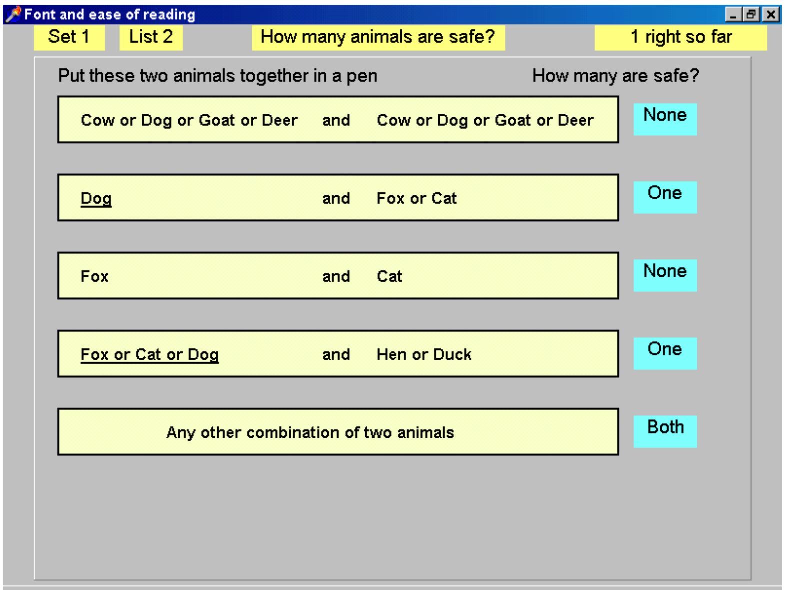

Figure 3.9 Pens game - the screen for displaying the rules. During practice sessions volunteers forgot to use this so it was replaced by a paper version using the same large font and layout in the actual experiment.

Examples of the various levels of task difficulty prepared for the Pens game.

In fact 5 levels of task difficulty had been prepared as shown below. It was found in preliminary work with older users while they were doing practice examples that level 1 and level 2 led to similar performance, level 3 was as hard as the older users could cope with and levels 4 and 5 led to frustration and non-performance. Hence after the practice session levels 1 and 3 were used in the actual experiment as the low and high levels of difficulty. Levels 4 and 5 are of interest in that they were easy for middle aged pre-test subjects and considerably too hard for the older group of volunteers.

Level 1 - simple list in pen order (low task difficulty as used in experiment)

Pen 1	goat	deer
Pen 2	dog	duck
Pen 3	cow	cat
Pen 4	hen	fox

Level 2 - text paragraph version in pen order (not used except in practice)

Looking into pen one you can see a goat. One animal in pen one is a fox. Pen two has a deer in it. A cow can be seen in the back of pen two. Looking into pen three you can see a duck. You can see a hen in pen three. Pen four has a cat in it. A dog can be seen in the back of pen four.

Level 3 - Text version with randomized pen order (high task difficulty as used in experiment)

Pen four has a deer in it. Looking into pen one you can see a cat. A cow can be seen in the back of pen four. A goat can be seen in the back of pen one. One animal in pen three is a dog. Pen two has a fox in it. You can see a hen in pen two. Looking into pen three you can see a duck.

Level 4 - Text with random pen order and extra irrelevant information (found to be too hard, not used except in practice)

Pen two has a deer in it. The hen should be groomed today. A fox can be seen in the back of pen two. Pen four has a hen in it. The pen at the end needs repairs to the wire. Looking into pen four you can see a cow. A cat can be seen in the back of pen one. The duck was shifted yesterday. You can see a duck in pen three.

Looking into pen one you can see a goat. In pen one the animals are not getting along. One animal in pen three is a dog.

Level 5 - Text with indirect naming of pens, random pen order and extra irrelevant information (the older volunteers could not achieve results with this format, hence not used except in practice)

Looking into the pen after pen three you can see a deer. The goat should be groomed today. The pen at the beginning has a fox in it. Pen two has a cow in it. The pen at the beginning needs repairs to the wire. A hen can be seen in the back of the pen at the beginning. You can see a dog in the third pen. The fox needs worm pills. One animal in the pen at the end is a cat. A duck can be seen in the back of the pen after pen two. The hen was shifted yesterday. Looking into pen two you can see a goat.

3.5.2 First Comprehension Study - results

The expectation from the pens study was that poor display formats would affect task performance. This was not found. The following graphs summarize the results obtained. Neither error rate or time taken was highly affected by the use of fonts and font sizes that individuals had previously rated fair or poor. There is no statistical support for an interaction effect and even if one were found with larger numbers of participants it would be unlikely to be of practical effect for actual interface designers as the hint of an interaction seen in Figure 2 only applies to the font / size combination rated as "poor" which should be unlikely to occur in even moderately well designed interfaces.

On the other hand task complexity had a major effect on time taken. It would also have had a practical effect on error rates except that the older participants adopted strategies such as counting on their fingers to cope with the difficulty they were encountering. They did not use these strategies in the simple list condition. Obviously task complexity levels that force users to attempt to supplement what is provided by the interface indicate undesirable levels of difficulty.

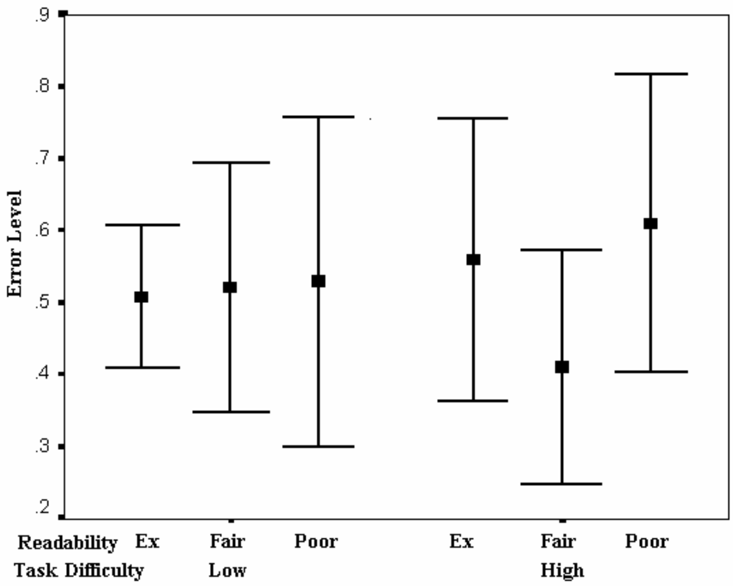

Figure 3.10 Errors made per trial (means and 95% confidence intervals) by task difficulty by readability. In the majority of trials no errors were made. This held under all conditions.

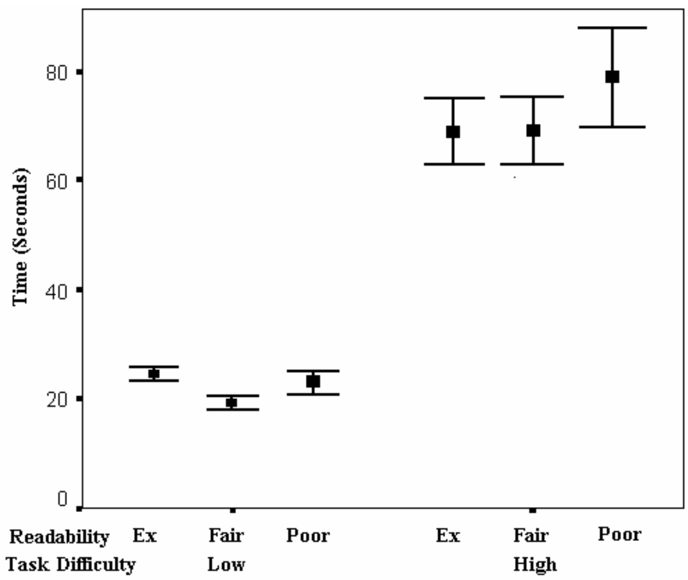

Figure 3.11 Time taken (means and 95% confidence intervals) by task difficulty by readability

3.5.3 First Comprehension Study - discussion

The group proved to have difficulty with an on-line version of the rules of the pen game, the problems were twofold. Firstly participants did not remember to use the rules display when it was needed though they did remember the command to display the rules. A second problem was that the rules display using a large font and a clearly set out design took up most of the screen, this meant that the user had to remember the rule involved, close the display and then look at the information on penned animals. This appeared to disrupt the memory of how many safe animals had been counted to that point. The solution was to provide a paper version of the rules in the same large font format as the screen version. This proved trouble free.

The older users took around 20 seconds per trial in the simple list condition and over 70 seconds per trial in the random order paragraph condition. This compares with the times of 10 seconds (list) and 40 seconds (paragraph) taken by the middle aged subjects used for pretesting the design.

3.6 Second Comprehension study - the Web Quiz

This comprehension study was intended to repeat the testing of the hypothesis of a competition for older users' cognitive resources between the substantive task and the interface task. Again the difficulty level of the substantive task and of interface task were manipulated but within a different context. The intention was to show that if the hypothesis of resource competition was supported, it could be generalized over more than one task/interface combination.

As a way of providing an experimental setup that would allow this manipulation, software was constructed that allowed the volunteers to take part in a web based quiz where they evaluated a set of statements about the information presented in four web pages.

The hypothesis under test was that given limited cognitive resources on the part of the older volunteers, interface difficulty should interact with substantive task difficulty. It was also expected that there should be main effects where time taken and accuracy were affected by both syntactical complexity and by interface difficulty.

3.6.1 Second Comprehension study - method

Software was constructed to present the statements and the web information pages as well as to record the volunteers' responses and calculate time taken and error rates. Three short Discovery Channel type articles were presented in Web page format. The topics covered in the articles were; eclipses, boomerangs and tuataras. Each article was four Web pages long using a large san-serif font. Scrolling was not required to read any page.

A within subjects design was used. A participant read and was tested on each of the three articles and met each of the three display styles while doing so. Data recorded included sequence of moves between pages and test page, time spent on each page, accuracy in answering questions and time taken to answer questions. Participants did a practice session using a fourth article with its own comprehension test. For each of the actual tests, results from the first question were discarded to eliminate settling down time.

Substantive task

The subject first read the four web pages of an article. Then statements intended to test the subject’s comprehension of each article were presented one at a time on a further Web page. The subject could make one of four responses to each statement using on-screen buttons. The subject could re-read any part of the article while attempting to answer a question. There were 24 statement for each article.

The participant could make one of four choices about a statement. (Figure 3.12)

1. It was supported by the information in the web pages.
2. The statement was denied by the information in the web pages.
3. The statement was not covered by the information in the web pages
4. The information in the web pages mentioned the topic but was not clear enough to say whether or not the statement was actually supported.

Task difficulty was manipulated by varying the sort of comprehension activity needed to answer correctly. The statements were constructed so as to provide a range of difficulty based on the assumption that statements that simply agreed with material given in the web pages would be easier to evaluate as agreeing with the web information than statements that were not covered by the web information. It was assumed that these in turn would be easier than statements whose agreement with the web information required making inferences based on the web information. Thus variation in substantive task difficulty was achieved by presenting each volunteer with a range of statements that required different types of information extraction from the material in the web pages.

The 24 statements were constructed so that there were six statements whose correct answer corresponded to each of the four choices available to the participant, supported, denied, not covered or unclear. Within each of these sets of six, two statements could be answered immediately from the web material, two statements required inference and two statements were such that the material needed to evaluate them was not available in the web pages. The order of presentation of the 24 statements was randomized.

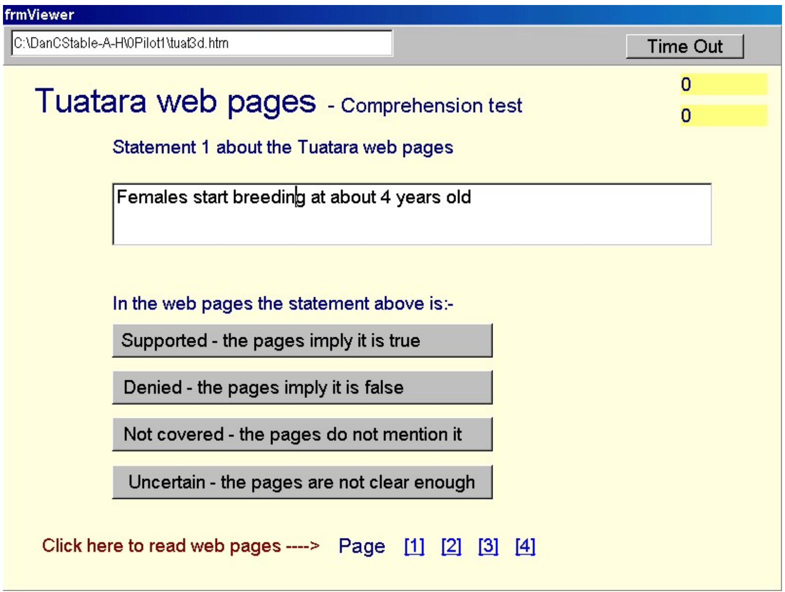

Figure 3.12 The page for presenting comprehension statements. Subjects read the statement, then could use the numbered links at the bottom to browse the web pages containing the article. After they had decided if the statement was "supported', 'denied', 'not covered' or that there was 'insufficient information' they came back to this test page and clicked the matching button.

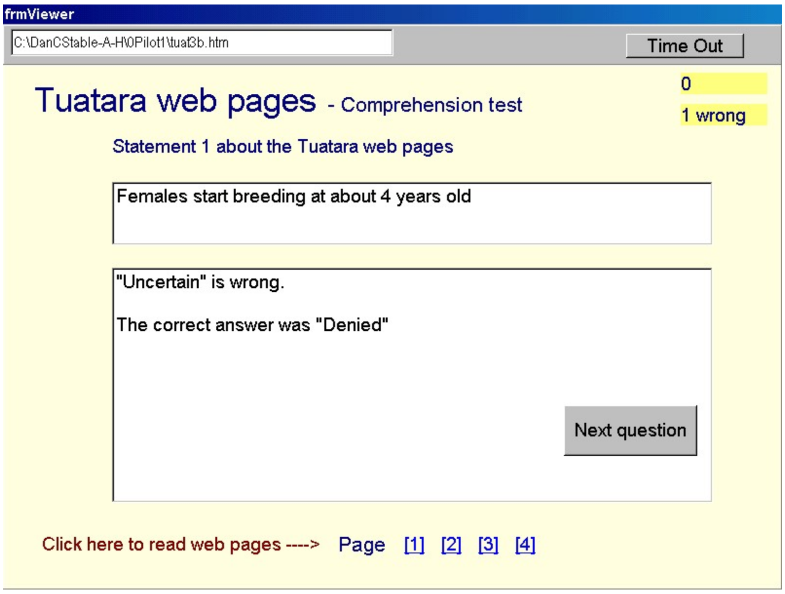

Figure 3.13 The page for presenting comprehension results. When subjects had made a choice they were given feedback and proceeded to the next question via the button shown.

Interface difficulty

As well as varying the difficulty of the substantive task the experiment varied the presumed difficulty of the interface by altering the amount of distracting information shown on the pages that presented the web information. Display quality was manipulated as follows. Each article exists in three formats: “good” - simple display, clear font; “moderate” - italic font, patterned background, “bad” - italic font, pictorial background and distracting and irrelevant animated graphics. Text position on the Web pages remained consistent over each display condition.

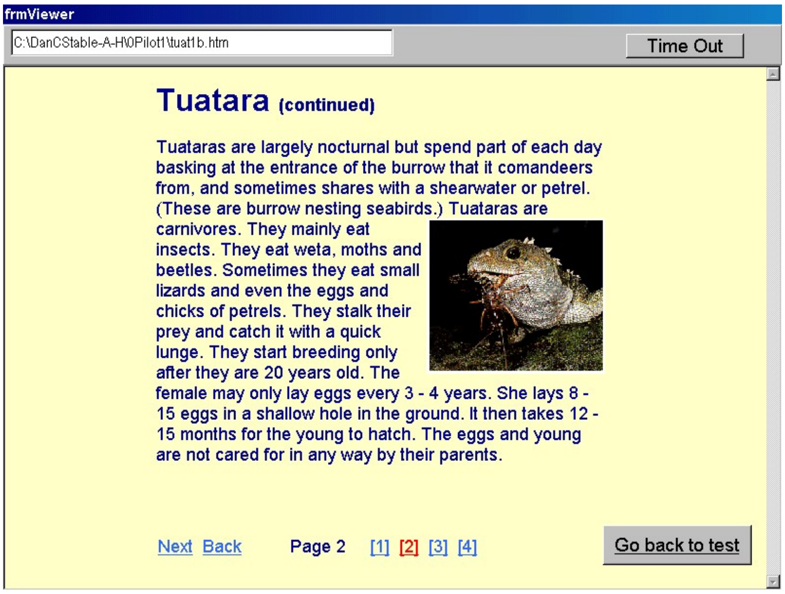

Figure 3.14 The easy level of readability was given by 14 point dark blue Arial text on a light cream background. There was only one static illustration per page. The [Go back to test] button returned the subject to the test page. The links shown at the bottom gave access to the other three pages in the article.

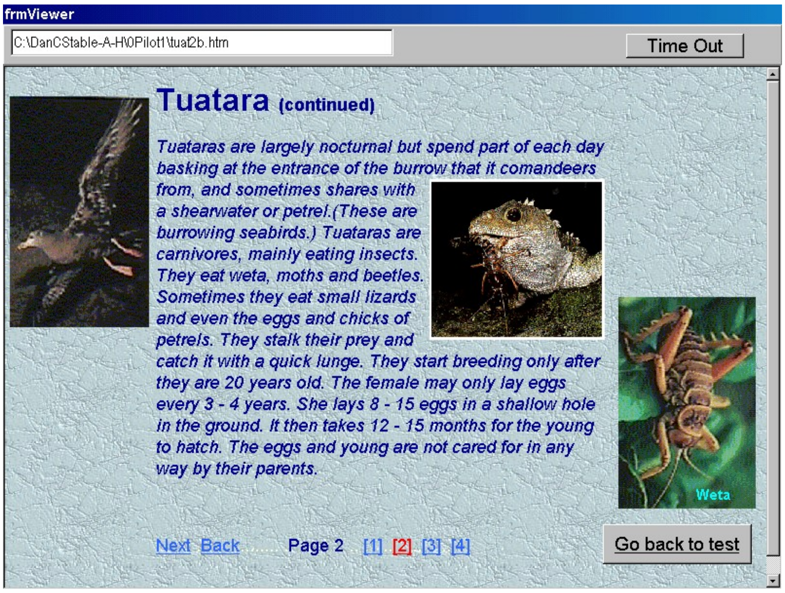

Figure 3.15 The moderate level of readability put a 12 point italic blue Arial font on a medium blue textured background and increased the number of illustrations.

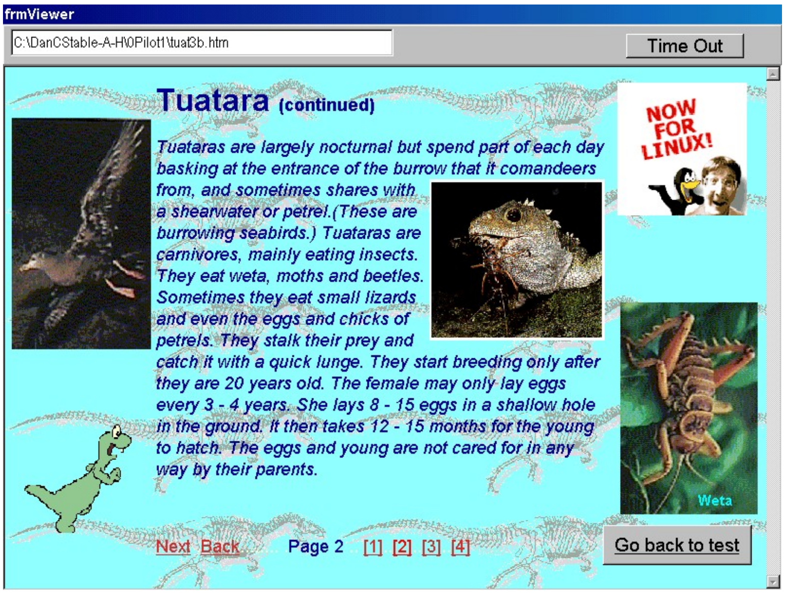

Figure 3.16 The difficult level of readability put the same text on a pictorial background and introduced two animated GIF displays in the bottom left and top right corners.

After the first six participants it was noted that no differences were emerging between good and moderate display formats. For the second six participants the moderate format test was replaced by one where the test was still given in Web page format but the article was given on paper. Font size, text layout and graphics of the paper version were the same as the "good" Web page design with the exception that the paper version occupied two A4 pages compared with the four screens of the Web version.

3.6.2 Second Comprehension study - results

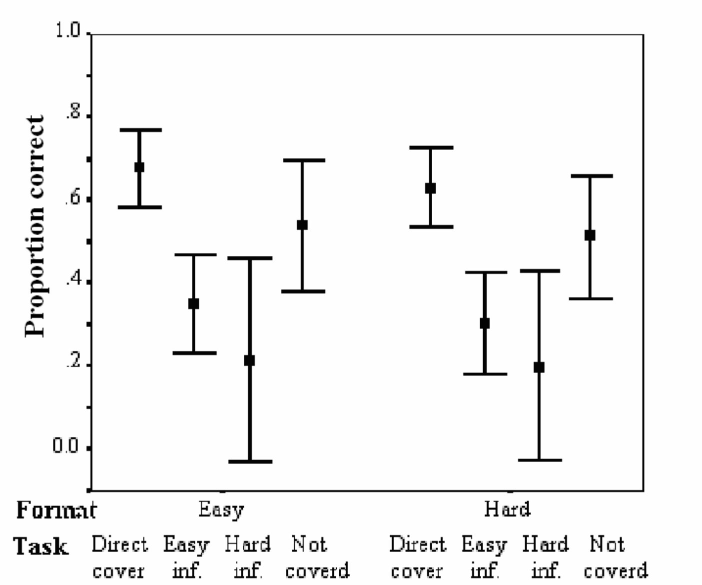

Figure 3.17 Proportion correct (means and 95% confidence intervals) by format difficulty and task difficulty

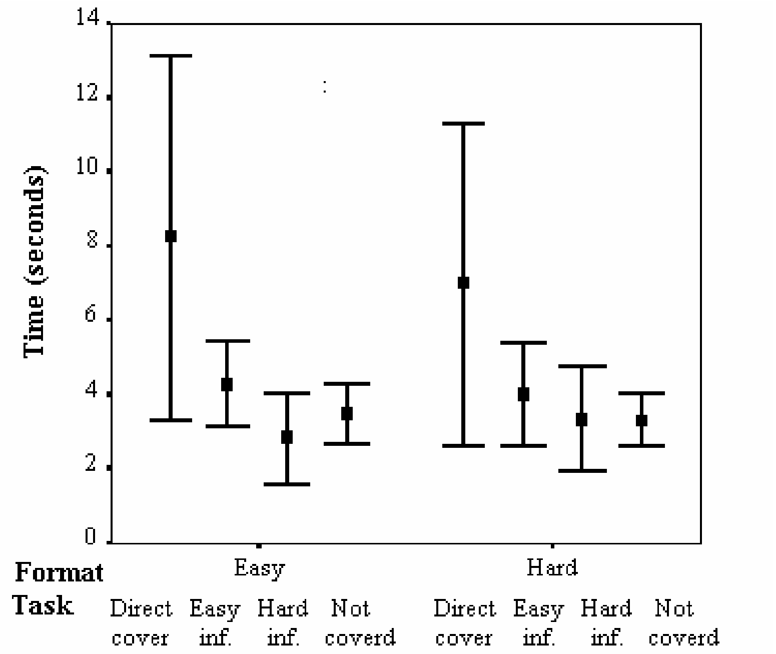

Figure 3.18 Time taken (means and 95% confidence intervals) by format difficulty and task difficulty

"Task" in Figures 3 and 4; task refers to task difficulty: The labels used indicate different ways in which the comprehension items related to the material in the Web articles.
Direct cover – the comprehension item was directly covered in the Web article.
Easy and hard inferences – inferences had to be drawn from the Web article to answer the comprehension item.
Not covered – the comprehension item was not covered directly or indirectly in the Web article.

The task difficulty clearly affected the error rate as shown in Figure 3. Equally the format used for the Web pages did not affect errors. There was no indication of an interaction. After considering the time taken data I was worried that users might be dealing with comprehension items that required inferences simply as if the material was not covered. Therefore the number of times the various possible answers were chosen were compared over types of comprehension items.

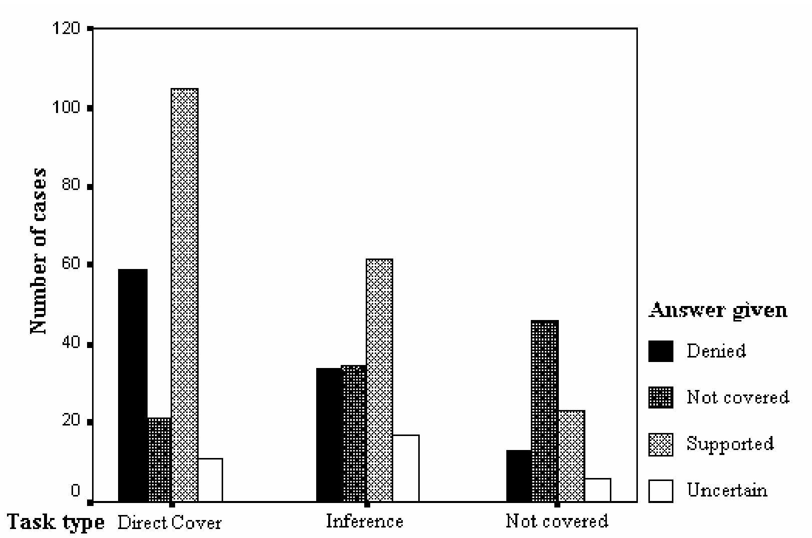

Figure 5. Actual answers given by participants under various task conditions

The results shown in Figure 5 indicate that people responded differently to comprehension items requiring inference versus comprehension items where they needed to identify that the information was not covered. (Because of the small numbers easy and hard inferences are combined).

It remains unclear why items involving direct cover were given longer time by the subjects than items involving inference or items that were not covered. The pattern is the reverse of what might be expected. It is possible that subjects did further reading to check their findings when the material appeared to be covered directly but that subjects disengaged when they did not find easy answers.

Interface format

Although format did not affect performance it did affect participants' ratings of likes and dislikes. This can be seen in Table 3.5.

Table 3.5 Ratings of preference choices for the Web page formats on a 7 point scale. Higher values indicate higher acceptance.

Easy to read		Like - dislike		Use - avoid	
plain	animated	plain	animated	plain	animated
6.6	4.2	6.4	3.7	6.2	2.6

The participants could make use of the Web pages with the deliberately distracting format but they did not like doing so. They were asked to rate the different Web page styles in three ways: did they find the style easy to read from, did they like or dislike the style and given a choice would they use or avoid pages using this style. In all cases the plain style was rated ahead of the animated style. The difference was particularly pronounced on the question of use versus avoid.

Paper versus Web display

Half the group used a Web page format which used a patterned background and italic text as the third presentation style. This format was rated as virtually the same as the plain style by most participants, two participants rated it as slightly worse. The other half of the group used a paper version of the Web pages as the third presentation style.

Here there was a consistent but slight preference for the paper version over the plain on-line version. Table 3.6 shows the ratings for paper versus web display for this group of 5 people.

Table 3.6 Ratings of preference choices for the Web page versus paper on a 7 point scale

Easy to read		Like - dislike		Use - avoid	
plain	Paper	plain	paper	plain	paper
6.6	6.8	6.2	6.6	5.6	6.8

3.6.3 Second Comprehension study - discussion

The lack of effect from Web page format was surprising. The Web page formats were designed to cause difficulty for older people with impaired sight and this group had excellent corrected vision. The filtering effects of selecting volunteers who were existing computer users and who drove themselves also need to be considered. However even within the group studied, the fact that they were able to use a particular poor Web page format did not mean that they enjoyed doing so. In particular animation led to participants stating that they would prefer to avoid pages like this. The most frequently made comments on the animated style were that it was irritating or stressful. Given that use of Web pages is generally voluntary this suggests that pages designed to catch the interest of younger viewers may irritate older users to the point where they do not read the material on heavily animated pages.

The results from task complexity were also unexpected. The group generally did not achieve high levels of accuracy even where the comprehension item covered some fact which was directly stated in the Web articles. They had similar if slightly poorer performance when identifying that a comprehension item had not been covered in the Web article. However when it came to making inferences accuracy sank to chance levels. From Figure 5 it does not appear that comprehension items requiring inference were treated in the same way as comprehension items that were not covered in the Web articles. It appears that the participants tried to find answers other than "not covered" for inference items but usually failed to do so correctly. This is consistent with data provided by Schaie and Willis (1993) indicating that as people age there can be a 25% drop in reasoning ability by the mid seventies.

3.7 General Discussion of the Dual Task Study

The older users involved were generally from occupations indicating a high degree of career success and capacity to learn. They are currently computer users and driving themselves around the city. They are interested in taking part in research. This makes them an unusual group of older people. They still found the comprehension tasks involved difficult. They also showed strong evidence of reduced performance with increased complexity in both the pen and the Web study. This raises concerns about the coping ability of a less selected group of the older population.

The difficulty seems to lie squarely within the comprehension task. The interface manipulations did not affect comprehension task performance. There was no sign of an interaction effect or even a main effect with interface difficulty. This is of interest in that it suggests limits to a simple model in which cognitive load due to coping with the interface competes with the main task for the user's available cognitive capacity. It does not totally rule out the role of large fonts and simple backgrounds in suitable design for older users. Firstly there are older users with impaired sight who were not represented in this sample but whose needs should be considered. Secondly the experimental software itself was designed specifically with easy to read fonts and simple explanations. It won praise from the participants as being particularly easy to read and use.

All users learnt to use the experimental setups in the pen and Web studies rapidly, in under 25 minutes. They sometimes had additional questions when they met the first question of the experimental tasks but then settled down and completed the tasks without needing assistance from the experimenter. There was no evidence of a learning effect in either the Web study or the pen study. The conclusion here is that this older group was very capable when learning a new program with a simply designed and clearly laid out user interface (ie the experimental software itself). This does not translate into satisfying achievement when dealing with complex applications. The group was asked to rate their satisfaction with their progress in general computer use and the average rating was 3.6 on a five point scale where 5 indicated highly dissatisfied.

The focus groups indicated that by far the dominant computing activities of the group were email and word processing. The issues underlying the experimental tasks, decision making and extracting information from complex environments were simply not relevant to the day to day computer use of the group studied. Computer tasks such as on-line banking and tax returns or obtaining entitlement information are more likely to involve older users in the near future and in tasks of this nature comprehension will become of greater importance. The participants were distressed by their failure to do well in the comprehension exercises. They were also not particularly interested in these activities. There was a marked contrast in the attitude of the participants in the font preference study where the idea of finding readable fonts appealed to the volunteers and they were enthusiastic in taking part. Again in the focus groups the participants enjoyed the chance to talk about their experiences and exchange these with other older computer users.

The fact that the older users could cope with the more difficult forms of the interface displays did not mean that they liked them. They clearly stated that given a choice they would avoid situations that involved interfaces similar to the difficult one’s used. Bailey (1993) argued that we should be skeptical of interface claims based on preference since they do not reliably indicate performance. This is borne out here, but the preference factor is still relevant to behavior if the users have choices. In an environment such as the Web where sites are competing for viewers this becomes crucial. The other point is that the older users described their dislike of the more difficult interface styles in terms of stress, annoyance and strain. I see it as probable that this indicates that performance could fall off, or older users might simply opt out, given prolonged use of these interface styles.

3.8 General Conclusions from the Dual Task Study

Reflecting upon the dual task study had a pervasive effect on the direction of my research. Its first effect was to raise questions about what was an appropriate research focus for a thesis aiming at guidance for interface designers who were concerned with older users. It also gave me a series of insights into working with older participants that shaped my further work. Rather than being simply a failure to confirm an attractive hypothesis, it proved to be a valuable starting point into productive research.

3.8.1 Appropriate research focus

Even if the dual task hypothesis was supported, given that the aim of the thesis is "how to design usable software for older people", what is the value of the hypothesis about dual tasks and resource competition? Was experimentation in order to examine a theoretical mechanism really a suitable focus for the thesis? Especially since application of the literature review suggestions and development with in-house older users suggested that successful software could be designed without such a theory. Again the variability of aging effects in older people argues against the role of a single mechanism in shaping the responses of the interface designer.

There may be common sources of much of the variance in older people’s performance in such things as cognitive slowing but the interface designer is working at the level of countering the effects, not at the level of countering the original cause. It seems likely that the level of explanation used in the literature survey based on more specific sensory, physical and cognitive aspects of aging is a more appropriate level from which to shape the interface designer’s responses to the needs of older users. Therefore applied research into interface design can usefully address issues at these levels rather than attempting to consider how design may be affected by some overall underlying aspect of aging.

Task competition remains as a possible mechanism underlying older people’s generally poorer performance when using computer applications but I now see it as one of a number of contributions. A simplistic concept of overall interface difficulty may not be useful in estimating the competition between the user’s task and the effort required to manipulate the interface. With hindsight one should analyze the detailed demands of using a particular interface and see how each competes with the perceptual, memory and processing demands of the user's substantive task at particular points in time.

3.8.2 Simplicity means Simple

In terms of improving older people's performance the key issue highlighted here is redesigning tasks to avoid complexity. Where the pen study provided simple lists or the Web articles gave simple facts relevant to the questions that were asked, then the older people performed relatively well. However asked to handle the same tasks in ways that increased demands on short term memory (random order for pen information in the pen study) or required making inferences (Web study) performance decreased markedly. Remember that in the pen study the older users used compensatory strategies such as finger counting to maintain a low error rate in the face of task complexity. A well designed interface should remove the need for such strategies.

It is relevant that I, as the designer, was surprised by the strength of this effect even though I had expected older users to need simplicity. Levels of complexity that the middle aged subjects I pre-tested the designs with, found only slightly more difficult, nearly defeated the older users. This occurred with a group of older users whose career achievements indicate that this had been a decidedly high performing group. Young interface designers are at risk of missing the importance of extremely simple representations of the task. Perhaps young designers are also at risk of not understanding how their view of simple fails to match that of older users. This has subsequently been strongly borne out in Newell et al's (2005) study of the assumptions that designers brought to a project for older users.

3.8.3 Selection effects and Diversity

I am concerned about the generalizabilty of experimental findings using older volunteers. The filtering effect of selection bias means that the computer-using older users who volunteer are probably atypical. Asking participants to come to an experimental site rather than observing users in their daily activity seems likely to accentuate such bias. This is particularly likely in a widely spread out city with considerable traffic congestion and poor public transport.

The individual results were remarkably variable. Even if larger numbers of experimental subjects had meant that small yet statistically significant interface effects had been observed, such results would not have characterized many of those who took part. This illustrates the issue of whether statistical analysis based on measures of central tendency is appropriate when dealing with research on older computer users. It would seem that studies of interface design for older users need to address the point that difficulty with an interface for older users is a very individual matter based on the particular combination of aging effects that the older person has.

What this study underscores is that selecting a representative group of older learners is problematic. Hertzog (1996) has called the problem of selection bias the Achilles heel of research on aging and this study bears this out. The easily available older people for studies of interface design and aging are existing computer users connected to email. They are unfortunately not representative of the general older population.

Studies on designing computer systems for older people should carefully define their aims. Is one trying to improve the access of existing older users, trying to design for older people who are currently not computer users but may be faced with a need to get computerized services or is one trying to design general purpose interfaces and using older test subjects on the basis that they are more sensitive to (some) interface problems. The study aims need to be explicitly linked to selection of participants.

3.8.4 Ethical involvement with older participants

Although the study had received a formal research consent and was well meaning, it ended up exposing the older participants to a situation that led to failure. Further this failure distressed the participants and led them to question their identity as competent people in that what should have been relatively simple problem solving was beyond them. The issue of asking older volunteers to fail and the consequent distress and re-evaluation of their belief in their competence needs to be considered in any research design. In particular the standard experimental evaluation of task performance tends to set tasks that will provide a percentage of failures over n trials. This tends to be taken for granted in the research literature but if there are other ways of obtaining the desired information these other approaches need consideration.

3.8.5 Motivation

One of the crucial points illustrated is that the decision making and information gathering scenarios around which the study based its tasks were not typical of the older group's normal computer use and were not seen as relevant by the participants. They also led to higher levels of failure than the participants were comfortable with. The result was that there was a tendency to partly disengage from the tasks. To increase the realism of the levels of task performance obtained from older participants there should be careful selection of tasks so that the tasks are seen as relevant and so that the overall level of success achieved is acceptable to the participants.
A lesson from this study is that in designing research on interface design for older people we need to look more closely at what older users are actually doing, what they would like to do and what actually prevents them achieving their aims. Information

gathering (which in this pilot study was carried out in the focus groups after the experimental phase) should be done well beforehand and shape the design of any later experimental work.

Charness and Schaie (2003) argue that understanding how older people learn to use new technology is a crucial aspect of designing for older users. Salthouse (1996) points out that acquiring competence on complex tasks in older people takes more time than we have available in laboratory based experiments, he suggests that this means studying older people as they learn in real life. The lack of engagement found in the less rewarding parts of the dual task study suggest that if research moves to areas that are more representative of older people's actual lives we will obtain more relevant and higher quality information.

3.9 Towards a desirable research format

The Dual Task study left me with a concern about the narrowness of the information gained in the experimental setting compared with the focus groups. The question arose of finding ways of studying older computer users in ways that allowed serendipitous findings and in ways that were ethical. There was also an emerging insight into the need for obtaining realistic engagement from the older volunteers by way of tasks that were seen as relevant and activity that was experienced as rewarding. Techniques for doing this looked as if they could be found in making the research occur in settings that functioned as social gatherings and by changing the role of the volunteers from research subject to research participant. It was hoped that enjoyable activities would provide an ethical way of rewarding volunteers. There seemed to be an advantage of exploring the older people's lives in more depth to obtain more insight into the context within which they approached computer use. At the same time the experience from the focus groups in the Dual Task study seemed to offer encouragement for the general thrust of the implications for interface design raised in the literature survey. The older users had concerns about the difficulties they experienced with computing that definitely reflected the issues raised in the literature survey. These points led to a rethinking of the research methodology that would be fruitful in pursuing a study of what interface designers should consider in undertaking interface design for older users. This methodology was refined in the studies that are reported in the next three chapters and the eventual methodology will be discussed in detail in Chapter 7.

Chapter 4 MEETING THE NEEDS OF OLDER BEGINNERS

4.1 INTRODUCTION

This chapter looks at the issues for older beginners by examining insights gained from the development of the WinTutor tutorial. WinTutor is an interactive tutorial for older beginners that was designed after the completion of the literature review. The impetus for constructing the tutorial came from exposure to older beginners attempting to cope with poorly designed instruction. The construction of this system and the accompanying interaction with older learners and tutors of older learners gave a chance to reflect on how the implications of the literature review could be put into practice. The research that led to WinTutor was not initially designed as research into developing for older beginners, rather it was aimed at broadening my understanding of, and exposure to, older people. However the WinTutor project did in fact lead to useful understanding about design for older people and it was instrumental in shaping the direction of subsequent research. There are several threads to the WinTutor study.

- Because WinTutor is an interactive tutorial, its development involved constructing an application that very inexperienced older users could work with comfortably. Hence the WinTutor study provides a basis for looking at the interface design issues when constructing an application for older beginners, both at the level of individual screen designs that communicate well with, and can be successfully manipulated by, older beginners, but also at the level of an overall application architecture that could be understood by older beginners.
- An interactive tutorial constructed in association with older people gives the designer repeated experience with developing screen designs that work for older people and repeated experience in discovering screen designs that may please the designer but which do not meet the needs of the older participants. Developing the 57 screens used in interactive tutorials proved to be an excellent way of sharpening my understanding of the interface needs of older people.
- The interface guidelines used in the development of WinTutor follow the broad outline of the implications for user interface design for older users derived in the

literature review. Hence the success of WinTutor can be considered as offering some support for those implications.

- The WinTutor study makes a start on establishing aspects of a methodology that allows a researcher / designer to realistically explore and address older people's needs.
- The development of WinTutor offered a chance to look at what is needed when providing training for older people. It will be argued that this training is significantly different from that needed for younger people and that providing suitable training in basic skills is important to allowing older people to become effective computer users.
- The WinTutor study provides a look at the difficulties of older people when learning how to use computers. These difficulties should be seen as relevant to the wider issues of older people and the design of user interfaces to suit them.
    1. Firstly the difficulties of older beginners will shape their later attitude to computing and may persuade some older people to give up the idea of becoming computer users. Hence understanding how to reduce these initial difficulties is important.
    2. Secondly the difficulties when older people try to learn a new piece of software will have some similarities to those they faced when they first began computing.
    3. Thirdly some of the gaps in computer knowledge that older beginners display are likely to persist given a.) the poor provision of training currently available for older users and b.) the general difficulties they face in retaining learnt material. Hence the initial gaps found in older people's computer knowledge act as warnings to the designer of knowledge gaps that are likely to be present in at least some of their older users.

In what follows this chapter will first look at the observations of older beginners that prompted the WinTutor study. This consisted of observations of older users in a conventional teaching environment, these gave an, at times, vivid illustration of the issues identified in the literature review. The design of WinTutor is then discussed pointing out the way in which the design features that WinTutor implements and the design approach followed in WinTutor's development are aimed at providing solutions to the identified issues of older beginners. The extent to which WinTutor can be seen as effective is then considered. This will be followed by a section that specifies the design recommendations that emerge from the development of the tutorial, including recommendations for the methodological approach. Having established the contributions of the WinTutor study to the overall research, the conclusion of the chapter looks at the further issues that needed exploring and hence shaped the subsequent studies. For convenience a detailed summary of all the recommendations from the WinTutor study and the other studies is provided in Appendix E at the end of the thesis.

4.2 Study format

At the time the WinTutor study was begun the main format of the research was intended to be an experimental examination of older people's interaction with interfaces. However there was also a need to flesh out the rather academic picture of aging that came from the literature review and allow some observation of older people that was not constrained to what could be framed in an experimental context. I considered that it would be important to make contact with older people in a way that let me gain a wider overall picture of their needs, attitudes and difficulties. To this end I sat in on three courses for older people run by Unitec.

The Unitec courses were aimed at teaching introductory computer skills to older people in a Windows environment. The courses consisted of five two hour sessions run with one or two day gaps between sessions. Two separate tutors were involved, one taking two courses and the other one. Neither tutor had special training in working with older people. Class sizes were around ten people. The age range was from sixties to late seventies. With the agreement of the tutors I chose a flexible role as both an observer and a teaching assistant, this gave me the freedom to become involved in older learner's individual difficulties, to intervene at times and to observe at others. I attended all sessions and the afternoon tea breaks in the middle of sessions.

My personal reaction to the effects of these classes on the older beginners was considerable distress. After the first two courses I intervened, providing a rushed, very crude tutorial that provided some simple interactive exercises on the computers in front of the students. This will be referred to from here on as "the intervention tutorial" so as to distinguish it from WinTutor. The exercises were designed to be easy to read and to carry out. The response observed from the tutor and the students was highly positive.

This suggested that one way of examining the application of the guidelines that were being developed for older users would be to use them in constructing a carefully designed interactive tutorial for older beginners. This led to a decision to design and test an improved tutorial for older beginners. This became the WinTutor tutorial described below. Much of the development involved testing with two 55 year olds who were willing to devote extensive time to short sessions of impromptu interface testing in order to help the project and to learn the skills they needed. These people had jobs that required them to learn Windows skills for the first time and they were finding themselves remarkably unable to do so. It would have been preferable in some ways if there had been usability subjects readily available who more closely matched the target age group, but, as will be seen, the final acceptance of the product suggests that the insights my available test users provided were relevant. There was also the considerable advantage of being able to form a close working relationship with these people so that there could be free discussion of the failings of each version of the topic screens in the tutorial as they were developed and of the difficulties that they as learners were experiencing with their own skills and abilities, with Windows concepts and with skill development.

Once the tutorial was in a state where it could be considered to be a credible product it was provided to a selection of experienced New Zealand SeniorNet tutors and the tutorial was refined in response to their feedback as they trialed it on their older learners and discussed it with their colleagues.

Another useful source of reflections and ideas was to set design exercises based on problems in the WinTutor tutorial to classes of (young) students doing graphical user interface programming and interface design courses. This tended to highlight the incomprehension of young designers when faced with a request to design for older users' difficulties with actions and concepts that the younger designers considered absolutely self evident.

4.3 OBSERVATIONS ON OLDER BEGINNERS

The experience of being involved in the Unitec classes was frankly distressing. Most students gained little, they were frequently confused, much of the material was incomprehensible to them and not relevant to what they wanted, which was practical instruction in how to do simple computer tasks. Though he did not express this to the class, one tutor privately expressed the view that he was wasting his time and that the older people were simply not capable of acquiring computer skills. A number of students left the courses feeling that they were too affected by age to continue with computing. In my view this was unnecessary. The Unitec classes for older users provided a rich ground for observing and intervening in older beginners' issues. However because of the poor outcomes and the negative self evaluation of many of the older students resulting from their experiences, it would be highly unethical to deliberately set up such an environment.

4.3.1 Observed issues for older beginners

Vision

The older beginners in the Unitec introductory computer courses were faced with teaching material intended for younger users. Visibility issues arose quickly, some of the students could not make out the text and features on the datashow display at the front of the class. Some of the students could not see the printed material or use it in combination with the screen display. The default font used on the students' machines was set to a 10 point font that was too small for the students.

These older beginners struggled with small fonts on screen and with instructional material on paper. From the items that these older users had difficulty in identifying it is clear that the need for larger readable fonts applies to all text the older user needs to read; captions on buttons, menu and pop-up menu fonts, help text, listboxes and labels explaining other features as well as to blocks of text to be read or input by the older user. In the quickly produced intervention tutorial, Arial, with its simply formed, well spaced letters, was observed to be easily read on screen by the older users, this accords with the findings of the Dual Task study. Many of these older learners struggled when asked to combine paper documents with on-screen work. There was much shuffling of spectacles, peering closely at screens (this involved body positions that the older people found uncomfortable) and forgetting of instructions as they moved from paper to screen. Corrected vision for comfortable reading does not provide for clear focus at the slightly greater distance involved when reading text on a computer screen.

In the Unitec courses the older learners were noticeably slow to find features the instructor referred to, particularly on those MS Works screens that were more complex. This is in line with the findings on older adults' reduced ability to perform visual searches over complex backgrounds. In the intervention tutorial, the screen layouts were very simple, consequently the problems with locating features practically vanished.

These problems with font size and search were also observed in the older users I involved in the development of WinTutor. The consensus that we reached after experimenting with a variety of typefaces was that an Arial 14 point font was easy to read while an Arial 12 point bold was a possible alternative for short text items such as button caption. We also found that reading large blocks of text on screen in almost any font could be an effort but that a slightly off white background was seen as making this easier.

Manipulation

There is research reported in the literature review that shows mouse movement is less well controlled by older users, see Schieber (2003). This slower and more erratic mouse movement with a tendency to overshoot small targets is a good description of what was observed with older users in the Unitec classes and during the development of WinTutor. In addition some of the older beginners had incomplete control over their fingers as they moved the mouse so that there were instances of inadvertent clicks while the mouse was being moved. Further some of the older people seen in the Unitec classes and in other sessions I ran with older people had learnt a poor style of holding the mouse where the base of the hand is in the air rather than resting on the mouse pad. These people were likely to move the mouse significantly when making even single clicks and needed to be taught a more stable way of holding the mouse. Drag and drop features in this context meant that older users could start unintended drag operations as well as make unintended drops with little understanding of what had happened or why. Even after tuition on how to hold the mouse not all of the older beginners could manage to double click. Also at times older beginners would miss the borders of a window and be bewildered by the consequence of the window being sent to the background, by a click that they were unaware was outside the window. They were also at a loss as to how to recover from such a situation. Aula (2005) notes similar problems for older novices observed in Finland including a striking example where an unintended click on the mouse wheel locked the mouse movements into controlling scrolling. Her users then made their usual response of trying to find the mouse cursor by moving the mouse about and were bewildered by the text and screen movements that this caused.

Menus and Sub-menus

The older beginners in the Unitec classes had difficulty in finding items in Works menus, generally they could find an item mentioned by the tutor but only after effort and occasional false choices. This corresponds to the reports of older people's greater difficulties with visual search and difficulties with acquiring small targets. A further difficulty in searching was provided by the distraction that occurred when the mouse moved over the main menu and triggered successive sub-menu displays. Note that in the Unitec classes the menu text was in the default MS Sans Serif font at 10 point size, this was in itself too small for easy reading or searching by the older students. Once a menu item had been located it was not always a sufficiently large target to be accurately clicked on by the older user and mistakes were not uncommon.

The provision of sub-menus added an extra difficulty in that under the Windows operating system the mouse movements required to capture a sub-menu item assume the user maintains a certain speed and accuracy in order for the sub-menu opened from a main menu item to remain visible as the user traverses to from main menu item to sub-menu item. The older beginners could not reliably produce this combination of speed and accuracy so there were repeated instances of the older user losing the sub-menu display. This occurred either because they ventured off the main menu item while trying to move horizontally to the submenu item or because they attempted to move diagonally directly towards the sub-menu item but moved so slowly that the operating system interpreted their intent as a move to a different main menu item, not a move to the sub menu. Older beginners found these results confusing and frustrating.

Typing

Typing was a major source of difficulty for many of the older beginners observed at Unitec. Their text input was upsettingly slow for both the older users and the tutors. Given their reduced effectiveness in visual search some older typists can be described as, "hunt, hunt, swear, hunt and peck", and they can be observed going through the same agonizing process for the next occurrence of a letter that they have found only a few seconds before. Thus the core problem observed was an inability to find keys quickly while searching the keyboard. However this combined with less than flexible fingers and a lack of knowledge of what keys produced various required editing effects such as entering capitals, a space, a new line, removing text or repositioning the insertion point. The older beginners at Unitec were observed to be confused about the difference between the insertion point and the mouse cursor. Charness (1998), using informal observation, noted that older users had serious difficulty understanding the difference between the mouse cursor and the insertion point indicator. My own observations confirm that this occurs and is important in hindering older people's gaining typing competency.

Because of problems with keyboard skills, errors were frequent in the exercises provided. I watched older users use the mouse when trying to position the insertion point in order to make corrections, and it was apparent that the older users were trying for targets (text characters and the spaces between them) whose size strained the older users' ability with mouse positioning unless the fonts used are very large. Similar problems were noted by Aula (2005).

Although it should be simple to approximately position the insertion point using the mouse and then make fine adjustments using the arrow keys, in practice older users were not seen doing this when revising, they tend to persist with mouse based attempts to position the cursor before switching to the keyboard to enter corrections. Alternately, if errors occurred during typing the older users would backspace-delete even quite large portions of valid text in order to get back to the mistake. What appears to be happening here is the lack of a flexible strategy for swapping between mouse and keyboard or between character keys and position keys.

A further problem was that because older people usually look at the keyboard when typing (as well as having a poor model of what the caret signifies and trouble locating it) they are likely to type into text entry areas other than those they intend to, only discovering the mistake after they look back at the screen on completing typing. Again similar problems were noted by Aula (2005).

Scrollbars

The older users in the Unitec classes were observed to have numerous difficulties with manipulating and understanding scrollbars. They were confused by the reversal of direction, a down arrow meant that the text moved up. They struggled to capture the up and down arrows. They did not know about the functionality of the track and slider and if shown were likely to drop the slider when trying to drag it. They did not understand the information contained in the relative size of track and slider. A typical problem was that they would be typing a fairly long (one or two paragraphs) document into MS Works and at some point they would inadvertently click on the track of the scrollbar while trying to click on the text in order to make a correction. (remember that typing and positioning errors were frequent.) The older user would be unaware that they had clicked the scrollbar instead of the text. Confusingly the scrollbar track would respond to a click by making the viewing window jump to a radically different part of the text, at times to a place where the page was in fact blank. The older users virtually all interpreted this as meaning that they had done something that had destroyed their work. This was especially distressing because typing in one or two paragraphs can be a major effort and achievement for an older user. Faced with having apparently lost their work, the older beginners often proceeded to do things that did in fact cause the loss of what they had typed in, such as starting a new document ready to begin again.

Although the older beginners did gain a general understanding that scrollbars were for moving to different parts of text they did not use the tool effectively and restricted themselves to repeated single clicks on the up or down arrows so that they moved through text one line at a time. They also failed to generalize the scrollbar concept. On the forth day of the course students were asked to choose a piece of clip art and insert it into a document. The tool for selecting from the available pictures included a pair of horizontal arrow buttons [<] and [>] that scrolled the user through the images. None of the older users that I observed made the connection that these buttons were to be used to move through the selection of available images. Each student needed to be told what to do.

Comprehension

It was frequently the case that tutors in the Unitec classes asked the older beginners to start a new topic while they were still unsure about the current topic. It became apparent that material to be taught to older beginners needs to be covered at a sufficiently slow pace to allow students to understand it and that this pace is slower than that for younger users and needs to be accommodated into the teaching schedule.

A number of the incidental topics that the tutors brought into the course appeared to reflect the tutor's concept of what was needed to be a respectable computer user, "well of course everyone should know about binary data". Observation suggested that the course material should be ruthlessly pruned to remove items that are not relevant to the older student's immediate learning needs. A large amount of spoken material was presented between each exercise and the students did not take up enough of this material to succeed in the exercises without considerable step by step handholding. This material included items from the history and theory of computing that were both confusing to the older beginners and irrelevant to what was needed for the subsequent practical exercises. It was also my impression that, in the Unitec classes for older beginners, the provision of background information on computing history and concepts impeded the students. For example there was confusion when the older users were introduced to binary storage, they did not readily see how text characters could really be held as one’s and zeros. When the class then proceeded to learn how to save their work, worrying about the need to understand binary storage, and how binary storage was relevant to what they were doing, appeared to interfere with learning the steps needed to save a document.

Navigation

The older users became confused when attempting to navigate around MS Works. MS Works gives a notable example of an application that combines a lot of features that are unfriendly to older users and older beginners. The older beginners had considerable difficulty in finding how to get to the appropriate part of MS Works in order to do text entry exercises. In part this was because they did not appear to form a usable model of the structure of MS Works and how the Navigation Center let users jump to the various parts. They found problems in finding the Navigation Center, in locating the word processor and in extracting themselves when they visited the wrong locations in MS Works. They also evidenced considerable confusion when faced with the difference between separate windows within a single program that gave access to different functions and the windows of another program that offered yet another function. Why when they were using MS-Paint was there no obvious way to get to the navigation center of MS-Works but when doing word processing in MS-Works they were expected to get to the Navigation center to do other exercises. Throughout the five days of the course the older students frequently became lost and needed to be rescued.

Memory and learning

To say that the older users had trouble learning and comprehending the course material offers an explanation that is at too high a level to identify the multiple sources of difficulty involved, and hence at too high a level to plan effective intervention of interface designs that circumvent these problems.

In the Unitec classes, the tutors used an existing full featured application for younger users (MS Works) as a basis for teaching the older students and asked the older beginners to carry out exercises in this environment. The intention was to teach MS Works as well as teaching elementary skills. While this had been found to be workable for younger learners it badly overloaded the older learners.

The tutors were well intentioned, polite, patient and considerate but had a timetable that they wanted to keep to so that they could compete the scheduled content. The differences in the individual speeds at which students mastered material and the extent to which the students needed individual assistance meant that tutors were forced to leave students behind and to terminate some exercises before all students had succeeded. When older users came to subsequent sessions they appeared to have retained relatively little of the material from the sessions of the previous days.
One of the other points that came up in discussion of learning experiences was that teachers with Windows experience but without experience in teaching older beginners tended to teach a number of different ways of achieving one result. The same approach was seen in Help manuals. Older users were found to be surprisingly united in their condemnation of this. Their strongly expressed preference was to be told one way of doing things and they said that being told of multiple techniques was confusing and made remembering any of them more difficult.

From observation it appears that initially skills such as using the Delete key to delete a character, delete a blank line or delete selected text are learnt individually, the older

users observed appeared to take time to see the overall role of the Delete key and this was complicated by the similar but distinct action of the Backspace key.
Watching the older beginners' efforts and attempting to find out what prevented them from proceeding it was evident that at worst they operated from a mishmash of a partial memory of the large volume of recently presented information by the tutor, a difficulty in comprehending new concepts, disruption from trying to cope with errors, a limited ability to see, interpret and find the features that were being referred to, the fact that some manipulation tasks were likely to generate further errors and a lack of knowledge of idiomatic features and jargon that the tutor assumed were obvious. In the midst of the distress caused by this situation they would then be asked to move on to another equally confusing topic.

Idiomatic knowledge

Older learners faced with a computer for the first time are beset with the need to learn a very large number of "factoids" almost simultaneously. The essence of what is mean here by "factoids" is that they are small simple facts and rules that exist in isolation from each other. There is little connection between each fact and little obvious reason for many of the actions and patterns that make up the user interface of the (Windows) operating system. Consider text selection for example. The basic questions are, how do you select text and what do you achieve when you do this? But there is nothing really intuitive about the available mechanisms for text selection. Dragging over text, using the arrow and position keys with Shift held down, typing Control-A or double or triple clicking words and paragraphs form an apparently unrelated jumble of methods. For any beginner of any age there is a period of needing to deliberately remember each of these skills individually. For young users there is a rather rapid transition to automated behavior whereas older users appear to struggle to remember for far longer than young beginners.

Cooper (1995) makes the point that very little about graphical user interfaces is really intuitive, rather Cooper suggests that what a graphical user interface presents to a user is a rich set of idioms. Cooper argues that what distinguishes an idiom is that it is an easily memorable association between a stimulus and a meaning but that this association is not inherent in the idiom, it must be learnt. What was seen in the Unitec classes was that older people did not learn idiomatic skills quickly or reliably in the midst of learning other skills.

One of the successful features in the design of the intervention tutorial was that the idioms needed by older users to complete exercises were identified in advance of the exercise and the intervention tutorial deliberately taught the needed idioms first as separate and distinct items of learning.

One of the crucial differences between younger and older users illustrated by the Unitec classes is that older users do not readily acquire idiomatic skills through incidental learning while engaged in developing higher level skills, such as learning to use a word processor. Because of the number of idioms needing to be rapidly (and nearly simultaneously) acquired for competent computer use, the idiomatic nature of the graphical interface is initially a barrier to older learners rather than an assistance. Lacking idiomatic skills and not being able to acquire them in the midst of other learning is a major obstacle to further computer learning by older users.

Communication between young and old

In the Unitec classes the resource materials were unsuitable. There was a not very powerful datashow used to project the tutor's computer screen which was set to unsuitably small font sizes. This resulted in a poorly lit display at the front of the class that most of the class could not clearly interpret. There were several pages of printed handouts with boring content as well as small font sizes. The main software used was an early version of Microsoft Works which proved to have a navigation structure that often bewildered the students and that they were unable to cope with on their own. The older students were stressed and largely failing to achieve their goals.

One might have expected armed revolt. Instead the students were unfailingly polite to the tutors and took the attitude that the tutors were doing as best they could in the very difficult situation of teaching "old people like us". The students did not see that there were possibilities in providing different resources that were more suited to their needs as older users. Overwhelmingly the students blamed themselves for their difficulties, they apologized for being silly, forgetful and slow of understanding. They were apologetic about making extra demands on the tutor's time.

Older people repeatedly report that younger teachers and relations, "go too fast, try to cover too much, get impatient and assume I understand things". Remember that in the Unitec classes, the intention was to teach MS Works as well as teaching elementary skills. While this had been found to be workable for younger learners it made too many simultaneous demands on the older learners. One of the design points in the intervention tutorial was that each screen was designed to provide an exercise for a single elementary teaching point. This was observed to noticeably reduce the confusion of the older users. The other point that was evident from the Unitec classes is that being told or even shown a skill was not sufficient for the older learners. They needed to be told, shown and then have repeated opportunities to practice before they felt comfortable with proceeding.

In conversation with SeniorNet members I have encountered a widely held belief that having older people taught by younger people leads to poor learning and unpleasant experiences. What was seen in the Unitec classes lends considerable substance to that. However it should be noted that it is not necessarily the age difference that causes problems nor do same aged tutors always eliminate problems. I have also talked with ex-SeniorNet students who have said that their (same aged) tutors knew too much about computing to adjust to the needs of beginners. Some of the key issues appear to be anticipating the likely needs and knowledge gaps of older people, reflecting this in the teaching materials provided, providing sufficient individual assistance (SeniorNet classes tend to have three students per tutor), and that the tutor and others in the class are sympathetic to, and experienced with, the difficulties of older learners.

Motivation

The Unitec classes were demotivating for the older students. The key factors that could be seen were the lack of readily available success, the lack of instruction and materials that were easy to understand, the frequency of getting mired in errors and needing rescuing, the tutors who were unable to empathize with the older beginner's position and the general feeling of being incompetent and out of place that the classes generated in the older beginners. It was noticeable that the response of the students to the intervention tutorial was more positive, it was when using this tutorial that they gained the highest frequency of successful actions. However the intervention tutorial did not change the overall nature of the course which was to teach older beginners a wide variety of skills such as using a word processor, in spite of the evidence that the older users were inadequately prepared for this sort of learning.

My impression was that older people were more likely to get stuck than younger people using the same application. Looking at the problems encountered by my older testers as WinTutor was developed it became apparent that they did not possess the background knowledge that means that elements in a screen can be rapidly scanned and evaluated for their potential in offering solutions. It was also observed that often the older users appeared as if blind to features that were distant from the area of the screen in which they were working. However there was an additional factor in that the older users were found to be much more cautious about trying any feature whose function was unknown. If they did try an unknown feature and obtained an unexpected and undesired effect they had more difficulty in getting back to the starting point. This increased potential for getting stuck if an older user explores an application may contribute to what I see as less willingness to explore in older users. Older students need an environment in which mistakes are minimized and in which the response to being an older student is encouragement and understanding (from peers, including the tutor), rather than a felt pressure to apologize.

Because of the class numbers, tutor expectations and room layout there was almost no student-to-student interaction and assistance during exercises. Although the class had an afternoon tea break, the stresses and self-judgments that the older beginners took from the class inhibited socializing and the somewhat glum mood of the tea breaks was not socially rewarding.

Later when starting to work with the two older in-house testers they did some of the exercises in the rapid intervention tutorial and commented that while they could do the exercises they did not enjoy them much. Simply acquiring a skill was not enough motivation to persist with learning in a boring environment. And so one of the checkpoints as WinTutor was designed was whether an exercise had been enjoyable and fun to engage in.

Perpetual Newbies and Fragile learning

Watching the older learners at Unitec over time and talking to SeniorNet tutors and to older computer users in the community it seems that a significant group of older people will spend their computing lives as "perpetual newbies". A "perpetual newbie" is someone who in spite of repeated instruction does not master more than a very basic (and somewhat inadequate) set of skills.

Interestingly I find that people I classify as being in this group can recall additional relevant learning if prompted, but, un-prompted, make no apparent effort to go beyond their basic skills. My impression from watching older users is that the effort required to access those basic skills prevents accessing or integrating further material. I have watched one such "perpetual" novice over six years and while their skill range has in fact increased markedly, the slowness of this increase is noteworthy and affects their self evaluation of their computer competence.

My observations suggest that for older users, learning new idioms is slow and prone to forgetting and fragile learning for extended periods. Fragile learning is where material is learnt and can be demonstrated by the older person at the time it is presented but on repeated later occasions it is forgotten or only partly remembered. Thus the older user has been shown and repeatedly practiced an idiomatic skill and they appear to be comfortable with using it in exercises in the same learning session. However the skill may be forgotten after the end of the session and may need to be re-learnt several times before it becomes reliably available. Older people find that having to repeatedly ask how to perform an activity over a period of days or weeks is embarrassing and demoralizing. "I get told about it and I can do it but then two days later I have to ask again. And it still doesn't stick. I've been told three times now and I am too embarrassed to ask again, I am trying to find out from a book, and I am not finding out there either."

Supporting the older person's needs and context

There were payoffs from examining not just the older users but also the context within which they worked and the other people who were involved with them, in this case the tutors and the design of the Unitec course. The Unitec course aimed to teach introductory word processing and desktop publishing. It had not been designed with the expectation that basic skills such as holding or clicking a mouse would need explicit teaching. The tutors were observed needing to make frequent individual interventions in order to tell students how to use features that the tutor had incorrectly assumed would be self evident. The older learners observed in a traditional computer class situation had very varying speeds at which they became comfortable with the material being presented. This meant that when the tutor attempted to set an overall pace for the class some students were hopelessly left behind while others were bored and tried things on their own which often led to situations where they too needed to be rescued by the tutor. This in turn took up more time and left other students unguided and ready to make mistakes of their own. What emerged from these observations were pointers that enabled the intervention tutorial and later WinTutor to be designed in a way that met the needs of those surrounding the older beginner as well as the older beginners themselves.

4.4 DESIGN AIMS FOR A TUTORIAL FOR OLDER BEGINNERS

The design suggestions from the literature review were reinforced and made more specific in the course of observing the older learners at Unitec. This section looks at how this translates into a set of design aims that directed the building of the WinTutor interactive tutorial.

4.4.1 Identify and provide training for the skills needed by older beginners

The observation of older learners at Unitec made it clear that the older learners needed to acquire a wide range of elementary computing skills. Hence the tutorial needed to be based on identifying the skills older beginners needed and addressing training in such skills. When the skills needed in order to be able to get any satisfactory results at all on a computer are broken down into individual items the sheer number of things that need to be learnt is remarkable. WinTutor in fact covers a total of 164 skills and facts, the way that these are distributed by topic is shown in the following table.

The observations of older users struggling with idiomatic skills suggest that older users need to be specifically taught the idiomatic skills that apply in their particular graphical user interface environment prior to teaching older users any significant applications. And it is precisely this idiomatic skill set that is the thrust of WinTutor.

Table 4.1 The distribution of the skills initially needed for basic computer use in Windows

Skill area	**Skill count**	**Screens**
Mouse skills	30	13
Keyboard facts	20	1
Windows concepts	28	5
Scroll bar techniques	13	7
Making choices	34	11
Text skills	39	20
Total	164	57

4.4.2 Vision

From the way that the older learners at Unitec struggled with small fonts, information on paper and displays at the front of the room it was apparent that a useful tutorial would need to address issues of age restricted vision. Hence text displays should be able to be easily read by a wide range of older people. Exercises should be presented on screen without the need for additional information on paper or on a tutor's display.

The instances of visual search in the tutorial should be simple for older people to succeed with. Relevant graphic material should also be such that older people will comprehend it easily. The visual design of the tutorial should not present distracting graphics.

4.4.3 Manipulation

From the issues that presented when the older learners at Unitec tried to work with mice the following design aims emerge. Older users should first be specifically trained in the idioms that underlie mouse use and given opportunity to practice such skills before proceeding to other work that depends on those skills. Older users should always be given targets that are visually obvious and within a size range that allows for easy manipulation. This includes such items as menu options and working with text characters. (Where this is not possible due to operating system constraints on such things as scroll bar display it was found that prior training of older beginners on scroll bar skills appeared to sensitize them to perceiving scrollbars and seemed to allow older users to cope more effectively with the small targets they present.) The design should be such that older users are not exposed to unexpected consequences from inadvertent mouse actions.

4.4.4 Comprehension

Failure to understand the material presented was a significant aspect of the observations at Unitec. This seemed to come from a variety of causes; lack of background concepts that had been assumed by the tutor, departures from topics that were strictly relevant to the training in hand, speed and language used in presentation among others. Thus in the proposed tutorial the material presented should be limited to that required for the older users to be able to acquire the skills being taught, in particular, general background and technical information on computing should be avoided. Information and instructions should be given in a way and at a speed that the older learners understood them and could use them effectively.

4.4.5 Navigation

Remember that the older students in the Unitec classes easily became lost, both when navigating between parts of MS-Works and when asked to transfer to different programs that violated the partially learnt navigation rules that the older students were trying to acquire for MS-Works. Older beginners also stumbled into navigation "pitfalls" when they inadvertently clicked outside of the borders of screens they were working with. Avoiding these navigation problems removes a source of upset and distraction for both students and tutor.

Navigation should be such that older students do not get lost and can effectively navigate to any part of the system they need to reach. Hence the navigation built into the design of an interactive tutorial needed to provide a high level of simplicity and consistency.

4.4.6 Skill sequence

The tutorial was to be aimed at the mass of largely idiomatic skills that are needed as a foundation prior to learning how to use applications. It should be assumed that the older learner knows virtually nothing about computers at the start. Necessary knowledge should be built up step by step in a workable sequence within the tutorial so that the student is not frustrated by not possessing some piece of knowledge. This required a breakdown of the components in such apparently simple acts as a mouse click and ordering the introduction of these components so that the most basic are learnt first.

4.4.7 Exercise structure

The aim of each step in the tutorial should be simple and readily understood by an elderly user. The amount to be learnt at any one time should be restricted. A step to be learnt should be learnt as a topic in its own right with no need to proceed or consider other material until a topic has been mastered. It should be easy to repeat steps.

4.4.8 Motivation and reward

One of the observations from the Unitec classroom observations and the early focus groups was that older people bring a fairly fragile sense of competence to their initial interaction with computers. This was reinforced by the observations in the Dual Task pilot study.

Learning exercises should be such that success is very easy to achieve. There was seen to be a need to combat the readiness of older people to blame themselves when things went wrong and a need to minimize the likelihood and consequences of their mistakes.

The tutorial would need to be designed so that the student could proceed through the material at their own pace. This meant that instructions and information needed to be given in such a way that they could be taken in without reference to the tutor, for most students for most of the time.
The tutorial would need to be reasonably entertaining.

4.4.9 Typing

Typing was a major source of difficulty for many of the older beginners observed at Unitec. Typing speed was often extremely slow and those older beginners who did not have prior typing skills (the majority) were stressed when trying to type. The tutorial would need to be designed so as to minimize such difficulty and stress.

4.4.10 Designing for the older beginners' context

The design would need to reduce the skill needed by tutors or family members when attempting to provide instruction for older beginners. The design would need to provide a way of reducing the level of overload experienced by tutors working with classes of older learners. Finally the design would need to cope with older students' need for relearning of material over a long period of time, longer than the duration of any practicable class.

4.5 RESULTS

WinTutor was constructed from an analysis of older beginners' problems in the light of my reading on aging, my observations of classes, my experience as a teacher and point by point feedback from the two late middle aged people I worked with as the tutorial was developed. The continuing demand for WinTutor and the praise it attracts from older users and tutors suggests that it has addressed some of the issues that older beginners face. WinTutor continues to sell to SeniorNet clubs and members and has so far sold over 1200 copies on word of mouth recommendation alone. Since some copies are for classroom use in SeniorNet clubs and there are some unlicensed copies this figure considerably underestimates the actual number of older beginners who have used the tutorial.

The experienced SeniorNet tutors who reviewed the later versions have said that their concerns have been met and the comments from SeniorNet branches and from users have been positive. A representative sample of these comments follows.

- This is exactly what I needed when I first started to try and use a computer.
- Congratulations on a very good product.
- Both programs are well received by our members and tutors.
- Thank you very much for the WinTutor program, its an excellent program
- Many thanks for WinTutor. We have already installed it on one PC and worked through it. It is just what we were hoping for so we are about to install it on the rest of the PC's
- Both programs (WinTutor and FileTutor) have been well received here, we are using them as the basis for our Introductory and File Management courses.
- I have viewed WinTutor and believe it would help many people get to grips with computing and be more confident much quicker.

- Yes, we did receive WinTutor last year but it was returned as it was decided not to use it at that time. However, in discussion with members from Napier, we find that they are using it very successfully with beginners and it seems that the time has come to change our decision.
- I think this is the best learning tool I have ever seen and I regularly encourage new students who I feel could do with a little help to buy it. I have noticed marked improvements in those who buy one and practice on it at home.

It is this pattern of response from those who use WinTutor as students or tutors that justifies a closer look at the interface design issues for older beginners on which WinTutor is based.

4.6 A BRIEF TOUR OF WINTUTOR

The aim of this section is to give the reader sufficient exposure to WinTutor to capture a feel of how the multiple concerns expressed above can be interwoven to create a workable design for older beginners.

4.6.1 The WinTutor Main Menu

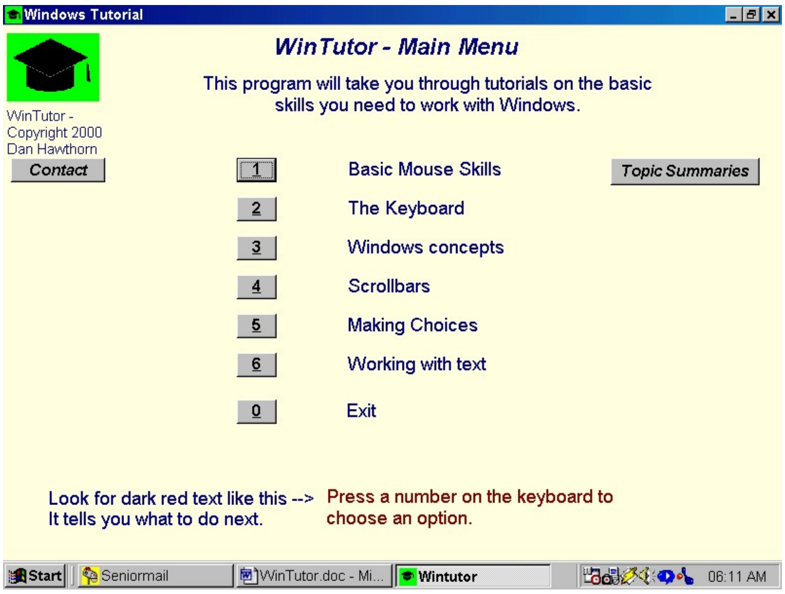

Figure. 4.1 The WinTutor main menu screen.

Having watched older users become confused when attempting to navigate around MS Works gave a strong impetus for providing a very simple system of navigation throughout WinTutor. The initial screen for WinTutor offered a menu of six buttons for the six topic areas. Number keys can be used to make button choices as an alternative to the mouse. This screen provides the home base of the navigation system and as will be seen there is a simple way of returning to this menu screen from the tutorial topics.

4.6.2 WinTutor Navigation within topics

The theme of simple accessible and consistent navigation continued within the topic screens. Once a topic had been chosen the navigation through the screens that made up the topic sequence used [Forward] and [Back] buttons in a standard position at the bottom right of each screen. The menu screen could always be accessed by the [Menu] button.

Figure. 4.2 The standard navigation buttons used in WinTutor were positioned at the bottom right of each screen within a topic.

For those students who were doing revision there was a second system of access via the summary pages that let users step into the main sequence of a topic at a particular point. This navigation system allowed a basically linear approach to navigation through the topic screens for first time users but meant that people doing revision did not have to go through all the screens in a topic if they were only wanting to revise a small part of it.

4.6.3 Developing mouse skills in WinTutor

The points made about the design considerations that drove the development of WinTutor can be reinforced by taking the reader through the designs of the WinTutor screens used to introduce older users to the mouse.

First mouse topic

The first screen in the mouse skills topic presents only a few simple facts in an uncluttered layout. It assumes very little prior knowledge of computer skills. Illustrations are kept simple and are well labeled. The cursor is referred to as a pointer at this stage to reduce the jargon level.

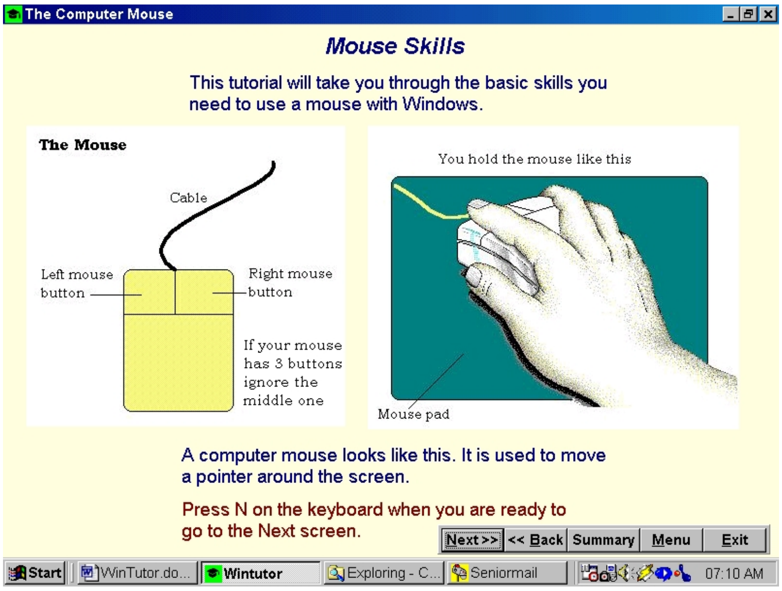

Figure 4.3 WinTutor - Mouse skills Screen 1: First facts

There is no assumption that the older user can use the mouse. Progress to the next screen is by pressing N on the keyboard. However for those older users who are able to use the mouse and are revising earlier work, mouse clicks are supported by the navigation buttons.

The two meanings of "Button"

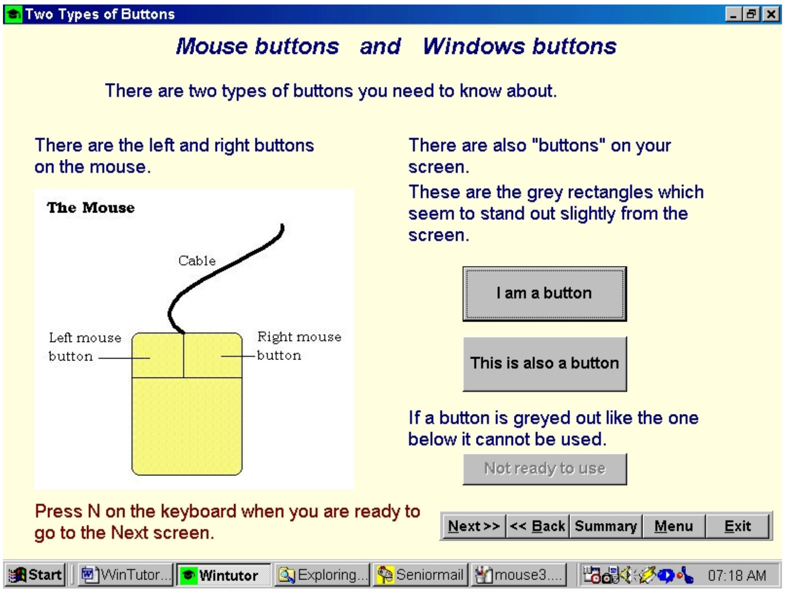

Figure 4.4 WinTutor - Mouse skills Screen 2: Types of buttons

The second screen in the series simply makes obvious the distinction between mouse and screen buttons. Note that it is not being in possession of this sort of apparently "obvious" fact that creates a gap between tutor and older learners. As an aside this is too early to introduce the idea of disabled buttons, at this point in the instruction sequence the concept of a disabled button asks the older learner to "hold on to" a fact that has no immediate relevance.

First use of the cursor

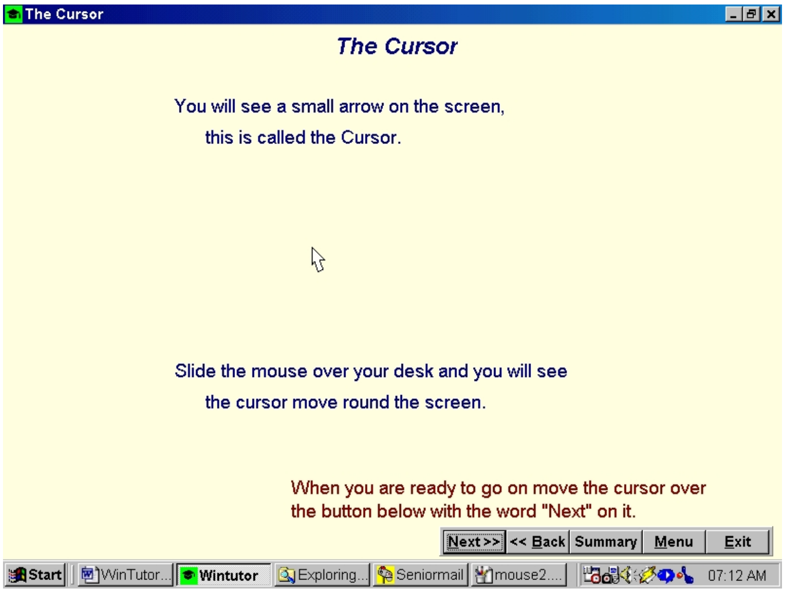

Figure 4.5 WinTutor - Mouse skills Screen 3: The Cursor

The third screen initially shows with the cursor in the position shown with a large area of surrounding whitespace so that movements of the cursor are easy to pick. For the same reason the amount of text is kept to a minimum. Sliding the cursor is actually the first exercise the older student undertakes. Moving to the next screen by sliding the cursor over the [Next] button introduces the idea of the mouse + cursor as a tool for interacting with the computer and this is emphasized in the following screen.

Reinforcing cursor skills

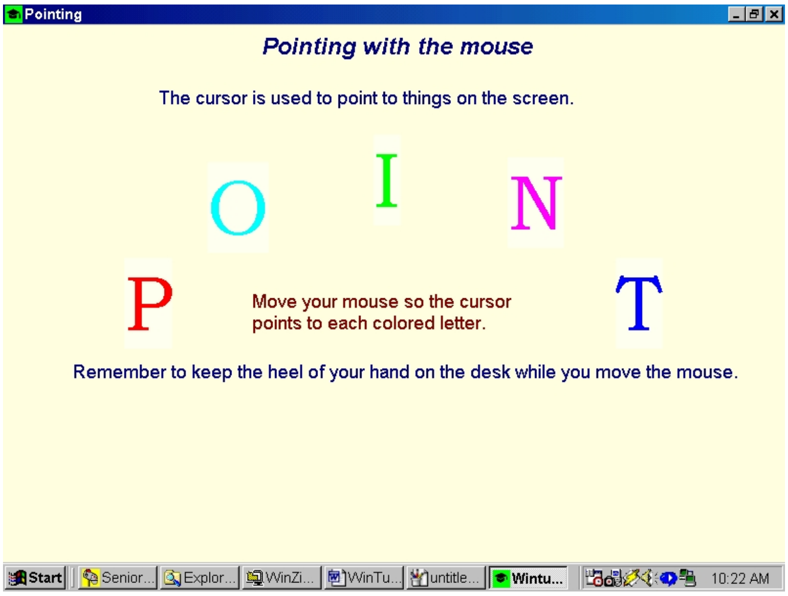

Figure 4.6 WinTutor - Mouse skills Screen 4a: Pointing exercise, before pointing

The targets here are the large colored letters spelling out P O I N T and as the mouse moves over each letter that letter vanishes. The first time the screen is seen the navigation buttons at the bottom right are hidden so that the student cannot make an unexpected jump to another screen by unintended mouse movements, Figure 4.6. After the student has successfully completed the exercise the navigation buttons are shown and they remain visible for subsequent practices so that the student can move on at will, Figure 4.7.

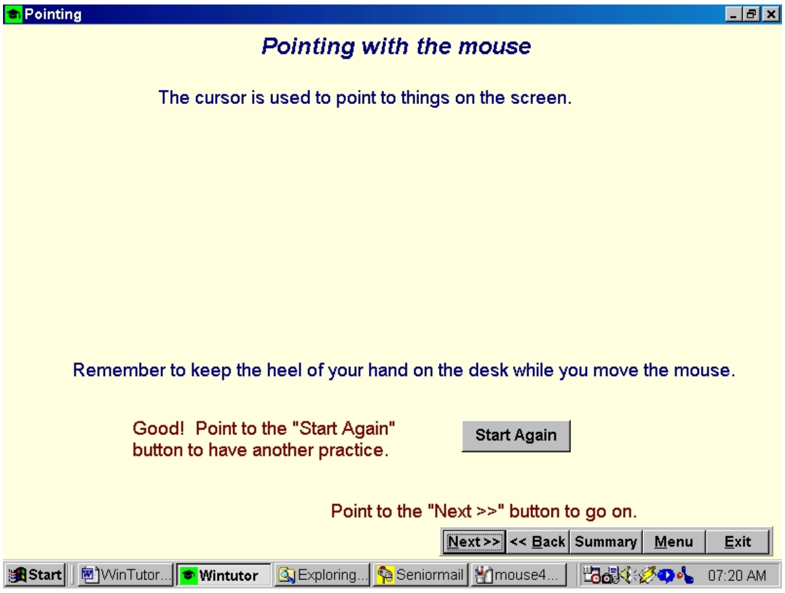

Figure 4.7 WinTutor - Mouse skills Screen 4b: Pointing exercise, after pointing to all targets

When the student has pointed to all the letters in P O I N T and made them vanish, the screen changes and a [Start Again] button appears together with the words "Good! Point to the 'Start Again' button to have another practice." The navigation buttons also appear now that it is assumed the student has enough control over the mouse not to point to things unintentionally. Several issues are illustrated here. The exercise is deliberately set to be easy and non-threatening. The initial targets are made very large. The target letters are given different colors to provide visual appeal but the colours are chosen to maintain a strong contrast with the background colour. The movement from target to target is close to the natural sweep of the hand holding the mouse. There is no penalty for missing a target and no time constraint. The feedback for success is simple and introduces a note of fun, the target letter vanishes! The change when all letters have been captured offers simple reinforcement with the display of the word, "Good!" The screen offers simple instructions on how to repeat the exercise. The user is in control of how many times they need to repeat an exercise. Further the skill needed to repeat the exercise or to navigate to the next screen is the skill that has just been taught. Note that the [Start Again] button is a standard feature of other WinTutor screens where the user needs to return to initial state of the screen needs to repeat an exercise.

Introducing mouse clicking

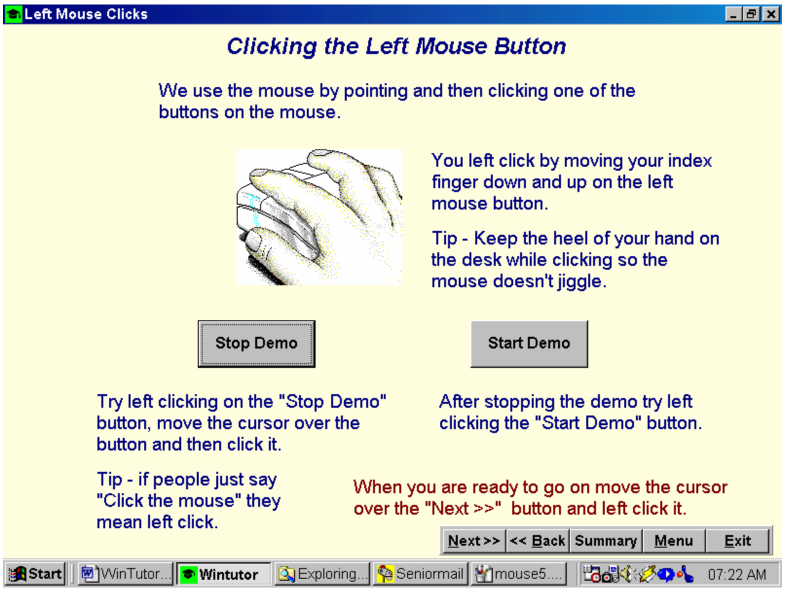

Figure 4.8 WinTutor - Mouse skills Screen 5: Introduction to clicking

The difficulties of the older beginners in the Unitec classes emphasized that there is a real need for progressing slowly using very small steps when teaching older beginners. It is only here in the fifth screen that the act of clicking the mouse is introduced. The action of clicking is shown first, the picture of a hand actually provides slow animation demonstrating the finger action of a left click. Note that again the new skill becomes the way to move to the next screen.

Reinforcing mouse clicking skills

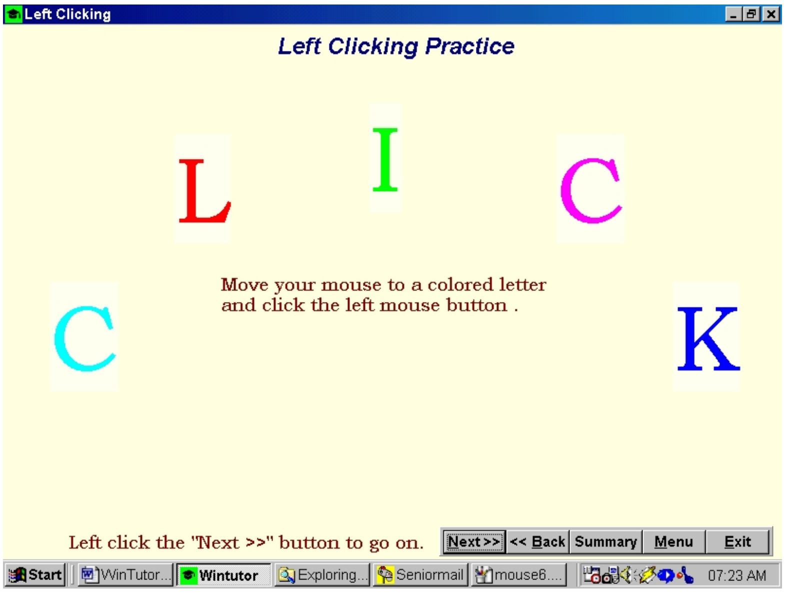

Figure 4.9 WinTutor - Mouse skills Screen 6a: Before clicking targets

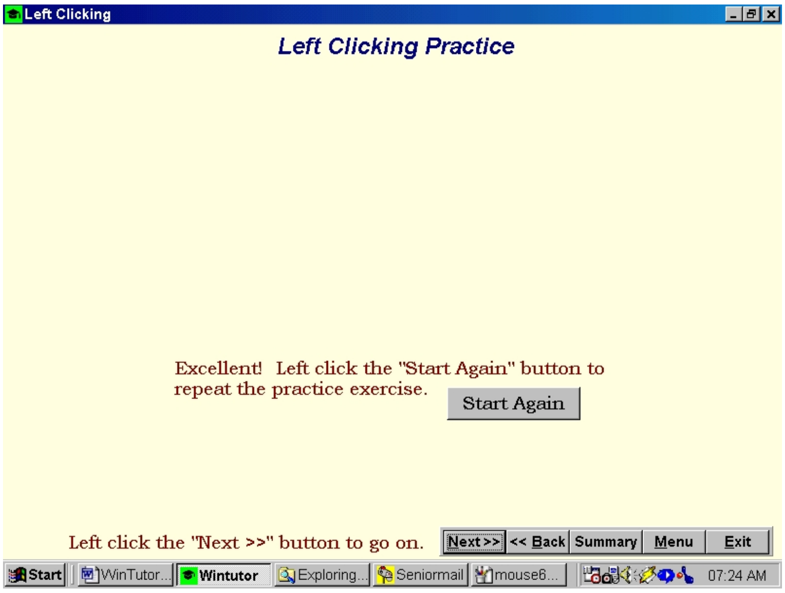

Figure 4.10 WinTutor - Mouse skills Screen 6b: After clicking all targets

Here the pattern of the earlier pointing exercise is repeated although the navigation buttons are always visible since with clicking rather than pointing there is not the same problem with unintended actions. See Figure 4.9.

The assumption is that rather than being bored with the similarity of the pointing and clicking exercises, older learners will feel supported by working in a familiar setting. WinTutor makes the assumption that older learners have no prior computer skills. In reality some of the people using WinTutor will have some background knowledge, although if they have enrolled in a beginners' course this probably implies that their computing knowledge is ineffective. For example several of the older people who enrolled in the Unitec courses did so because efforts by relatives to teach them computer skills had not been satisfactory. I was initially concerned that older people with some knowledge would be bored by repeating material that they knew or would feel patronized. What seems to emerge from observation is that older users are more willing to do exercises that revisit their earlier knowledge than I would expect of younger students. My impression is that, within limits, being able to successfully use existing skills is seen as affirming for older users.

In fact feedback on WinTutor has indicated that this slow elaboration of skills in a familiar setting is well received. The SeniorNet tutors who were consulted strongly supported this approach to teaching older people.

The rest of the mouse skills topic

The tutorial on mouse skills then proceeds to cover the further sub-topics of dragging and dropping, double clicking, right clicking and the meanings of common cursor shapes, finally ending at the summary screen for mouse skills shown in Figure 4.11. The exercises use variations on the now familiar format. For example double clicking is not going to be possible for some older users. The instructions make this clear and there is a colored box on screen that tells the student if they have timed the two succeeding clicks too far apart.

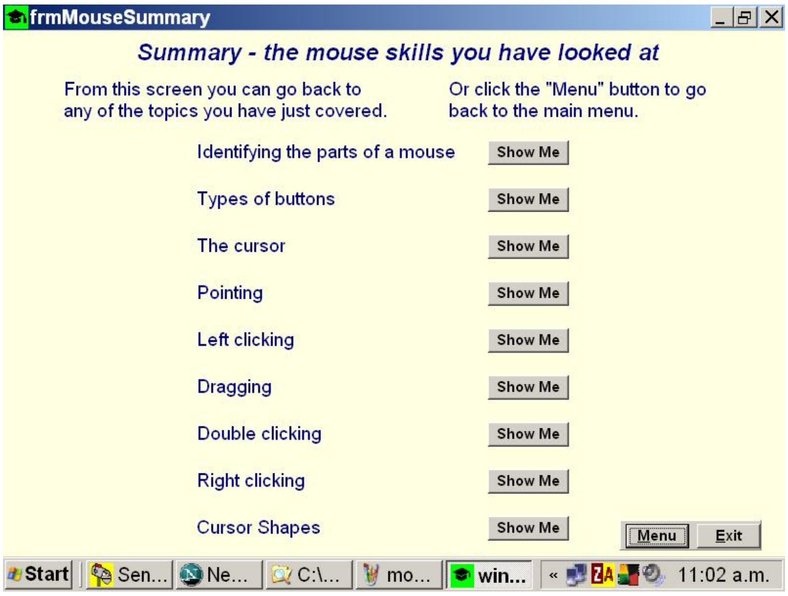

Figure 4.11. The summary screen for mouse skills

The tutorial deliberately does not go into detail at this point about altering the timing required for double clicks or setting Windows to respond to single clicks. These are useful pieces of knowledge but they operate at a level of abstraction (the operating system controlling the definition of a double click), and detail (the steps required to make the change), that are considered will overload older learners at this early stage.

4.6.4 Typing in WinTutor

Remember that typing was a major source of difficulty for many of the older beginners observed at Unitec. There were a number of problems; inability to find keys quickly while searching the keyboard, less than flexible fingers and a lack of knowledge of what keys produced various required editing effects such as entering capitals, a space, a new line, removing text or repositioning the insertion point. WinTutor in fact uses 20 screens to lead the older beginner through 39 useful pieces of knowledge about typing and text entry. Throughout this an effort is made to kept the amount of typed input to a minimum. Once again the concern is to introduce the skills needed for text input in a slow manageable sequence where skills are introduced, practiced and then used for building further skills.

Here are the first two screens in the tutorial on working with text.

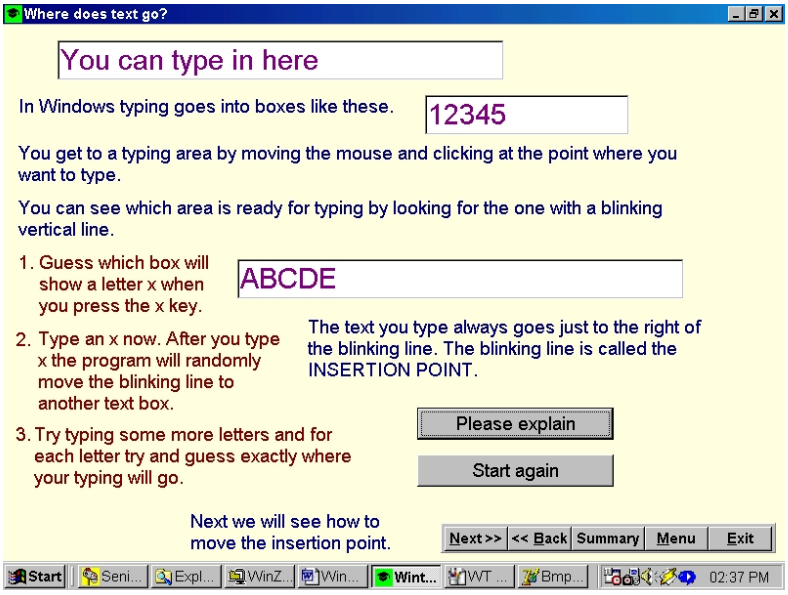

Figure 4.12 WinTutor - Typing screen 1: Where will text go?

The older beginners at Unitec had been observed to be confused about the difference between the insertion point and the mouse cursor. The first exercise concentrates on training the older beginner's awareness of the insertion point. Note that there is little need to find letters on the keyboard and the insertion point is introduced by itself, without reference to the mouse cursor. Also note the very large text used for input. One advantage of using this large font here is that it is accompanied by a correspondingly large insertion point so that the older beginners have a reasonable chance of spotting an important item that is unfamiliar to them and hence harder to search for. The explanation of the insertion point is shown in response to the user clicking the [Please Explain] button.

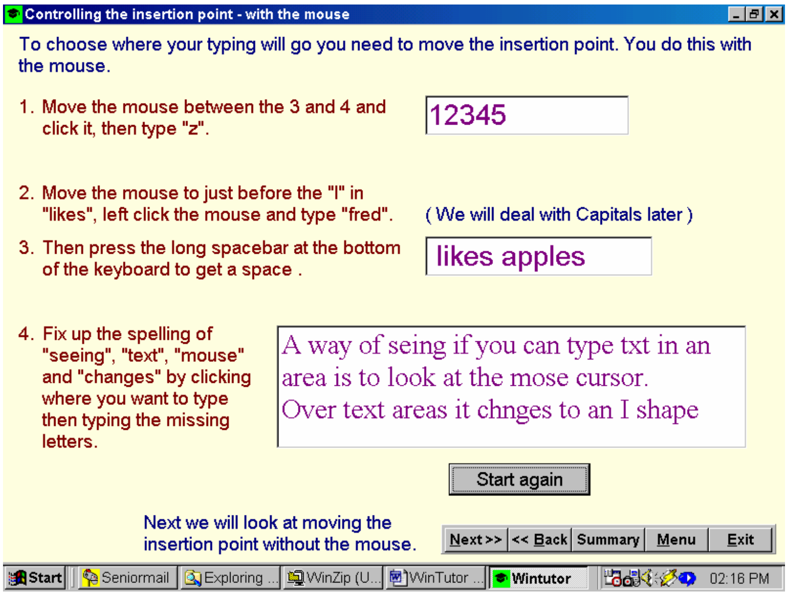

Figure 4.13 WinTutor - Typing screen 2: Setting the insertion point position

The screen shown in Figure 4.13 is the second screen in the typing tutorial. Having established the role of the insertion point WinTutor now proceeds to give an exercise in controlling where to insert text using the mouse. Again the font for the text boxes is very large, this time the advantage is that the targets (such as the space between the numbers 3 and 4) are large enough for most older users to acquire the intended target. Again typing is kept to a minimum. The exercise moves from a very minimal skill level to a realistic task of fixing spelling mistakes. A further 18 screens are used to complete this part of WinTutor, covering basic text entry skills.

4.6.5 Scrolling in WinTutor

Scrolling was another skill that caused difficulty for the older beginners at Unitec. Again in WinTutor a scrollbar was treated as a set of skills that needed explaining, practice and serial development instead of being treated as a single, simple, self explanatory idiom. Here are three of the screens from the sequence of seven screens that covered the 13 aspects of scrollbars that underlie this apparently simple idiom.

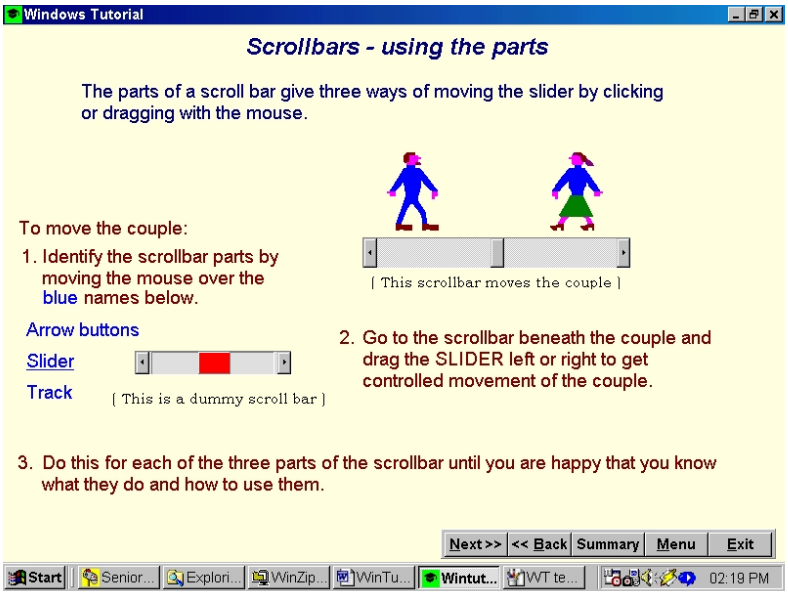

Figure 4.14 WinTutor - Scrollbars screen 3: Exercises in using the scrollbar parts

The observations of older people using scroll bars suggests that they are likely to only use the arrow buttons and that they are unaware of the names or function of the other components of a scrollbar. Hence these features need deliberate introduction. In the first two screens of the scrollbar topic the older learner is introduced to the different parts of the scrollbar and the third screen shown in Figure 4.14 repeats the process of identifying the parts and now gets the older learner to apply the knowledge to a simple exercise. In this screen, as the user moves the mouse over the words shown below instruction 1; "Arrow buttons", "Slider" and "Track", then the content of instruction 2. changes to ask the user to do an exercise based on that part of the scrollbar. Figure 4.14 shows the instructions for the suggested exercise that display if the user moves the mouse over the word "Slider". On MouseOver the word "Slider" is underlined and the slider in the dummy scrollbar is highlighted in red. This aids the older user in remembering the choice they had made, and the part they are dealing with, as they do the relevant exercise. Note that the first choice in the list of parts is "Arrow buttons" so that an exercise is first undertaken for the simplest and possibly the most familiar aspect of the scrollbar.

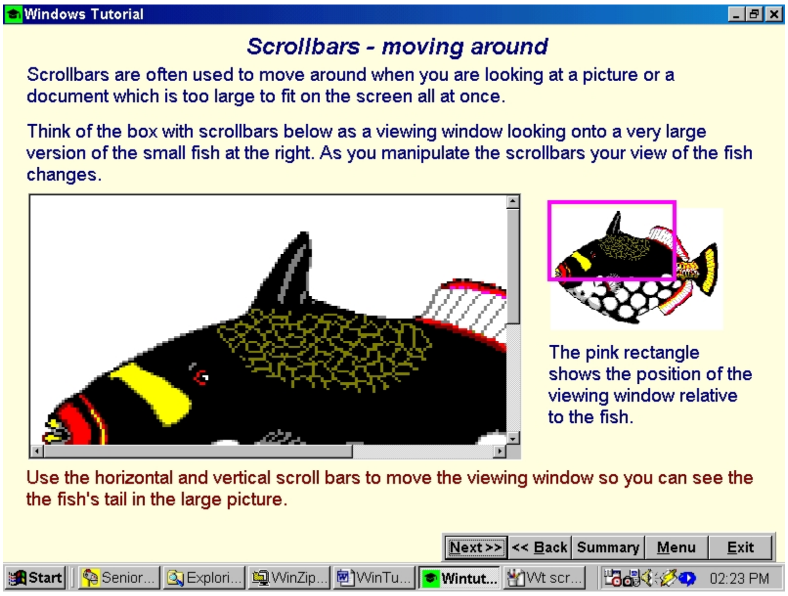

Figure 4.15 WinTutor - Scrollbars screen 4: Seeing part of a larger whole

In discussion with older users I gained the impression that at least initially they found difficulty in seeing the scrolling window as a viewport onto a larger underlying document. The exercise shown in Figure 4.15 attempts to address this directly. Older users were found to be able to carry out this exercise and they enjoyed doing it but they do not automatically generalize what they had learnt to understanding the roll of a scrolling window onto text. Hence this exercise needed to be followed by a similar one using a text based example. This appears to typify older people's learning processes where abstraction and generalizations emerge at a rather slow pace, initial learning appears to be concretely focused on specific aspects of specific tools.

As another example of older people's difficulties in generalizing from prior learning, older users, who had some experience with scroll bars, failed to comprehend the basis of a couple of arrow buttons [<] and [>] without a connecting track bar, that were supposed to allow the user to move through a list of clip art pictures.

The exercises on using scroll bars to navigate the underlying larger document were followed by two exercises that brought to the older users' attention the information available in the size and position of the scrollbar slider and provided exercises in making use of this information. Again my observation was that older learners were much slower than younger users to integrate such extra information into their overall understanding. Sometimes in fact older users remained unaware of the information available in the slider size and position, so WinTutor needed to provide direct instruction on this material. After these two exercises in perceiving and interpreting the information made available by the scrollbar, the older beginners were able to succeed with the exercise shown in Figure 4.16. Again the pattern is that in order to prepare older users for a useful real life skill the elements underlying that skill need to be deliberately taught and practiced, not just explained even if a simple explanation would suffice for a younger group.

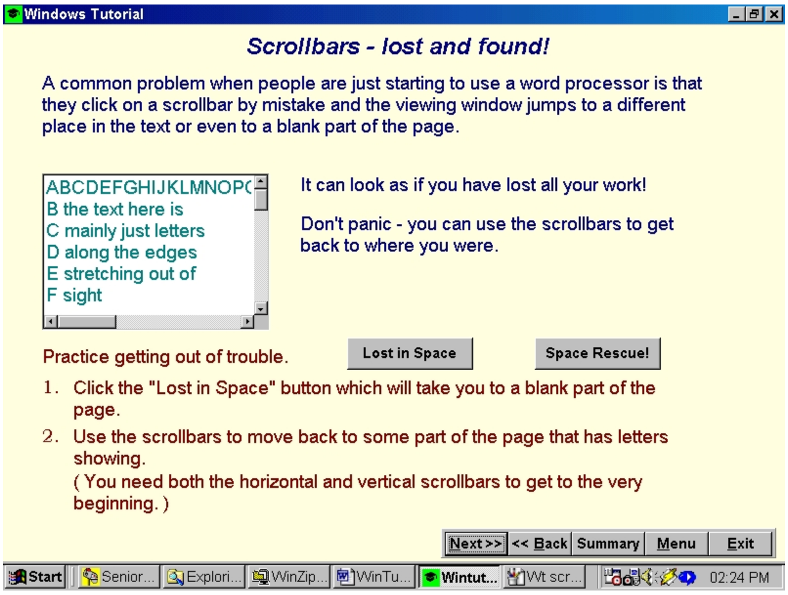

Figure 4.16 WinTutor - Scrollbars screen 8: Lost in Space!

Here the older users can practice placing themselves in a situation where their work disappears and is replaced by a blank screen. They can then use the scroll bars to understand what has happened and to escape from the problem. It remains unclear, however, if older users will reliably remember these skills in the midst of dealing with an unexpected problem.

4.7 DISCUSSION OF WINTUTOR INTERFACE DESIGN ISSUES

The recommendations in this section arise from the fact that developing WinTutor provided considerable experience in developing an application suited to older beginners. Although the skills taught are simple the 57 screens used for teaching these skills present repeated non-trivial exercises for the interface designer in creating interfaces that work for a range of older users. As such these guidelines are relevant to the general question of interface design for older people. The first sub-section looks at issues that are related to application design. The following sub-section looks at recommendations that apply more specifically to designing instructional material for older users. However anyone designing an interactive tutorial will find relevant information in the sub-section on application design while application designers will find aspects of the material in the sub-section on instructional design relevant to making their applications easy for older users to learn and comprehend. The final sub-section of the recommendations looks at the implications of the experience gained in the WinTutor study for guidance towards an effective design approach for developing for older people. Although these recommendations are expressed in terms of their grounding in the literature review and the WinTutor study, they have also been reinforced by additional experience from the two further studies of developing for older people that followed the WinTutor study.

4.7.1 Application design issues

This sub-section covers a variety of issues related to application design for older users. It looks at visual design including thoughts on suitable animation for older users. Manipulation issues are examined including those related to menus and to typing. This is followed by a look at what was learnt about making applications comprehensible and here we also deal with the issue of older people meeting idiomatic knowledge.

Vision

Remember that the older beginners in the Unitec introductory computer courses, faced with teaching material intended for younger users, struggled with small fonts on screen, or on the VDU displays at the front of the class. In the quickly produced intervention tutorial, Arial, with its simply formed, well spaced letters, was easily read on screen by older users. The consensus reached after experimenting with a variety of typefaces while developing WinTutor was that an Arial 14 point font was easy to read while an Arial 12 point bold was a possible alternative for very short text items such as button caption.

Although older users work best with black text on a white background, Charness (1988), my observations suggest that this effect appears to vanish as font size increases if a strong contrast is maintained between text and background. It was felt that unrelieved black text on white could contribute to boredom and possibly to glare and eyestrain over long periods. In WinTutor navy text was used to provide facts that needed learning, maroon text was used to provide step by step instructions for carrying out the exercises. Reading large blocks of text on screen in almost any font could be an effort for the older participants but a slightly off white background was seen as making this easier. User response to WinTutor was that it was particularly easy to read and follow.

Older users also struggled with instructional material on paper. Reading material from paper for application on a computer screen brings up the point that for people with corrected vision the correction for comfortable reading does not provide for clear focus at the slightly greater distance involved with text on a computer screen. There also appears to be an issue that it can be harder to remember instructions when they are read in one place and then applied in another. Hence all instructional material for WinTutor was provided on screen and was closely integrated with the exercises the screen provided.

Older learners were noticeably slow to find features, particularly within more complex screens. In the intervention tutorial, the screen layouts were kept very simple, consequently the problems with locating features practically vanished. This approach was continued in WinTutor. Older users appear to benefit from very simple layouts with few elements all clearly related to a single topic.

Animation

The intervention tutorial provided examples of animation accepted by older beginners while the Dual Task study gave examples of animations older users found unintelligible. From analyzing the differences the following recommendations emerge, aimed at a.) increasing the chance that the animation will be correctly perceived, b.) increasing the comprehension of the relevance of the animation and c.) allowing the older users to examine the rest of the screen on which the animation displays without being disrupted by the movement of the animation.

The animation used to introduce mouse clicking in the intervention tutorial and carried on into WinTutor appears to be an example of suitable animation for older users. Suitable timing parameters for this animation were established by trial and error with older users, the action is slowed down, the change is simple and there is a relatively long gap between repetitions of the action shown. There is also no time limit on how long the older user has to absorb the information. The slow action and the pauses between repetitions reduce the level of distraction the animation offers while the older users are trying to read the accompanying text. The animation has a limited number of elements and these elements are familiar to the older viewer. Most elements in the animation do not move. There are only two moving elements, the button and the finger and they spend much of their time unmoving. The moving elements stay in a nearly constant relationship to the unmoving elements and their identity is prompted by the identity of the non-moving elements. The click animation is running when the user first sees the screen and remains running until the user clicks the [Stop Demo] button. In trying out the skill the user is gaining control over the animation which provides an element of reward. There is a clear emphasis in the instructions on the need to use the left mouse button so that the chance of students making mistakes is reduced.

Manipulation

Some older beginners were likely to move the mouse significantly when making even single clicks and there was a tendency to overshoot small targets. Therefore a designer should provide large targets. This includes larger buttons but also includes providing large fonts for entering text or when using listboxes, radio buttons and menus. Observation of older learners had shown that positioning the text insertion point accurately was an area of difficulty. The use of a 24 point Arial font for the initial text exercises removed this problem, beginners were able to insert and delete characters easily when using text of this size. Slightly later in the tutorial the older learners worked competently with 16 point fonts but the initial use of very large fonts appeared to be useful for the first exposure of older beginners to using a mouse with text..
Older beginners showed slower and more erratic mouse movement with a tendency to wander off constrained paths. Hence with older users the designer needs to allow for slower more wandering mouse movement, more difficulty following tightly defined paths and slower reactions. The designer should not ask older users to capture targets under time constraints.

Not all of the older beginners could manage to double click so that designs should provide alternatives to double clicking. Scrolling was difficult and in part this was due to the small size of the controls on a scroll bar but in part this was due to lack of knowledge of the idioms that are required to interpret scrollbars. It was observed that older beginners who had been given detailed instruction and practice on scrollbars made fewer inadvertent scrolling actions and were better able to recover from those they did make.

Some of the older users' difficulties with the mouse included inadvertent clicks while moving the mouse. Older beginners were likely to fail to observe, or fail to understand the significance of, the borders of a window and be bewildered by the consequence where the window was sent to the background, by a click that they were unaware had occurred outside the window. They were also at a loss as to how to recover from such a situation. The designer should preferably use full screen windows and expect older users to have limited ability to drag or resize windows or to find a window that has become hidden.

Menus and Sub-menus

Older beginners were observed having difficulty in finding items mentioned by the tutor while searching Windows menus. A further difficulty in searching was provided by the distraction that occurred when the mouse moved over the main menu and triggered successive sub-menu displays.

Sub-menus provided a further level of difficulty. While younger users make fast and accurate enough mouse movements to travel diagonally from an item in the first level menu to the desired target in the pop-out menu older users will move the mouse too slowly and the system will interpret this as a move off the menu item rather than a move towards a pop-out menu item. The consequence is that the pop-out menu to the right vanishes and may, confusingly, be replaced by the pop-out menu for an adjacent menu item. Thus in Figure 4.17 an older user trying to use the diagonal white path may loose the "Settings" sub-menu and have it replaced with the "Find" sub-menu.

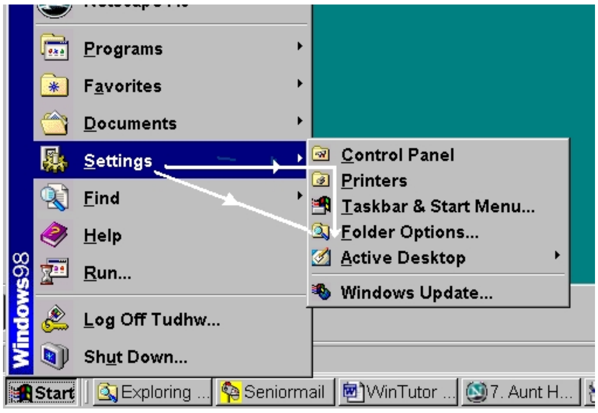

Figure 4.17 Neither of the paths shown in white from "Settings" to "Folder Options" offers a problem to younger users. Both are difficult for older users.

The alternative technique is to move along the menu item horizontally until the mouse is over the space of the pop-out menu and then move vertically. This is more achievable for older users. However older users in my experience often do not know about this technique. If they are told and then try, those with more erratic mouse movements, may, in attempting to follow the required path, wander off the primary menu item and spend sufficient time on the adjoining menu items to drop the pop-out menu for the original item. Hence trying to follow the alternate path in Figure 4.17 shown by the horizontal and vertical white lines can potentially lead to dropping the "Settings" sub-menu and displaying either the "Find" sub-menu or the "Documents" sub-menu. I noted that even those older users who could make adequate mouse movements along the horizontal then vertical path showed signs of concentration while doing so. There is another issue here in that older users are reported as more distracted by and less able to inhibit responses to irrelevant stimuli. Moving vertically and slowly through a sub menu may trigger the further display of sub-sub menus and this will offer considerable distraction.

Remember that older people are less able to inhibit responses to irrelevant stimuli so it was not surprising that this additional distraction appeared to lead to pauses and further wandering in the older person's mouse movement. It was also observed that older beginners were confused by adaptive menus. In general if one is designing for older users it seems worthwhile to consider alternatives to Windows style menus and if one has to use menus then avoiding multiple level menus and exercising control over the menu font size seem useful.

Typing

Typing is a major stumbling block to computer use for many of the current generation of older users. In addition, given the slow pace at which older people acquire and consolidate new skills, typing seems likely to remain a hard task for many of these older struggling typists for years. Applications for older beginners in particular should minimize the amount of typing required of older users.

Typing by older users is frequently error prone but the effects of errors in the text are compounded by small font sizes. The font size chosen for tasks and exercises involving typing is not just a matter of readability but also of how easy it is to acquire text targets with the mouse. For experienced older users my observation is that Arial 14 point is a suitable default font for both entering text and reading blocks of text. However, for older absolute beginners doing short typing exercises involving inserting and deleting text a 24 point font was found to make target acquisition simple.

Comprehension

Any students are less able to cope with new material when they are struggling to integrate previous information. Older students, who take longer to absorb concepts and procedures, are particularly vulnerable to teaching that insists on introducing new material to a fixed schedule.

Designers are steeped in computer expertise and use computer jargon as a normal (and hence unconscious) part of their vocabulary. Older people in contrast are often at the trailing edge of new trends in society and are likely to have less exposure to basic computer concepts and elementary computing terms than younger people. Hence what a designer considers a simple clear instruction, or explanation, may be seen by older users as ambiguous or centered on jargon that does not convey meaning. Instructions should be simple, unambiguous and free of jargon. However because of the gap between (young) designer and older user, the message actually conveyed by instructions should be checked through user testing with typical older users.

Screens should have a minimum of features whose layout provides a clear mapping of the task at hand. Screens should not show features that are irrelevant to the task the older user is trying to complete. A suitable interface needs to work in terms of procedures that have simple (for older users) steps, involving simple actions carried out on obvious features. Comprehension can be assisted by providing the older user with only strictly relevant information. Relevant here means, needed in order to carry out basic task orientated procedures. It seems likely that comprehension problems can be compounded by difficulty in seeing, finding or understanding features, difficulties with manipulation and lack of knowledge of standard idiomatic ways of proceeding.

Keep the application model simple. There should be as few parts to the application as possible and each part should have a clearly designed task. The aim is to make it very easy for the older user to form a simple and accurate mental model of the application. Navigation should have a simple, consistent and easy to follow basis. From observing older users trying to learn MS Works, multi-purpose applications appear to confuse older users, at least initially, especially if some of the application features are irrelevant to the older users' needs.

Idiomatic knowledge

As previously stated Windows has over 150 idiomatic skills that are useful for fairly basic computer use. These skills are usually patchily mastered by older people. A designer should expect older users to have large gaps in their knowledge of basic idioms of the graphical user interface environment they are in. A lot of design depends on users seeing a cue such as a button and jumping to the "obvious" conclusion that they should click it. We interpret the screen based on a wide knowledge of standard ways of doing things in our particular graphical user interface. However in designing for older users, expect older people to have a fragmentary knowledge of such standards. Do not ask older users to learn a number of new idioms for a new application. Unlike younger users, older users will have difficulty acquiring skills and idioms that are intended, by a young designer, to be learnt in a single use. While one should keep instructions simple there is a need to clearly spell out "obvious" procedural steps.

4.7.2 Tutorial design issues

This section looks at recommendations from the WinTutor study that apply more specifically to designing instructional material for older users. Here we cover concerns with accommodating older people's needs with respect to memory and learning, the issues that bedevil communication between young and old, ideas about motivating older learners and the questions of "fragile learning" and older "perpetual newbies".

Memory and learning

Older people repeatedly reported that younger teachers, "go too fast, try to cover too much, get impatient and assume I understand things". The wide variations in the speed at which older people learn imply that some of the learning needs to be self paced, with easy access to repetition. Teaching resources need to be structured to accommodate older learners' likely perceptual needs and manipulative skills as well as providing a workable sequence of skill acquisition that begins from very elementary skills.
Where possible explain a single effective way of doing a task and do not give information on alternatives. Older users' strongly expressed preference was to be told one way of doing things and they said that being told of multiple techniques was confusing and made remembering any of them more difficult. Remember that one of the successful design points in the intervention tutorial was that each screen was designed to provide an exercise for a single specific teaching point. It was also found that being told or even shown a skill was not sufficient for the older learners. They needed to be told, shown and then have repeated opportunities to practice themselves before they felt comfortable with proceeding.

A topic such as text entry or mouse skills should be broken down into a number of very small sub-topics. The sequence of such sub-topics should build skills based on the assumption that one cannot expect that older beginners have any particular initial items of background computer knowledge. The number of skills built within one sub-topic / exercise should be very restricted. Each sub-topic should be provided with a simple hands on exercise that gets the older user to practice the relevant skills. Exercises should be self-paced and allow as much repetition as the older learner feels that they require. Hence, re-starting an exercise should be very simple to do.

Communication between young and old

In the section above it is noted that older people repeatedly report that younger teachers, "go too fast, try to cover too much, get impatient and assume I understand things". It seems much of the expectations of younger people engaged in communication with older people are embodied in a relatively unconscious communication style. Younger people may be slow to notice that their communication is not working and be poor at adapting to older people's needs without descending to "elder-speak". In the other studies that followed the WinTutor study, similar communication problems were found to apply to family members and friends trying to support older users as well as to professional tutors. The contrast between the SeniorNet classes and the Unitec classes when observing tutor pupil interaction and peer to peer interaction was striking. The advantages of the SeniorNet classes appear to offer support for providing older learners with similar aged co-learners and similar aged tutors.

Younger people taking on the role of instructors are likely to need to learn how to communicate effectively and non-patronizingly with older users, yet younger instructors are unlikely to be aware of how much older learners require an altered teaching style. Instructors need to slow, not their speech, but the rate at which they introduce new concepts. Older learners may wish to have time to make notes on procedures in their own words. Instructors should resist the temptation to correct the older learner's language. Instructors should expect, and make allowances for, slow and incomplete learning by some older learners. The emotional response by the instructor should be empathic acceptance of what it is to be old, not politely concealed impatience. It was found useful to use gentle humor to defuse anxiety on the part of the older learners. The company of other older learners is desirable, both as moral support and to reframe learning as an enjoyable social event. Older instructors may be better able to understand, to allow for and show empathy with, the needs of older users but computer knowledgeable older instructors can still overload older beginners.

Motivation

A large part of the levels of motivation I have observed with the older users I have worked with can be linked to the ratio of positive to negative reinforcement that they have encountered in the particular environment that they were working with at the time. Older beginners come to computer learning with an expectation that failure is possible or even likely. What I have observed is that they respond to failure with poorer coping mechanisms than I would expect in younger users. On making an error, older people are likely to be less able to work out what has gone wrong and are less likely to recover from the problem. Older users are also more likely to blame themselves for error and interpret errors as meaning they are "too old for computers" or at least too old to learn the particular skill they are currently having problems with. Errors and difficulties appear to activate and reinforce older people's negative self stereotypes with relation to age, see Levy (1996). It is therefore important that a design for older users establishes a low error rate and a high rate of positive reinforcement.

My experience is that older people are more likely to get stuck than younger people using the same design. Further, older users may not possess the background knowledge to understand the potential of design elements for offering solutions. At times older users may not even see features that are distant from the area of the screen in which they are working. The designer needs to consider that the standard response from older users who get badly stuck is to try Control + Alt + Delete. The other likely response by older users is to stop using the program. The decision in WinTutor to make it very easy to restart any exercise meant that there was an easy and painless exit and recovery from any error.

The older users seen in the Unitec classes were severely overloaded. They were failing repeatedly, they were unhappy and they were bored by typing exercises that asked for paragraphs of typing irrelevant content, they had limited social support from the other older learners. The older learners seen at SeniorNet classes in contrast were happily involved in a social event. Doing (successful) computer learning in an appropriate social setting with other older learners is in itself rewarding so that designing to support a group environment is in itself a useful source of reward and reinforcement. Again the older in-house users I worked with while developing WinTutor baulked at the idea of simply learning facts and doing exercises, they wanted a measure of entertainment, and visual responsiveness. Hence there should be some measure of entertainment (visual interest and gentle humor) in exercises presented in interactive tutorials.

Tasks and exercises should be easy for older beginners to succeed on, so as to counter older users' expectations of difficulty. Make positive reinforcement frequent and easy to obtain for people working at the lowered skill levels of older beginners. A learning environment for older beginners should minimize the likelihood of negative reinforcement from sources such as bewilderment, failure or easily made errors. The interface for carrying out exercises should reduce the likelihood of error and make it easy to recover from errors.

Perpetual Newbies and Fragile learning

The designer should expect older users to spend longer than young users in a state of incomplete knowledge of both the designer's application and of basic computer knowledge. Because of problems with remembering what has been learnt older users' shaky grasp of basic points may be different from day to day. A significant group of the older people who need applications designed specifically for older users will spend their computing lives as "perpetual newbies". A "perpetual newbie" is defined as someone who in spite of repeated instruction does not master more than a very basic (and somewhat inadequate) set of skills. Hence in application design allow for some older users who will not be able to master more than a few basic skills. The design should be such that this basic skill set is sufficient to access the core functionality of the application.

For older people, learning can be filled with examples of "fragile learning" where things that have been learnt are rapidly forgotten after instruction has ended. Older people find that having to repeatedly ask how to perform an activity over a period of days or weeks is embarrassing and demoralizing. Where an older user has been shown and repeatedly practiced an idiomatic skill they can appear to be comfortable with using it in exercises in the same learning session. However the skill may be forgotten after the end of the session and may need to be re-learnt several times before it becomes reliably available. In teaching older users and in tutorial design, plan for limited carry over from one session to the next. Make it easy to carry out revision. For example a tutorial should not assume that all older learners will progress from start to finish. It should be easy to find and re-visit any topic at any stage. Make it easy for older learners to get repeated assistance on a topic without embarrassment.

Teaching idiomatic knowledge

To reiterate points made earlier, Windows has over 150 idiomatic skills that are usually patchily mastered by older people. Older users, in my experience, do not manage the sort of single exposure learning that is expected when younger users encounter idioms. This means that older learners need to be specifically taught the meaning of and actions associated with an idiom where such teaching would not usually be needed by younger learners. When constructing instructional material for older people it is important to analyze the structure of idioms such as a button or a scrollbar and to develop teaching that deliberately introduces the underlying structure in the course of teaching older learners an idiom. New idioms need to be repeatedly practiced and may in fact need to be broken up into simpler steps as was done with the introduction to clicking a mouse in WinTutor.

Supporting the older person's needs and context

The point that started to emerge in the WinTutor study was that it was important to consider the special needs of the people who supported older users as well as the context within which they worked. In this particular case the "class + tutor" context provided a number of tensions with older people's learning abilities. It was useful to include these tensions in the design rational for the tutorial. For example there is a major problem with classes for older people in that older people tend to learn at very different paces so that a tutor is in danger of over pacing the students who need most help in an attempt to keep the class together. Again older learners are likely to need more help in dealing with errors so that the overall demands made on the tutor in a class for older learners are likely to be high. One of the advantages of the WinTutor design was that making the older users more independent had the effect of reducing the demands on the tutor. An interactive tutorial has an advantage in that it lets students proceed at their own pace and changes the role of the tutor to that of a facilitator for individual students. This reduces the level of demand on the tutor.

As another example, there is not enough time in a typical class, or in the time that an older person can maintain concentration over a single session, to master many computer skills or to spend a lot of time on a particular skill. However going over exercises again in their own time increases the amount of information that the older users remember. Make the training materials available for the students to take home and install themselves. This reduces the time constraints of a class situation. There is a useful payoff from making an interactive tutorial very easy to install, by the older person, on their home computer.

4.7.3 Instructional materials and typing

To repeat points made in the design recommendations, typing is a major stumbling block to computer use for many of the current generation of older users. The font size chosen for tasks and exercises involving typing is not just a matter of readability but also of how easy it is to acquire text targets with the mouse. Hence when designing instructional materials one should minimize the amount of typing required of older users. For introductory typing exercises use a very large font, possibly up to Arial 24 point.

4.7.4 Design approach recommendations

This section looks at the way in which the WinTutor study contributed to the design approach that eventually emerged as one of the products of the overall research. Although at this stage the ideas were tentative, they are important as they made a strong contribution to a change of direction away from an experimental approach towards a more observational study. With hindsight an experimental approach was initially adopted simply because it was a traditional way of proceeding but as discussed in the chapter on the Dual Task study it did not seem to be give access to the concerns I was interested in.

Pointers towards a design approach

The research intention that began the WinTutor study was simply to gain a wider knowledge of older users with the object of fleshing out the more theoretical material in the research literature on aging. In a new area such as interface design for older users it is reasonable to open one's perspective to allow a wide range of unstructured observations that are not filtered by pre-existing theory. The aim is to develop the background understanding that will adequately inform later theory building. What emerged was the unexpected utility of engaging with older users and their computer use at a direct and personal level. As I have mentioned, the literature on cognitive and physical aging tends to be reports of experimental work aimed at testing possible mechanisms for various parts of the aging process. The research is not in general aimed at application of the findings to older people's lives. Older people may have a higher frequency of reduced vision or poorer skills with visual search but practical guides as to how large a font is needed or how simple the search space needs to be in a screen design are not spelt out. What the interface designer for older people needs is information about the ways in which design can compensate for effects of aging. I find that my mental model of who I am designing for is always tinged with the assumption of someone like me. But what I found was that it is often in exactly those design features that I take for granted (and hence assume that all other users will also include in their common understanding) that I meet the differences that age creates for older computer users. Direct engagement with older people made me consider aspects of design for aging users that I would have missed or taken a long time to comprehend. Direct engagement with older people was starting to look essential in order for younger designers to overcome the handicap of being young.

Nor does the research on cognitive and physical aging offer a personalized view of the lives of older people or an extended view of the context within which they approach such things as computing. However the approaches to interface design embodied in "Task Centered Design", "User Centered Design" and "User Sensitive Inclusive Design" all ask the designer to be highly aware of the context within which the user will be using the design. What emerged from the WinTutor study confirmed my personal view of how very valuable gaining that contextual view becomes when the group one is designing for differs markedly from the group the designer belongs to.

So the WinTutor study made a useful contribution to the eventual design approach for developing applications for older users that I have developed over the course of my research. From the WinTutor study the following recommendations towards that design approach emerged.

Older users are in fact very different from younger designers in ways the younger designers are likely to repeatedly miss unless they work directly with older users. Hence observation of, and discussion with, older computer users is highly productive. There is a special advantage in doing prototype testing with older users in that the errors they produce are not necessarily those that a young designer expects.

Observing older computer users in pre-existing non-ideal situations can offer useful insight. However for ethical reasons one should not create such situations as part of one’s research.

Consider the context within which an older person will use a product. This includes considering the needs of the people who are supporting an older user in their computer use. There is an advantage in allowing for unstructured or very loosely structured observation of older users in order to allow room for unexpected areas of relevance to emerge.

Because older people are more disrupted by errors there is an extra payoff for them in reducing the chances of error making in an application. Design work needs to aim at preventing ("designing out") the more likely of the errors that older people commit.
In order to effectively do this a designer needs the close support of a few older users on a day to day basis. The process of designing for older users also benefits from support by experts on aging. In the WinTutor study the expertise was provided by the literature on cognitive and physical aging, and by the experience of the SeniorNet tutors as they evaluated WinTutor in the light of their knowledge of teaching older users and then as they trialed the program with their classes. One of the functions of the designer absorbing the available expert knowledge is that it provides the designer with a more sensitive basis for understanding their own observations of older people's problems. Expertise in the nature of aging acquired by the designer also improves the designer's selection of possible interface solutions for older users.

4.8 DISCUSSION

What does the WinTutor study tell us if we are interested in interface design for older users? The first point is that older people are slower to acquire elementary computer skills and are likely to attempt to use the interfaces that are designed for them with a lesser set of skills than designers would expect from younger users. I have observed WinTutor being used successfully with young immigrants and with classes of women returning to work who wanted to acquire computer skills. This suggests that the skills older people need to acquire are not a distinct set from those needed by other users. What is different for older users is the slowness and difficulty of acquiring and retaining these skills.

At the start of this chapter the point was made that the development of WinTutor was important to the subsequent direction of the research. As the chapter has shown, the fact that this was an interactive tutorial meant that in developing it I was engaged in developing an application for older users. In addition I was doing this on the basis of daily engagement with my older design assistants. Thoughtful reflection on this process provided a number of suggestions that could be used as general guidelines in designing applications for older users. The sections on vision, manipulation and comprehension indicate a number of considerations that I see as important in the success of the design that emerged. The design principles underlying WinTutor came from attempts to provide solutions to observations of older learners' problems. These considerations accord with the overall implications for interface design originally derived from the literature review of the physical and cognitive effects of aging. Hence the success of WinTutor as an application that older users could understand and control provides a degree of support for those implications.

The chapter has included a section on a number of points towards a useful approach for developing for, working with and understanding older users suggested by the experience gained in the development of WinTutor. This design approach was expanded in the later stages of the research but it is the development of WinTutor that first gave a strong picture of the benefits of direct engagement with older users and of the virtue of thoughtful and sensitive observation of their needs, successes and difficulties. Obviously developing WinTutor also gave considerable opportunity to consider how to improve training for older beginners. It is worth noting that the use of the interactive tutorial format and the details of implementing this format were derived directly from an analysis of the observed problems that older users found in conventional teaching situations. Thus the WinTutor project offers a different argument for supporting the use of interactive tutorials with older people. Although there have been a number of recommendations suggesting that interactive tutorials are a desirable way of training older users, (and some studies that dispute the virtue of interactive tutorials), these papers tend to do an overall comparison of the learning achieved from an interactive tutorial with the learning achieved from a different teaching format and to be unable to explicate the reasons for the better performance of the interactive tutorial where this is found. In contrast the WinTutor study builds a set of solutions to the observed problems that are found when conventional teaching is used for training older beginners. These solutions are framed within the format of an interactive tutorial. It is not argued that an interactive tutorial is always to be preferred for teaching older beginners but a case has been made that an interactive tutorial offers a useful container for meeting the typical problems older people meet when trying to learn computer skills.

The point was made at the beginning of this chapter that the difficulties of older beginners will shape their later attitude to computing or even persuade some older people to give up the idea of becoming computer users. Hence understanding how to reduce these initial difficulties is important if we want to make computer use available to older people. In fact the conventional teaching approach was seen to lead some older beginners to abandon their attempt to become computer users. In contrast a number of SeniorNet branches now use WinTutor as a required preliminary before older students begin learning specific applications such as a word processor or email. Not all SeniorNet branches use WinTutor but the general approach of teaching elementary skills before tackling applications is common within SeniorNet.
It is my experience that older computer users do not suddenly become computer literate after a basic computing course. They acquire familiarity with a number of idioms but the full range is unlikely to be reliably absorbed. Some computing skills will remain in the realm of fragile knowledge for months or even years. Other skills will be met in training and then simply forgotten. The sheer number of facts and idioms that underpin use of a typical graphical user interface are simply too many to expect most older users to gain overall fluency in them. Hence, as suggested at the start of the chapter, the initial gaps in older people's computer knowledge act as warnings to the designer of knowledge gaps that are likely to be present in at least a number of their older users.

4.9 DIRECTIONS FOLLOWING THE WINTUTOR STUDY

Although the WinTutor development offered a range of insights and appeared to be highly successful in meeting the needs of older beginners there were several reasons for further research. There was no direct formal evaluation of WinTutor and its effect on older beginners' learning, so claims for its success need to be treated with some caution. In spite of the benefits that seemed to come from direct involvement with and observation of older users there was limited observation of older users working with WinTutor apart from the two late middle aged people who provided day to day feedback as development progressed. Another point is that a soft research methodology based on observation but not on an experimental approach needs more replication if it is to offer believable results. For these reasons the decision was made to provide a similar study to the WinTutor study but to include a number of improvements to the research design based on the limitations of the WinTutor study.

In the next chapter the development of a second interactive tutorial is described. This development was specifically aimed to address the weaknesses of the WinTutor study. It was planned from the start as a research study of a design project for older users. It adopted a quasi experimental method where the older people recruited were people who had failed to learn the topic of the new tutorial in previous attempts using a variety of methods, if they could be shown to succeed using the new tutorial this would offer support for the methods that the tutorial embodied. It involved the participation of a relatively large number of older people in the refinement of the interactive tutorial. It involved ways of structuring the participation of the older users so as to increase the amount of understanding of their needs, issues and the context in which they worked. Further it provided a test of the ability of these people to apply information gained from the tutorial. In addition it was intended that this new study could open some new areas of investigation, dealing with how to introduce complex conceptual material into an older persons' computing skill set, looking at older people's ability to learn moderately complex applications and taking advantage of the increased contact with older participants to deepen the understanding of how to turn the implications for design offered in the literature review into a useful application design approach for older users, based on a somewhat more demanding application.

Chapter 5 OLDER USERS AND LEARNING MORE COMPLEX COMPUTER SKILLS

5.1 INTRODUCTION

The WinTutor study had apparently indicated a successful approach to teaching older beginners through designing and using an interactive tutorial. The WinTutor study also gave some indication that working extensively with older users during the development of a product designed for them was a key aspect of creating a successful design. Further the WinTutor study confirmed and expanded the design implications for older users derived from the general literature on cognitive and physical aging. But as mentioned in the conclusion of the previous chapter there were drawbacks to the study, the amount of direct observation of older people working with the program was insufficient (apart from the older in-house testers) and the use of measures such as continuing sales and SeniorNet tutor satisfaction was only indirect evidence of the program's successful design as an interactive tutorial.

It looked as if it would be desirable to carry out a similar study with a design that allowed more direct confirmation of the findings. This would still involve interaction with selected older users during the design stage but would provide a more direct and more objective approach to testing the success of the resulting design. The revised design should also allow for observation of a more widespread set of older users. The problem was that the thesis was intended to address design issues for older users and was not intended to change course and become a study of older people's learning. On the other hand the WinTutor study, though centered round an interactive tutorial, had managed to address a number of themes that were useful to the overall direction of the thesis. It had also seemed to give a broad and useful picture of the early needs of older computer users.

So the aim of this next study was to provide a degree of confirmation of the findings from the WinTutor study while working with older users in a way that added to knowledge about the way to design applications for older users. Again discussions were held with SeniorNet tutors to identify a topic area that was going to be seen by older users as relevant to their needs and where there were likely to be numbers of older people who had had difficulty in managing the standard approaches to the topic. The result of these discussions was the choice of the Windows file management system as a topic area. As this was reportedly seen by older users as a complex and difficult area, it would be a more challenging area to work in but offered the chance to address some themes that extended beyond what had been examined in the WinTutor study.

It was decided that one additional theme of the study would be to examine whether a set of findings on how to train younger users by restricting initial complexity would hold true for older users. Carroll et al (1990) had shown that trainees learnt more effectively if shielded from all but essential features of applications during the initial learning period. Their subjects were young but it seemed reasonable that their findings should apply with equal if not greater strength to older users, given older users' problems with complexity.

It was therefore hoped that a study of older users' issues with the Windows file management system would help address the following points.

- Provide further experience with the emerging design approach for working with older participants during design.
- Provide further experience with interface design for older users as the interactive tutorial itself was designed.
- Provide additional confirmation that interactive tutorials were a useful way of helping older people learn computer skills and extend this finding to cover the case of more demanding computer skills.
- Provide a way of examining the use of Carroll's "training wheels" and "minimal manual" approaches with older learners.

Therefore, working in cooperation with some older people, an interactive tutorial on file management under Windows was constructed and this tutorial (FileTutor) was put through cycles of usability testing. The observations made while conducting these usability tests provide much of the basis of this chapter. In what follows this chapter will look first at the existing literature on training older users in computer skills and the varied views of the value of interactive tutorials for this purpose. The study design is then described. This is followed by a description of the results of usability tests with 25 older users. Having established that the interactive tutorial was in fact useful in assisting older learners the chapter proceeds to provide a description of the design aims behind the tutorial and of the tutorial itself. We then continue with a discussion of the design principles used in the construction of the tutorial and provide observations from the usability study that illustrate the effect of these design principles in practice. The chapter concludes with a look at what was achieved in this part of the overall research and an examination of further research issues.

5.2 PREVIOUS WORK ON TRAINING OLDER PEOPLE IN COMPUTER SKILLS

Previous work on the effectiveness of various methods of training older people on computer skills is reviewed in Chapter 2. Work by Mead & Fisk (1998), Morrell, et al. (2000), Rogers, et al. (1996), Czaja & Lee (2001) looked at a variety of training formats. These studies used limited tutorials constructed purely for use in their experiments. The overall recommendations on training provided by the following authors Morrell and Echt (1996, 1997), Morrow and Leirer (1999), Morrell et al. (2000), Rogers (2000) and Willis (2004), are given in the following list (repeated from Chapter 2).

- Instruction structure: Use lists in a standardized format, language structure and vocabulary should be kept simple, avoid the use of negatives, use an active rather than a passive voice.
- Provide an active learning situation and provide sufficient practice with task components. Ensure that the training environment is free from distractions.
- Content: Emphasize procedural steps and leave out background conceptual information, use concrete examples, some instructions should be accompanied by relevant simple illustrations since some information is not well conveyed in text, slowed animation may be useful. Training material should be well organized and important information should be highlighted.
- Ensure that help is available and easy to access
- Delivery: Allow extra time for training. Training should be self-paced and may work better in small groups

- Instructional materials for older learners should be designed so that attention can be focused on single areas, being mindful of older adult's issues with maintaining divided attention.
- Text formatting: Use a typeface with rounded distinctive sans-serif letters (e.g. Helvetica), use 12 to 14 point with strong contrast between letters and background, use short, left justified lines with a maximum of 65 characters per line, use whitespace to increase clarity.
- General: Be aware of older peoples' problems with: reductions in working memory capacity, reductions in ability to deal with complexity, reduced color discrimination particularly in the blue green range.

Another approach to training people in the use of applications comes from the work of Carroll (1990) who investigated the value of making a ruthlessly simplified version of the application and its manuals the core of the training approach. While this was successful with younger users it has not been investigated with older users. Carroll (1990) summarizes a number of studies in which his team demonstrated with younger users that "training wheels" and "minimal manual" approaches gave better learning of computer programs. The key feature of these approaches is to restrict the options available and the amount of information provided as much as possible. Given that older people are more likely to have problems with complexity, these approaches should be well suited to older learners. Carroll also supported the value of active learning where the user performs the task being learnt. Carroll showed that once users had absorbed basic information they were then better able to handle the extra features, special cases and exceptions that deter users if presented during initial learning. This is compatible with the findings of Morrell et al. (2000) who found that providing older learners with background conceptual information in addition to step by step instructions led to poorer performance both immediately after training and on retesting one week later.

One of the distinguishing features of the FileTutor study is the wider scope of the considerations for constructing the tutorial as it draws on the widespread implications of aging considered in Chapter 2. Again the design approach for the construction of FileTutor involved ongoing participation by and feedback from older users. This is not part of the previous published work on tutorial design. A further difference is that the tutorial examined here was designed as a commercial product for real life training of older computer users in a substantial computer skill and is now succeeding in that role.

5.3 STUDY FORMAT

5.3.1 Initial scoping

After discussion with SeniorNet (NZ) members, file management and the use of Windows Explorer was chosen as a topic that was reasonably challenging to seniors and that seniors saw as relevant and were motivated to learn. Initial conversations were held with SeniorNet tutors that spelt out the sorts of difficulties they encountered with teaching file handling. Samples of instructional material proposed by some SeniorNet tutors for teaching file management to older users were also examined. In the main, this material was worrying in that it presented older learners with a number of technical aspects of data storage that seemed to be irrelevant to their needs and likely, from the experience with the UNITEC classes, to cause the older learners considerable difficulties for no practical gain.

5.3.2 Prototype development

On the basis of these discussions a set of key file handling concepts and skills was developed. The material was analyzed in order to determine a suitable teaching sequence that allowed for the dependencies of some topics on others. Work was then commenced on creating a prototype interactive tutorial covering the file management topics that had been selected. This prototype was developed with the participation of two "in-house" older users who were in their mid fifties, had no knowledge of Windows file handling and found computing in general to be a difficult set of skills to acquire and retain. The interactive screens that demonstrated specific file management topics and skills were tested and discussed daily with the in-house users as they were developed. The in-house testers worked with each individual screen of the FileTutor and WinTutor tutorials. These screens were presented as code based prototypes, the in-house testers were observed trying to use them and comments were collected. New screen versions were then produced and the cycle continued until the issues raised by the in-house testers had been resolved. Once a preliminary version of the whole tutorial had been created it was shown to SeniorNet course advisors and the resulting useful feedback was incorporated.

5.3.3 Usability testing

The resulting interactive tutorial, FileTutor was put through three usability cycles with older users.

A total of 25 older users aged between 60 and 88 (15 male, 10 female, average age 69.8) were recruited by advertising on the internet for people over 60 with Windows experience who wanted to learn about file management.

The usability findings in this paper draw more heavily on the difficulties of some participants than others. Rosenthal and Rosnow (1975) note that volunteers for research projects tend to be more intelligent, of higher status, more articulate and more self-confident than the community average. This was true in this study but because the project offered instruction that was genuinely in demand, and because some of the initial volunteers encouraged other friends to enroll with them who would not have joined the study on their own, there were 7 volunteers who appeared more typical of the general community. They were less educated, less articulate, had clerical or manual careers and were less self-confident. This "more average" group included most, but not all, of those who had greater difficulty coming to terms with file management concepts.

The "more average" group was particularly valuable in the FileTutor project. This group had more difficulties and were of considerable value in showing areas in which FileTutor could be improved. The "above average" volunteers made a useful but different contribution. They personally were more able to cope with the problems in the earlier versions of FileTutor but they were happy to adopt a role of identifying things that they felt might cause difficulties for other older people, these included misleading instructions, and errors in spelling and grammar but they also offered some useful suggestions for style and sequence. However the "above average" group did not spot many of the pitfalls that the "more average" participants exposed. The advantages of partially countering the effects of self selection by volunteers should be borne in mind when selecting older users for product evaluation.

Participants came to Unitec, an institute of technology in Auckland, New Zealand, for three 2 hour sessions spaced two days apart. In the first and second sessions participants worked with FileTutor to gain file management skills. After the first session they took a copy of FileTutor home and installed it on their own PCs and either repeated material they had learnt at Unitec or proceeded to work on new topics as they saw fit. Participants maintained a log in which they rated each example screen and they were encouraged to ask the researcher / tutor for assistance when they became stuck or when they found things that they thought could be more clearly stated, these issues were recorded. Difficulties encountered at home were logged and then examined at the beginning of the second and third sessions. In the third session the participants did a practical file management exercise using Windows Explorer to evaluate how well skills gained with FileTutor transferred to a real life task. The testing protocol for this task is described in Appendix B. Testing on the real life task was followed by a focus group discussion on issues for older computer users and issues in learning about file management. Participants also completed a questionnaire and evaluated the overall usefulness of FileTutor.

The researcher took on multiple roles as observer, usability tester and tutor, the participants were genuine students but also volunteered to assist in finding ways to improve the tutorial for other older people who came after them. Three sets of usability sessions were run, one in December 2000 and two in January 2001. Between sessions FileTutor was altered on the basis of problems found and ideas that were prompted by what had been observed.

5.4 DESIGN AIMS IN DEVELOPING FILETUTOR

The design aims were developed from the material in the literature survey, the experience of designing the WinTutor program and, in the case of designing the simplified version of Windows Explorer, from Carroll's (1990) description of the key aspects of his "training wheels and minimal manual" approach.

Comprehension, Memory and learning

The design aims here were taken from the experience in constructing the WinTutor tutorial. It was assumed that older people would benefit from having a slow pace of introduction of concepts and that learning should be in a form that made the older learner an active participant. In the design of the instructional material the aim was that there should be a careful development of knowledge and skills so that the sequence in which they were presented provided the older learners with an adequate foundation for understanding and acting each time they proceeded to new material. In that older beginners had been observed to have widely differing time and repetition requirements in mastering new material the aim was to make the exercises self paced and capable of being repeated without difficulty by the older learner.

Confirmation, feedback, difficulty levels and motivation

Older learners were observed to be likely to have an expectation of failure and to need assurance that their actions had succeeded. Older people in the dual task pilot study had also been observed to disengage from work where the difficulty levels were set too high. Hence a design aim was to provide easily obtainable success in each exercise combined with clear indications of when success was achieved.

Vision

- Problems with less flexible visual accommodation mean some older users will have difficulty reading from information on paper in combination with carrying out on-screen tasks. Hence a design aim was to provide all exercises and instructions and conceptual material on-screen without relying on printed material.
- Again older people have poorer memory for pictorial information. The design aim resulting from this was that as far as possible graphics and text that explained them should occur on the same screen.
- Older people may have problems with reading text over colored or patterned backgrounds and have problems with small fonts. The aim was to provide easily readable fonts for all text by careful choice of font style, size, color and background.
- Older people may have problems inhibiting responses to irrelevant information so a design aim was to reduce distractions such as purely decorative graphics.
- Older people are poorer at locating visual targets, they also have a narrower effective visual field. Hence a further design aim was to provide a visual environment in which locating features would be simple for older users, the

emphasis here was on simplifying search spaces and reducing distractors while keeping instructions, locations where actions are taken and locations where feedback occurs, close together.

Manipulation and timing

Older users have reduced manipulative ability and when difficult manipulation is performed controlling such manipulation may involve greater cognitive load for older people. Hence in an environment where the older learner should be devoting their cognitive effort to learning new concepts it seems desirable as a design aim to reduce any competition for cognitive effort that could arise from manipulation. This meant making targets reasonably large, reducing drag and drop operations, largely avoiding the resizing and other manipulation of windows and producing designs that did not require double clicking.

Menus and Sub-menus

In line with Carroll's concept of the minimal manual and training wheels approaches the design aim was to restrict and simplify the menus available in the application being learnt, (Windows Explorer).

Typing

Typing remains a severe problem for a number of older users. As in the WinTutor program a design aim was to avoid having older learners put effort into entering more than short passages of text.

Scrollbars

A number of older users were observed to scroll inefficiently. Further where information on a screen required an older user to scroll in order to see all the information it was felt that this would reduce the older person's chances of fully understanding the information presented, both because short term memory problems where what could be seen at any stage would have been a partial version of the whole and because the concentration needed to scroll successfully could interfere with the task of remembering the information that was being hidden and relating it to the information that was being exposed. Hence a design aim for a good learning environment was to reduce the need for scrolling.

Navigation

The design aim was to structure the tutorial into a set of topics where a topic consisted of a set of screens each of which provided a self contained step towards the desired mastery of the topic. The intention was to repeat the simple progression available in WinTutor but with some adaptations because of the more conceptual nature of the topic. Thus it was intended to make additional background notes available for students who wanted extra information.

Carroll's "training wheels and minimal manual"

One of the requirements of effective file management under windows is the use of the Windows Explorer tool for file management. This is in fact a fairly extensive and multi-featured application that had been observed by SeniorNet tutors to cause problems for older people. It seemed probable that Carroll's approach would also be appropriate for training older users on an application and so one of the design aims was to provide training on Windows Explorer in such a way that 1.) instruction was limited to the basic features of the application (Carroll's minimal manual), 2.) training would be done on a simplified "training wheels" version of the application and 3.) training would proceed through a set of "active learning" exercises.

5.5 RESULTS FROM TESTING FILETUTOR

In the focus group discussions in the third and last session all participants reported having tried a variety of methods of computer instruction with generally poor results, the partial exception was training specifically for older people provided by SeniorNet branches. All participants had previously tried (and failed) to find out about file management from a variety of sources. The overall response of the participants to FileTutor was that they were meeting a tutorial that was unusually well suited to their needs as older users. In effect the study design contrasts FileTutor with the variety of existing instructional formats for computing skills instruction that had been tried by these older people. It provides strong support for FileTutor being preferred. Participants praised the overall format of FileTutor as being very easy to work with but, as we shall see, that format is based on a myriad of considerations.

The findings of this chapter are of more interest if FileTutor can be shown to be successful. In response to the question "Would you recommend FileTutor to other older people wanting to find out about files and folders?", using a scale rated from 1 "strongly recommend" to 5 "would not recommend", twenty-two participants responded with a 1, two responded with a 2 and one with a 3. All but three participants said they had gained a lot from using FileTutor and intended to continue working with it.

The practical file management exercise was done with Windows Explorer outside the FileTutor environment, after the FileTutor training sessions. Twelve participants completed the exercise independently, five completed the exercise with minor prompting, five completed the main parts of the exercise with significant prompting and three failed to complete the exercise, see Table 1.

Table 1. Results from the file management exercise. Numbers of participants completing the exercise at various levels of independence.

Level of independence	Percent (n = 25)	Error levels
Completed exercise without prompting	48% (12)	Trivial 0 - 2
Completed exercise with 1 - 2 prompts	20% (5)	Trivial 1 - 4
Completed main parts of exercise with 3 - 5 prompts	20% (5)	Medium
Did not complete exercise	12% (3)	Severe

With respect to the error levels in Table 1, trivial errors were one’s that were understood at once when shown to the user, could be recovered from by the user without further assistance and were the sorts of errors that could easily be made by people who were competent in file management. Medium errors suggested a lack of such competence. The group who needed significant prompting said that they were confident that they would become independent with more practice. Of the three who did not complete the practical exercise and were not enthusiastic about FileTutor, one had limited vision and was unable to see Windows Explorer clearly enough to manipulate it, the other two because of inexperience and disability had made very slow progress through the FileTutor topics and had simply not reached the topics that were relevant to the exercise.

5.6 A BREIF TOUR OF FILETUTOR

This section gives a brief description of FileTutor. This is intended to orientate the reader in preparation for the later section (Section 5.7) where the design solutions for the design aims of the tutorial are discussed.

5.6.1 The FileTutor Main Menu

The initial display was a menu of numbered topics, choice of a topic led to a sequence of topic screens giving explanations and exercises for that topic. Each sequence ended in a revision quiz. Option 10 in the first menu led to another similar menu with ten more topics dealing with Windows Explorer so there are 19 topics involving nearly 80 topic screens in all.

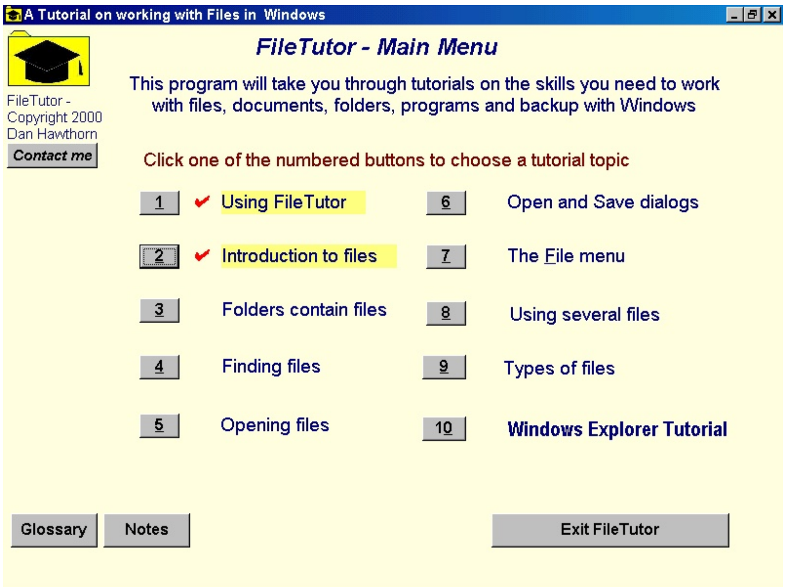

Figure 5.1 The FileTutor Main Menu. Topics 1 and 2 show as completed. The next menu, for the Windows Explorer tutorial, is reached from button 10.

5.6.2 FileTutor Navigation

Topic screens, such as those in Figure 5.2, were displayed maximized and could not be resized, they could only be exited from by a set of Next, Back, Menu buttons at the bottom right. There were no hyperlinks. The intention was to deliberately restrict and simplify navigation. All participants used these buttons easily, without prompting, after brief initial instruction.

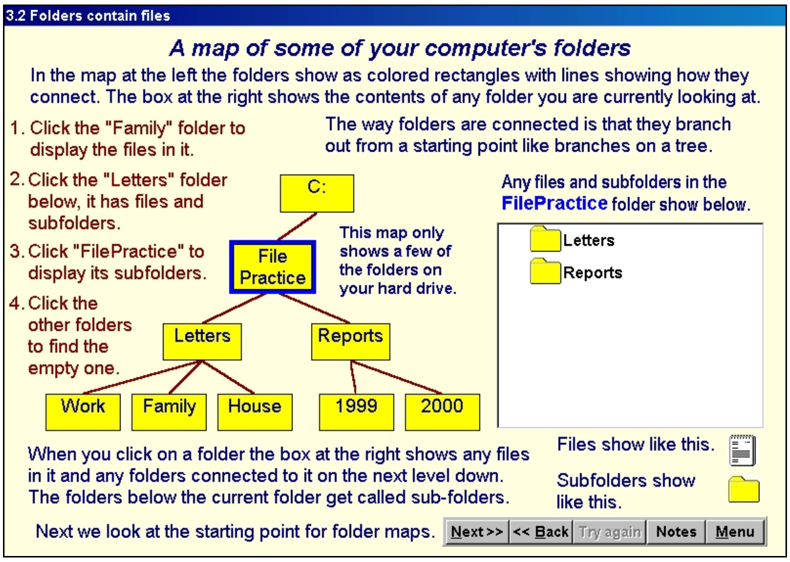

Figure 5.2. A typical FileTutor topic screen showing the navigation buttons in the lower right corner. The screen shows the results of carrying out step 3 from the instructions at the right.

Each screen involving an exercise was provided with a "Try again" button. This returned the screen and the file system to the way it was before the exercise began. Background information was available through a "Notes" button, see Figure 5.3.

5.6.3 FileTutor topics and Interactive Exercises

Each topic in FileTutor consisted of a series of screens that developed the concepts and skills required for mastering that topic. The next series of figures follows the screens from one of the introductory topics where the basic reason for having files is explained and then demonstrated.

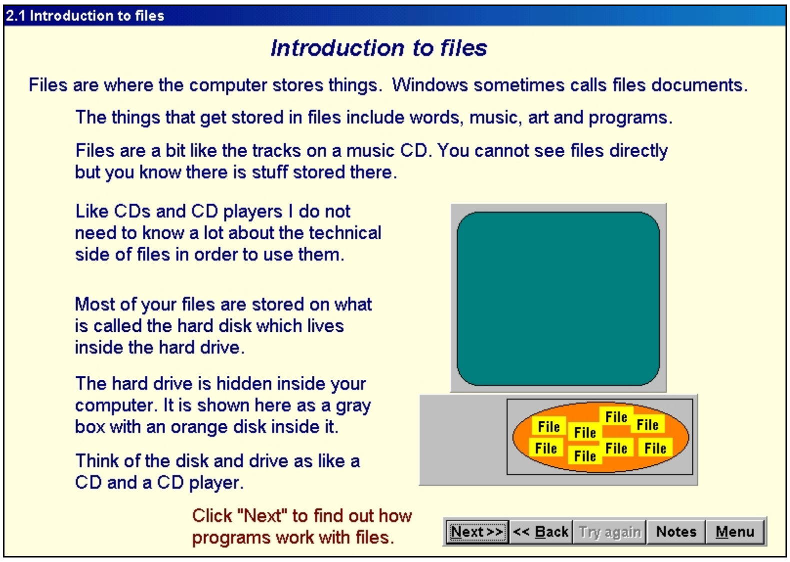

Figure 5.3. First screen in the "Introduction to files" topic.

The screens give simple information backed with pictures that reinforce the text. Technical information is deliberately avoided.

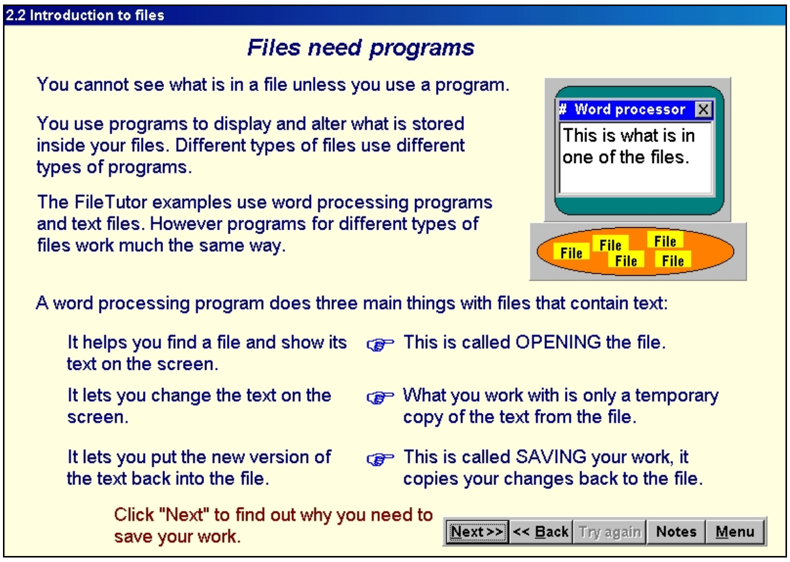

Figure 5.4 Making the link between a file and a program.

Note the very low level of initial knowledge assumed in this series. There was a need to provide very basic background information and definitions of terminology.

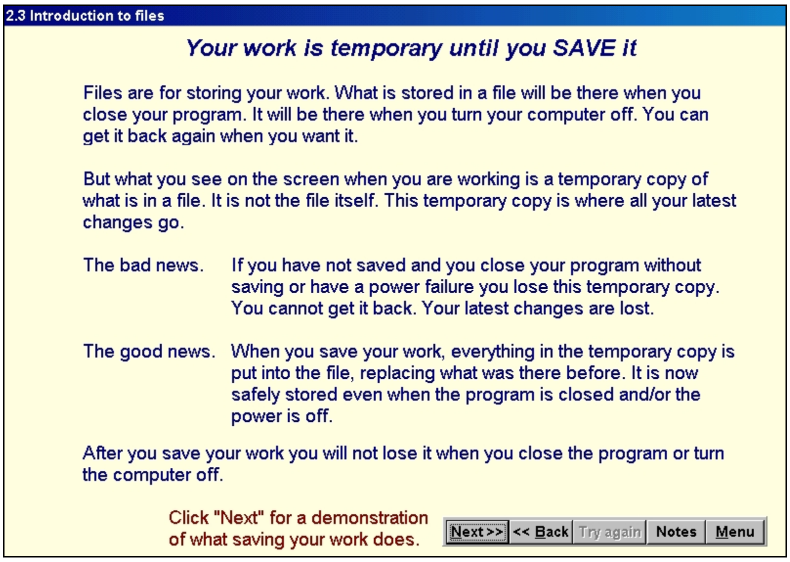

Figure 5.5. Save it or lose it

One of the concerns in constructing FileTutor was to provide the needed information in an appropriate sequence so that each new concept or skill was adequately scaffolded by those that had gone before. There was also a tension between the amount of textual information provided and the more effective activity based approach that is the core of the interactive nature of the tutorial. The problem was that some verbal preparation seemed to be unavoidable as seen in Figures 5.4 and 5.5 (above) but that the older users struggled to retain textual information until they had actively made use of it in exercises such as that shown in the next series of figures. This next set of screen shots shows the steps involved in carrying out the first interactive exercise in the tutorial. This exercise follows the screen shown in Figure 5.5 above and puts its ideas into practice. (Figure 5.6 to Figure 5.9 below.)

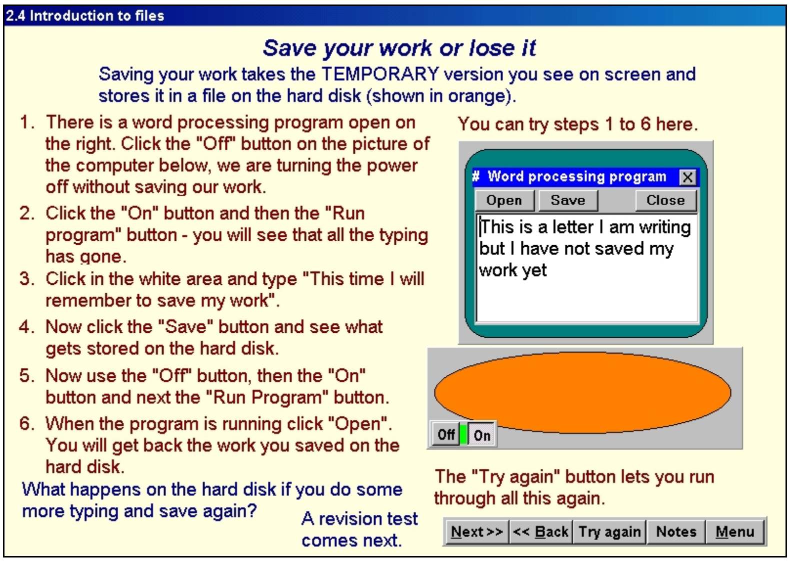

Figure 5.6 The first interactive exercise as it is first displayed. The aim is to create a hands on experience of the effect of saving or not saving work and the link between the Save command in the application and the resulting storage on hard disk.

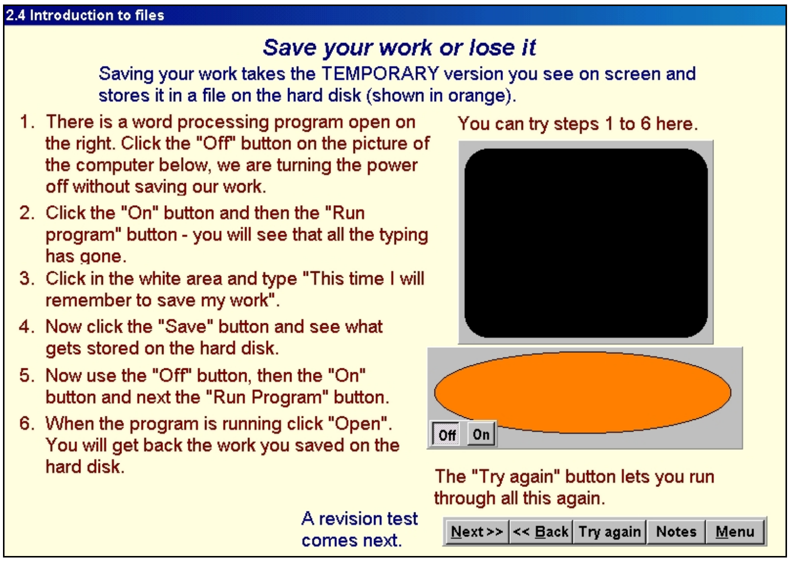

Figure 5.7 The first interactive exercise after carrying out step 1

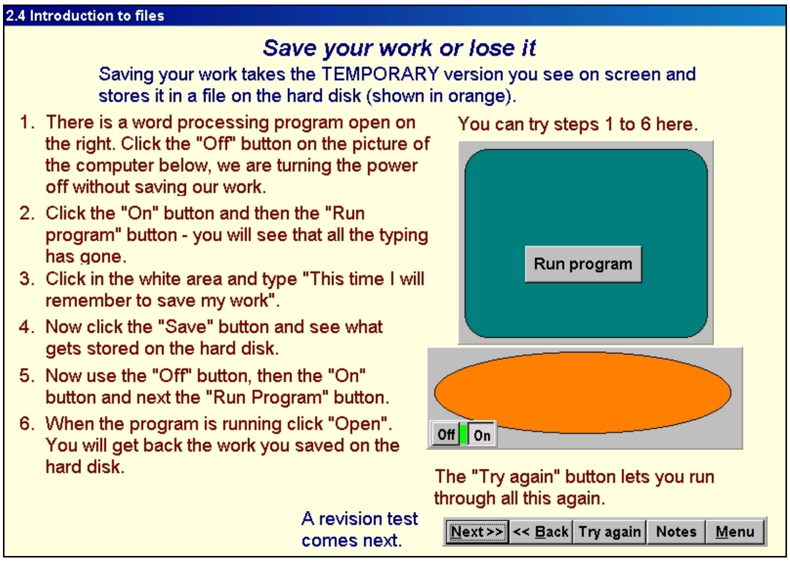

Figure 5.8. The first interactive exercise part way through step 2

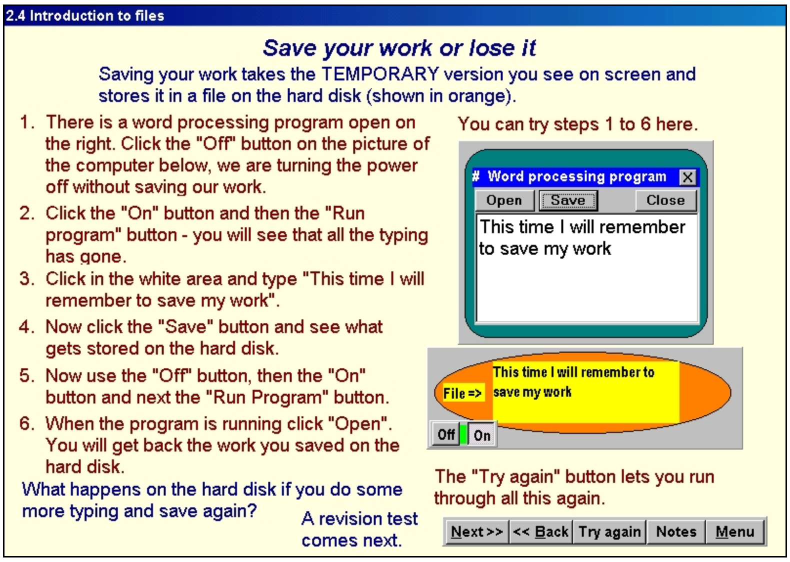

Figure 5.9 The first interactive exercise with step 4 completed showing that saving has stored text on the hard disk.

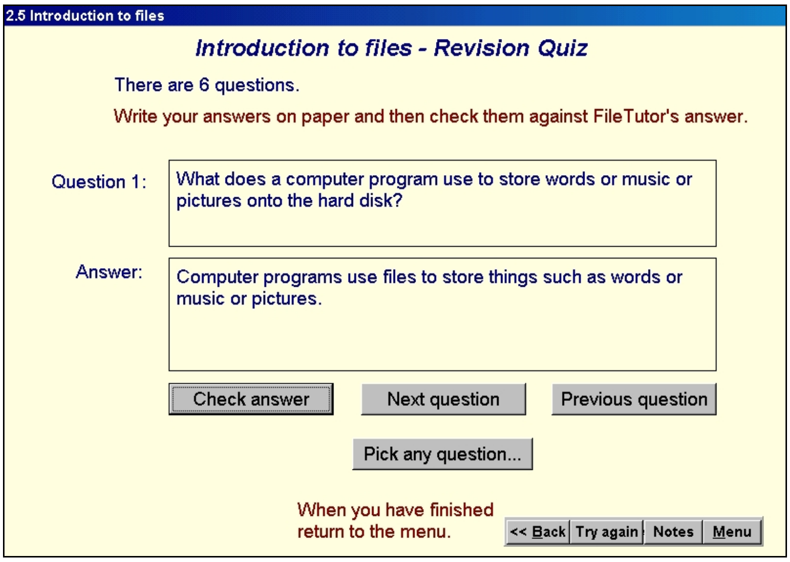

Figure 5.10. Each topic sequence ended in a revision quiz that some, but only some, of the older learners found useful.

Figures 5.11 to 5.14 provide another example of an interactive exercise. In this case older beginners were found to be confused when it came to copying text between documents. Part of the confusion appeared to be in uncertainty about the difference between copying an entire document to another location and copying text from part of a document to a position inside another document. It also seemed that combining four separate operations was in itself a source of difficulty. The beginner had to find and open a file, select and copy some text, find and open another file, find a position in the file and paste the copy into the new position. There was further confusion over what the copying (to the clipboard) step achieved since the clipboard is invisible.

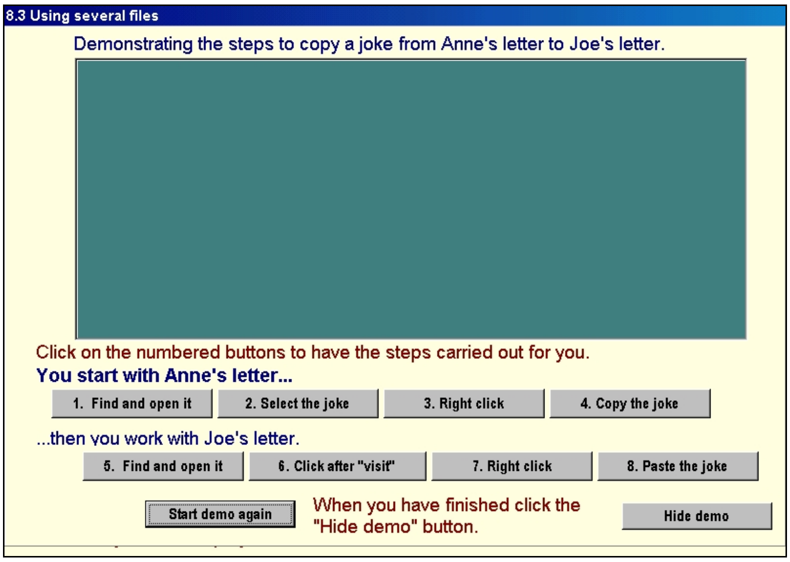

Figure 5.11. Interactive exercise demonstrating copying text between files - as first displayed.

Extended written instructions were tried but did not seem help, nor did more careful phrasing. However the demonstration shown in the next sequence of figures (Figures 5.12 to 5.14) did clarify the concepts.

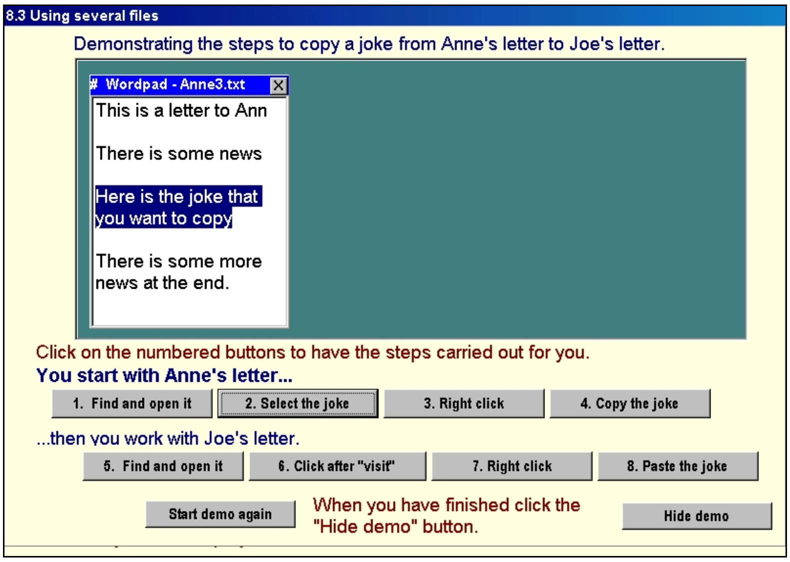

Figure 5.12. Interactive exercise demonstrating copying text between files - after clicking the [2. Select the joke] button

One of the important points about the interaction in FileTutor was that the user controlled the initiation of each new step in the demonstration.

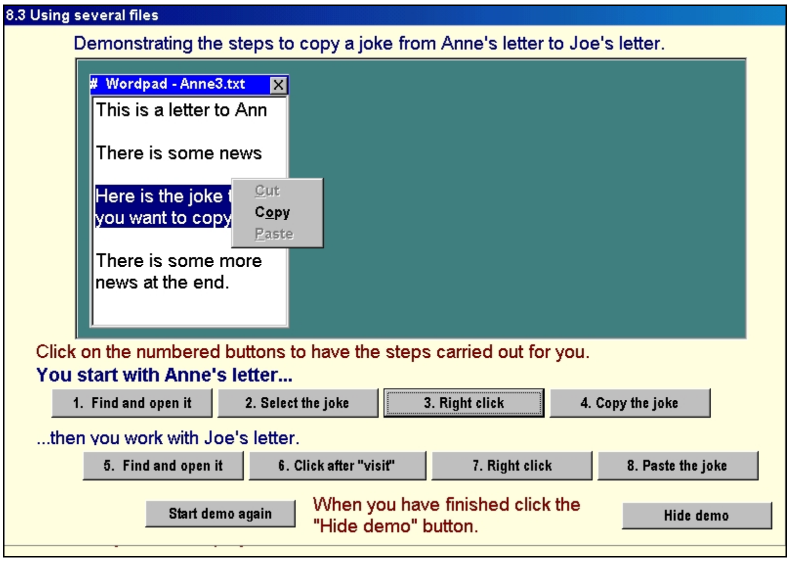

Figure 5.13. Interactive exercise demonstrating copying text between files - after clicking the [3. Right click] button

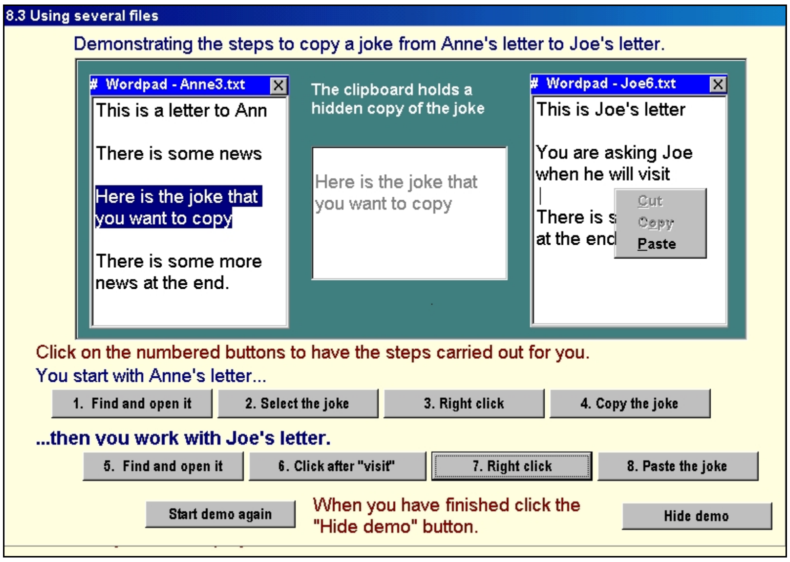

Figure 5.14. Interactive exercise demonstrating copying text between files - after clicking the [7. Right click] button and ready to complete the copy by either clicking Paste in the pop up menu or clicking the [8. Paste the joke] button. Note that the clipboard is made a visible part of the demonstration.

This demonstration of text copying was followed by an interactive exercise in which the older learner was guided through and actually carried out each of the steps previously shown in the demonstration.

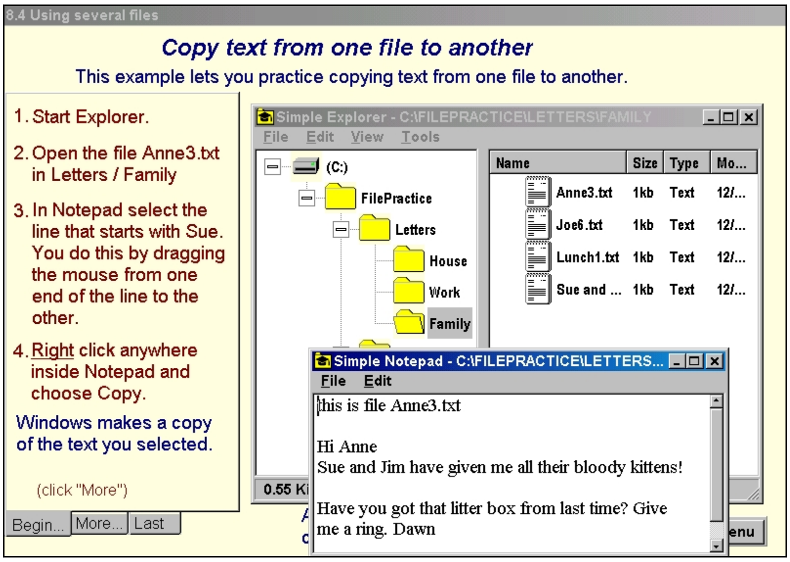

Figure 5.15. Interactive exercise in copying text between files. Step 2 has been completed. Note the tabs used to provide sufficient space for fully detailed instructions.

5.6.4 The Windows Explorer Tutorial within FileTutor

The second part of the tutorial is aimed at teaching the older users how to work with the Windows Explorer tool for managing files. This is reached from button [10] on the FileTutor's main menu. When this button is clicked a further menu is shown giving the topics displayed in Figure 5.16.

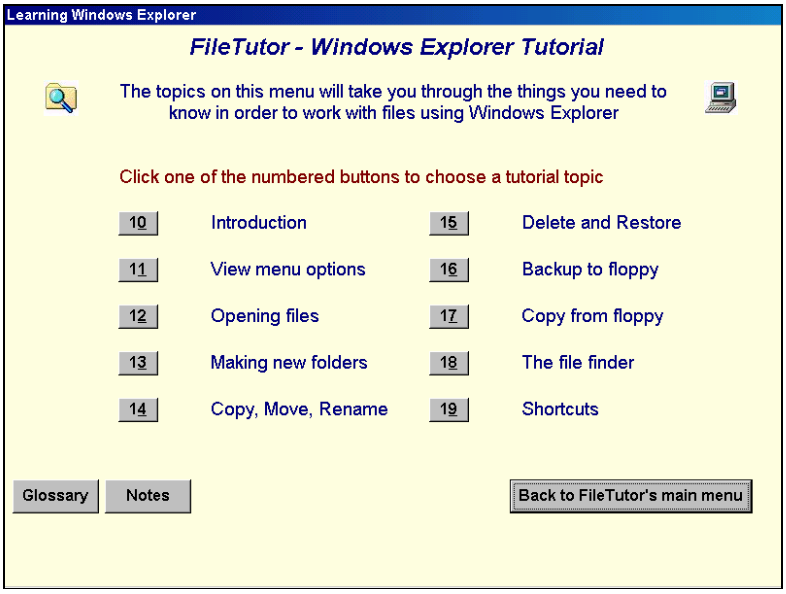

Figure 5.16. The FileTutor sub menu for the Windows Explorer tutorial

One of the central features of the way that FileTutor introduces Windows Explorer to the older learners is by use of a simplified version of Explorer that embodies both adaptations for the effects of aging and aspects of Carroll's minimal manual and training wheels approaches to computer instruction. In the sequence of figures that follows (Figure 5.17 to Figure 5.19) a simple exercise using this training version is shown.

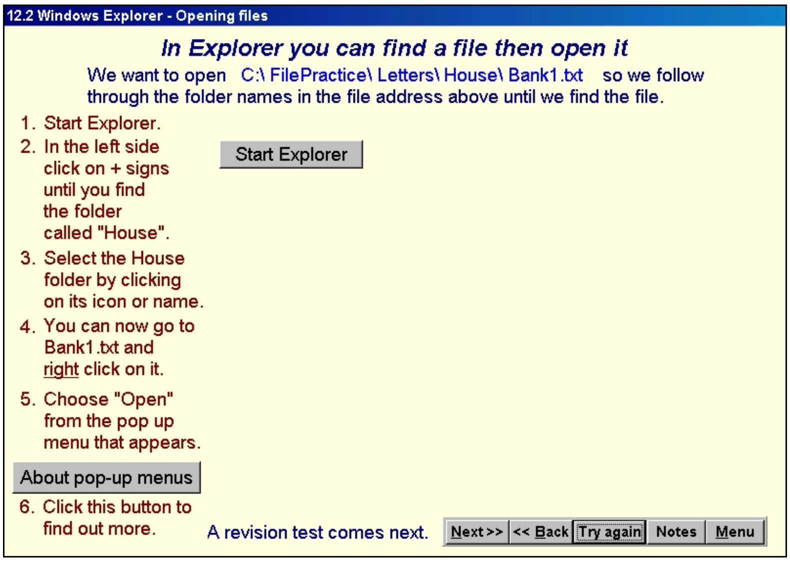

Figure 5.17. The Windows Explorer exercises typically begin by getting the user to start the Simple Explorer program via the [Start Explorer] button. A series of instructions to carry out during the exercise is given on the left side of the screen.

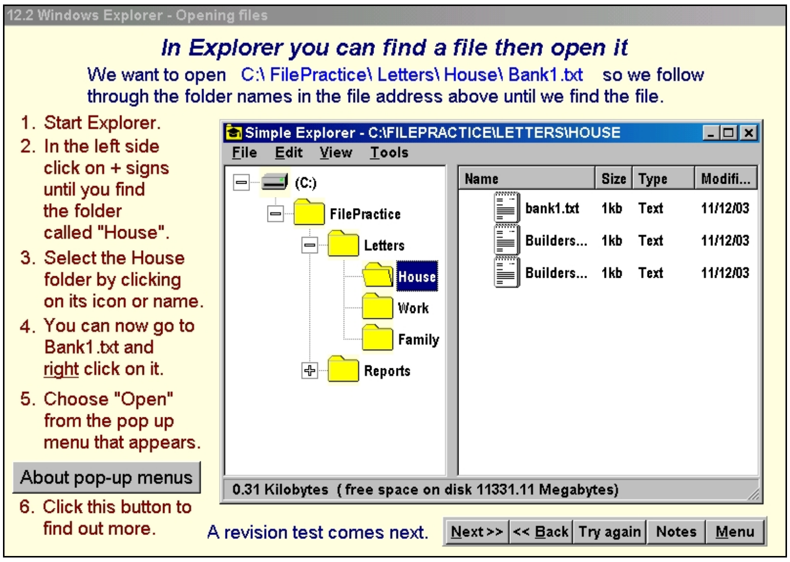

Figure 5.18. Using Simple Explorer - here the user has completed steps 1 to 3.

The simplified and age adapted version of Windows Explorer that can be seen in Figure 5.18 is always displayed in the space to the right of the instructions as a float on top window that will remain on top if the older user inadvertently clicks outside the window. It gives a simplified version of the core functionality of Windows Explorer along the lines indicated by Carroll's training wheels / minimal manual philosophy. In addition features such as the large + and - controls for controlling the tree view, the large icons and the larger font make this version more suited to manipulation by older users.

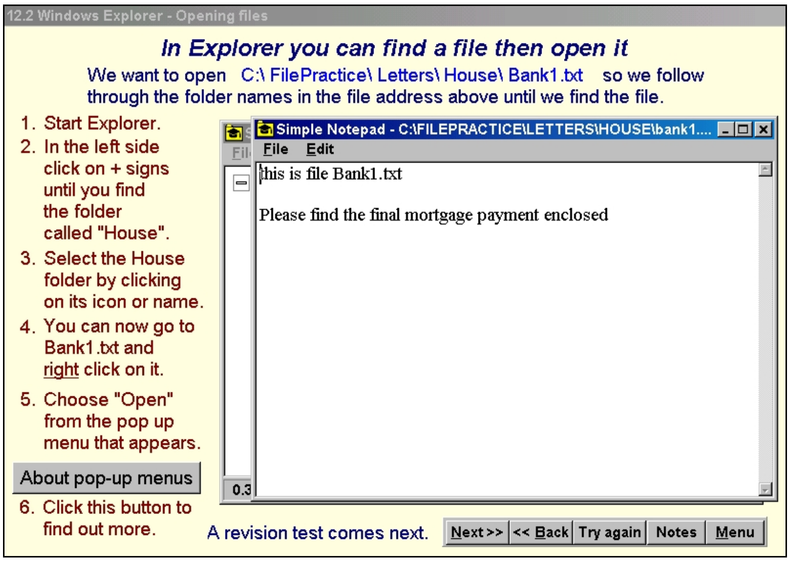

Figure 5.19. On completing step 5 the file is opened in a simplified text editor that displays the text in a large font.

Moving to the next screen in the topic sequence will automatically close the Simple Explorer and the Simple Notepad.

5.7 DISCUSSION OF FILETUTOR INTERFACE DESIGN ISSUES

5.7.1 Designing for the older user's background

Design for older people needs to be shaped by observations of their difficulties and discussion of their needs. Observation of attempts to teach older users computing skills, talking with older people during early FileTutor development and the focus group discussions accompanying this study were all important in shaping understanding of the background within which FileTutor would be used.

Fear of the unknown and fear of not succeeding or of getting lost in confusion were common themes in the focus group discussions of older users' experiences with computing. This affected behavior in many, perhaps unexpected, ways. "I was always scared of the right (mouse) button, I thought it was for something else". Self blame and apology are pervasive features of this older group's description of their experience with computers. "Things go wrong all the time, I have usually done something wrong, or there is something wrong with the program. I am never certain which. If necessary I just reboot and try again." The spirit of senior computing is one of partially overcoming odds, perpetually mixed success and failure. There is also a sense of venturing out with a few rules of thumb but no real picture of why the rules work or in what circumstances they will fail to work. The resulting pattern of activity tends to emphasize avoidance of novel or unexplored features and rebooting as a problem solving tool, rather than building effective schemas. Tutorials for older people need to counter this background. Activities should consistently provide high probabilities of success and likely areas of failure should be identified and "designed out".

In the focus groups participants reported that they were worried by the chance of doing things that might make their computer unworkable and lead to long waits for relatives who could fix the problem or difficult and potentially expensive trips to repair shops. Making mistakes is part of normal learning, hence older users need a safe learning environment clearly allowing mistakes and exploration without penalty. One implication is that older users need an easily understood "Undo" feature. In FileTutor each screen involving an exercise was provided with a standard [Try again] button. This returned the screen and the file system to the way it was before the exercise began. As part of protecting students (and tutors) from the consequences of student errors FileTutor creates its own small tree of practice folders on the hard disk and rebuilds them automatically as needed. In addition the training wheels version of Windows Explorer used in FileTutor does not let trainees work with the file system outside this practice area.

Again in terms of the context in which older users operate, attending courses for computer instruction is regarded as a desirable social event. FileTutor and WinTutor are designed so that they can be used to aid tutors teaching such courses, rather than replacing them. Morrell and Echt (1996) note that there is agreement among those who have worked on tutorials for older people learning computer skills that learning in small groups results in better learning than individual instruction. But there is also agreement that self-paced learning is desirable. There is a conflict here. In order to complete a predetermined session the tutor is often inclined to move on, even though not all members of the group have absorbed the material. Again tutors of such small groups tend to be swamped with many simultaneous demands for assistance for essentially repetitive problems as the older people involved work at different paces and differ in the number of repetitions they need in order to grasp a point. Interactive tutorials, if they are effective, mean that students can work as part of a small group but at an individual pace. The role of the tutor changes to one of facilitator and other students can also provide assistance which increases the social effect of the group. Experience during the FileTutor usability sessions was that, when dealing with topics that had been debugged by earlier usability groups, participants became nearly independent and the researcher's role as a tutor was relaxed and low key.

The focus groups all agreed that the training and support generally available to older people had significant failings. Most of the support that the participants reported came from family members but all complained that the people who helped them went too fast, were too technical and did not give the older people time to practice properly. A particular set of problems lies in the older user's need for repetition over long periods of time which places a strain on helpers. There is also the problem that even though an older person may have completed a task while the helper is present the task knowledge is subject to rapid decay unless practiced. A common report was embarrassment where older people had been shown a task and now needed to be shown again. It is worth remembering that older people observed in poor teaching situations tended to be unfailingly polite and were supportive of the tutor, incorrectly blaming themselves for the fact that they were not learning.

Discussion of older people's experiences with standard manuals and "For Dummies" type books gave a clear picture of the older people being swamped in detail. FileTutor needed to be designed so that older people could control the pace at which ideas were presented and could return to previous exercises without difficulty. Since the time required by older people to become comfortable with new learning will not necessarily fit into class timetables, FileTutor needed to be designed so that older people could use it at home for revision after attending classes. This means that the tutorial itself should be very easy to install and operate.

A striking observation from the usability groups was the amount of variation in preferred learning styles as people used FileTutor. Some people followed instructions in lock step, others skimmed ahead and then came back. Some wrote their own notes, some printed out the FileTutor notes and screens, others took no notes. Some people read explanations and instructions with great care and only proceeded with the exercise when they felt they understood what would happen, others did the exercise and then returned to the text in order to understand what they had achieved. Many people did each exercise once then clicked the "Try Again" button to repeat the exercise but some were comfortable with a single run through the exercises. Some people were almost resentful of the verbal emphasis in FileTutor, they learnt by doing. A few read the background notes in addition to the basic explanations and instructions, most people however ignored the background notes. Some saw the quizzes as valuable revision, many said they did not feel they needed them. Some participants made a lot of use of the tutor/researcher, others were almost completely independent. The time taken varied widely, both overall and within individual screens, by up to a factor of three. About the only common ground was the fact that 24 of the 25 students used FileTutor to revise what they had done once they got home. A strong factor in the success of FileTutor is that it supports such a mix of approaches.

5.7.2 Vision

Morrell and Echt (1996, 1997) suggest that clear, simple and relevant illustrations are needed to convey meaning to older people where such meaning would be difficult to convey simply with text alone. User testing supported the need for such illustrations. Attempts were made to make graphic details large and obvious, remembering that older people are poorer at visual searches involving finding a target in a complex background. However realistic application behavior was maintained. For example older users would have benefited from a more distinctive icon to indicate an open folder in the simplified Windows Explorer folder tree but this was not provided, since dependence on a cue such as a deeper yellow for open folder icons, would not have been applicable in the real Windows Explorer that learning was to be finally applied to.

Because of the large amount of information that needs to be conveyed, even in a stripped down approach to the file system, and because of the limited capacity of any one screen once a large font, short sentence format had been adopted, some FileTutor screens used text without graphics to describe what the user will see and do on the following screen. The older users found more difficulty with these screens and even though some users adopted the strategy of switching back and forth between the text and the following illustrated screen they would have preferred to have illustrations directly combined with text on the same screen. This would have speeded comprehension and reduced working memory demands. This is consistent with findings that memory for visual images declines in older people, Smith and Park (1990) and that older adults have particular difficulty comprehending information that requires linking physically distant passages of text, Rogers et al. (1999).

Note that it seems to be important that visual feedback and results of actions are given close to the site of the actions that cause the effect. The ideal is to work within the reduced width of older people's effective visual field. Early versions of the Drive letters screen shown in Figure 5.25 had a greater distance between action and effect and confused older learners but reducing this distance made the screens effective. As another counter example, creating a new folder with Windows Explorer means working with the File / New / Folder menu options at the top left of the application, followed by renaming a folder called "New Folder" in a different part of the screen. This caused noticeable hesitation for many users. Not only was the new folder often a considerable distance from the menu but the simple addition of another small line to a list of folders was not attention grabbing nor was the display of the "New folder" caption as selected text understood as an invitation to overtype. A much more effective approach is already available in Windows from the standard Save dialog box where if the user clicks the New Folder toolbar button an attention grabbing popup text entry box is displayed that clearly invites text entry, see Figure 5.21.

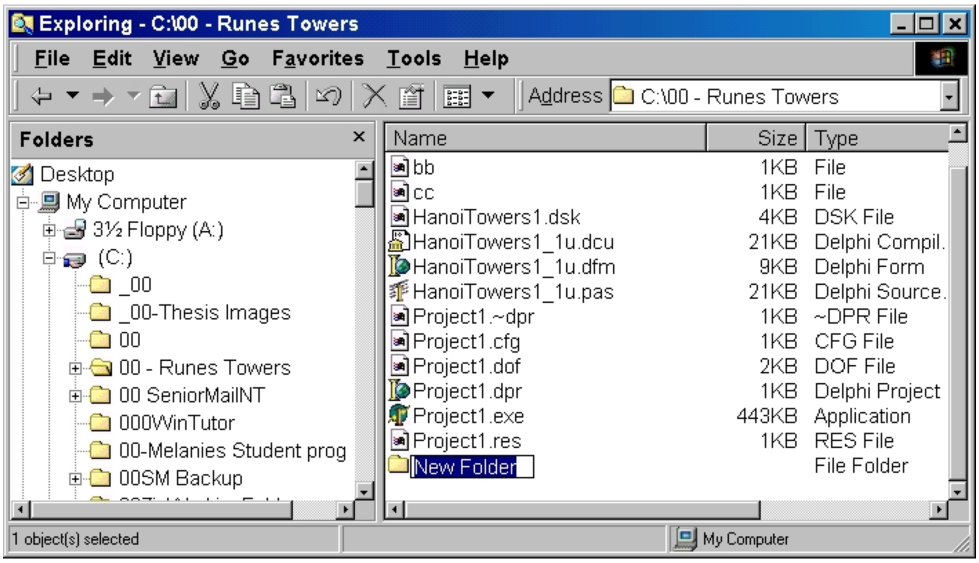

Figure 5.20. The technique for creating new folders in Windows Explorer causes problems for older users because there is too much separation between the File menu where action is initiated and the bottom of the right hand pane where the new folder is displayed for renaming.

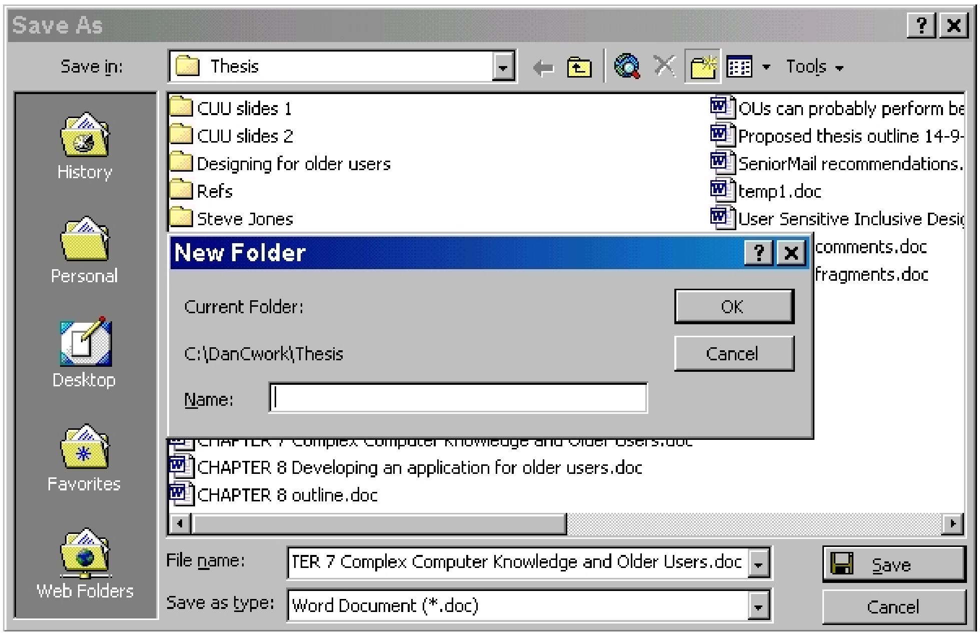

Figure 5.21. Avoiding such separation between action and result leads to a better result for older users as shown here in the Windows Save dialog approach to creating and naming a new folder.

Morrell and Echt's (1996) idea that slow-motion animation might be useful for demonstrating concepts to older students was not applied in FileTutor, partly because animation seems poorly suited to learning skills involving large numbers of small steps as in this particular group of topics and partly because Hawthorn (2000b) found that even fairly slow animation was misinterpreted by some older users. However Morrell (2001) reports that their older users did in fact understand the information conveyed by the animations they saw.

A review by Kelley and Charness (1995) found that in several studies, older people's success in learning a new application was correlated with their scores on spatial ability. This finding was repeated by Echt et al (1998). It is also known that spatial ability declines with age, especially as task complexity increases, see Craik and Salthouse (2000), Morrel et al. (2000). FileTutor made extensive use of two spatial metaphors, folder maps and folder trees. However the maps were kept simple and the same maps and folder tree were used repeatedly with the intention of building familiarity in spite of possible initial problems with spatial concepts. It was observed that, at the end of the tutorial, participants did in fact know which files were located in which folders.

5.7.3 Text format for instructing older users

The text used in FileTutor is 14 point Arial. This could be read by the participants with poor sight but was not seen as too large by the rest of the rest of the group who were able to read fonts down to 10 point Arial. Navy text was used for information, maroon text was used for instructions but instructions were also numbered so that color coding was not used alone. The choice of navy as one of the text colors goes against findings that the eye is poorer at distinguishing fine detail in blue colors. However participants stated that they found the text easy to read, probably because of the very large (sans-serif) font used. A light cream background was used to reduce glare and the navy and maroon colors gave clear contrast against this background. These colors are from the VGA color range supported by older machines. At the time that FileTutor was developed a number of older users owned older machines handed down by their children when the children upgraded. Hence the system needed to work effectively on such machines.

Reviewing previous work, Morrell and Echt (1996, 1997) and Morrow and Lierer (1999) note that older adults are more likely to have comprehension problems with complex text. They suggest that comprehension can be improved by using a standard format, keeping instructions simple, putting instructions in list form, using an active rather than passive voice and avoiding negatives. There is also a suggestion that line lengths should not exceed 65 characters. Hartley (1999) also suggests the importance of whitespace in enhancing comprehension. All these recommendations were followed in FileTutor and appeared to be useful.

During testing with early prototypes, participants worked with a mix of simple lists and numbered lists of instructions, there was a strong preference for numbered lists and these are now used throughout. It appears that numbered lists facilitate carrying out one instruction and then returning to the correct position in the list in order to read the next instruction. This may be due to reduced demand on working memory since less information needs to be held in order to reacquire one’s position in the list.

A few of the older participants had marked short term memory difficulties. Since they moved the mouse to accompany what they were reading they could be observed reading and re-reading the full set of instructions two or three times before proceeding to carry the instructions out. They could also be observed returning to an instruction in the midst of carrying it out. They proved to be vulnerable to multi-part instructions, often the second or third part would be missed out in an instruction of the form "5. Do A then B and follow this with C". When such an instruction was split into separate instructions on separate lines, "5. Do A", "6. Do B", "7. Do C", the problem vanished.

The use of detailed step by step instructions means that in a few places a large number of simple steps are needed. Faced with a body of text that required scrolling older people often forgot to scroll or they found scrolling awkward, involving overshooting and corrections that in themselves placed a load on working memory. Therefore the decision was made to put long sets of instructions on tabbed pages. These pages were placed at the left of the screen in the standard position for FileTutor instructions. Apart from the tabs the instructions followed normal FileTutor conventions. The tabs were at the bottom and as people reached the bottom instruction on the first page they met a note in brackets that said - Click “More” - where "More" was the caption of the next tab. If a third tab was needed it was captioned "Last" and dealt with in a similar way. The first tab was captioned "Begin", see Figures 5.22 and 5.23. This approach succeeded, all participants used these tabs without needing any instruction from the tutor.

Instructions that asked users to type specified file and folder names used dual font labels that put the text to be typed in bold bright blue which contrasted with the maroon of the rest of the instruction. SeniorNet tutors had warned that beginners asked to type "Joe" would often include the double quotes in what they typed. The dual font approach worked well. Double quotes were used to identify names found on features the users needed to interact with, as in: -Click the "Back" button.

Older people have been reported as being more disrupted by mistakes and problems than younger groups, Vercruyssen (1996). It became evident that the older users in the usability tests had a low tolerance for ambiguity. Where participants did not know what to do or where what they did led to something unexpected they tended to stop. There was less exploration of alternatives in order to resolve ambiguity or get around a problem than would have been expected in a young group using such a tutorial, particularly among the "more average" group. One of the key benefits from the usability testing was to ensure clear unambiguous instructions combined with exercises that clearly illustrated the point and worked as the older users expected.

Some of the "more average" users said that at times, with long sequences of instructions, they could carry out the instructions but ended up not understanding what it was that they had done. However they also reported increased understanding on going back over earlier exercises. In response to this, in some places where there were long sets of instructions, explanatory sentences were put into the instruction sequence explaining what had been achieved by the actions so far or what was to come. See Figures 5.22 and 5.23 for examples.

Over half of the older users in this sample reported difficulty in combining reading from printed text with using the screen. To do so they had to change glasses or deal with fuzzy text. Computer screens are typically placed at a distance from users' eyes that is not well served by typical bi-focals, screens sit in the fuzzy gap between reading distances and long sight. Alternately spectacles that make the screen clear are unsuited for reading with. Only two people in the sample could afford (and adapt to) graduated lenses. The interruptions due to the need to change spectacles or to struggle with out of focus text are another source of working memory difficulties for older people. This provides one more reason for using on-screen tutorials rather than printed manuals for older learners. However older people are no keener than the rest of us when it comes to reading vast amounts of text on screen so on-screen tutorials need to keep their text as lean as possible.

In spite of the difficulty of combining text and on-screen work, a couple of participants wanted at least a written tip sheet that would come with FileTutor or be printed from it, so that they could get quick information about files and folders when using other programs. In the focus groups people described their home computing environment as depending on lots of (scattered) bits of paper with notes about how to do things. For older users, the ability to print out summaries of procedural steps may be a useful feature of a tutorial or application. However some of the older users made the point that it was important for them to write down notes in their own words if they were to be able to understand them.

5.7.4 Manipulation

The target audience for FileTutor is expected to have basic mouse skills. However older people are less accurate in controlling mouse movements and so manipulation was kept to pointing, clicking, scrolling and some drag and drop actions all involving fairly large targets. The training wheels version of Windows Explorer was constructed to show larger fonts and to provide significantly larger menus, pop-up menus, file icons and plus and minus symbols for tree manipulation. This meant that the older users did not have to struggle to read file-names or to acquire minute targets with the mouse.

The decision was made to tell users to carry out all tasks on the training wheels version of Explorer with the pop-up menus obtained by right clicking file and folder icons. The drawback is that there is no visible indication that such an affordance exists, the two advantages are that 1.) a wide selection of useful functions are made available at the site of the intended action and 2.) the user does not need to double click which some older people find difficult or impossible, see Smith et al. (1999). Most of the older users in the study could double click but some were unable to do so reliably. It was of interest to see how well older users would adapt to using an invisible affordance. In fact all participants used right clicks without prompting by the tutor after the first couple of screens in which the topic was introduced. Successful use of right clicks continued into the practical evaluation in the third session (done outside the FileTutor environment).

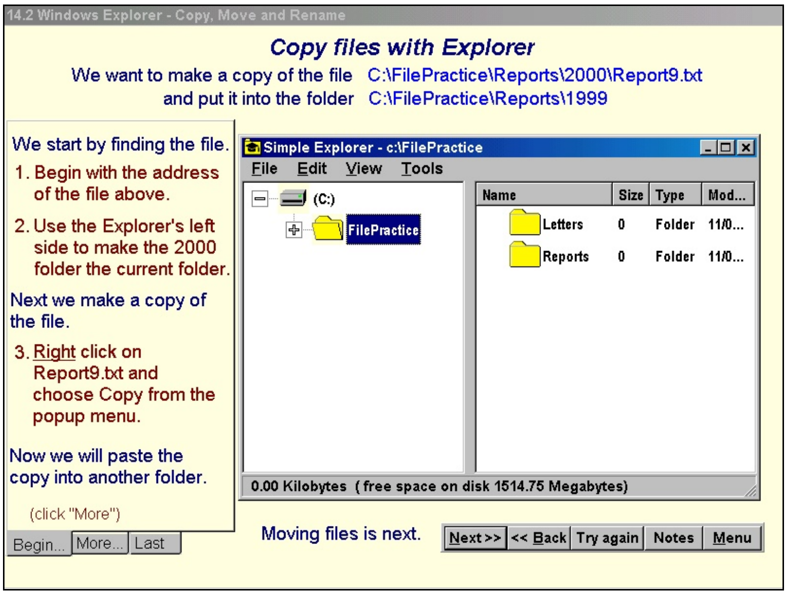

Figure 5.22. The training wheels version of Explorer.

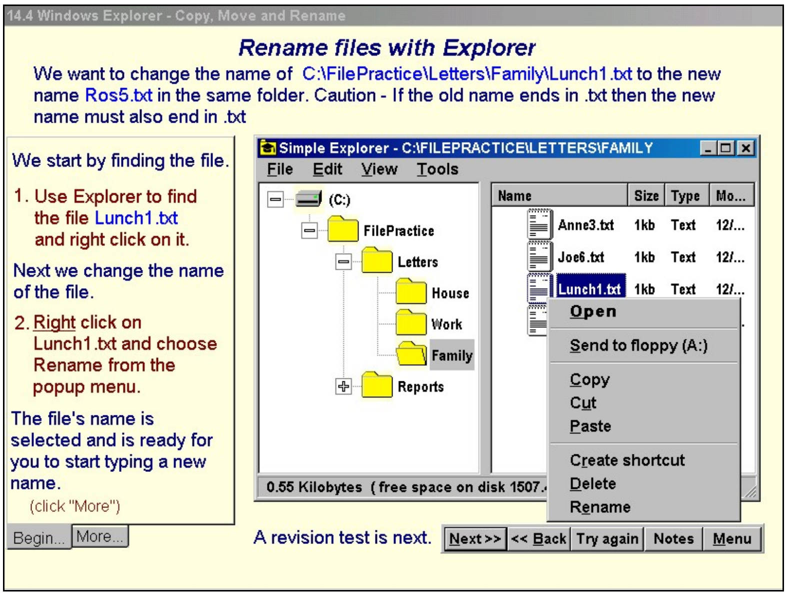

Figure 5.23. The training wheels version of Explorer. showing the simplified pop up menu resulting from right clicking.

In keeping with the training wheels approach the initial pop-up menus were kept to four options (Open, Copy, Cut and Paste) and the extended set of options shown in Figure 5.23 was only available in the later exercises. This set of options is still considerably simpler than the pop-up menu used in the real life Windows Explorer.

5.7.5 Interactive graphics

What are termed interactive graphics are a key feature of FileTutor. The graphics shown in Figures 2 to 4 are all intended for the user to interact with step by step as they work through the instructions. The user clicks and drags objects, enters text and uses menus in the graphics and the graphics alter in response to what the user has done. In addition the approach to interactive graphics used here involves embedding a simplified but working version of the application being learnt into the tutorial.

- We want trainees to learn by doing and to be motivated and engaged while they do so. This means easily achievable success and an element of entertainment in carrying out the exercises.
- We want to provide visual feedback as a guide to the users' progress through the steps of the task.
- We want close (single screen) integration between instructions and the examples and application being learnt and manipulated.

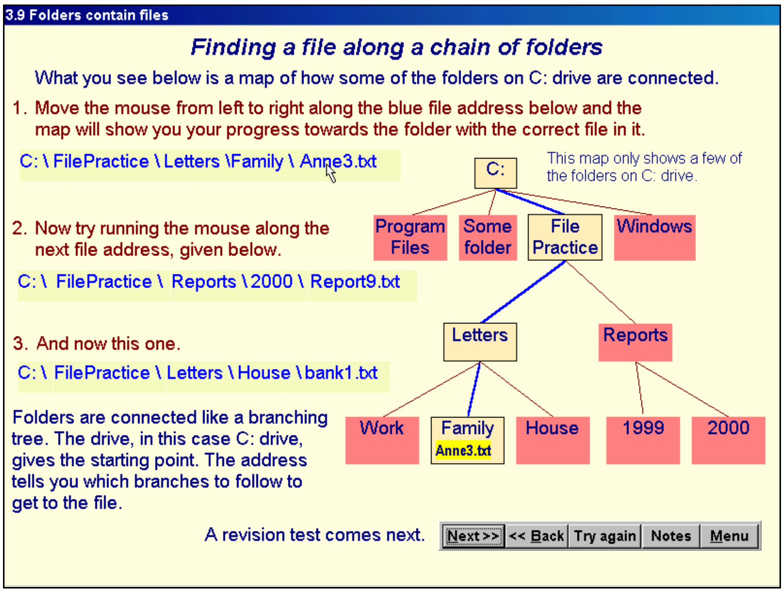

Figure 5.24. An example of interactive graphics.

We want to keep the essential new conceptual material as simple as possible. Here the evolving visual images reinforce and illustrate the concepts being learnt while reducing the reliance on text.

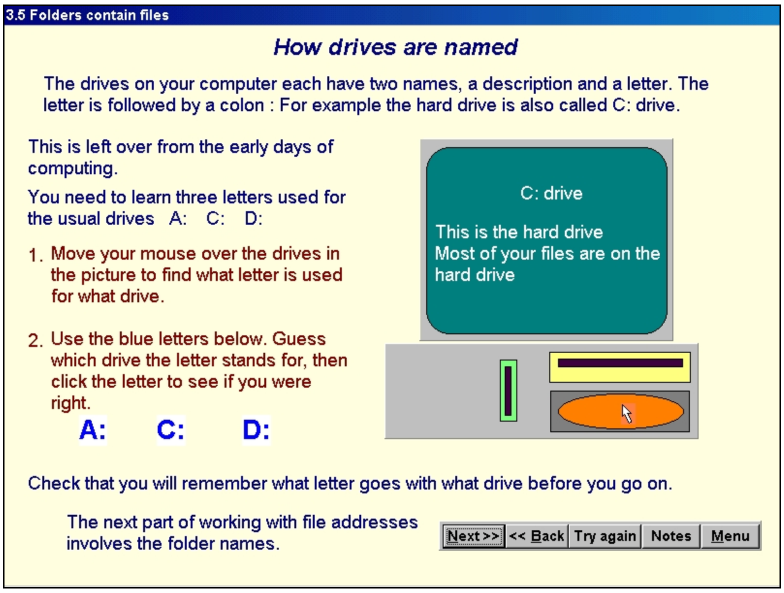

Figure 5.25. A further example of interactive graphics.

Examples of such interactive graphics can be seen in Figures 5.24 and 5.25.

Figure 5.24 is part of a series of screens teaching users how to interpret Windows file paths and relate them to navigation through a folder tree. A map of the standard set of practice folders that FileTutor works with is shown together with three typical file paths. As the trainee moves the mouse along the text in the file paths the corresponding folders light up in the folder map.

Figure 5.25 shows the second of two screens aimed at getting trainees to remember the identifying letters for drives. The "computer screen" displays drive information as the mouse moves over the "drives". Clicking on the large capital letters shows a pointing hand symbol beside the relevant drive and displays the drive description on the "screen".

FileTutor uses interactive graphics to support Carroll's (1990) ideas of the active learner, the minimal manual and the training wheels approach. FileTutor depends heavily on a "training wheels" version of Windows Explorer that is a key element in over half of the interactive examples. This can be seen in Figures 5.22 and 5.23. This version of Windows Explorer is functional but has fewer options, uses an increased font size and the + and - icons for expanding and contracting the folder tree have been made larger for easier manipulation. Further aspects of this "training wheels" version of Windows Explorer are described in later sections. Where FileTutor deals with embedded versions of file management tools there are two aims.

- To reduce the available options and simplify the perceptual demands and the manipulative requirements of the tool while still preserving realism.
- To guide the trainee through real-life tasks that are relatively complex and where the user is working with a multi-purpose tool in which it is relatively easy to become lost.

It is argued that manuals or interactive CDs are less suited to older users in part because of the need to remember instructions as the user swaps between the page or screen containing the tutorial and the application being learnt. In the interactive graphics used in FileTutor, working memory load is reduced by integrating instruction and the example or application being interacted with into a single screen. Another contribution to successful learning is the active role of the learner. In some interactive CDs the student is essentially a passenger on an animated tour with pauses to carry out activities in between animations. In FileTutor there is no animation, each and every change to the graphics occurs as step by step feedback to actions of the student. This seems to place the student far more in control of their learning and to make the student more responsible for and more engaged with, what occurs.

A final point is that the exercises done in the interactive graphics should be as quick and easy to perform as possible. While there are obvious limits to how simple you can make interacting with an existing application such as Windows Explorer there are other areas in which you can assist older learners. For example older users include some people who struggle to type and so the exercises in FileTutor avoid requesting any lengthy typed input.

5.7.6 Menus and Sub-menus

To keep within Carroll's training wheels and minimal manual philosophy the number of menu options available in both the main menu of Simple Explorer and the pop-up menus available from a right click had considerably fewer options than their equivalent in Windows Explorer.

5.7.7 Typing

Typing was kept to a minimum and text entry was done within text boxes that used a large clear font.

5.7.8 Scrollbars

Scrolling was kept to a minimum and where possible the exercises using Simple Explorer used choices of files and folders that could be found without scrolling. As described above tabbed pages were used to avoid the need to scroll long sets of instructions.

5.7.9 Navigation

A variation of the linear navigation format used in WinTutor was repeated in FileTutor. As before the use of standard [Next] and [back] buttons was readily managed by the older users. One change involved dropping the [Summary] button option since topics were kept shorter and were not as sub-dividable as those in WinTutor. Other changes were to place the [Try Again] button on the navigation bar and to add a [Notes] button that gave access to background information if required by the user.

5.7.10 Comprehension , Memory and learning

The approach was taken in FileTutor was based on the "training wheels / minimal manual / active learner" approach described in Carroll (1990). The tutorial and exercises only gave access to essential features and avoided alternative approaches and advanced features. To cater for the few older learners who demanded more detail, extra information was provided as an optional extra through the "Notes" button, however most participants ignored this. Making the extra background information optional allows flexibility while still giving most of the older learners an environment that conforms with Morrel's (2000) finding that that insisting on extra prior conceptual material disadvantages older learners.

Only a subset of file management topics was covered and the examples that participants worked through tended to reuse and reinforce recently acquired skills. At the same time the topics were developed with a view to helping participants develop a workable schema for understanding files and folders, not just a grab-bag of actions for doing file tasks. Feedback from participants who had some prior knowledge went along the lines of, "I have been told about files and folders before but I never had it explained in a way that let me fit it all together like this."

However acquiring the overall picture took time and the initial work was done with the feeling that things only partly made sense. The initial exposure to FileTutor was confusing for some of the less articulate participants. "When I was reading the first screens it was all too wordy, I couldn't see what you were getting at, but afterwards when I had done other topics I came back and it was all much easier". Reasonably clear explanations are not enough to carry all older users through an introduction to a novel environment. There is also the question of whether there is a common vocabulary at the beginning. Older novices cannot be assumed to share the instructor's definitions of terms. What is a topic, wasn't the whole topic about files? What is a screen? If the user thinks of the screen as the physical object they look at, the idea of a number of screens per topic is nonsensical. At the same time providing endless definitions will simply bog the beginner down. We are asking our older beginners to take on faith that things will make more sense over time. A problem with this is that many of them have experienced computer systems and explanations that, for them, have not made more sense over time. One person came armed with this comfort from her friend who had done an earlier set of FileTutor sessions, "Don't worry, it's much easier on the second day". Both in terms of avoiding endless elaboration of instructions to cope with possible misconceptions and in terms of providing initial encouragement, having a person facilitating the first exposure of older people to an interactive tutorial helps considerably.

Botwinick and Storandt (1974) point out that older adults are less able to make use of recently presented material. Morrell et al. (2000) found that providing additional conceptual material reduced performance. These findings present a difficulty in providing training about file management skills since the possession of some conceptual understanding is essential for the learnt actions to be meaningful. The approach taken in FileTutor was to provide extensive training in concepts such as the use of a tree of folders in the early parts of the tutorial. Instead of simply being told about the concept the trainees did several interactive exercises related to such things as using a folder tree before doing later exercises that required this knowledge.

An assumption made in designing FileTutor was that part of an individual's schema for handling file management tasks is a mental map of their own folders and files (a folder tree). Possession of such a map is assumed to significantly help a user in carrying out file management tasks. The participants were generally new to file management and had not worked with folder trees. Folder trees were introduced early in FileTutor but the same set of folders was used throughout so that by the time participants began later exercises with folders in a simplified version of Windows Explorer they were becoming familiar with the layout of "their" set of folders and this familiarity was reinforced throughout the tutorial. Participants then worked competently with a different folder tree in the practical evaluation exercise following the usability sessions.

The first half of FileTutor deals with basic ideas about files, programs, folders and drives. The second half consists of learning to use a simplified version of Windows Explorer for file management tasks. It was found that the older users were happy to go over material they already knew something about. This is in contrast with younger users who become impatient in similar circumstances. Beginning at a very basic level for all users dealt with surprising gaps in older people's computing knowledge that would otherwise have disrupted progress. For example the term "select" was often unknown. At least half did not know about dragging or resizing windows.

Since the aim of a system for older users is to support as many older people as possible the system should aim for fairly low levels of initial ability, a lowest common denominator approach. In an early version of FileTutor the level of detail in the instructions on how to find a file was progressively reduced on the assumption, that, after repeated exercises that involved finding files in the same small set of folders, people would have internalized the steps needed. After testing this was revised and step by step instructions are provided almost throughout FileTutor. Some older users simply do not internalize instructions in anything like the time frame younger designers would expect. Several of the participants displayed examples of fragile knowledge where knowledge gained from FileTutor was present but could not be accessed. For example, people got stuck trying to start Windows Explorer, but if prompted "If you hold down the Windows key what then?" they respond "Oh I press the E key". In addition the ability to use components of a schema does not necessarily correspond to the user's ability to put rules for such use into words. One user was observed attempting to deal with a question in the quiz for the introductory topic on how to use FileTutor itself. She was trying to answer a question asking "In FileTutor how do you move from one screen to another in a topic?" While attempting to find an answer she was in fact busily moving from screen to screen in the first topic using the "Next" and "Back" buttons. Another recurring response to the quizzes was, “I know how to do it but it's hard to put into words.” Older users do consolidate their knowledge over time but with complex subjects such as file management we may be talking weeks rather than eight or nine repetitions. Craik and Salthouse (2000) note that we should not assume that investigation of real-life learning in older people will fit conveniently into the timescale of typical experimental sessions.

5.8 DISCUSSION

What has been achieved in this study? The study confirms that with well designed learning support some older users can be trained to use relatively complex software and computing concepts, including older users who have previously failed in attempts to learn this material. If we return to the aims of the study set out in the introduction we can see that they have largely been achieved

It was hoped that the study would provide further experience with the emerging approach *for working with older participants during design.*

Making appropriate design decisions was markedly assisted by the focus group discussions where the older participants reflected on their work with the tutorial and related it to their previous computing experience. Again the utility of involving older in-house participants in the day to day development of the design was amply verified. Interface design for any group should involve considerable understanding of, and interaction with the users. However it is argued that, because of the degree of difference between older users and the average designer, it is of particular importance to involve older users right from the start of a design. User testing with older people was found to be highly informative, and enjoyable. Note that user testing is regarded as necessary in addition to a theoretical knowledge of the design implications of the various aspects of aging. Charness et al. (1996), and Hawthorn (2000b) both found that putting theoretical interface design recommendations into practice did not always lead to the results that theory would predict. A point made by this study is the value of undertaking usability studies designed in a way so as to increase the amount of background information that is provided by the older participants.

It was hoped that the study would provide further experience with application design for older users as the interactive tutorial itself was designed.

The study provided a further test for the application design principles that had been developed by considering the implications of the general literature on aging, the experience with developing WinTutor and the existing literature on such things as text design for older readers. The study demonstrates the value of using the general literature on aging for implications for interface design. The initial WinTutor design started with observations of older peoples' difficulties in learning basic computer skills. These observations were combined with ideas of the likely design implications of aging from recommendations made in Morrell and Echt (1996, 1997), Morrow and Leirer (1999), Morrell et al (2001) and Hawthorn (1998a, 1998b, 2000a). As the design of FileTutor progressed the dominant influence was extensive informal observation of, and interaction with, older users. The design that emerged and the responses met during usability testing largely reinforce the earlier recommendations on design for older users. In some cases this study specifically extends these recommendations, for example the virtues of numbering procedural lists and avoiding multiple steps within a list item. In other cases this study suggests ways of implementing the more general ideas these authors support, for example the use of tabbed pages as a way of avoiding scrolling while reading long sets of instructions. This is the first time of which I am aware that these recommendations have been combined and evaluated in an actual product intended for use outside an experimental setting.

It was hoped that the study would provide confirmation that interactive tutorials were a useful way of helping older people learn computer skills and extend this finding to cover the case of more demanding computer skills.

Again this study lends weight to those authors who argue that interactive tutorials are suited to older learners rather than those like Gist et al (1988) whose findings were against the use of interactive tutorials for older learners.

It was hoped that the study would allow for examination of the use of Carroll's "training wheels" and "minimal manual" approaches to older learners.

Authors such as Morrell et al. (2000) and Rogers, et al. (1996) have pointed to the need for simplifying the material presented to older learners and for involving older users in active learning. What is new in this study is the explicit demonstration that the approaches to computer training suggested by Carroll for younger learners are suited to older learners. This includes the use of modified "training wheels" versions of the software being learnt and the demonstration that older people learning on such training wheels versions can successfully transfer their skills to the real life version.

Fisk et al. (2004) argue that understanding how older people learn is a crucial aspect of designing for older users. It is easy to argue that Windows Explorer in its various guises suffers from numerous design flaws, see Interface Hall of Shame (1999). We have the apparently ironic situation that a project investigating rules of good design for older users should aim at teaching those older users to cope with a poor design. In fact interacting with poor designs will always be part of people's computing experience and acquiring the ability to do this is a highly relevant skill for older people. It has been shown that it is possible for some older users to cope with a flawed design but the cost is considerable time spent on learning an application that younger users learn to make adequate use of relatively quickly.

Also note that while the older people who took part in the usability tests generally did well, acquired file management concepts and skills and were highly enthusiastic about the tutorial as a learning experience, outside the study environment within SeniorNet organizations FileTutor does not sell as many copies as WinTutor. This may reflect the point that fewer older users are interested in putting in the extra time that they need to devote if they are to gain the use of more complex computer skills. The fact that, given sufficient support and well designed training materials, older people can improve the level at which they work with moderately complex applications, does not mean that moderately complex applications such as Windows Explorer suit older users. The more likely reality is that many older users will avoid applications that demand extensive training and hence these older people will limit their ability to cope in a computing environment.

5.9 RESEARCH DIRECTIONS FROM THE FILETUTOR STUDY

There are some issues that are not resolved, for example the FileTutor design made the assumption that animation would be unsuitable for older learners while Morrell and Echt (1997) recommended slowed animation. Finding more about the conditions under which older people benefit from information contained in animation is one of many fertile areas for future research. The recommendations in the discussion section could be refined and given greater support by more experimental research but this is an area where there is a need for an immediate practical solution for use while research proceeds. The FileTutor study straddles the areas of tutorial design and application design. Future research could usefully look more closely at application design for older users, It was apparent when observing the older participants in the usability study that individuals had developed an number of personal adaptations to support their needs as older people. More deliberate study of such adaptations could be a way of both gaining further insight into the sort of support appropriate to older users and a start on building such support into applications.

The issue was raised of using “intelligent” tutorials that adapt to a user’s level of knowledge as a basis for tutorials for older people. I suspect that the underlying model of reliable learning, where if a student shows correct answers on the start of a topic they can advance more rapidly, will be problematic for older people. Older people’s generally more fragile and concrete learning does not fit this model. From the relatively small group of older people involved in the FileTutor study, repeating already covered material was generally seen as useful and desirable. I would also expect difficulties with older people complaining about perceived inconsistency where “intelligent” tutorials alter the topics presented on the basis of past successes, “Last time it showed me about scrollbars and this time it doesn’t”.

It is worth asking how specific the recommendations are to older people. From the focus group discussions these older people identified themselves as a distinctive group that needed training materials specifically aimed at their needs and for whom most available training was unsuitable. On the other hand the recommendations of this study aim at producing an interface that is easy to use by reducing cognitive and manipulative effort. This has been a standard goal of interface design for many years. What appears to be the case is that older people are more sensitive to departures from the ideal than younger people because of older people's limits in perception, manipulative skill and cognitive ability. It has been suggested that because of this older people are desirable subjects for user testing. This may well be the case for some aspects of any interface design but the reality is that some specialized applications will need to be designed to support highly able people in their prime who are working to the maximum of their physical and cognitive capabilities, we should not hobble such designs to cater for older people. (Though possibly such applications may acquire modes that reduce their power, so as to adapt to older users.) At the same time there are an enormous number of general applications where catering to the needs of the older population should both provide a realistic adjustment to the changing population profile and provide an improvement in usability for all users. Taking interface design for older users beyond the research setting has the potential to provide widespread benefits that are urgently needed in a world of an expanding older population faced with increasing needs for computer involvement.

There is a further possibility that emerges from the work done in the FileTutor project. The aim of the overall research is to extend the range of older people who can make use of computer software. If there are older people who cannot make use of full versions of applications and either do not benefit from training or are unwilling to undertake extensive training, the way in which FileTutor has encapsulated Windows Explorer deserves consideration as a way of making simplified forms of software available to older users. If for example one wanted a file management tool for older users, the interface could be such that the older person started by choosing a file management task from a main menu and then is taken to a screen where a simplified and elder friendly version of a file management tool is embedded within a set of procedural instructions for carrying out the task. This is in effect what FileTutor already does as a teaching approach but there is the possibility of making this approach the normal way that some older people carry out software tasks, where the software is embedded in the sort of lists of instructions to themselves that older people have been found to rely on. If some older people are not able to progress to unaided use of stand alone software, this embedding of software within task specific instructions, that are framed to suit older users, could be a useful way of extending the range of older people who can accomplish software tasks.

Chapter 6 DEVELOPING AN APPLICATION FOR OLDER USERS

6.1 INTRODUCTION

Chapter 4 (the WinTutor study) had focused on the problems that are met by older beginners in first learning to use computers. Chapter 5 (the FileTutor study) had looked at the way in which older users can be introduced to complex applications (Windows explorer) and complex concepts, (the Windows file system). Both studies provided insights into what older users need if an application's user interface is to suit them (as well as providing insight into older users’ learning and computer use). The next stage was to focus specifically on application design for older users and see if the emerging principles for interface design for older users would allow the design of an application that allowed older users to achieve more than they were able to achieve on the mainstream equivalent.

In describing the development and testing of an email application for older users this chapter will address a number of issues. First, it tests the argument that the design principles developed in the previous studies form a successful basis for producing an application that older users find useful. Second, the chapter shows and examines an example of successful application design for older users. Then the chapter looks in detail at how various design needs of older users were met in this design. Finally the chapter looks at the consequences of the design approaches used in determining the suitability of such designs for more general users.

What was found in the SeniorMail study was that the design approach and principles of the earlier studies did provide a basis for application development for older users. Extensions to the principles also emerged as the focus became more specifically on application design.

In reporting on the contribution of older participants to the design the chapter considers the limitations of a manageable group of older development participants in representing the variety of older users. There was a definite role for knowledge of the effects of aging in order for the designer to amplify the understanding gained from working with older users. The chapter will examine the way in which designing simultaneously for numbers of specific aspects of aging leads to design decisions that interweave a variety of concerns about older users and make tradeoffs between different aspects of aging. Hence one concern in working with the older users who participated in the development was that adjustments made for a particular aspect of disability would not negatively affect those in the group who did not have a marked degree of this particular result of aging. What emerges again is that, while the design principles for older users are a useful sensitizing perspective for designers, working with older users is also required to assist the translation of awareness of older people's needs into useful design features.

The organization of the chapter is as follows: The chapter will first describe the format that was used to create a case study that would allow examination of applying the design principles to the development of an application for older users. Then the chapter moves to describing the design aims of the email system. These design aims were developed in response to understanding of older users' needs gained from the earlier studies and in the focus groups that began this email study. After this the results of testing older people's performance on the system will be presented. This section will examine the extent to which this system allowed older users to achieve more than they had achieved on mainstream email systems. The resulting email system, nicknamed SeniorMail, will be described. Then the way in which the design aims were met by this system will be discussed in more detail. The chapter concludes by discussing the way in which the design approach developed for older users restricts the universality of the resulting application. The techniques used to realize a design that suits older users, lead to a design that limits the number of features that can be incorporated into the design and hence limits the suitability of the resulting application for younger users who have a higher level of demand for features.

6.2 STUDY DESIGN

In this section the design of the SeniorMail case study will be described.

6.2.1 Application area

The first issue was to choose a suitable application area for studying the development of an application design for older users. The main aim in choosing an application area was to get realistic performance from older participants as they tried to use the emerging design during its development. As seen in the Dual Task pilot study (Chapter 4), this would require an application area that older people saw as relevant to their needs. A second aim was an application area that represented a non-trivial problem for older users. In order to test whether the design principles led to improved performance this should also be an area in which it was possible to recruit numbers of older people who struggled with mainstream applications in this area. After discussion with SeniorNet tutors it was determined that email represented an area in which older users were motivated and in which it would be relatively easy to find a sufficient number of older users who struggled with existing email applications. This turned out to be the case.

6.2.2 Initial scoping

The experience from the earlier studies suggested that the requirements should be specified in response to needs expressed by both older users and the people who were supporting them. To this end three focus groups were held with supporters of older emailers, typically younger family members. Another set of focus groups were held with older people who regarded email as difficult. These included two groups of older computer users living in a residential facility and a variety of community dwelling older people. The focus groups discussed what older users wanted from email and what they found difficult. The focus groups were semi structured with an agenda of discussion items that was used by the researcher to guide discussion and was given to the attendees at the start of the session. Topics covered included level of use, types of interface difficulty that occurred with standard email systems, the nature of support required, typical correspondents, levels of understanding of the email model and responses to examples of early prototypes of the email system.

Because of the exploratory nature of the investigation at this stage attendees were encouraged to bring up any other issues or concerns they had relating to email. The agenda served as a way of maintaining an overall plan within this freedom. The focus groups were tape recorded and the tapes were then analyzed. The picture that emerged was one of very limited email use, rigid learning of a few rules to allow minimal performance within Microsoft Outlook Express (MSOE), uncertainty and forgetting within that limited performance and, although there were relatively few needs, most of these needs were beyond what the older users could achieve. The older users in the focus groups, when trying to act independently, had difficulty at the level of replying to emails, saving emails, saving addresses and finding old emails. The supporters of the older users confirmed this picture and suggested that email tasks at the level of adding or opening attachments were often too difficult to be even attempted by their older relations. One theme that emerged was the considerable effort needed by the younger relatives to support older email users. Repeatedly the supporters described encouraging older relatives to take up email as a way of keeping in touch and then finding that the older users had a painful struggle with email, did not learn enough to be capable and needed a level of support that was beyond what the younger relative had anticipated or could conveniently provide.

As part of giving the focus groups a practical focus a variety of mockups of possible email designs for older users were presented for comment. It was apparent that the older users struggled to make sense of the mockups and struggled to envisage how they would be used. They markedly drew back from versions that suggested any level of complexity. On the other hand the supporters tended to reject versions that did not provide features that they saw as useful in their own email use. There was little tendency for the supporters to take a perspective on what made a suitable email design that really included the older person's reduced needs and reduced abilities.

6.2.3 Prototyping and participatory development

After this scoping stage the study moved to the development of a prototype email system. One of the lessons learnt in the earlier studies was the advantage of having older people participate in the day to day development of designs. To include this sort of involvement by older people in the development of the email system nine older people who found email difficult, or who had decided that they could not use Microsoft Outlook as it was too complex, were recruited to act as partners in the prototype development. This group will be referred to as "the development group". Six of the group were in their late seventies, one was in their early sixties and two were in their mid 50s. The development group provided a reasonably severe challenge to the interface design. They included a person who after a year of using Microsoft Outlook Express (MSOE) did not use the Reply or Forward features - this person sent all emails from their address book. Another two people had left all emailing to their spouses because MSOE was "too complex". Three of the group had only a few hours of computer use. Two had poor vision including one person with the start of macular degeneration and the person with the longest computer experience was one who had been observed to be very slow in acquiring competence with new applications. None of the group had successfully worked with email attachments. Since overall numbers were small, only a few of these people showed any particular disability such as reduced eyesight or failing memory. Discussions were held with these people to determine if their wants matched those of the older people in the focus groups, (they did).

It was clear from the responses of the older people in the focus groups that traditional prototyping beginning with low fidelity designs was not a suitable approach. The response of the older focus group members to low fidelity prototypes had been stressed incomprehension of the partial designs rather than useful insight into possibilities for the final product. Hence based on the focus group discussions and on the design principles developed in the previous studies, a initial credible working prototype was developed. Parts of this prototype were trialed with two of the younger people in the development group as they were developed. Once the credible working prototype had been developed, the other older people in the development group, given an environment that fostered free discussion, were happy to make suggestions for changes that could adapt the prototype to what they wanted.

The credibility of the initial working prototype was established by asking the members of the development group to carry out the tasks set out in a set of scenarios that had the users carry out a wide range of email tasks. In summary a user had to see if there was any new mail, open the 3 new dummy messages provided by the system, go back to one of these messages and save the address of the sender, send a new message to a person in their address book and then go back to one of the initial messages and reply to it. The next task was to add an email address to the address book. This was followed by deleting one of the initial emails and seeing if there were any further new emails. The new dummy email provided at this stage came with an attachment and the user needed to view the attachment as well as replying to the new email. The user was then asked to check the contents of an email they had sent, followed by forwarding an email, finding an email containing a key word and finally sending an email with a specified attachment. For a complete description of these tasks see Appendix C.

The older people were asked to try out the initial version of the working prototype using the scenarios described above. Typically this was done with the older people working in groups of two and discussing what they did and did not understand with each other and with the researcher. These discussions were tape recorded. As well as trying the prototype these older participants were asked to try a number of variations on the basic design that illustrated points where I as designer was uncertain of the best way to proceed. These variations were presented as high-fidelity, computer based, screen designs with working components. After trying the prototype the participants took part in debriefing discussions that covered the versions that they had just used. Again these discussions were tape recorded. The observations and discussions took place in the homes of the older people involved. This also provided the opportunity to observe how those older users who already made some use of email, functioned when using MSOE on their own computers.

The working prototype was modified and the changes checked with the members of the development group. This phase of the study occurred over 12 months. During this time five of the older development partners became long term users of SeniorMail adopting it as their only email system. This allowed the study to explore whether the design met the needs that emerged as experience and long term use occurred.

An aspect of the development approach lay in design for diversity. It was not expected that the older people involved in development would all benefit from all aspects of the design. The approach was to design for many age related disabilities at once. This was followed by checking that the few people who presented any particular disability did in fact benefit as planned from the features that addressed their disability. However another important aspect was checking that the older people in the development group who did not have particular disabilities were not disadvantaged by the changes made to accommodate other people's problems.

6.2.4 Usability study

After the prototype satisfied the development group a usability study was conducted with a relatively large group of older people who found email difficult and had not previously been exposed to SeniorMail. Staff at an Auckland Citizen's Advice Bureau (CAB) were asked to take part in evaluating the current version of SeniorMail. These 22 volunteers ranged from 60 to 82 (average age 72) and were selected on the basis that although answering email enquires was officially part of their duties they were unable to satisfactorily deal with the MSOE email system used by the advice bureau. A set of scenarios dealing with basic email tasks and a follow-up questionnaire had been constructed for use by the development group. This material was reused with the CAB group. The scenarios are outlined in the section on prototype development above. See Appendix C for the full text of the scenarios provided to the test participants and the follow-up questionnaire. The tasks in these scenarios were well beyond the scope of anything the CAB users had previously attempted. The volunteers were given a five minute introduction to SeniorMail consisting of a tour going from the menu where the [Check for new mail] button was emphasized, to the in-box where the use of the toolbar was demonstrated for opening an email. This was followed by a look at the viewer and the editor as the tour continued with the steps of reading the email and replying to it. The volunteer could then ask questions about the use of the system. After this the users were then asked to carry out the tasks from the scenarios while the researcher observed, took notes of each problem encountered and where necessary offered prompting to help the volunteer continue. The time taken and the level of prompting required were recorded. After each day of testing any significant problems were identified and the system was altered accordingly.

This system was also tested with a group of 15 computer literate staff members from the local polytechnic some of whom taught office computing skills and some of whom taught business computing. The average age of this group was 45 and the aim was to see whether a system that had been developed for, and in conjunction with, older people would be suitable for younger more competent users. This group was given the same introduction and the same set of tasks as the (older) CAB group.

The next section will describe the design aims that emerged from the previous studies and from the scooping and the refinement of this scooping during development of the SeniorMail application. The results of various forms of testing of the resulting SeniorMail system will then be described in the succeeding section (Section 6.4).

6.3 DESIGN AIMS IN A SYSTEM FOR OLDER EMAILERS

In general the problems with vision, manipulation and comprehension that had been observed in the previous studies were again seen in the focus group descriptions of older people's problems with email and as the older development partners worked with the prototypes. The design of SeniorMail was planned with a view to minimizing these difficulties. This section will very briefly set out the design aims that were chosen in response to these issues.

Accommodating a range of older users

The system was intended to satisfy the needs of a wide range of older users and so the design proceeded in terms of the issues of aging described from the literature survey, not just from the issues that were apparent in the group of older users who took part in development and usability testing.

Vision

The aim was to provide easily readable fonts for all text. This would involve font style, size, color and background. A further aim was to provide a visual environment in which locating features would be simple for older users, the emphasis here was on simplifying search spaces and reducing distractors.

Manipulation

The aim was to avoid forms of manipulation that had been found to be difficult for some older users. This meant making targets reasonably large, avoiding drag and drop operations, avoiding the resizing and other manipulation of windows and producing designs that did not require double clicking.

Menus and Sub-menus

As some older users had been observed to have difficulties working with menus the aim was to provide an application that did not depend on the ability to work with menus.

Typing

Typing remains a severe problem for a number of older users. This issue has not been addressed in SeniorMail.

Scrollbars

A number of older users were observed to scroll inefficiently. A design aim was to reduce the need for scrolling.

Comprehension

Some older people have difficulty in dealing with complexity, especially if they are in novel situations. It was also observed that the focus groups indicated that older users had very simple email needs. The assumption was made that the presence of any feature that is not required exacts a cognitive cost. The user has to learn to ignore it and has to learn to minimize its influence as a distractor when they are searching for other features. Hence a design aim was to achieve a set of features that would allow older beginners to cope with the system while supporting a reasonable range of needs as the users became more able.

At the same time there are some features of email that are inherently complex such as the use of the file management system. Another design aim was to shield older users from this complexity as much as possible.

Navigation

Older people working with MS Works and with MSOE had been observed to struggle with navigation models that were non linear and required detailed mental models of the possible destinations. On the other hand the linear navigation model previously developed for the interactive tutorials was readily used by older beginners. Further, older people had been observed gaining a more detailed model of a file system with repeated exposure over the course of working with FileTutor. Hence one of the design aims was to provide a linear navigation model that would suit beginners but to provide an additional way of engaging in more flexible navigation as the user's system model developed.

Memory and learning

A key issue was identified as the problems that many older users have with learning new applications. Although the FileTutor study had shown that it is possible to devise an approach that allows an older person to gain competence with a complex application it was also shown that this demands considerable time and commitment from the older person. The older people in the email focus groups did not want to devote days to learning to use an email system. Again the learning of new computer skills was seen as stressful in that for many older users it led to episodes of "fragile knowledge" where material was repeatedly learnt and then forgotten. This was seen by the older users as showing up their lack of competence and as causing strain for supporters. There was a strong awareness among these older people that their supporters had already taught them some skills several times. Supporters in turn felt overloaded by the user support needs of the older people whose computing they had taken responsibility for and felt guilty about this.

This led to the following design aims; the email system should be very simple to learn, the penalty for forgetting what to do should be minimal and there should be an easy way of recovering if a user forgets what is to be done. This recovery should not involve asking for help nor should it involve restarting the application or rebooting.

Idiomatic knowledge

Older people had been observed to have a limited grasp of the idiomatic knowledge needed to operate in a Graphical User Interface (GUI) environment. They were also observed to be slow in acquiring such knowledge and liable to forget idioms unless they were regularly used. Hence a design aim was to make consistent use of a limited range of GUI idioms.

Confirmation and feedback

Older users were observed at times to have an expectation of failure and to need assurance that their actions had succeeded. Hence a design aim was to identify points at which older users needed confirmation of the success of their actions and to provide appropriate feedback.

6.4 RESULTS

The following results support the argument that SeniorMail has made email accessible for older people who previously found it difficult or too hard. It has not however made a comparable difference for middle aged people who do not suffer from the effects of aging that the design is aimed at countering. In what follows "Non-specific prompting" would be where a user did not know how to proceed and the researcher responded with a statement such as, "You want to delete the email, do you see anything that might help you do this". These prompts were deliberately stated in a way that did not direct the user to specific features. "Specific prompting" in contrast would be where, after non-specific prompting failed, the user was directed to a specific feature, "To delete the email first click on the email and then go up to the task bar, find the Delete button and click that".

6.4.1 The older development partners

The two users in the older development group who were involved in the preliminary development that led to the credible prototype completed all tasks in the scenario when it was presented to them at the end of this stage of development. However this was not seen as particularly significant given that these two users had had substantial prior exposure to the ideas behind the design. The other seven users in the older development group (who were not involved in the preliminary development that led to the credible prototype), completed all the tasks in the scenario with enthusiasm and only non-specific prompting using the first version of the working credible prototype during their first encounter with it. They were slow, carrying out 13 tasks took over an hour as they were discussing what they found as they did it. However their work consisted of linear progress towards goals rather than trial, error and frustration. Features in the slow completion included very deliberate reading of screen information, discussion with other older people in the group as to how to proceed and very slow typing. All participants were surprised and pleased by their success rate. The universal question at the end of the session was, "When can I get a copy?" Another telling response was the frequent and heartfelt question, "Why can't other computer programs be this easy to use?"

6.4.2 The long term users

Six of the older development group went on to become long term users of SeniorMail. The experience has been positive, follow up visits over two years show continuing high levels of enthusiasm for the system. There have been no requests for major changes with the exception of more support for working with images. Little further education has been required. The supporters of these users report that the amount of effort expended in supporting their relatives has been reduced while the level of email performance has improved beyond expectations. They are now independent and competent email users. Supporters of these users reported greatly reduced need for supporting the use of email. This was seen as a highly desirable result.

6.4.3 The CAB usability testing group

Of the 22 users in the usability tests undertaken with Citizens Advice Bureau volunteers 19 stated that they found the SeniorMail system easy to learn and rated it as excellent. These 19 all completed the usability tasks with only non-specific prompting and clearly demonstrated that they were moving towards independent use of the system after some forty minutes. When asked these older people did not suggest any extra features that they wished to be added to this email system. Two older CAB users with almost no MS Windows knowledge completed the usability tasks only with substantial specific prompting and would have been unable to proceed independently. One person in the CAB study, who was over eighty simply did not gain sufficient understanding to make productive use of the system.

6.4.4 The middle aged computer literate group

In contrast, a group of 15 staff members of a polytechnic business computing department (average age 45) trialed the SeniorMail system and although they all successfully and quickly completed the usability tasks without prompting, only 3 of them said that they would want to use the system as their home email system. This, they stated, was because it either ignored, or made less available, features that they regarded as necessary. Interestingly there was little agreement on what extra features were desirable. It appeared that in order to satisfy this group's wishes an email system would need to include a very wide range of features.

6.5 A BREIF TOUR OF THE EMAIL SYSTEM

This section provides a quick tour through the main screens of the SeniorMail system. This is intended to orientate the reader before the next section (Section 7) which provides an in-depth discussion of how the design aims were achieved.

6.5.1 The SeniorMail Main Menu

The main menu screen displays on startup and functions as a "home base" for users, It is shown in Figure 6.1. The design points that underlie the main menu screen are the decision to simplify and expose the conceptual model and to reduce the level of manipulation by avoiding Windows menus, overlapping screens or screen segments such as a preview window. The main functionality of the system is laid out for the user to see.

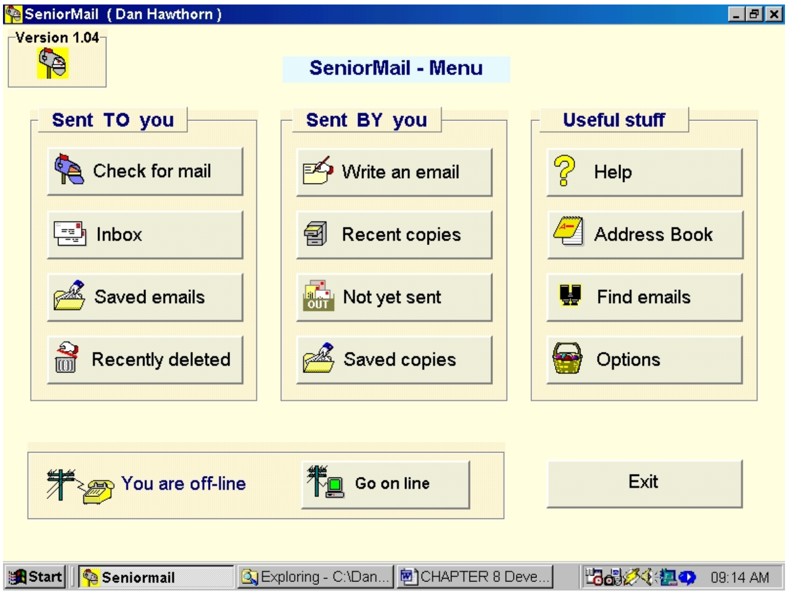

Figure 6.1 The SeniorMail main menu.

Visual search is simplified by grouping the buttons into three groups for inwards mail ("Sent to you"), for outwards mail ("Sent by you") and other features ("Useful stuff"). Within each grouping the requirement is for a simple linear visual search (downwards) and this is backed by enclosing the buttons for each group in a separate panel. Buttons use a larger text and a lighter background than standard Windows buttons. By way of contrast standard Windows buttons can be seen on the task bar at the bottom of the figure. There are some additional features of the system but they are not required for basic functionality and so to keep the system as simple as possible for the older users the additional features have been effectively hidden in that they are reached from the [Options] button. Considerable work was put into finding wording for the hints and the button captions that the older development team found intuitive but it was not possible to get complete agreement on ideal wording.

In order to begin the user clicks the [Check for mail] button and is show a dialog box that shows progress in dialing out, connecting to the user's internet provider and downloading any new email. To avoid overlapping forms, small fonts and a further level of complexity of involving a step that is external to the email program, the code for dialing out is internal to the SeniorMail program, the standard Windows "Dial out" dialog box is not displayed. If there are no new emails, a message box displays this information, otherwise the progress window tracks the downloads and then, once all new emails have been downloaded, the user is automatically taken to the Inbox where the headers for the new emails are displayed.

6.5.2 SeniorMail Navigation

The main menu sets out an easily available display of all the main features of the SeniorMail system. Once a main menu button has been clicked to go to another screen each of the screens reached will have a standardized toolbar at the top of the screen. The toolbar of the Inbox screen layout (Figure 6.2) shows some of the basic features that are common to all the SeniorMail screens apart from the main menu and the dialog boxes. The commands that can be carried out are displayed as large button options on a toolbar located at the top of the screen. The number of options is restricted. If the user pauses the mouse over a toolbar button a hint is shown, in the Inbox example the hint for the [Open] button can be seen.

Those options specific to the window being displayed are grouped at the left of the toolbar. There is a title giving the purpose of the screen in the space to the right of the first group of buttons. There are always [Help] and [Menu] (or [Back]) buttons displayed in a second group at the right of the toolbar.

6.5.3 New email and the Inbox

The Inbox is shown in Figure 6.2. It has a number of differences from the MSOE Inbox. There is no preview panel and the whole screen apart from the toolbar is devoted to showing a list of new email headers. Getting new emails from the user's internet provider is separated from the Inbox functionality and is only done when the user clicks on the [Check for mail] button in the main menu. There is no display of folders into which new mail can be dragged. This simplifies the concept of email headers to items in a list rather than thinking of them as files in a folder, makes less demand on mouse skills and, if the older user has a relatively low volume of email, reduces the need to scroll. The action required to work with an email header is to click on the header line and then click the relevant toolbar button. Email headers stay in the Inbox until the user either deletes them or saves them. If the user deletes or saves the email headers are transferred to the Recently Deleted or Saved Emails lists, both of which are available from the main menu.

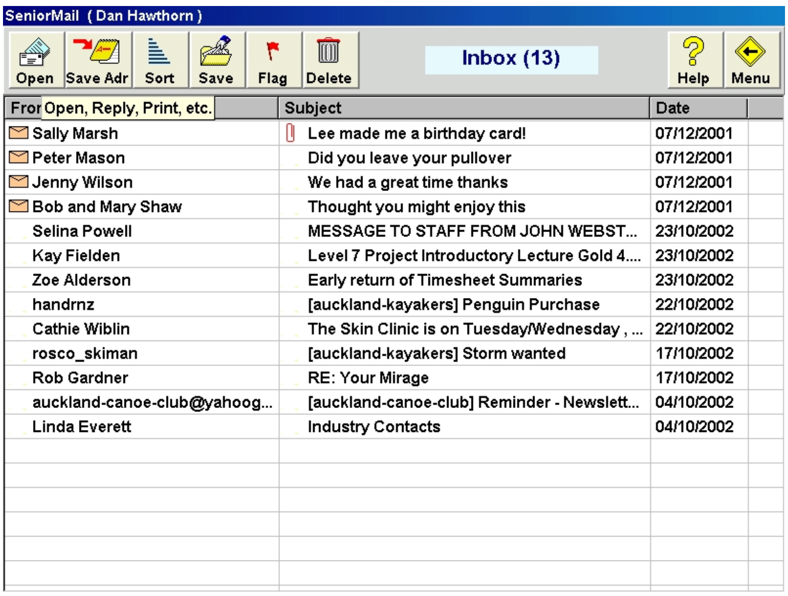

Figure 6.2 The SeniorMail Inbox showing the hint for the [Open] button

6.5.4 Email lists rather than folders

Instead of user-customizable folders SeniorMail has fixed collections (lists) of email headers for new mail (the Inbox) and for Saved and Recently Deleted emails as well as for Recent copies and for any copies that the user wants to save long term (Saved

Copies). These lists of email headers are displayed using the same layout as the Inbox and can be reached from the main menu. Unread emails are shown at the top of the list with an unopened envelope icon. A red paper clip icon is used to indicate attachments. Although a user can double click on a header line to open an email, the system supports those older users who cannot reliably double click, these users click on a header line and then click on the [Open] button. This displays the email in the Viewer window.

6.5.5 The email viewer

The screen for viewing email content is shown in Figure 6.3. Again this screen uses the standard "toolbar at the top" layout. The default font for displaying emails is Arial 14 point though this can be adjusted by the user or their supporters. An advantage of the full screen approach is the reduced need to scroll if messages are reasonably short. Tasks such as saving an address to the Address Book have been simplified and made available from the toolbar. The available email header information has been stripped down to recipient, date and subject. Information such as file size was found to be of limited relevance to older people and information such as the CC field while somewhat more relevant was found to add too much visual detail for the older users to be comfortable in extracting the core header information.

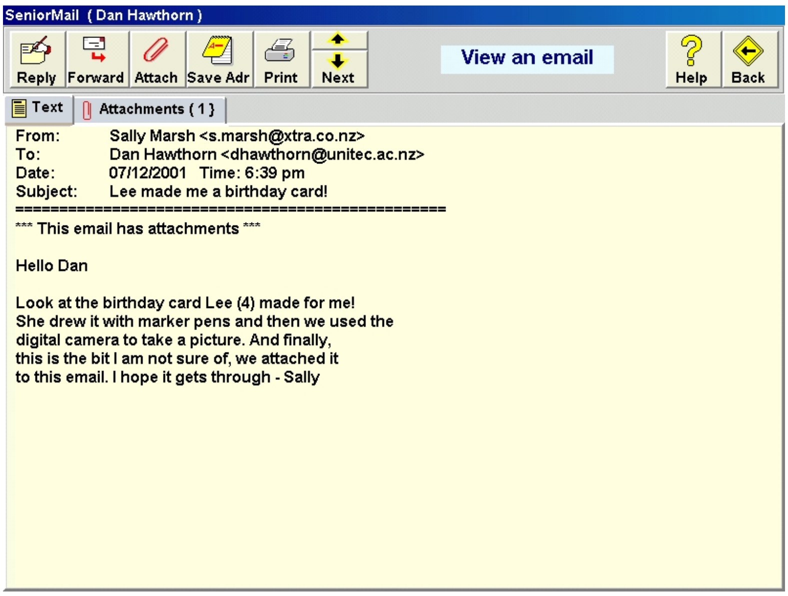

Figure 6.3 The SeniorMail Viewer Window

The older users tended to have problems identifying that an email had attachments. Therefore an extra line of text, ***** This email has attachments ***** is added to the email as well as displaying the paperclip icon in red and giving a count of attachments on the caption of the attachments tab. A striking problem was that having been given a rule that said "To do anything look at the buttons on the top toolbar" the older users were remarkably blind to other features on the screen. Most of the older users ignored the tabs captioned "Text" and "Attachments" even though they were positioned just below the toolbar. This blindness to the tabs persisted even when icons were added to the tabs to make them as similar as possible to the toolbar buttons. The [Attach] button on the toolbar is a late addition to the design that successfully lets the older users get to the attachments display while keeping to the "use the toolbar" rule. (Note that in the latest version of SeniorMail the tabs have been dropped altogether.)

When the user chooses to view an attachment, image files can be previewed within SeniorMail but all except small documents need to be opened using the appropriate program by clicking the [View] button. This was because the available preview component was very slow to open even moderately large documents.

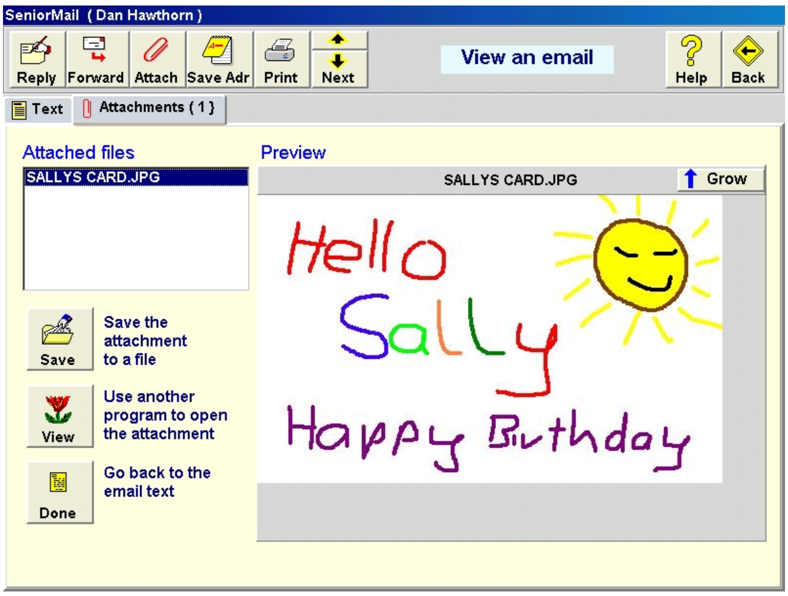

Figure 6.4 Viewing an attached graphics file

6.5.6 Writing emails - the Editor

The editor screen is shown in Figure 6.5. If the user clicks the [Reply] or [Forward] button on the Viewer toolbar they are taken to the Editor screen. The Editor can also be reached from the [Write an Email] button on the main menu. Again this screen uses the standard "toolbar at the top" layout.

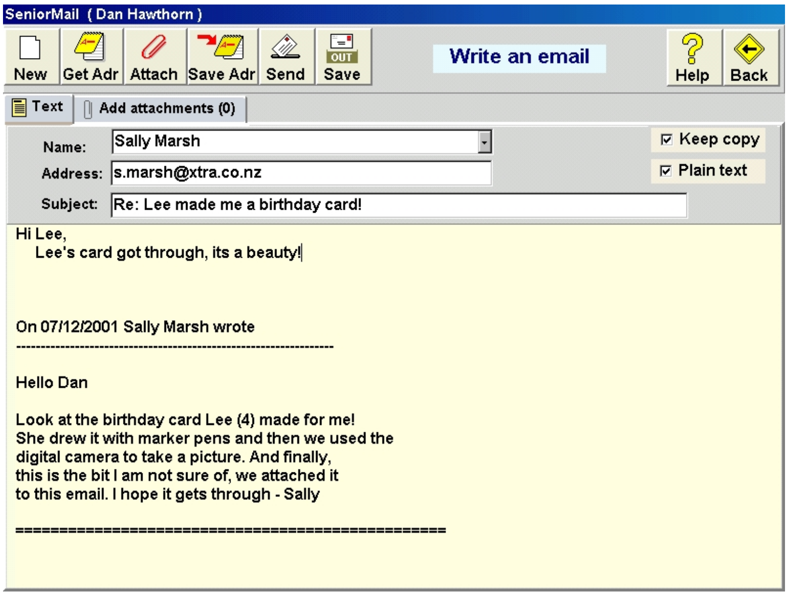

Figure 6.5 The Editor screen in SeniorMail

Emails can be saved into the Outbox using the [Save] button and sent when the user decides to go back on line, but the usual approach is to click the [Send] button when finished and SeniorMail will re-connect with the user's internet provider if needed. If the user is writing a new email or forwarding an email the Name field can be set by the older user's supporter to predict the likely recipient based on the first letters typed, a type ahead approach. However if the older user finds the resulting pattern, of names that change as they type, confusing it can be switched off in the Options screen. The alternative to type ahead is to display a modal dialog displaying a list of names from the Address Book. This can be seen in Figure 6.6, it is reached from the [Get Adr] button.

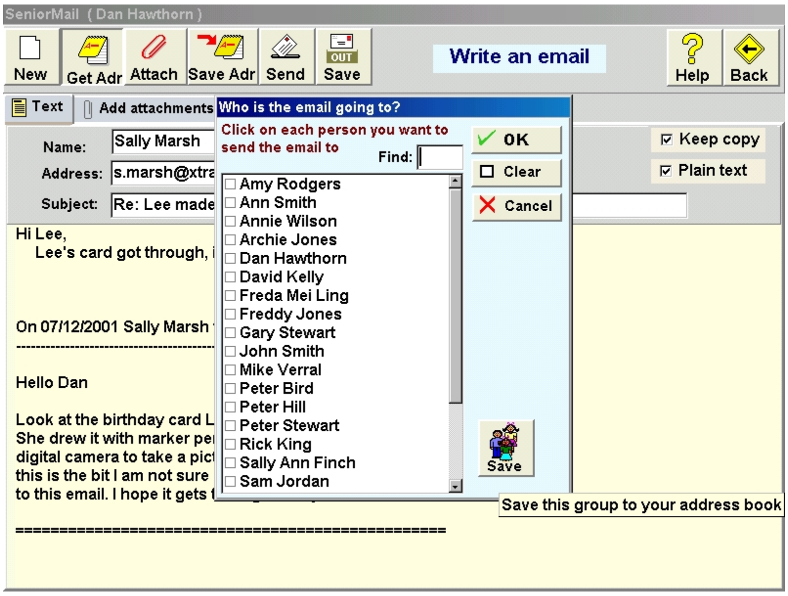

Figure 6.6 Dialog for choosing one or more addresses.

The user can send an email to more than one recipient using this dialog box. It is also possible to select a set of recipients and then to save this set as a group entry into the Address Book.

6.5.7 Sending attachments

The tabs for text and attaching files provide the same problem as found with the tabs in the Viewer and again a toolbar [Attach] button provides a solution. The screen used to add attachments is aimed at providing a way of simplifying the amount the older user needs to know about the Windows file system. It is intended that a supporter chooses a few folders that are the likely source for attachments that the older person wants to send. These are additional to three folders automatically selected by SeniorMail; My Documents, My Pictures and My Attachments. This latter folder is created by SeniorMail and is the default destination when a user saves an incoming attachment. Once the user selects a folder they can then see and select a file from that folder and then attach it to the email. The use of numbered instructions is taken from the development of the FileTutor tutorial and appears to be a useful way of guiding an older user through an unfamiliar or infrequent process.

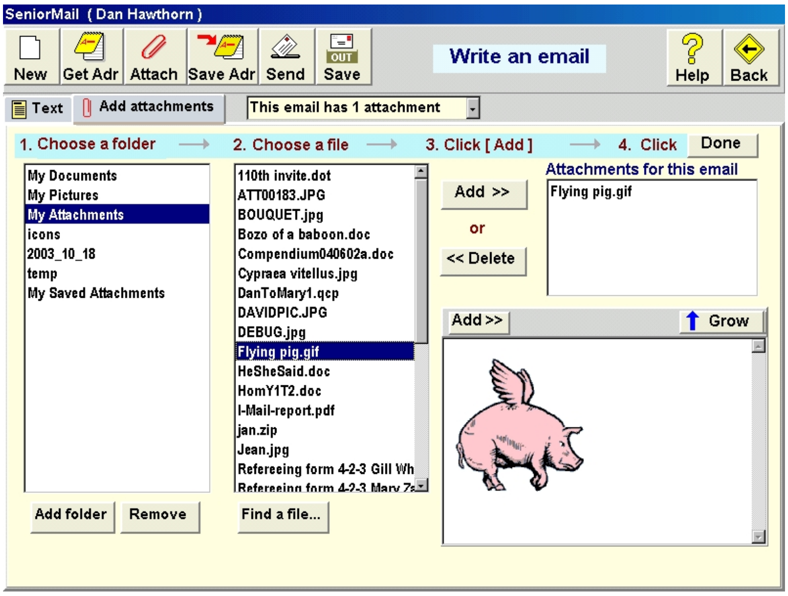

Figure 6.7 Adding an attachment to an outwards email

It was observed that the older users did not feel comfortable that an attachment had really been added to the email when they returned to the tab displaying the email text. This was in spite of the fact that they had added an attachment and that the Attachment tab now displayed the count of attached files. The older users apparently did not model the tabbed pages as parts of the same whole, for them the text was the email and it was the text view that needed clear confirmation that an attachment had been added. A solution to this problem can be seen in Figure 6.8 where a prominent drop down list now shows at the top of the email's text page if attachments have been added.

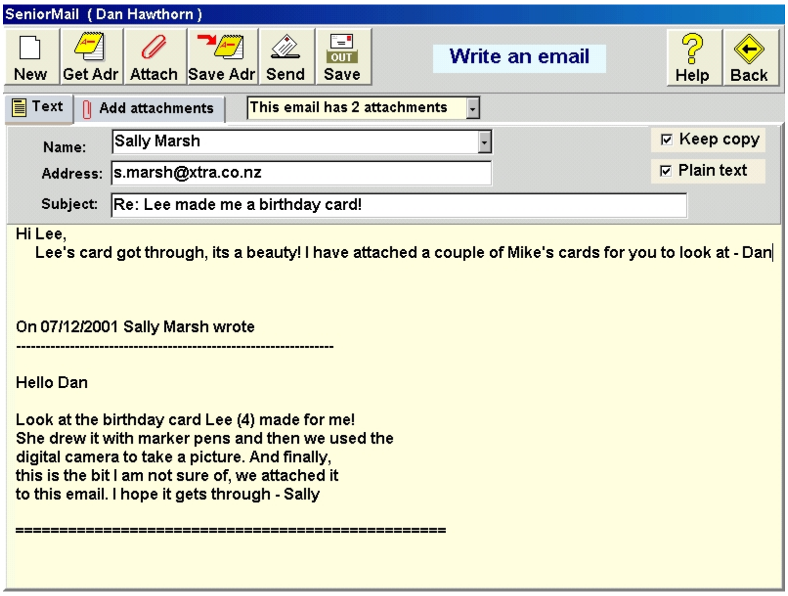

Figure 6.8 Older users want confirmation that an attachment will be sent with an email

6.6 DISCUSSION OF SENIORMAIL INTERFACE DESIGN ISSUES

SeniorMail allowed a group of older users to succeed on email tasks at a level beyond that which they had previously achieved. The experience of carrying out these tasks was seen positively and the users typically ended by wanting to own copies of the application. These results indicate that the design issues tackled in SeniorMail are worth describing. This section will describe the issues and concerns that shaped the design responses in SeniorMail to typical difficulties that older users find with learning, vision, manipulation, navigation and complexity of the system model.

6.6.1 Managing the design environment

One of the key features of developing the SeniorMail application has been the way in which the group of older people contributed to the design. Although there is a separate chapter on working with older people is should be re-iterated here that the design approach consisted of starting with a credible working prototype that arose from two sources. It reflected the expressed wishes of the older people (and their supporters) when they talked about email in the focus groups. However the other starting point for the design lay in the design implications that had been extracted from the literature on aging and had tested in the earlier designs of the two interactive tutorials. Thus when the initial design is referred to a credible working prototype, the implication is not just that it was capable of sending emails at this stage but also that it was credible in the sense that it already addressed basic concerns of older people such as conceptual simplicity, ease of getting started and issues with memory, learning and vision, etc. But given this credible working prototype the other key aspect of the design environment was to combine a feeling that the work the older contributors were doing was useful for other older people, with a sense of fun and play. In this situation failing to see how to use a feature was a matter for amusement and discussion. To this end the fact that the prototype was already surprisingly easy to succeed with boosted the older people's sense of being capable and the decision to have the older design contributors work with other older people when exploring SeniorMail meant that problems were commented on and discussed with peers as they were encountered. This increased the level of insight available to the researcher / designer.

6.6.2 User sensitive inclusive design

Again this point is covered more fully in the chapter on working with older users but the question of how the older people in the development group contributed needs to be considered when looking at the discussion of the SeniorMail design issues that follows. Newell and Gregor (2000) make the point that the designer should be sensitive to the various needs of different older users. Newell and Gregor extend this to argue for designing to include these older users (and other users with special needs) by adapting the design to allow for their needs while still being usable by the wider population. I am more concerned with design that is specifically for older people and am less concerned with the fully able population. However design for older people still contains a version of the inclusion issue that Newell and Gregor identify. If one identifies a particular disability then most of a typical older population do not suffer from it in a severe form. Therefore they are either not particularly assisted by the design changes for that disability or they potentially disadvantaged by the tradeoffs required in the way the overall design has been adapted for a disability that is not central to them.

Therefore one of the key issues in working with the older design contributors was to ensure that all of the group could cope with the email system without being overly inconvenienced by features that did not address their own particular forms of aging.

There is however another aspect that is captured by the term "sensitive". In a realistic size for a group of older people involved with shaping a design there will be only a few representatives of any particular problems with aging. Thus as well as considering those with good eyesight when designing for the people in the design group who had poor vision it was also important to be aware that the people in the design group with poor vision did not provide a widely representative sample of vision problems in aging. The design response was to engage all the members of the older design contributors in discussion on particular disabilities and try and deepen the designer's understanding of each issue from a moderately broad perspective. This was backed by the information available in the general literature on aging. However the narrowness of the sample is a basic reality of the design approach and has the implication that as the user group widens other variations on aging related problems may be met that are not well served by the current design. One of the design principles that emerges is a degree of humility and an acceptance that the approach does not necessarily produce an ideal design for all older people. As can be seen from the results, the approach does seem to have resulted in an application that suited a reasonably wide group of older people taken from the Citizen's Advice Bureau but it would be useful to have more examples of the design approach being used and the breadth of its success evaluated before the approach is established as a clearly acceptable way of developing designs for older people.

6.6.3 Simplicity

One of the central issues in the system design was to reduce complexity. The starting point for doing this was to remove features that were not needed by older users. Focus groups with older people were used to examine the use patterns of older email users and identify the features that were most important for an email system tailored to their needs. The key points that emerged were that these older users had fairly simple emailing needs and sent relatively few emails per week to a very small group of people. However the ability to send and to receive emails was important to them.

One could design an email system stripped right down to a [Get new email] button, a viewer and [Reply] and [Send to…] buttons. Such a system would use predefined addresses and would not store email once read. However such a system would be too simple for many older users and would be unlikely to be accepted by the people who advise older users on their software choices. Further from the standpoint of research on designing software for older users it would avoid rather than address most interface issues. Therefore the challenge that has been taken up was to design an email system that achieved easy use by older users with restricted needs and at the same time could be used as the regular email system for users who make somewhat more extensive use of email. The current long term older users did not identify any extra features that they needed over the first year and indicated that the number of features provided is in the upper range of what they feel comfortable with. However an exception emerged later, with the rise in the popularity of digital cameras, older users were now eager to receive and view images (particularly of younger family members) as attachments.

6.6.4 Learning

Older users are typically slow learners of computer applications, reasonable effectiveness with a low level of mistakes can take weeks or months to achieve, Bosman and Charness (1996). This is a demanding period in which older users can experience considerable levels of frustration and may abandon attempts to use the application. A central principle of SeniorMail was to design a system that required almost no learning to use effectively. Typical systems ask users to find and remember the purpose, name and location of features buried in menus, to experiment and to remember a plethora of small details and to transfer knowledge gained from other Windows packages. As younger or as experienced users we take a large number of simple skills for granted and perform them at an automatic level. We manipulate and remember menus, tab to new fields, Alt-Tab to different applications, resize and manipulate windows, drag and drop, select, copy and paste and use a host of other skills with little conscious thought. It is sobering to watch older users who lack such skills and who find difficulty in acquiring them. Competent computer use (and typical interface design) depends on a large number of automated user skills, each of which is individually simple but needs initial learning. Few computer actions are really intuitive for absolute beginners. If such learning (and automation) does not occur, users are simply unable to act in ways that designers take for granted. Particularly for older users, actions, that we would assume to be standard and straightforward screen manipulation, become an exercise in frustration and in trying (and failing) to remember and co-ordinate a multitude of sub-tasks.

What was done in SeniorMail to reduce learning was to make it easy for the user to search for the feature that they wanted if they failed to remember where it was located. The search was restricted to a linear scan over a few standard buttons. In the main menu shown in Figure 6.1 the buttons were grouped and the search was within a vertical group. All the other SeniorMail windows followed the pattern shown in Figures 6.2 and 6.3 onwards, where the buttons that gave access to features were always located on a toolbar at the top of each window. The basic learning required was, "Look along the toolbar at the top for a useful button". Novice users were found to be able to perform tasks successfully with almost no errors, although they were initially slow to select the right button.

Crucially, the design let users to perform relatively complex tasks without previous experience. It was observed that the older users had begun to remember the location of the most commonly used buttons after completing only two or three tasks from the scenario. The expectation is that the older users will, over time, remember the button locations reliably, increase their speed and build an effective mental model of the system. This appears to be confirmed by the experience of the long term user group.

An important point here is that this design protects older users from the frequent experience of forgetting parts of previously learnt skills. Termed "fragile knowledge" this phenomenon is common among older learners and a significant barrier to competence, but with this design there is relatively little penalty for forgetting exactly how to carry out a particular task, one simply resorts to searching the top toolbar again.

6.6.5 Training wheels

SeniorMail has also benefited from the FileTutor study in that a set of practice exercises and a training version of the system are part of SeniorMail. When this version is activated the beginner can receive a set of dummy emails and send replies to them following a script that is available as a document. This means that the support person can let the beginner go repeatedly through “sending” and “receiving” emails without needing to generate real emails or worry about who the dummy emails will be sent to.

6.6.6 Visual and Manipulative design

The ideas behind the screen designs used in SeniorMail came from previous work by Morrell et. al. (2001) and Hawthorn (2000) on designing for older users as well as from the experience gained in constructing the two interactive tutorials described previously. Usability testing was then done with a group of older users to fine tune the designs.

SeniorMail uses a full screen design rather than using overlapping Windows. This increases visual simplicity and allows the use of larger fonts and larger components. Further reasons for using full screens are covered in the section on navigation below.

A number of older users suffer from a degree of impaired vision. SeniorMail used several simple approaches to counter this. The font used is Arial, this had been found to be easily readable for older users in earlier work, Hawthorn (2000b). The basic font size for message headers and text was reasonably large (14 point) and could be further increased up to 16 point. A larger than normal font was also used on buttons and hint windows. Standard Windows error message dialogs were replaced with message boxes using a large Arial font on a light background.

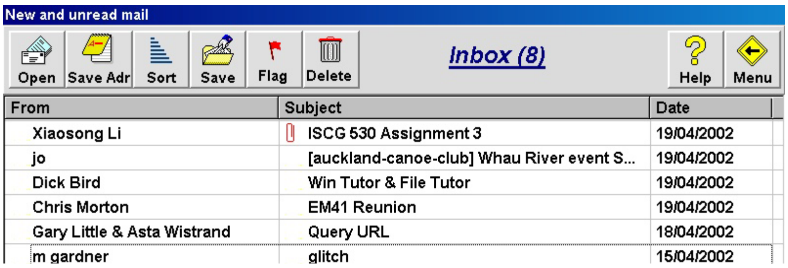

Figure 6.9 The screen layout used for lists of email headers.

With macular degeneration in particular, sufferers struggle to distinguish text against colored or patterned backgrounds. It was observed that this included reading the captions of standard Windows buttons prior to Windows XP, (black text on a mid gray background) even with an increased font size. The solution was to use a non-standard button background color, a very light gray ($00DFDFDF) with a slightly darker window or toolbar background ($00DBDBDB). The result was much improved readability for older users with poor eyesight. In some ways it would have been desirable to move away from the standard Windows button color scheme altogether but it was considered that doing so would break the users' expectations of what a button looked like. Large blocks of text as in the Viewer, Editor and Help screens were displayed on a very pale yellow ($00EAFFFE) background to reduce glare, another area that older users find difficulty with. A couple of users with deteriorating vision, including one with the onset of macular degeneration, noted that the system was exceptionally easy to read.

Older people are less able to filter out extraneous information so that the presence of information in the display that is irrelevant to the immediate task increases their cognitive load. This was part of the reasoning behind the decision to use full screen windows rather than tiled or overlapping windows. Again in order to reduce irrelevant detail no decoration was used apart from icons on the buttons. Older users were asked if they desired icons on buttons and the balance of opinion was that they did. The icons were not necessarily interpreted accurately but they served to make it easier to distinguish between buttons when searching. The icons used with the toolbar buttons needed to be reasonably distinctive. However the captions and hints given to the buttons were intended to be the primary source of understanding what a button was for. It was assumed that not all of the older users would see the icons clearly or understand the intended meaning. The icons were intended to make the buttons distinctive so that they could be located more quickly during visual search and there would be less chance of clicking the wrong button. This also serves to allow a user who has become used to SeniorMail to continue to use the system in spite of declining eyesight. It is also possible that this distinctiveness despite blur could facilitate learning of the system by partially sighted users. As a way of checking whether this distinctiveness was achieved the Gaussian blur test used by Schieber (1998) for evaluating the legibility of road signs was adapted as a tool with which the designer could check that as blur increased the icons remained distinctive. As the following image indicates this was achieved. In fact the full color version of this test shows that icons remained distinctive for users with color vision down to the greatest level of blurring used.

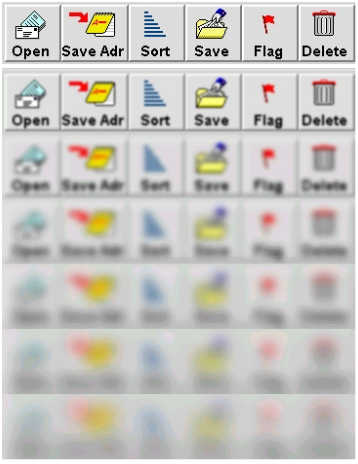

Figure 6.10 Blur testing on the icons of the Inbox

Icons were also used to direct attention to buttons that were off the main toolbar. For example when updating details in the Address Book the user needs to click [OK] or [Cancel] buttons, these were missed by some users until the buttons were provided with icons. "Flat" toolbar buttons should, in theory, be desirable (they provide an additional cue for successful target acquisition and offer a reduction in extraneous detail by removing the borders of irrelevant buttons) however when given a choice older users definitely rejected flat buttons. From discussion it appeared that in order to search comfortably for buttons the older users required buttons that remained recognizably buttons at all times.

Older users are poorer at visual searches unless there are preparatory positioning cues and / or restrictions on the search area. At the same time older users have a reduced effective visual field and may miss tool or navigation features that are widely separated from the area of the screen they are working with. Watching older people working with MSOE indicated that they had problems in scanning a two dimensional space for appropriate choices. Older people are also slower and less effective in scanning lists, older participants in the SeniorMail project have been observed missing MSOE menu items they were searching for, apparently because of the sheer volume of choices. Therefore, as far as possible, all SeniorMail features were accessed from a few, consistent, large toolbar buttons at the top of each screen. The number of buttons was restricted to eight at the most even where this meant restricting the available features.

For example [Reply] and [Forward] buttons would have been convenient on the toolbars for the email header lists but, because extra buttons would overcrowd the toolbars for these screens, these options are only available from the Viewer. There is a deliberate tradeoff in the direction of achieving visual simplicity even if access to features then requires more steps. It is worth noting that where the pattern of relying purely on toolbar buttons was broken, as in the tabbed pages used in the Viewer and Editor, novice users did not see or understand the tabs until these were pointed out to them. A later version of SeniorMail, using icons on the tabs so that they are more akin to the toolbar buttons, slightly increased the ease with which older users found the tabs but finally an [Attach] toolbar button was needed to give access to the attachment window in a form that the older users could reliably find.

Flexibility is restricted in the basic version of the SeniorMail system by a decision that the task bar button at the top of each form should only offer options that were directly relevant to the window on display. Hence the task bar on an email list will offer options to open or delete items or sort the list but not to begin a new outward email. Limiting the available buttons in this manner increases the immediate intelligibility of the toolbar options but at the expense of making it harder for the user to switch tasks, say from viewing inwards mail to writing a new unrelated email. In the basic version the user is required to go back to the main menu in order to make a task switch of this sort. Some novices needed to be reminded several times to return to the main menu if they could not find the option they required on the toolbar of the window they were currently working in. Another area that troubles novices when first using SeniorMail was the need to open an email to get access to options for replying, forwarding or printing. There are arguments against making these options available for an unopened email. Potentially an older user may reply to or forward the wrong email if this is done from the header line instead of from a fully opened message. The trouble is with a naïve user faced with a list of emails and no toolbar buttons for the job they intend to do such as replying to a previously read email. The rule in SeniorMail is to open the email if one wants to read, reply, forward or print but this conflicts with the other SeniorMail rule of returning to the main menu if one cannot find the option wanted. The hint or tool-tip associated with the [Open] button was changed to “Open, reply, print, etc.”. Experienced SeniorMail users showed no difficulty in either of these areas and beginners appeared to learn what was needed after two or three trials so the inconsistency has been left.

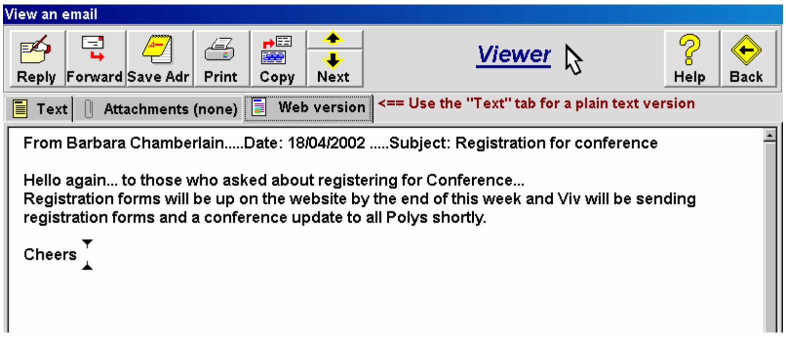

Figure 6.11. An earlier version of the Viewer design. The Viewer with the HTML view showing and a plain text view available. Note the oversized cursors added to the screen dump, the default cursor is to the right of the word "Viewer" at the top, the text cursor is to the right of the word "Cheers" at the bottom.

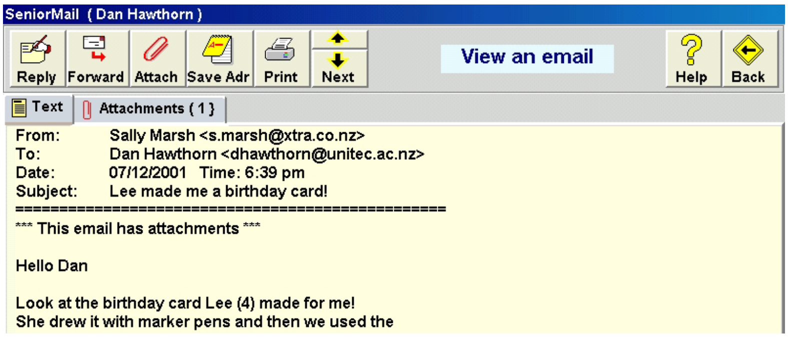

Figure 6.12. The version of the Viewer used at the time of CAB testing. Changes include an [Attach] button, a light cream background for the email text, greater contrast for the title of the window and a change in the wording of the title from the technical "Viewer" to the colloquial "View an email". The [Copy] button, intended to make it easier to copy and paste text has been dropped as it was neither used nor well understood.

Moving away from the tabbed page design also allowed the design to remove another similar source of difficulty. In the version of SeniorMail used at the time of CAB testing the tabbed page for displaying attachments still retained the Viewer toolbar and had a second group of buttons for managing attachments. As with the tabs the older users often did not see the second set of buttons.

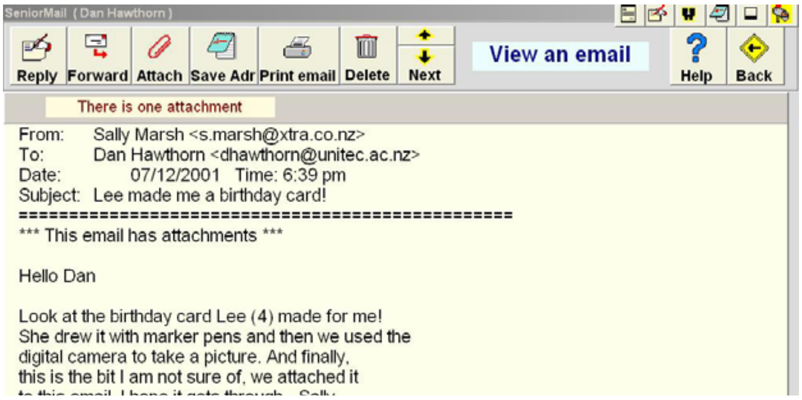

Figure 6.13. In the current version the troublesome tabbed pages have been removed altogether and the background cream has been made lighter.

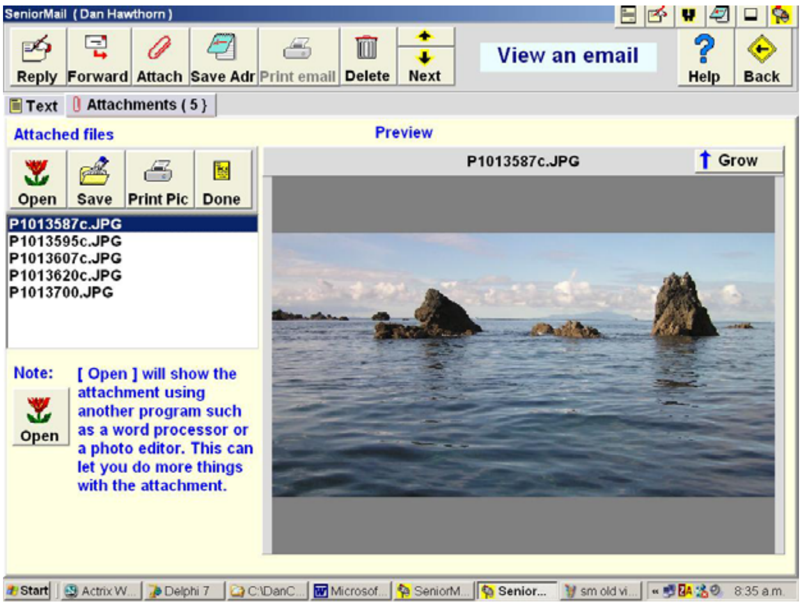

Figure 6.14. Two frustrations were seen in attempts to use this version of the attachment viewer. The [Open], [Save] [Print Pic], [Done] buttons were not seen by older users intent on searching the toolbar and users did not understand why the [Print email] button on the toolbar would not print the image. A newer version of the attachment part of the viewer now has a toolbar with only buttons that are relevant to working with the attachments.

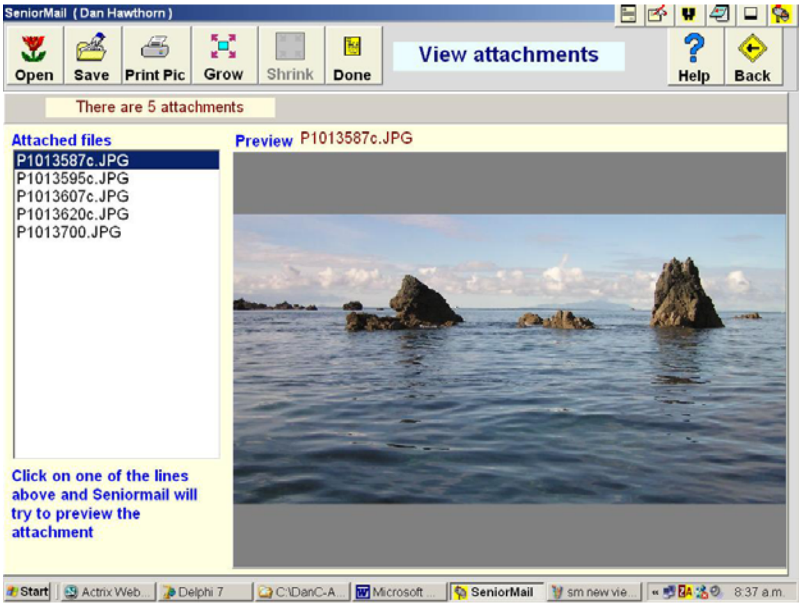

Figure 6.15. The current version of the attachments screen is redesigned to be consistent with the rule that all features are found on the toolbar button and the toolbar button only has features that are relevant to the display. Printing now refers to printing the image.

Another example of the problems of older users with visual search is the observation that some users had difficulty in locating the standard cursors against a background of email header lists or message text. Hence SeniorMail uses a very large default arrow cursor with a double width black outline and a new, large, text cursor that is particularly easy to find, see Figures 3a and 3c.

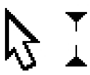

Figure 6.16. The cursors used in SeniorMail were designed to be easy to find

The cursor designs were developed and tested by trying to hide a variety of cursors in email text and against the toolbar features and then getting older users to attempt to find them. Finding the cursors was treated as a game and the older participants responded with enjoyment. Standard cursors were relatively easy to hide and the older users did not reliably find the standard cursors even when they moved the mouse to try and detect cursor movement. Possibly the lightness of the cursor lines, the relatively high speed of the movement achieved and the limits to the older user's effective field of view contributed to this effect. However the modified cursors proved virtually impossible to hide from the older users in the development partner group and were much easier to spot when moved around. These modified cursors were enthusiastically supported by the older users in the study.

The Viewer is intended to display emails that include HTML or enriched text formatting instructions. However, since the format chosen by the sender may be poorly designed from an older reader's perspective, SeniorMail provides a plain text view as the default with a web browser view as an alternative if required.

Older users are likely to find it difficult to resize overlapped or tiled windows by dragging the edges. The edges of windows are too small a target for many older users to acquire. Older users are also likely to unknowingly click outside the boundaries of foreground windows and be mystified when the foreground window vanishes. These arguments contribute to the decision to use full screen windows in SeniorMail. In addition all pop-up windows were displayed modally so that clicks on the background had no effect.

Scrolling is another area of difficulty where attempts to scroll through a long document can frustrate older users who typically are unsure of the differing consequences of clicking different parts of the scrollbar and may have problems dragging the slider along the track. The use of full screen windows for email header lists and viewing emails in SeniorMail reduces the need to scroll but does not eliminate it. One could provide buttons that allow the user to control scrolling without using the scrollbar but a useful alternative is already available in the use of the Page Up and Page Down keys and Up and Down arrow keys. The issue is how to make older users aware of these keys. A possible approach that has not yet been implemented would be to monitor mouse movement and provide suggestions about using the keyboard alternative if trouble was evident with mouse use while scrolling.

Tool tips or hints are the small text displays that appear beside a mouse when the mouse hovers over a control. It would seem that, as age restricted users have difficulty in remembering what to do, hints would be an obvious contribution to increasing usability. However, a number of complications arose when the effect of hints was examined in SeniorMail. It should be remembered that age restricted users tend to have poorer eyesight and to be slower in processing new information, thus small rapidly flashed hints do not work for them. Because age restricted users typically have a fairly limited useful field of view and have problems integrating spatially distant sources of information they are less likely to be able to take advantage of status bar information at the bottom of the screen although this would be one way of eliminating the time and size constraints of hints. Hence the first consideration was hint font size, the standard MS Windows font for hints is simply too small for most age restricted users. So Arial 14 point font was adopted for hints. This size of font was easily readable but it became apparent that the time that the hint displayed on the screen was too short for the age restricted adults to read any but very short hints. The problem with reading the hint within a restricted time period was tackled in two ways. The hint text was shortened and simplified following the recommendations in Hawthorn (1998a, 1998b, 2000) and Hartley (1999) so that it could be understood in as little time as possible. The age restricted users were still found to need more than the standard time allowed for hint displays so this was raised from the default of 2.5 seconds to 4.5 seconds. These changes led to readable hints but led to further difficulties. Older people tend to be more disrupted by unexpected events than younger people. They are also less able to make sense of partially obscured visual displays. The effect of bigger fonts and longer hint display times was to create a somewhat disruptive environment in which large hints would appear, grab the user’s attention whether this was desirable or not and be slow to vanish. Further, because of the text size the hints obscured more of the screen, in addition standard hint behavior in MS Windows is to appear close to the mouse cursor. These two factors combine to mean that the enlarged hint often displays on top of the control to which it refers. The combined effect of the changes to this point was that readable hints were reducing usability considerably. The solution involved two changes. Since age restricted users tend to be slower in their mouse movements they have more chance of triggering an unwanted hint display as they move over controls. Therefore the time that the mouse had to be over the control before the hint was displayed was increased from the default of 0.5 seconds to 1.5 seconds. The effect is that hints are only seen when the user makes a significant pause over a control. (If the user moves immediately to another control after the first hint display the next hint is displayed immediately). The second change was to control the position in which hints are displayed. The controls on which hints were available were the toolbar buttons on the top of each screen, the system was altered so that hints always displayed just below the toolbar, under the button the hint referred to. These final changes prevented the hints from obscuring useful information and causing unnecessary distraction. Younger users however found the large hints unnecessary and intrusive.

6.6.7 Navigation

Older users have been shown to perform more poorly in navigating complex web sites, advanced searching or working with complex programs, (Czaja and Lee 2001, Sharit and Czaja 1999). Unfortunately moderate levels of complexity are usual in the design of popular email systems. Typical email systems provide a flexible navigation model where the user can jump to nearly any folder or tool from any starting point usually in one or two steps. There is also a mixed pattern of tiled and pop-up overlapping windows, intended to present as much of the system as possible. This is combined with menus, toolbars and a forbidding level of jargon.

For older users there are drawbacks to having multiple visible windows. As noted above the overall screen display is more complex because it presents more navigation choices and this requires the user to have a reasonable mental model of the system and to remember more about the location of features that allow access to parts of the system. Older users often have significant difficulty with both remembering navigation features and with searching for them in a visually complex space.

Complex screens also imply a need to reduce the font used in order to give space to all the competing features. Another implication is the reduction in target size as well as the proliferation of targets. There is the implied expectation that users will be comfortable with relatively frequent navigational jumps and windows management acts such as resizing, repositioning, maximizing or minimizing. For older users with poor vision, reduced manipulative accuracy and poor short term recall of immediately preceding actions, this is likely to result in misplaced clicks that can mean unexplained jumps to unknown parts of the system with no self evident way of getting back. Again the argument supports the use of full screen window displays.

The main SeniorMail task windows are accessed from a simple main menu screen, see Figure 6.1. Options on the main menu screen are grouped so that visual searching is through a vertical linear space within one of three main groups. A choice on a main menu button typically leads to a window displaying a list of email headers. These list displays are standardized with some large buttons on a toolbar at the top and a list displayed below, see Figures 6.2 and 6.3 onwards. To open an email the user clicks a line in the list of email headers and then clicks the [Open] button.

Navigation is usually linear. Users move outwards by selecting options such as the [Open] or [Reply] button. They then return step by step to the main menu using a consistently located [Back] or [Menu] button. Typical patterns are:

Viewing:

menu -> list -> viewer
menu <- list <- viewer

Replying:

menu -> list -> viewer -> editor
menu <- list <- editor

Write email from menu:

menu -> editor [-> popup address list]
menu <- editor

Write email from address book:

menu -> address book -> editor
menu <- editor

This system of toolbars with limited options and consistent [Help] and [Back / Menu] buttons has two basic implications, the user can always return to a previous screen and eventually to the main menu screen so that simple navigation back to a known starting point is always possible. Secondly if the older user forgets what to do at any stage the one rule that they need to remember is, "Look along the toolbar and see if there is a useful option". Elderly novices were observed to succeed very rapidly with this constrained but simple model.

However the standard email browser design does address a useful issue where one wishes to do things like writing an email while referring to an unrelated email. The SeniorMail solution is to provide a small “float on top” navigation bar that lets users jump between the main parts of the system; the Menu, Viewer, Editor and Address book. This navigation bar (shown at the top right of Figure 6.13) is convenient once the user has become familiar with the system but it was felt that initially age restricted users should learn on the basic system first before increasing the navigation options.

Another problem encountered by older users was the terminology used in many email systems. This does not lead to the sort of simple understanding of what features are available that leads to effective navigation. For example in MSOE the button labeled [New Mail] does not indicate if this is inwards or outwards mail, a window captioned "Composer" does not clearly express that this is the window to be used for writing a new email. The design approach used was to discuss button and list captions with older users and select those that gave greatest clarity in indicating the purpose of the button or list.

It is assumed that the typical SeniorMail user will have some support from a more competent Windows user and so some features such as the details for connecting to one's internet provider, setting up a list of commonly needed folders to search for attachments or setting up email categories for classifying stored emails are available from the Options window rather than directly from the main menu.

6.6.8 Confirmation and feedback

Many age restricted users appear to operate with a low expectation of success. This low expectation of success was noticeable in a two situations in SeniorMail where the user requested an action such as sending an email and/or saving an address. In earlier versions of SeniorMail the system responded by doing the job and simply closing the Editor or the Address dialog. However, age restricted users were frequently uncertain as to whether they had done the correct thing and asked whether their action had been successful. The solution adopted in SeniorMail was to insert an artificial pause in which the system displays a message for about one second telling the user, “Email saved to the 'Not yet Sent' list” or “Saving address” and then the message is automatically hidden and the Editor or Address dialog is closed. Age restricted users were now confident that their actions had succeeded but younger users, when questioned, said that these messages were superfluous. Other examples of adding more explicit feedback and confirmation for older users can be seen in the progress dialog boxes that accompany getting new mail and sending emails as well as the redundant displays used to indicate that attachments have been added to an email.

6.6.9 Managing complexity

Designing for older users highlights the tension between providing simplicity and providing features. There are a number of features that can be excluded as irrelevant to a basic email system but there are other inherently complex features that are required for various reasons. For example managing attachments requires some way of dealing with the file system and older users can have considerable difficulty in conceiving of, or using, a hierarchical tree of directories. Other areas of difficulty involve organizing and finding one's emails. The tasks required here are all potentially difficult for older users; creating new folders, dragging and dropping, remembering or finding where items were actually stored and maintaining folders. Another area of complexity can lie in the navigation model itself. A typical email system like MSOE aims to provide the user with quick access to a wide variety of features, tools and folders. To do this the multiple screens and menus provide so many options that older users frequently feel overwhelmed, older users are not particularly good at visual searches of complex displays, nor are they skilled at routine windows management tasks.

The point will be made in the discussion of solutions to these problems that the solutions involve trade-offs that limit the number of easily accessible features and hence the suitability of the system for power users. The challenge in the SeniorMail project is providing a reasonable set of features while maintaining a sufficient simplicity of interface design such that older novices are able to function and to increase their skills over time. In what follows the paper will look at details of how the areas of complexity described above are handled in SeniorMail.

Avoiding File System Complexity

Observations from the email study and from the previous studies suggest that many older users do not achieve a good understanding of files and directories and continue to have difficulties using them. With email this becomes an issue when attachments are to be saved or more particularly, found and sent. Discussion with groups of older users and with groups of supporters of older users identified attachments as a significant area that older people had difficulty with and usually avoided.

Opening attachments was not a major problem, although older people usually reported having been initially puzzled by the meaning of the paper clip or similar icons used to indicate attachments. Again some older users are not confident about task swapping or may not immediately consider closing a window in order to return to one that has apparently vanished. Hence when opening an attachment transfers them to another program they may find difficulty in returning to SeniorMail. Opening attachments as embedded documents was tried but is not completely successful because of the slowness with which large documents load and the limited viewing area available. In the current version of SeniorMail images are shown as previews within SeniorMail but all except small Word documents require the user opening them in MS Word.

The major difficulties older users had with attachments were in saving them and in finding files, attaching and sending them. The central issue was the (unmet) need for older users to have an understanding of file management in order to save or find attachments.

SeniorMail tries to sidestep this issue. Firstly an additional special folder "My Attachments" is created by the program under "My Documents" and incoming attachments are saved there by default. Secondly the older user's support person is asked to select a few folders that are likely sources of attachments that the older user may wish to send with outwards email. The program then uses these folders and the Windows special folders as the basis for a simplified process for finding and sending files as attachments.

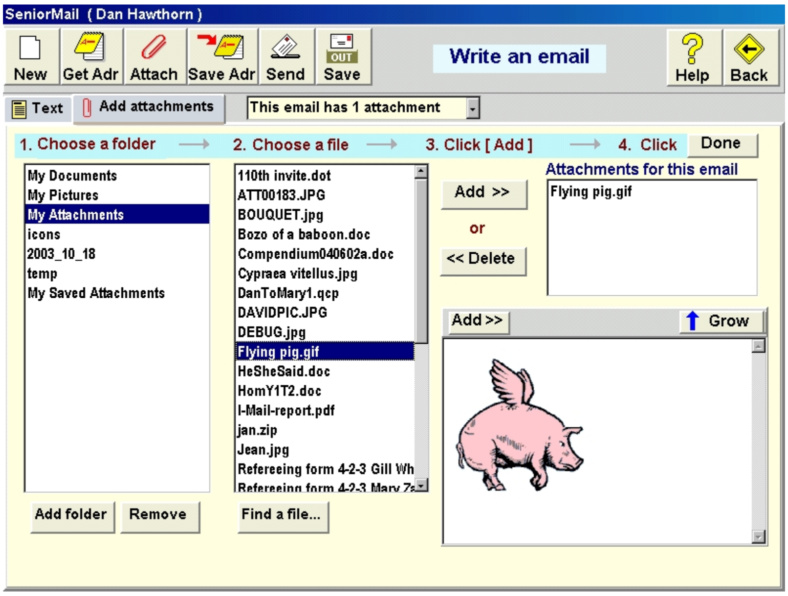

Figure 6.17. Adding an attachment in the editor using numbered instructions

Since this may be an infrequent process SeniorMail leads users through sending an attachment by using numbered instructions, see Figure 6.17. Numbering instructions was an approach that succeeded in earlier work with older users, Hawthorn (2002a). However the form shown above was not ideal as the wide spacing of the instructions and possibly the horizontal orientation meant that novices initially took time to find the next step and to see that the steps were spelt out along the top. A later modification has been to try and emphasize the grouping and to use color changes to highlight the next step. As with the viewer the tabbed pages have been dispensed with.

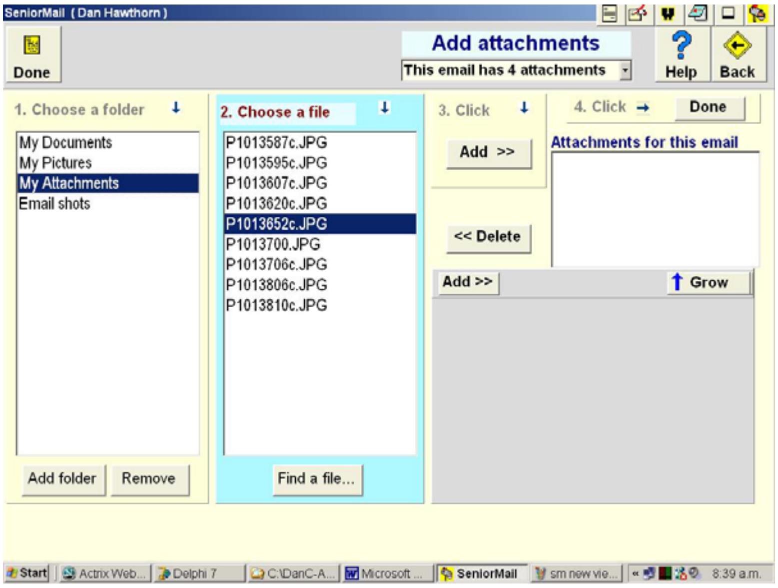

Figure 6.18. This approach to attaching files worked with older novices and it can be argued that it makes sparing use of supporters' time. However it is a distraction for those older users who are competent in file system usage, even though they can obtain a standard open dialog box by using the [Find a file] button shown at the bottom right of Figure 3.

Handling information storage complexity

The next area of significant complexity lies in organizing one's emails. The standard solution is to use folders and allow the user to create extra folders. Folders typically require levels of manipulation that are not easy for seniors, the standard drag and drop approach to moving messages to and from folders is unworkable for a number of seniors who have poor mouse manipulation skills.

Folders also increase the level of complexity in finding and disposing of mail. When finding saved mail the older user has to think of the correct folder, or use a finder that in itself introduces a further level of complexity. Much of one's personal correspondence does not classify neatly, a letter may be from one's daughter and refer to one’s house, one’s grandchildren and a planned trip overseas. With poorer long term memory (and possibly a higher proportion of multi-topic social messages rather than single topic business messages) some older users can be expected to find difficulty in using the classification that folders provide. "Did I put that in there? I thought I did but I cannot find it. I wonder where…?"

SeniorMail in fact uses a number of fixed folders; the Inbox, Saved emails, Recently deleted, Recent copies, Not yet sent and Save copies. These folders are referred to as lists and displayed as such in SeniorMail - reducing the level of jargon to be coped with. Emails are transferred between these lists by selecting lines in the list and clicking [Delete] or [Save] buttons thus avoiding drag and drop. The user cannot create additional folders thus preserving a simple and understandable structure.

The tools for locating mail after it has been read or saved are a column sort within individual lists and a Find option that generates a temporary list of email headers by applying a simple search for a single word or phrase to all the fixed folders. This avoids the problem of an older user having to search several folders to find a saved email.

An issue is that older users may forget to regularly clean out their folders. SeniorMail automatically removes old items from the Recently Deleted list but there is the potential for the Saved list and Copies of Sent Mail to grow. As lists get larger the manipulation involved in scrolling becomes more difficult as more precise manipulation is required with a smaller slider.

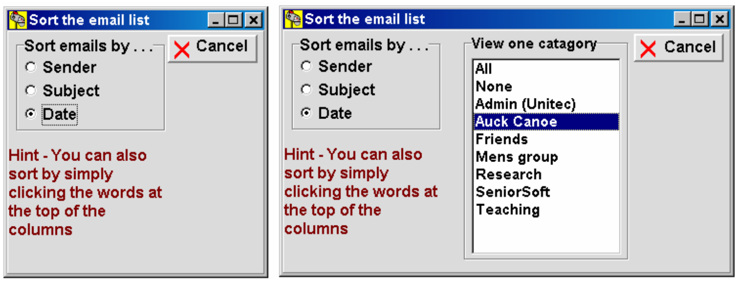

Figure 6.19. The Sort Dialog changes if categories are in use

In addition older users have trouble with moving text so that searching a list as it scrolls is difficult.

There is a way of adding further structure for those who desire it. An option is available to let the user place the list items into categories when transferring them from the inbox to the saved emails. A window for maintaining a set of categories is available from the Options screen. If the user is working with categories the behavior of SeniorMail changes at a couple of points. The display resulting from the Sort button is enlarged to allow filtering of the saved emails by category, see Figure 4. In addition the Save button now displays a dialog box where the user chooses a category to save under. Note that the system only adopts this more complex behavior on demand, users who do not need to further classify their mail do not have to consider the features that work with classification thus preserving the design simplicity.

It is worth considering that older users may have trouble remembering that a feature has been switched on or in fully comprehending the implications of a feature being active. When categories were introduced into SeniorMail the Saved list was left in the state in which it was last accessed including any filtering by category. The user response on returning to the Saved list was not, "I am looking at only the emails in the 'Bridge Club' category" but, "I have lost most of my emails". SeniorMail was altered so that any filtering by category is removed on leaving a list and the unfiltered list is what is seen the next time the user views it.

As it stands the Categories feature in SeniorMail is usable by seniors but of limited value, since classification is only done when saving mail. A set of rules for classifying incoming mail was considered and rejected on the grounds that seniors were expected to have trouble in effectively formulating rules for incoming mail and in remembering and understanding the implications of a rule over time. This expectation is based on the difficulties that older subjects show in using rule based searches as reported by Sit (1998) and others. Given the small volumes of mail the likely effort and stress seem disproportionate. However this does make it likely that the Inbox will grow to unmanageable proportions if older users join mailing lists, so the issue of folders and classification rules may need to be revisited.

6.7 DISCUSSION

One of the strands in modern HCI is to provide innovative features that partner the users' needs and abilities and extend the affordances of traditional features in order to allow the system to be as responsive as possible to the requirements of the user's task. Yet in the current chapter a rather old fashioned version of a mainstream application is presented that avoids all but a very basic subset of Windows features. So what is there in this prototype to interest or excite an HCI researcher? The interest comes from the intensity of the response by the older users who have tried the system. The limited group of older people who have so far tried the system are saying that this system provides what they need as older users in a way that other systems do not. They are also saying that they (strongly) want other applications to be like this.

Testing suggests that the email system described is considerably easier for older users than standard fully featured email systems such as MSOE. See also Newell et. al. (2005) for another study confirming that MSOE was found to be difficult for older users. The design techniques that provide this ease of use depend on trade-offs that limit the number of features available or their accessibility. Simple, large font, large target, full screen windows without menu bars only allow access to a fairly basic feature set. Presenting a simplified substitute for the file system when dealing with attachments sharply limits the number of file system tasks that can be achieved. The limited solution provided for classifying emails highlights the question of whether older users dealing with small volumes should attempt the sorts of classification rules younger, busier users need. While the system appears to meet its target of providing a reasonable set of email features in a manner that seniors find easy to use, the interface design techniques used are not one's that scale up to increasingly complex applications.

Interface design approaches that work for the current generation of older users are old-fashioned in more than one sense. They are fashioned using feedback from older users and using knowledge of the implications for interface design of the changes due to aging. But they also hark back to the time of relatively unsophisticated users of graphical user interfaces when simple interface design was appreciated by a user group that included a high proportion of novices. A number of current older users seem likely to remain in this novice group. Their uptake of new techniques is slowed by both the limitations age places on learning and by the fact that they do not need to make extensive use of their computers.

If it can be argued that there is a gap between the needs of current older and younger users, will this still apply to succeeding generations of older users who have significant computer experience prior to becoming old? Work on elderly retention of expert knowledge by Bosman and Charness (1996), Salthouse et. al. (1990) and others is not encouraging. Where older people retain expertise this appears to be within very narrow limits. There is no evidence of increased ability (in older experts) to master new tasks based on apparently closely related skills. In an ICT industry that thrives on rapid change and is economically driven by new features there seems to be a case for arguing that succeeding generations of older users will continue to want software that is simpler than that used by younger people. Firstly they are likely to have more modest computing needs once they exit the workforce. Secondly they are likely to need software that trades a reduced feature set for an interface that accommodates their aging cognitive, manipulative and perceptual abilities. Thirdly they may well want software that works within the paradigms that they were familiar with in their late 50s as many of us are less likely to learn new skills after this age.

Finally there will be some applications designed to make as much use as possible of (younger) users' abilities in order to apply their abilities in perception, manipulation and cognition as fully as possible to a problem. Such applications might present large amounts of information on screen implying small fonts, or provide contextual richness by way of a wealth of hyperlinks implying an ability to remember multiple threads of information. In providing such power in an interface it seems legitimate to offer whatever features are suitable even if these features are unsuited to the abilities of older users. It is hard to argue for crippling the power of an application to assist a younger user on the grounds that the interface features that best do this make excessive demands on older users. Again the argument seems to lead towards the provision of easy to use but more limited software for the older group. There are, however, positive aspects. As well as making suitable software available to older users, conscious design for the needs of the older user group could provide a range of well designed and highly usable applications that might be welcomed by younger people in the wider population who do not need, or wish to be, power users.

Schneiderman [2000] has argued that "dumbing down" of applications and the "innovation restriction scenario" are avoidable in creating interface designs that lead to universal usability. "Dumbing down" refers to techniques for increasing usability that restrict the complexity of applications. The "innovation restriction scenario" deals with a related concern where the limitations placed on designs in order to increase the usability of an application for some disadvantaged group leads to restrictions on the techniques that can be employed in the interface design in order to assist high end users. Note however that Schneiderman [2003] is now arguing for layering of applications where the layers for old or disabled users do in fact present a simplified, dare one say "dumbed down", version of the application.

What this chapter has tried to suggest is that design for age restricted users does not proceed from isolated facts about aging. Rather the possible designs arise from considering a number of aspects of aging in combination and such design decisions then impact on the possibilities remaining for future aspects of the design. Thus, it is not simply a matter of providing larger fonts but also of providing simple, linear and predictable search spaces. And once an interface design expression of these decisions (such as large toolbar buttons) has been adopted there is a substantial impact on the number of features that can be offered.

Further, because of the number of possible inferences from our understanding of aging and the wide gap between the designers' personal experience and the experiences of age restricted people, designers for age restricted users will remain very dependant on testing with a range of age restricted users in order to verify the assumptions made in their designs.

Overall, the techniques used in creating a successful email system for age restricted users are directly at variance with the techniques used by designers for supporting a modern, feature rich application. In designing for age restricted users we expect much less of the user and we limit the complexity of both screens and overall application structure. We preclude crowding an application with features if we foreswear menus and decide on a limited number of screens with large simple features and minimal scrolling. In some cases it may be possible to provide layering as a way to allow more complex features to be introduced when the user is ready for them. However, it is suggested that the application complexity required for full featured applications will be hard to implement in a way that both suits age restricted users and does not disadvantage younger users wanting nearly instant access to all the power that the application provides. There is also the issue of how one migrates between an age restricted users' and a power users' version of an application. Age restricted users are unlikely to be able to configure a simpler version of a complex application while younger users are likely to be impatient with any application that requires even one time configuring to make available what they see as basic and standard features.

There appears to be a tendency in some of the published papers on Universal Usability to think in terms of some idealized software plus hardware combination that makes everything available to everyone, see Schneiderman (2000). This could be seen as the UU equivalent of artificial intelligence, it makes for endless academic research, may lead to wonderful results in 30 years time and does not help much right now. The old quote applies here that the perfect is the enemy of the sufficiently good.

There is the question as to whether one should make multiple different products for different groups, make user scalable products, make variable products that are purchased as the senior version, the younger version etc? There are some reasons for concern about user scalable products, the age restricted users I have worked with are likely to have difficulties with managing such scalability. There are also notable communication barriers between would-be supporters and age restricted users which limit the solution of relying on supporters to manage scalability. Personally I mildly favor making multiple different products where those specifically designed for age restricted users are fairly basic. Given experience of what age restricted users need and find usable, versions of mainstream products that suit age restricted users are relatively easy to produce. However there is an argument for making products for age restricted users that can act as simplified training versions of more complex products for those age restricted users whose disabilities focus on learning rather than performance. Carroll's (1990) "training wheels" approach could be adopted to give a simplified version of an application that resides inside a more complex application. The complex application could be configured to present its simpler version on startup by the supporters of an age restricted user. There could however be problems where, as more features are made available, the interface design principles for age restricted users become compromised. Generally though, there are limits on the amount of complexity that age restricted users can cope with. The argument to be drawn from this is that fully featured applications will remain beyond the capability of many age restricted users and that it is not going to be possible to magically "seniorize" a complex application while retaining its full functionality. It may often be possible to retain universal access when we are dealing with information as in web pages, but as we shift to application design and look at the availability of functionality it is more difficult to envision making all levels of functionality available to all users.

Chapter 7 Research Methodology

7.1 Introduction

This chapter describes and discusses the research methodology that was developed and used in the course of the overall project. Note that the research methodology emerges from reflection on what worked as a greenfields investigation was carried out, hence the unusual positioning of the research methodology chapter after the chapters describing the research. The research methodology is a product of the investigation, not a primary driver of it. However the research methodology chapter offers an examination of the thinking behind the research decisions made in framing and conducting the case studies, it offers a picture of how research in applied aging can be carried out from a greenfields beginning and it gives an independent derivation of a research methodology that is very similar to that used by the UTOPIA team. The parallels between the two approaches are considered in detail in Chapter 9.

7.1.1 Methodology chapter outline

The problems raised by the Dual Task pilot study provided the basis for the questions that led to developing this methodology. The rest of this chapter will first look at the aims of the overall study in order to assist in clarifying what the research methodology needs to support. Experience from the dual task pilot study led to a decision that the subsequent research would not use a strict experimental approach and this decision is enlarged on in the following section. The chapter then examines possible methodological approaches among established research techniques and concludes that while they each offer valuable perspectives none of them by themselves can support the aims of the overall study. An outline of the research methodology actually adopted and its links with established methodologies is then provided. After this the research methodology used is explored in more detail.

There is a problem in that the research methodology is intertwined with the techniques I used for interacting and working with older people and intertwined with the design approach for creating interfaces that suit older people. However this chapter will focus on the research methodology and defer discussion of the two other areas until Chapter 8. This should facilitate reading of the thesis by people who are interested in designing for older people rather than in research. In the current chapter on research methodology, areas where the material referred to is expanded in Chapter 8 will be pointed out where necessary. A further chapter, Chapter 9, looks at the way in which the research and design methodologies that have emerged independently in the research for this thesis parallel the approaches developed independently by Newell and co-workers in the UTOPIA project at the University of Dundee.

7.1.2 Research issues raised by the Dual Task pilot study

It should be noted that the Dual Task pilot study was undertaken after a wide-ranging look at the literature on the cognitive and physical effects of aging. This literature had a strongly experimental focus and was largely designed to address theoretical issues in the mechanisms underlying aging. The research on which the literature is based comes almost entirely from the results of laboratory experiments. This literature is open to question as to how the findings fare when older people are dealing with basic well practiced routines in their lives or when older people deal with new tasks that combine multiple aspects of aging that are covered individually in the general research on aging. There is a challenge in extracting information from theoretical research and applying it to the much messier world of real life design and use.

The Dual Task hypothesis made a relatively straightforward jump from theoretical findings on dual task performance to a possible model for understanding the relationship between older people and their substantive and interface tasks. The indication of the pilot study was that the relationship (if it existed) was not as simple as expected. One option at this stage of the thesis would have been to conduct more detailed studies trying to find how (and if) the expected dual task effect actually operated in older people’s computer use. There were several considerations for not proceeding with this. The first was a recognition that a theoretical mechanism, even if supported, was not likely to be widely useful to designers in this area. It was felt that designers would be more receptive to more specific suggestions on vision, manipulative skill levels, complexity etcetera.

The Dual Task pilot also raised ethical issues about requiring older people to fail. In that study the older subjects were distressed when confronted with tasks that challenged their view of their competence. There was also a question of whether the contribution to the general good made by such a study justified the involvement of the older subjects with tasks that they felt were boring and unrelated to their wants. Along with this came the issue of getting realistic levels of motivation from the older people involved. However some tasks, such as trying to determine a suitable font or participating in the focus groups, clearly engaged and rewarded the participants.

At the same time the experience gained with observing older people trying to use and learn existing computer applications appeared to offer insights that were not available in the research literature though they could with hindsight be related to the research findings. One of my conclusions was that the area of older people and computer use was (in 1999) at a pre-scientific stage where hypothesis testing was premature. A wide rather than a narrow focus seemed to be appropriate. A further conclusion was that basic observations on what older people had trouble with and what they typically did not know could be of more direct use to interface designers than a set of experimentally supported hypotheses. It was, however, felt that it would be useful to try and link these observations to the effects of aging reported in the general literature on aging. This would give the observations a context in terms of what was known about the aging process and should allow the designer a better basis for generalizing to the particular system that they were trying to design. Finally the richness of the material provided by the focus groups and observation of the older learners at Unitec and the apparent direct relevance of this information to design issues, suggested that the research design should be such that it provided considerable opportunities for more observation of older people in naturalistic settings.

7.2 Aims of the overall study

In this section we shall restate the aims of the overall study as a way of focusing the issue of selecting a research method. The overall aim of the study is to produce a useful interface design approach for older people. To be useful an interface design based on the approach will allow older people to succeed with tasks that they have been unable to achieve when using designs with interfaces that ignore the design guidelines developed in the thesis. Inherent in this is the intention to look at a wide range of interface design issues for older users rather than to concentrate on detailed examination of one or two issues.

The research thus aims to

1. Identify the main areas of concern in designing for older people
2. Develop a design approach that address those issues

and

3. Provide support for the overall impact of using this approach to address these concerns in interface designs for older people.

The areas of concern include the following

1. The implications for interface design of the cognitive and physical effects of aging
2. The implications for interface design of the context within which older people use computers
3. Bridging the difference between the (younger and more computer experienced) interface designer and older people

The claim to be justified by the research method is that the design approach to be developed represents improved practice in terms of leading to systems that are more usable for older people than standard systems. This does not mean that the design approach has an exclusive claim to represent best practice.

What do we mean by guidelines in the design approach? The key is in describing sensitizing issues rather than prescriptions. For example in the course of this research some older people have been observed having difficulties with menus, this is a sensitizing issue. But instead of a prescription to avoid menus the guidelines as envisaged will first offer more detail on the nature of the difficulties observed - the list of difficulties is X, Y, Z. Then the guidelines offer the suggestion that designers of interfaces for older people either avoid menus or redesign the way menus are presented so as to address X, Y, Z. Or they might include menus in an interface in such a way that their use is not crucial to succeeding with the user’s task.

One of the needs that the research methodology should meet is that it allows the design recommendations to be built from a wide base of knowledge about older people and their computer use. Ideally the research methodology should allow a way to integrate findings on older people’s visual acuity, manipulative skills, cognitive ability, memory and visual search skills with observations made during the research of particular aspects of interface design such as menu use.

Given that the research draws together a large number of interface design recommendations for older users and examines their overall impact, how confident do we need to be in the individual recommendations? For example if the older people observed having difficulty with menus were unrepresentative it is possible that the guidelines end up advocating an unnecessary restriction on design for older users. The decision made was that the research methodology should provide a reasonable set of recommendations that could be shown to be useful when applied overall but that the research would not be concerned with proving the individual validity of each recommendation. However it was also of concern that the research methodology used provided checks that the adopted solutions for individual issues did at least appear to be suitable for those older users tested.

The research methodology should provide ways of evaluating whether systems using the design approach and its guidelines increase the level of usability for older users. The overall research methodology should also support the development of an interface design approach for interfaces aimed at older users.

This is intended to be applied research. The study aims at the development of an effective response to a problem (the difficulty that older people find with standard computer applications) and justifying the claim that the response is effective. In doing so the study is intended to cover a broad overview of the issues that surround older people using computers and interface designers attempting to improve the lot of those older people.

7.3 Reasons for not using an experimental approach

Following the Dual Task pilot study it was decided not to use an experimental hypothesis testing approach. Since experimental research is widely seen as providing a gold standard for research this decision requires justification. An experimental approach is valid within the context of well sampled populations, the use of randomized controls and precise but limited hypotheses that are well operationalized, Gribbons and Herman

(1997). Each of these areas meets problems in doing research with older users on an overall interface design approach.

Random sampling of the older population.

Getting truly representative samples of the older population is a major difficulty. Older people consist of multiple overlapping populations of persons with differing degrees and types of age related difficulty and in addition these difficulties are such that they are likely to amplify selection effects in sampling, this is discussed further in Chapter 8.

A precise but limited hypothesis

Given the number of possibly useful interface techniques and the trade-offs that may occur between them an exhaustive experimental study of suitable interface design is a task so large as to be impractical. There is also the issue of whether the field of interface design for older users, as a relatively new field, is mature enough to form robust hypotheses. Again there is a problem with the scope of the findings. Either, as in the dual task hypothesis, the findings may potentially be too abstract to guide practitioners or the findings may be too specific and it may not be clear how far they can be extended from the context in which they were obtained. An experimental study could contrast an overall design incorporating the design approach for older people with an interface aimed at a similar task that was not designed to the design approach. A problem here is that if the system that embodies the design approach is found to be effective there is very little that can be said about the relative importance of individual design points within the system and within the design approach guidelines.

A well operationalized hypothesis

Another problem with contrasting a system based on the proposed design approach with a system that fails to meet the design approach is the validity of the non-compliant interface, does it really represent a valid design for non-elderly users or does it simply represent an artificial, but meaningless, stalking horse for comparing the preferred interface against. A well operationalized hypothesis typically requires that subjects engage in an artificial activity allowing the hypothesized behavior to be expressed under relatively pure conditions. This was found to be de-motivating for older users yet it is desirable that older participants engage in the tasks being studied with levels of motivation that are comparable to those expected on real life tasks.

An experimental approach to studying human performance also typically requires that subjects work with tasks that in at least one experimental condition will involve high levels of failure. Chapter 8 deals with the ethical issues in working with older people. In effect older people are more likely to self blame and can in fact engage in enduring and potentially harmful self stereotyping if they are required to work on tasks where there is frequent failure. This rules out, on ethical grounds, setting up control tasks for older people when there is good prior reason to believe that such groups will experience high levels of failure in situations that are sufficiently realistic that the older participants generalize the failure experienced in the experiment to negative conclusions about their own real world competence.

The requirement for an objective stance and a controlled environment limit opportunities for making and reporting observation outside the framework of the experiment. An experimental approach also places the people being studied in a subordinate role and distances the experimenter from them. This was felt to be undesirable since the situations where I was informally involved with older people seemed to offer numerous insights. It was also felt to be undesirable to keep a formal distance between researcher and subjects, This was because the relationship between the designer and older people was starting to be seen as one of the issues in successful design and that the researcher could better explore this by encouraging more involvement with, and less control, over the older people taking part.

Thus an experimental approach was likely to meet difficulties in almost every aspect. Sampling to get representative samples of the older population is problematic. There appeared to be difficulties in framing hypotheses that would offer both precision and usefulness within the context of looking at the overall topic of design for older people. Operationalizing any hypothesis appeared to be likely to have problems with ethical treatment of the subjects, forming control conditions that have a degree of external validity and with obtaining realistic levels of motivation, especially in the control condition. Finally the objectified approach to research subjects that avoids the experimenter influencing the results also limits the researcher’s ability to undertake the sort of informal exploration that was starting to emerge as a desirable feature of researching design for older users.

The rapid intervention tutorial, described at the start of Chapter 4, had shown that by observing a situation that led to difficulties for older users and then drawing on the issues highlighted in the review of the effects of aging presented in Chapter 2, it was possible to make an effective intervention. A range of established research methodologies was examined, searching for an approach that would frame such interventions in a format that led to more detailed reflection on the sources of success and led to publishable results. This is described next.

7.4 Candidate research methodologies

A variety of established research methodologies offered some aspects of what was needed in this research. These will now be briefly summarized.

7.4.1 Quasi experimental research

The key feature of a quasi experimental study is that the situation studied contains some but not all of the requirements of an experimental study, to the extent that a case can be made that a causal inference about the results can be justified, Gribbons and Herman (1997). A possible format for a quasi experimental study could take the form of finding older people who were already failing to benefit from standard software and then getting them to carry out representative tasks on software that had been constructed using the design approach. In such a design the older people serve as their own controls. This has the ethical advantage that it does not involve asking older people to fail further and it has an element of external validity in that the software that caused difficulties can be argued to be representative of standard available software.

However many of the problems noted in the section on the difficulties of an experimental approach still hold true while the lack of control over the subjects' prior experiences with the standard software further reduces the power of the approach. By itself a quasi experimental approach seems to be insufficient.

7.4.2 Case study research

A case study is an in-depth report of a significant bounded episode, as defined by Stake (2000). The derivation is from medical and legal cases where a key element in professional practice is the examination of the details of the case of a disease in a patient or of a law case brought before a court. Stake (2000) makes the point that the defining factor of case studies in the social sciences is the choice to study a single case rather than a particular methodology. Thus within the range of case studies very different methodologies can be employed. However there are some common factors. Stake (1995), and Yin (1994) suggest that these are the typical data sources in case study research:

- Interviews
- Direct observation
- Participant-observation
- Physical artifacts
- Documents
- Archival records

The first four of these fit well with the sources used in this research.

Stake (2000) divides types of case studies into intrinsic, instrumental and collective. Intrinsic case studies are those done for the interest inherent in the particular case rather than for any interest in generalizing to other cases. Examples could be the cases of general practitioners or lawyers or case studies aimed at organizational review. Instrumental case studies in contrast are undertaken to advance understanding of a wider concern. Instrumental case studies fit Ragin's (1992) defining question, "What is it a case of?" while intrinsic studies deny the importance of that question. Collective case studies are simply studies where several instrumental case studies are undertaken to address the same body of knowledge. This is similar to Yin's (1994) concern with the repeated case study where the power of the case to contribute to knowledge is strengthened if similar findings can be obtained from case studies that address the same issues in the context of different situations and events.

Case study research does not specify the stance of the observer/researcher. Case study research is typically used where the researcher examines a situation over which the researcher has no (or limited) control. This research approach can be used to disprove a general rule Yin (1994) but it gives limited support for evaluating the effectiveness of an intervention because of the lack of replication and the lack of controls. Case study research can be made more powerful if the key findings can be replicated in other cases in different situations. Becker (1992) notes that inevitably issues of generalization and proof will linger in the mind of the researcher so that a tension will remain between the limits of what a case study can establish and what the researcher would wish for it to establish. This tension is acknowledged in my own research.

The individual studies in the research for this thesis can clearly be seen as case studies in working with older people in relation to their computing activities and the WinTutor, FileTutor and SeniorMail studies can also be seen as case studies in appropriate software design for older people. These are clearly instrumental studies, they aim to inform a wider understanding of what makes effective software design for older users. Thus the methodology used in the research for this thesis fits within the framework of a series of replicated case studies.

It is worth pointing out that in each of these three studies my personal focus shifted from intrinsic to instrumental. While creating each of the interface designs involved my focus was on the design process of that particular application and how to use whatever information I could in order to make it effective. This is a straightforward intrinsic focus. As the designs neared completion I shifted to an instrumental mode in which I analyzed the process that had been used and considered how it might contribute to understanding of more general knowledge about designing for older people. I would argue that this shift in focus is in fact appropriate since in part what is being studied is the interaction of a designer and older testers and potential users. Where some future designer is attempting to create a useful product for older people their focus will be intrinsic, a focus on the product development in hand. This initial intrinsic focus has been replicated in each of my design studies and then later analyzed in a more instrumental mode.
One of the aspects of case studies emphasized by Stake is that they place the events that make up the case within the situation in which they occurred, in terms of the personalities and organizational, physical and historical context. The aim is to allow the reader to draw their own conclusions and to give material to the reader that can assist in evaluating the researcher's conclusions. It is this need that has partly shaped my decision to maintain a narrative style in my reporting.

It is argued that case studies allow the description of the convergence of diverse factors in the observed outcome, Stake (2000). This corresponds well with a view of design for older people being in response to wide ranging effects not merely to older people's declines due to aging but also to the situations within which older people approach computing. Again Stake points to case studies as a way of “inviting attention to ordinary experience” and making that ordinary experience more understandable by linking it to theory while at the same time theory is illustrated and made accessible by ordinary experience. In the background of my reporting of “reduced effectiveness in visual search” and methods of designing to compensate for this, the reader should be aware of the figure of an elderly woman or man peering at a screen full of icons and failing to find the icon they need.

There are two points where case studies do not cover important features of the methodology used in this thesis. Case studies are typically done in situations where researcher and research subjects share a common culture. It will be argued that for younger researchers or designers there is so much that is unfamiliar about the experience of aging that this assumption of a common culture is no longer valid. In addition the typical case study is a study of a process or set of events external to the researcher and to which the researcher does not contribute. In the work for this thesis the researcher (as designer) is a key participant as well as observer, further the experiences of the researcher as designer are themselves seen as a valid subject for observation and reflection. For these reasons it is not enough to classify this research simply as case studies, we need to go further and consider the contributions to the methodology from ethnology and from participant-observation research.

7.4.3 Ethnographic studies

Before considering ethnographic approaches, can we make an argument that older people do constitute a distinct sub-culture? After all older people share (most of) a language with younger people and have been part of the mainstream experience that we all (partly) share. My basis for suggesting that there are gains to be made from treating older people as a distinct sub-culture are based on the following.

- My observations of the failures of younger people to communicate effectively with older people. This is coupled with the further failure of these younger people to understand the basis for this miscommunication or to easily find ways around it.
- Statements by my older informants that they behave differently when in the company of other older people.

- The existence of stereotyping and prejudice (from younger people) for the older group, as well as the existence of self stereotyping within the older group.
- The key experiences of being old; retirement and age related disability, are not shared by the younger people who interact with the older group.

There is also the argument for using an ethnographic stance that the observational skills and techniques of the discipline have already been successfully applied to product design. For a useful and well written description of the use of applied ethnography in product design see Sanders (2000).

Thus I am interested in exploring an ethnographic view of older people as representing a different culture from that of the computer literate, younger and more able generations, as well as a tool for observing their behavior. In this view the ability of the researcher to fully understand the reality of the other culture is problematic. Objective reporting of the behavior and responses of informants from the other culture is seen as a partial way of bridging the gap between the researcher and the researched. In my particular study the difficulty in bridging the gap is also reduced by limiting the scope of study to ways that older people can interact effectively with artifacts from the dominant culture or ways that the dominant culture can construct artifacts that suit older people.

Ethnographic studies emphasize the people being studied as having a culture that is different from that of the researcher. The traditional format has been for an academic from a Western culture to study a group from a different culture, reporting back on the structure, beliefs and practices of that culture. There are concerns about the validity of the observer’s view as a representative of a dominant culture and a representative of a particular system of values. Tedlock (2000) comments that though the classic concept of ethnography came from many sources it was Bronislav Malinovsky in particular who enshrined the importance of fieldwork and participant observation in the methodology. The classic tradition assumed there was little problem in the process of reporting back. The researcher provided an authoritative description of the world of the savages or natives.

However a series of events occurring in the climate of the rise of post modernism and deconstructionism has left ethnographic research divided and very conscious of the issue of what an outsider can validly say about another culture. Malinovski’s private diary was published posthumously and revealed the heroic figure of classical ethnography to be racist, imperialist and to have been less involved with the activities of his subjects than might be assumed from his reports. Another icon of classical ethnographic research, Margaret Mead had her field studies revisited after her death by Derek Freeman and in Freeman's analysis it appeared that Mead had colluded in a fable that conveniently coincided with her personal views, Freeman (1983). The debates that followed were acrimonious, there is still debate and there are still concerns about rehabilitating Mead, see Cote (2000). The confidence of the field of ethnography in its ability to achieve objective results was further shaken as anthropologically trained students from other cultures started doing ethnographic research within their own cultures and thereby drawing attention to the shortcomings of ethnography done by outsiders. As reported by Tedlock (2000) this left a discipline that had major disagreements within itself as to how much validity could exist in ethnography's attempts to find out the objective reality of other cultures and how inevitable was the biasing of reported findings by the view of the observer.

While academic ethnography has suffered, applied ethnography has expanded. Ethnography has contributed a thoughtful basis for observing other people and combining observation and elicitation of spoken information, behavioral observation and examination of artifacts and their use. As Sanders (2002) points out, this is well suited for gaining useful understanding of actual and potential users of products and so can be of vital assistance to product development. Saunders provides a good summary of issues to consider in the use of ethnographic techniques in product development.

There are common aspects between traditional and applied ethnography.

- There is a strong emphasis on fieldwork, placing the researcher in the natural environment of the people being studied.
- The approaches taken are open to change and refinement throughout the process as new learning shapes future observations.
- Study combines a range of research methods, including observation and open-ended forms of inquiry.
- Work is more likely to be exploratory rather than evaluative.
- Ethnography stresses discovering the local point of view and culture.

Applied ethnography will also engage in observing representatives of the target population working with existing versions of products or simulating work with proposed prototypes. The difference from the usability studies found within HCI is the placing of the observations within the user's natural environment rather than within a usability lab. Applied ethnography, while still time consuming, is much shorter in duration that traditional ethnographic fieldwork. Sanders suggests that while applied ethnography is more expensive than techniques such as focus groups, it can achieve a deeper level of insight about customers' emerging and unmet needs than other techniques. In part Sanders argues that this is because the use of observation in a natural setting allows the researcher to discover what people actually do rather than what they are able to put into words.

What is absent from typical applied ethnography is the gap between the culture of the researcher and the culture of the studied group. Here, I suggest, is where if we are to apply ethnographic methods to the study of design for older people, we need to go back to the concern of traditional ethnography with understanding a culture different from that of the researcher's.

But if we return to the traditional role of ethnography in reporting on and attempting to understand a different culture, do we bring in the question of the impossibility of obtaining an objective statement of the reality of a distinct culture? Remember that this is the issue that has mired and divided modern ethnography. My stance on this is twofold. Acknowledging the difficulty of reporting or understanding another person's reality is a very useful caution for people researching aging. However in working with older people on product design we are able to focus more on observable behavior and we need a relatively limited understanding of the totality of existence as an older person. Thus we can benefit from being sensitive to older people as significantly different from ourselves, we can benefit from the research methods aimed at partly bridging those differences and our aims are sufficiently limited to mean that they are achievable despite the gap between the experiential world of the younger researcher/designer and the experience of older people.

A further thread can be gained from the internal debates over the validity of ethnography. One of the shifts in ethnographic concern is from the observation of the informants (where the basis of their experience is partly unknowable) to self observation and reporting of the experiences of the participant observer, Tedlock (2000). In sharp contradiction of the objective stance associated with scientific reports, this viewpoint holds that there is value in reporting the responses of the researcher to the new culture that they experience since this experience is in fact something that the researcher can validly share with readers from the same culture as the researcher. While I do not propose making my thesis purely an ongoing reflection on my own experiences with older people, I argue that making some aspects of my responses available to the reader provides useful information for those readers who will in turn work with older users.

7.4.4 Action research

Action research provides a methodology where the researcher is actively involved in intervening in the problems faced by the people being researched. As discussed in Greenwood and Levin (2000) and Semmis and McTaggart (2000) there is much disagreement about the correct approach and many variations on the suggested format. There can be an element of activism in that the researcher is seen as taking part in a political conflict between competing interests. On the other hand there are studies that are reported as action research that investigate ways of resolving organizational problems, Baskerville(1999).

The position underpinning action research is that complex social processes cannot be understood by reductionist techniques and that further, the personal interpretive position that the researcher inevitably brings to the study is to be understood as a part of the researcher’s process in extracting meaning from their attempts to understand the system. As such the researcher becomes one of the subjects. This is strongly aligned with the postmodern rejection of objective meaning. As its name suggests action research is based on introducing an intervention to a social system and then observing and recording the unfolding results. “The fundamental contention of the action researcher is that complex social processes can be studied best by introducing changes into these processes and observing the effects of these changes”, Baskerville (1999). Action research designs involve a team that includes researchers and subjects as co-participants in the enquiry and change process.

Note that Baskerville suggests that “Action research is primarily applicable for the understanding of change processes in social systems.” This seems to suggest that action research is aimed at a somewhat different target than this thesis. Designing easier to use interfaces for older people may impact on the social systems surrounding those older people. Again some of the design factors may come from the study of the social systems that form the context within which older people use software. However the prime focus in this thesis is on understanding guidelines for software design for older users, not on deep understanding of the effects of such designs on the social worlds that contain older people. Again while an argument can be made for the inevitability of subjectivity in attempts to understand social systems, I see little benefit from wholesale generalizations about the socially constructed nature of knowledge and the impossibility of objective knowledge. For the purposes of this research statements such as “some older people have difficulty in double clicking and the usability of design for older people can be improved by providing alternatives to double clicking” are regarded as adequately objective statements if justified by observation and research.

Shorn of its post modernist rhetoric, action research appears to offer a common sense but not radical approach to examining a problem in a social setting. Susman and Evered (1978) describe the key steps as being;

- diagnosing the nature of the issue
- action planning, deciding on the nature of the intervention
- action taking
- evaluating the results of action
- specifying the learning that has resulted

Baskerville (1999) in his review cites these steps as still being current practice. This is a common sense description of the process followed in the research for the thesis and indeed in many other studies. The distinguishing feature of action research is the partly ideological and partly pragmatic demand that all of these steps contain involvement from all participants.

It should be noted that action research is not well established as a methodology outside the social sciences. Action research tends to involve the researcher in advocacy for the rights of the client group. A research stance based on advocacy for rights (of older and disadvantaged users) is already established in the Universal Usability movement in HCI, Schneiderman (2000) but it does not specify a specific methodology. Action research provides a way in which the researcher can justify wide ranging involvement with the group being studied. Action research also accepts that one of the ways in which research can proceed is to attempt to make a beneficial change to the conditions of the group being studied and for all involved to reflect on the results. In the field of Action research there are considerable issues over the shape of the intervention. In more recent work the stance is that the disadvantaged group must shape this for the research to be valid, see Semmis and McTaggart (2000). My assumption is that the older group is not able to be proactive in designing suitable interfaces but can be responsive to the suitability of different interface details within those interfaces and can take a major role in defining the main tasks that they want to achieve with such interfaces.

7.5 The derivation of the selected methodology

None of the candidate methodologies offered a full fit to the aims of the research. However each of the candidate techniques did have some features that offered a partial fit to the research aims. I therefore decided to use a selection of perspectives from each of the candidate methodologies; quasi experimental research, repeated case studies, an ethnographic stance, participant observation and action research.

7.5.1 Use of quasi experimental methods

Although an experimental approach appeared to be inappropriate for the reasons discussed above, I still wanted to provide the reader with a degree of proof that the design principles did lead to the construction of applications that were more suited to older users that standard applications. To this end the three studies following the dual task pilot study all chose participants who had difficulty in benefiting from the standard training approach or from standard software and then demonstrated that these participants had a much higher level of success when using email or training software that used an interface constructed according to the design principles. This quasi experimental approach was followed indirectly in the first WinTutor study. It was observed that standard training methods caused considerable difficulty for a group of older people. It was observed that a very simple interactive tutorial loosely following the interface design issues identified in the literature survey reduced the older beginners difficulties. When an extensive beginners interactive tutorial was constructed with careful attention to the design principles for older users the tutorial was widely praised and adopted by SeniorNet tutors and still continues to be used in SeniorNet training.

With the FileTutor study and the SeniorMail study the quasi experimental approach was implemented directly. The older volunteers who tested the products were specifically selected from people who had tried and failed to learn about file management using available forms of training (FileTutor study) and from people who had failed to learn how to use Microsoft Outlook Express (SeniorMail study). After training in the use of FileTutor or SeniorMail the volunteers were asked to carry out a series of test actions that were representative of the tasks that would be undertaken by typical users doing simple file management or emailing. The success observed was taken as an indication that the design principles led to software that was more suited to older users than standard software.

The lower power of a quasi experimental approach meant that there was a case for repeated studies to establish the usefulness of the design principles more fully. This led to the construction and testing of three different systems covering two different application areas (interactive tutorials and email).

7.5.2 Themes from Case studies

One of the aspects of case study research that fits well with the current research is the concern with utilizing a wide variety of available sources of information, hence the use of interviews, focus groups, observation and the study of the interactions of older people with artifacts – their computers and installed software. Another of the themes that is often taken up in organizational case studies is the roles of different groups in an unfolding event. In order to understand what is occurring the event is examined from the perspectives of the different groups involved.

This was picked up in the research for the thesis in terms of including discussion with people from groups that were related to, but distinct from, the older people using software. Thus the studies included conversations with those teaching older beginners, both teachers without specific experience in teaching older beginners (those at Unitec) and teachers who had specialized in teaching older students (the SeniorNet tutors). The studies also included focus groups held with people who were supporting older relatives to gain the perspective of another significant group involved in older people's computing experience.

Case studies also allow the researcher to provide an interpretation of what was seen usually in terms of whether the case being examined conforms to a particular theoretical background, Yin (1994). Thus the picture of aging derived from the literature review provides the theoretical background used in interpreting and explaining the actions of the older users. As with the arguments for using a quasi experimental approach, case study research implies that the contribution to theoretical knowledge is strengthened if repeated cases are observed over different situations. As discussed above the cases in the research for this thesis combine aspects of the intrinsic case and the instrumental case, the topics studied are of interest in their own right but in each case they are to be seen as cases of design for older users.

7.5.3 Themes from Ethnography

I regard it as useful to take from ethnography a concern with older people as members of a different culture set apart by the experience of aging, by shared experience with other older people, by appearance, by reduced abilities and by separation from mainstream working culture. From ethnography the study takes a concern with observing and letting the members of the culture talk about what is important to them. A key concern here is that the older people are seen as other, they are distinct from researchers and from potential interface designers who may want to use the design principles. People who do not belong to the culture cannot fully understand what it is to be a member of the culture and the knowledge transmitted to non-members is always approximate because the non-members lack the crucial experiences of aging.

Also from ethnography the study draws the need to consider the potential for older people to defer to the researcher and tell the researcher what they believe the researcher wants to hear. There is a need when working with groups of older people to grant shared authority to the older people in the group and to increase the relative status of the older informants in relation to the researcher. To this end some of the usability studies were done with groups of older people for FileTutor and for SeniorMail. It was found that a group of older people was more likely to challenge bad design than a single older person working one-to-one with the researcher. Another aspect of giving more authority to the older people contributing to development was to work repeatedly with the same groups of older people including the in-house older testers. Familiarity with the researcher led to expectations that critical comments and drawing attention to difficulties would be well received and acted on. Continued exposure to alternative prototype fragments (some of which were unsuited to older users) means that the older people become used to expressing their own preferences and to being valued for their insights.

An ethnographic stance stresses the need for the observer to go “out into the field” so that the people being studied are observed in their own territory. Hence in the overall study opportunities were taken to visit older people in their homes and observe their computing environment and observe how they worked within this environment. Older people were also observed in SeniorNet classes where they were learning in an environment specifically designed for teaching older learners. Again the use of an ethnographic stance argues for the value of observing older people in context where the observer does not shape the situation or influence it, where in fact the observer tries to avoid influencing the situation and takes on the role of an unobtrusive observer. This was true of the early observations of teaching older people at Unitec and offered useful information that was essential background for the later stance of action researcher where interventions were designed to improve the teaching situation. Finally an ethnographic stance requires that the investigator adopts forms of behavior that are seen as appropriate by the cultural group being studied. It became clear from listening to the stories of older people recounting their experiences with younger people trying to explain computing terms and skills to them that younger people simply lacked a concept of appropriate communication with older people. The question of what does constitute appropriate behavior will be expanded in Chapter 8.

From the more modern developments of ethnography comes the perspective that the responses of the researcher are a valid subject for reporting and analysis. It is argued that the researcher’s responses are an important part of understanding the process that occurred and are useful to those intending to make use of the research in understanding their own potential role in interactions with the culturally distinct group. It is from this viewpoint that I maintain limited reporting of my personal involvement throughout this research. This concern with the reporting and understanding of the researcher’s involvement is also shared with action research.

7.5.4 Themes from Action research

Ethnographic research emphasizes minimizing the influence of the researcher on the reporting (by participants) of their culture. However in studying software design for older users the intention was to first find out about the existing culture and then to alter a part of that culture by providing (hopefully) better software. Action research provides a framework for such interventionist research. The perspective emphasized is observation of an intervention in situations that are a natural part of the settings of the participants in the intervention. This study does not take the action research perspective that the researcher is engaged in challenging the aims of a vested interest group. However from action research the study did take the perspective that it is legitimate within a research activity to try to advance the aims of a disadvantaged group. One of the features of action research is that the presumed benefits of the action being undertaken with and for the disadvantaged group gives the justification for the time the people being studied make available to the researcher. This means that there was a concern with making the products of the research available to the older people who contributed to developing them. With one significant exception (the final testing of SeniorMail with the CAB group) this was done in this research.

Another concern of action research is the extent to which the action being undertaken is shaped by the researcher or shaped by the disadvantaged group. Some authors, see Semmis and McTaggart (2000), suggest that the researcher should have virtually no part in shaping the action in order to avoid paternalism and a patronizing approach to the people being studied. I took a pragmatic approach. In my experience older people had little skill in suggesting overall interface designs. They had expertise in their wishes for the tasks that they wanted to achieve. They also had little difficulty in pointing out features that did not suit them, provided they could critique the possible interfaces from within a group of peers. They could at times suggest individual features. This led to a situation where my discussions with the older people and their supporters created the proposal for the initial content. The initial approach to implementing interfaces to contain this content could then be decided by the researcher on the basis of the researcher's greater technical knowledge. These implementations could then be refined and reshaped by the researcher working with the in-house older testers and the older usability groups.

7.5.5 A note on participant observation

Participant observation is derived from ethnographic approaches and has further extensive use in the action research approach. Participant observation emphasizes the researcher taking part in the activities of the studied group as a participant rather than as simply a detached observer. Jorgensen (1989) in his classic introduction to the subject suggests that participant observation is particularly appropriate in cases where little is known about the phenomenon, were there are important differences between the views of insiders as opposed to the views of outsiders and where the phenomenon is in some way obscured from the observation of those not in the group. The beneficial effects of this form of research have also been covered under the previous sections on ethnographic fieldwork and action research. However there is a problem in applying participant observation to older people in a way that is distinct from the issues around participating in activities of other cultures. If one takes part in an initiation, digs crops or takes part in a hunt one has a shared stance with respect to the other participants. One is uninitiated, one is removing weeds, one is harvesting food to be consumed, one is chasing an animal. This common stance is seen as part of what makes it possible for the researcher to gain extra understanding of the group being studied through participant observation. I would suggest that direct participant observation with older people is frustrated by lack of such a common stance. When sharing the experience of learning or trying out new software with older people, the researcher is not, at any time; a novice, afflicted by age restrictions or subject to stereotyped expectations about limits to his or her own performance. Thus while I see fieldwork as being a useful part of design with older people and I obviously support being present while older people work with software I would argue for caution in calling the researcher's experience in such settings "participant observation".

7.6 Detailed description of the research methodology

The target of the methodology is to allow the construction, evaluation and support of a set of principles for interface design for older users. As such it relies on repeated studies of software development for older users that apply the available principles, allow refinement and extension of those principles and, in so far as the applications developed are successful, offer support for the use of the principles. Because of the very recent emergence of interface design for older adults as a research concern, my initial literature search was dominated by the more general literature on physical and cognitive aging. Hence the initial set of design principles arose from a study of the available research literature on aging, looking for the implications of the effects of aging on the interface design needs of older people.

If one were starting such a study as this currently, (in 2005) there would be a temptation to focus on the recent literature on interface design for older people. With hindsight I believe this narrowing of focus would be a mistake. My experience is that bringing an awareness of the implications of aging to a study of older people's interactions with interfaces gives considerable assistance in interpreting what is observed.

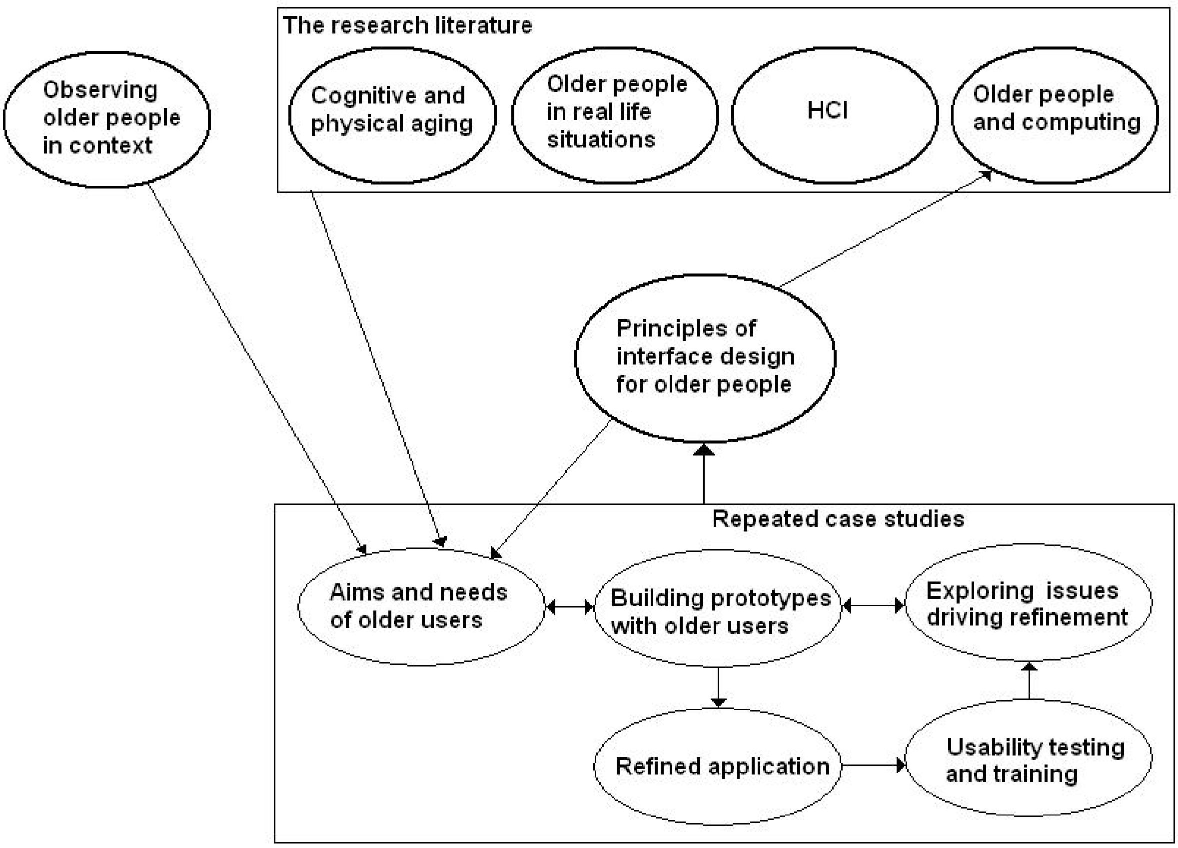

Figure 7.1. A diagram of the research methodology

The basic methodology can be depicted as in the diagram in Figure 7.1. The top level of the diagram indicates sources on which the study is based, a) observation of older people and their supporters in natural situations relevant to their computer use and b) the relevant literature within which the overall research is grounded. The middle level indicates the aim of the overall research, establishing a set of useful principles for creating user interface designs for older people. The bottom rectangle sets out an idealized format for the individual studies conducted as part of the overall study. The components of this methodology and their interconnections will now be discussed in more detail.

7.6.1 The role of observation of older people in context

Here the issue is to ground the research in a knowledge of the older participant's lives, at least as related to actual and potential computer use. As noted above, when investigating a new area the research design should be such that information gathering is not narrowly focused so as to increase the chance of serendipitous discoveries. Simply put, because of the gulf between the experiences of older people and generally younger researchers there needs to be a conscious effort on the researcher's part to broaden their experience of what it is like to be an older person. To this end the overall research involved wide ranging focus groups, not just with older people but also with their supporters. It involved home visits and discussions with older users of their current computing practice. It involved discussions with older people who did not wish to be involved with computers. It involved teaching older people computing skills and observing other people attempting to teach older users in various environments with varying levels of success. It involved casual discussions with chance-met older people about how they did or did not use computers. It also involved examining the performance and acceptance of younger people using the software I had developed for the older users to highlight areas where older users shared characteristics with younger users and where they showed significant differences. Although results from this work are discussed in the thesis the main aim of this aspect of the methodology is an informal and opportunistic effort to change the background understanding that a researcher brings to people much older than the researcher. The aim is to deliberately broaden the researcher's or designer's personal experience and understanding of the reality of aging.

This body of understanding based on interaction with older people contributes to the set of aims and needs of older users that need to be embodied in a particular design. In fact there is overlap between the information gained in the ellipse in the diagram labeled “Observing older people in context” and the information gained in the individual studies in the ellipse labeled “Exploring issues driving refinement” since the individual studies offered a wide variety of chances to learn from the older participants.

It can be seen that the interaction between researcher and older users is a vital part of this methodology. Simply put this methodology is ineffective unless it is used in the context of interaction with older people. However experience suggests that there are a number of issues that make working with older people a discipline that requires its own set of skills. It is not sufficient to simply work with older people, what is needed is an awareness of their needs and concerns that lets the older people involved give free expression of their needs and responses to the researcher. At the same time awareness of the vulnerabilities of older people can assist the researcher or developer in avoiding harm or discomfort to the older people who volunteer to take part. Thus Chapter 8 of the thesis will set out some practical approaches to working with older participants that have been found to be appropriate in the course of the research.

7.6.2 The role of the research literature

There are four groupings in the relevant literature within which the study is grounded. The literature on cognitive and physical aging has a key role. It is here that the overall study obtained its initial selection of the changes due to aging that were considered to be candidates for affecting the interaction of older people with user interfaces. It is here that the study can be grounded in relevant findings on vision, manipulative ability, attention, memory, learning and intelligence. It is this part of the literature that I drew on to obtain the initial set of implications of the changes due to aging for user interface design for older people, Hawthorn (1998a, 1998b and 2000). These initial implications have then been developed in the course of my research into the principles for designing for older users that emerge from the overall study. The literature on cognitive and physical aging has a further important role in that it provides a way of relating work on the interface needs of the current generation of older users to the needs of later generations who will enter old age with increased computer knowledge but still exposed to the cognitive and physical changes that age brings.

The published research on older people in real life situations, shown as part of the relevant literature in the figure, covers a small but wide ranging literature of applied research on aging as it applies to older people's lives. As there was initially very little published on interface design for older users it seemed useful to seek for any work on older people that had an applied focus. The argument was that such work would have made the same transition that this study was seeking to make, taking findings from theoretical research on physical and cognitive aging and using these findings to underpin applied research on older people. Hence the literature review includes work on a widely varied set of issues ranging from older people's reading of information on medicine containers to driving by older people and the changes that age appears to make for older pilots.

The third grouping in the relevant literature covers the traditions of user interface design that this study draws on, taken from the literature on people centered design, task centered design and participant design. This wide-ranging literature is not specifically covered in the literature review but it is assumed as part of the background in which the overall study is founded.

The section on older people and computing, (the fourth and final grouping in the relevant literature) was initially of limited relevance to my work on user interface design for older people. At the time the overall study began, the published research in this area had some studies on whether older people could use computers, some conflicting studies on recommended ways of training older people on computer tasks and papers that asked if older people could benefit from computer use. It had almost nothing of substance on user interface design for older users, see Czaja (1998), Hawthorn (1998a) and Czaja and Lee (2003) for backing for this contention. However over the later course of the thesis there has been a marked increase in the number of papers that address interface design for older people, both looking at specific topics (such as the order of selecting a feature and selecting an action to apply to that feature) and looking at general recommendations for interfaces for older users. As the research available in this area has grown so has the amount that it contributes to the emerging principles for designing for older users. As an aside these recent recommendations for interfaces for older users are largely in the area of web design. One of the distinguishing aspects of the current thesis is that it is one of few pieces of work looking at user interface design for applications to be used by older people.

7.6.3 An outline of the structure underlying the case studies

There is a common structure to these studies, more fully realized in some than in others. It is this common structure that is the concern of this and the following section. This section will simply outline the steps that underlie the structure of the individual studies as a set of numbered bullet points so as to allow the reader an overview of the approach. The subsequent section will then provide an expanded discussion of the concerns that underlie each point and the experience that supports them.

1. Find a development area where older people indicate that there is relevance and a genuine need.

2. Explore this development area, working with older people and their supporters to outline the requirements and context within which the system will be used and the need(s) met.

3. Examine the requirements and needs from step 2. in relation to the nature of aging as expressed by the literature, in relation to previous work on design for older users and in relation to previous observation of, and discussion with, older users.

4. Work with older people to develop a system that is designed using the interface design approach for older users. The interface design approach used here is described in detail in Chapter 8.

5. Recruit older participants who have not been able to adequately satisfy their needs in the chosen area by using mainstream software.

6. Conduct an evaluation of the performance of these participants on the system and of their satisfaction with the system.

7. Put the refined version into long term use with suitable users and obtain on-going feedback. Make further refinements and get the long term users to report on them.

8. Evaluate the observations from the study and report on what has been learnt about suitable interface design for older users.

9. Repeat the cycle within a different area of relevance to older users so as to check on and extend what has been suggested.

7.6.4 The rationale for the structure underlying the individual case studies

In this section (providing extended discussion of the steps that form the methodology underlying the research), the aim is to provide an indication of why the step was included in the methodology, a discussion of its rationale and implications and in addition, examples or extra description indicating how the step is actually applied.

1. *Find a development area where older people indicate that there is relevance and a genuine need.*

The overall aim of the research was to investigate suitable interface design for older users, but this implies that the older users involved in the research should be working at a level that gives a reasonable representation of the amount of effort and commitment that older users would be willing to apply in everyday use. The problems with user motivation in the comprehension experiments in the Dual Task pilot study showed that if older users did not see the tasks they were involved in as realistic or relevant to their needs their motivation suffered to an extent that made it hard to see their performance as representative of their real life abilities. Subsequent work with older users in the FileTutor and the SeniorMail studies supported the argument that, given an application that was felt to be credibly related to what the older participants wanted to achieve, the levels of motivation and the extent of persisting through initial difficulties increased greatly. It is argued that this more involved and motivated response is also more representative of realistic behavior by older users. Hence when researching older users' interaction with computer systems the example systems chosen or created should engage the older users. One route to obtaining such engagement is by developing example systems that are seen as relevant to the older users, by the older users. The way in which topics were found in the overall research was

a. By observing older users and seeing what they struggled with,
b. By talking with older users and their supporters about their use pattern, difficulties and wishes
c. By consulting with people who had a professional role supporting older users, in this case the SeniorNet tutors.

2. *Explore this development area, working with older people and their supporters to outline the requirements and context within which the system will be used and the need(s) met.*

Because the world of older people is very different from that of the researcher or designer there is a need to explore the nature of the area and the desired tasks and achievements that it contains from the perspective of the potential older users. This exploration was carried out personally by the researcher, it was not delegated to research assistants. One of the aims of the methodology is to give the researcher/developer direct engagement with older users.

It was also seen as important that this exploration was of a form that allowed, adapting Eisma et al's (2003) phrase, "answers to questions I did not know I should ask". Questionnaires were administered face to face with discussion about possible interpretation or answers that while true for a person did not fit the mandated format for filling out the response. Older people were observed working in the chosen area with mainstream solutions and their difficulties were noted. Focus groups were held not only with older users but also with their supporters. What was seen was not always what might have been expected. For example older users frequently carry out computing tasks with ongoing support from family and sometimes friends and this support can place considerable stress on the relationships involved, support was found to overload the older people's children at times and to be yet another theatre in which the guilts and demands of family relationships played out. It was much rarer that the idealized and romantic view of computer support as a route to expressing closeness and shared moments was found in focus group discussion, though this was often the children's initial intention in involving their parents with computing. Hence, as an example of emerging answers to important but unrecognized questions, one of the opportunities in successful design for older people may in fact be the reduction of the load that the older person's computing puts on supporters, with a consequent reduction in strain in the older person's relationships with family and / or friends.

3. *Examine the requirements and needs from step 2. in relation to the nature of aging as expressed by the literature, in relation to previous work on design for older users and in relation to previous observation of, and discussion with, older users.*

The design recommendations do not appear of themselves. As the designer considers possible solutions there is a major role for the knowledge of older people embodied in the literature and / or the ongoing observations of the older people who took part in the research. One way of viewing the literature on physical and cognitive aging is that each finding on the effects of aging represents a departure from the assumptions that a designer could reasonably make about what would work for younger users, hence the importance of checking ideas for interface design against the literature on physical and cognitive aging. But this background against which the interface design is prepared also includes building a personal skill set for the designer based on their ongoing interactions with, and observations of, older people in the context of the designer’s knowledge of aging.

The observations of the older participants during the background investigation and during usability trials should support the desirability of the individual recommendations, if I recommend that menus are not ideal for older users then this will be because I have observed cases where older users had problems with menus, typically in the background investigation that began the study. By itself such observations provide only a weak level of support for the recommendation, hence it is useful if the observations can in turn be supported by examining possible explanations for them in the light of findings from the literature on physical and cognitive aging.

Note that the older population is seen as being very diverse. It is not the case that each recommendation should suit all older users. In our ongoing example a number of older users may use menus with success. Instead what each recommendation should contribute is an increase in usability for some of the older population without significantly disadvantaging other older people. So can we design an alternative to menus that assists those older users who find them difficult while remaining satisfactory for older users who can use menus? Such trade-offs, I suggest, form an important part of designing for the mixed disability group that constitutes older users. For another example, recommendations on font size for the older group whose vision declines with age are potentially irrelevant or disadvantaging for those older people who retain acute vision in old age. In part what is needed in the recommendations is to establish workable trade-offs that mean a design for older users can be of use to a population with a wide mix of age-related disabilities. Providing the knowledge to decide what is "workable" in such trade-offs is again the role of the accumulated body of knowledge about older people's abilities as well as experiment and trial and error estimation.

The next four points (4, 5, 6, 7) deal with the way in which the research approach depended on observing the design process. Since the process of designing for older people is covered in Chapter 8, expanded information on these points is provided in that chapter.

4. *Work with older people to develop a system that is designed using the interface design approach for older users. The design* approach *used here is described in detail in Chapter 8.*

This step is in fact a series of steps that constitute an interface design approach for working with older users to produce interface designs aimed at the needs of older users. This interface design approach is described in detail in Chapter 8 and is one of the key components of the design guidelines that have emerged from the overall study. From the point of view of this chapter on research methodology the key point is that shaping the initial credible prototype involves considerable work with groups of older users in ways that are informal and promote discussion of problems involved. Such discussions provide considerable illumination of the issues that older people can face in using software.

5. *Recruit older participants who have not been able to adequately satisfy their needs in the chosen area by using mainstream software. Further detail is provided in Chapter 8.*

This reflects the concern with providing a quasi experimental approach in my studies. These people provide a good test case for showing that the design does provide the intended advantages. They are also people with a level of personal involvement in a useful design and so are well motivated to interact with the development process in a way that leads to a workable design. These were the people who found they needed SeniorNet assistance simply to get started with computers (and hence were good candidates for testing WinTutor), the people who had failed to learn how to manage files and folders (and hence were good candidates for testing FileTutor) and the people who had been unable to satisfactorily use standard email systems (and hence were good candidates for testing SeniorMail).

6. *Conduct an evaluation of the performance of these participants on the system and of their satisfaction with the system. Further detail is provided in Chapter 8.*

One of the key aspects of the way in which I worked was that the older users were supported by other older users as they did the usability tests or explored the design alternatives. The testing format allowed groups of people to “co-test” a prototype and discuss it as they did so. Groups of people who had attended different testing sessions were merged in later focus groups and commented on their experiences.

Some readers with a strong commitment to an experimental approach may be repelled by the fact that this means that the design principles include input that is distinctly impressionistic. My counter argument is that carefully collected impressions are not automatically an invalid basis for starting investigation of a new area and by making my design principles and research findings explicit I am making them available for later challenge and re-evaluation.

7. *Put the refined version into long term use with suitable users and obtain on-going feedback. Make further refinements and get the long term users to report on them. Further detail is provided in Chapter 8.*

As pointed out by Salthouse (1996) one of the significant limitations of laboratory investigation of older people is that the rates at which behaviors change will occur outside the timescale that is available to a laboratory study. There was also a concern that enthusiasm for a prototype during usability testing might not correspond with behavior during long term use in situations where the researcher was not present. Again it was felt that long term use gave a wider range of situations in which difficulties could manifest themselves and so by providing ways of capturing such difficulties one could both make a design more robust and obtain a wider set of relevant information for the overall research on older users.

Hence as part of the research informal long term follow up studies were included. The two interactive tutorial systems that were intended for relatively brief use by older users as they learnt computing skills were never the less capable of being placed in a situation of long term use and evaluation by making them available to New Zealand SeniorNet branches and obtaining feedback as tutors gained more experience of using the tutorials and tracking sales to confirm that branches continued to find the products useful, instead of having had a first flush of enthusiasm that died on further acquaintance with the tutorials. Similarly for SeniorMail which is a product intended for long term use, although the usability testing was short term and did not really address long term suitability, a small pool of long term users was established to check if they would continue to find the product desirable. They did.

8. *Evaluate the observations from the study and report on what has been learnt about suitable interface design for older users.*

Another departure from the typical model of user centered or task centered development is that there were at least two outputs, not simply the refined product but also a contribution to understanding of the interface issues that arose for the older users. It should be noted here that two of the projects, WinTutor and FileTutor also contributed useful understanding of the context in which current older users operate, within recently and partially acquired computer knowledge. This involves looking at the areas of understanding they may have trouble with (WinTutor) and at the way in which on-line instruction can be designed so as to be useful to older learners (WinTutor and FileTutor). The point here is that, in making provisional recommendations for a new area of understanding, there is a shortage of situations in which researchers can interact with older users and challenge, reshape and extend the knowledge gained so far. Each attempt at developing with and for older users, whether successful or unsuccessful, offers a chance to add to the observational base and to analyze the existing understanding in terms of the new results.

9. *Repeat the cycle within a different area of relevance to older users so as to check on and extend what has been suggested.*

Repeated demonstrations of success with different exemplars of the design approach are needed in order to provide an acceptable level of support for the findings. Given the quasi experimental and observational approach used, a single study provides a limited level of support for the findings. Hence the current thesis consists of several studies that examine older users' performance with designs that were developed using the design approach. It is argued that, by this means, the thesis provides an acceptable level of support for the recommendations that emerge by repeatedly showing examples of interface design that follow the for older users and provide a way for older users to perform tasks that they could not achieve using other applications or approaches.

7.7 Conclusion

In this chapter the rational for the research methodology developed in this thesis has been described. The aims of the overall study were first revisited. Then the lack of fit of an experimental approach with the overall aims was discussed. This was followed by a critical look at other established techniques and what they could offer to a research approach given the aims of the study. A composite technique that borrowed from these techniques was then set out. This will now be followed in Chapter 8 by a discussion of the design approach that was developed to work appropriately with older people during such development. Further reflection on the combination of the research methodology and the design approach occurs in Chapter 9 where my approaches are compared and contrasted with the independently developed approaches of the UTOPIA project.

Chapter 8 Designing and working with older people

8.1 Introduction

One might question why a thesis devoted to HCI recommendations for developing suitable interface designs for older users should devote a chapter to appropriate ways of working with older people. The first reason is that the design recommendations include a strong recommendation that the interface design is developed from a basis of frequent interaction with older people as to the suitability of the interface details. This in turn is based on the experience gained in the difference between my expectations of what should suit older users and the reality. Even though I have deliberately acquired a level of knowledge of the effects of aging that would be unusual in most interface designers I still found that I would not have achieved workable designs for older people without the on-going guidance of my older testers.

Having reached a position where I am recommending that continuing interaction with older people is essential for good design for older people I then turn to my observations of interaction between older people and younger relatives, supporters and teachers and include reflections on my own interactions with older people throughout the research. From my experience it is easy to create difficulties in interacting with older people that impede efforts to assist them, threaten an on-going relationship with those people, reduce the accuracy of the information obtained and may in fact influence some older people to make decisions about their potential competence with respect to computing that are not in their best interests. There is another side to this. In those interactions with older people where I have avoided the various pitfalls, I have found working with the older people who took part in this study to be a thoroughly enjoyable activity. I suggest that interaction with older people that is free flowing and enjoyable on both sides gives a greater chance of improved design quality.

This chapter will look at a summary of the approach used in designing for older people and then move to the difficulties that can occur in working with older people. The chapter will then look at three aspects of techniques for reducing these difficulties. The three areas of technique covered are; appropriate communication with older people, techniques for developing applications with older people and finally considerations on how to work ethically with older people. In fact these divisions are somewhat artificial and in actually working with older people the techniques used draw from all these areas.

8.2 An approach to creating interface designs for older people

The thesis gives wide ranging consideration of issues to be considered when designing for older people. As previously noted the design approach can be considered as an adaptation to User Centered Design or Task Centered Design rather than a radically new approach. What is attempted here is to summarize the recommendations for doing interface design for older people as a bullet pointed list. However one of the contentions of the thesis is that there is no narrow or simply expressible solution to designing for older people, hence a list such as this is regarded as a lead in to a wider set of concerns.

1. Before designing for older people, designers need to sensitize themselves to the realities of older computer users. This involves study of the literature on aging as related to design, including study of the rationale behind successful examples of design for older users. Each of the effects of aging that are relevant to interface design examined in the literature review can be seen not only as a need of some older users but also as a gap in the in-built assumptions of (younger) designers that they are designing for someone who is generally similar to themselves. As it stands the literature review has identified over one hundred and fifty such departures from similarity between the younger designer and older users. This is before differences (from the younger designer) in older people’s specific computing or operating system knowledge are considered.
2. The process of designers sensitizing themselves to the realities of older computer users also includes sensitive observation of, and involvement with, older people. This is not part of a typical design process for a young to middle aged target group. It is suggested that even skilled designers for a young to middle aged target group need to acquire extra skills and understanding in order to undertake effective design for older people and it is suggested that designers without experience of older users may find difficulty in appreciating how important this “enculturation” stage is.
3. Requirements definition obviously needs exploration of older people’s needs and aims related to the proposed application but this exploration needs to be done

within the social and physical context in which older people will use the application. This includes working with older people's supporters, visiting older peoples' dwellings and discussions with experts in aspects of aging. However the core is in finding ways of communicating with older people themselves about what they need and can do. This moves requirements gathering for older peopele to the area of applied ethnography as described by Sanders (2000).

4. Unlike most product development the focus of requirements definition for older people is not on adding new features to standard applications but on pruning features not needed by older people and in designing the remaining needed features so as to be usable for a variety of age restricted users.
5. Where the application is a version of a standard computing application that is being designed to be suitable for older users, observation of older people attempting to work with standard applications in the application area is used to identify core areas of difficulty that these applications pose for older people. It is possible however that some applications for older users may be novel, such as games for memory training or increasing dexterity.
6. The design team needs to recruit older people who can act on a near daily basis as in-house testers. It may also be useful to recruit a further pool of older people who can be involved in additional testing during development on a less frequent basis so that there is a check on "capture" of the in-house testers by the design team.
7. The design team needs to construct hi-fidelity code based initial credible prototypes that can be seen to address the general concerns of older users and the core areas of difficulty in the application area being designed for. Unfortunately it is possible that the initial attempts at a credible prototype may be sufficiently far from what would be usable that they could discourage the in-house testers. It may be that there should be an initial period of investigation of what constitutes an initial credible design with a group of less involved older people before the in-house testers are asked to take up long term involvement with the project.
8. The initial credible prototype is then refined and extended by working with the in-house testers in order to increase the ease with which the older people involved with the development can meet the aims identified in the requirements definition.

9. The exploration of older people, started in the early stages of the project, continues over the life of the project. Firstly because of the difficulty of adequate communication between the culture of the younger highly technical designer and that of the older users there is no clear point at which the designer can say they understand all the requirements. Secondly because the older population is highly variable and the number of in-house testers is limited, experience with different older people has a high chance of giving fresh insights.
10. As in any standard interface design process the prototype is then tested with people from the target group who were not involved in the design development so as to identify remaining usability issues. These usability issues are noted, fixed and undergo further usability testing. However the process of usability testing may be more informal than it would be with younger users and involve group evaluation and discussion in order to support the needs of working effectively and ethically with older people. Depending on the application, testing may also need to consider learnability and to be conducted over longer time frames than would be the case for a younger target group.

8.3 Problems in working with older people

This section of the chapter may appear to paint a picture of unrelieved gloom about the issue of communication between younger researcher/designer and older people. In fact some errors are inevitable and older people are used to dealing with communication problems from the young. Part of what makes dealing with these issues practical is good will, persistence and effort on the part of the older parties to the interaction. Another part of what the younger person can bring to the interaction is awareness of the issues, good humor, patience and an appreciation of the older people as people who are finding strategies to cope with difficulties that will affect us in turn.

The points that follow cover the main problems that were encountered when working with older people in this research. After that section 8.4 will examine these issues in more detail and discuss the solutions used to overcome them.

- **Differing experience**

  It would be unusual for a younger researcher / designer to share the limits of perception, manipulation, memory and cognition that are part of being old. My experience is that these effects are difficult to design for when one is designing from an impersonal knowledge of aging. Bluntly you as a designer will not adjust your expectations of what older people can and cannot manage to a realistic level until you observe older people working with computers. Working with older people in a way that lets them share their perspective on possible designs becomes a key aspect of producing successful designs for older users.

- **Issues of respect**

  We live in a culture where older people are stereotyped as being generally incompetent in many areas including working with technology. In this situation the younger researcher / designer is in danger of confirming the older person's expectation that they will be treated as less than competent and inferior. Older people are likely to "buy into" a picture of their general incompetence. The older person in turn is likely to collude with the younger researcher / designer in producing unrealistically low levels of performance.

- **Balance of power and deference**

  In communication between a younger researcher / designer and an older person about technical issues the younger researcher / designer has more power. There are negative consequences that can come from this. If the older person responds to the situation by "going along" with the younger researcher / designer, then the younger researcher / designer is largely left with their own view of the older person's world (which in my view is inadequate to support good design). The older person may experience such interaction as unsatisfying and de-motivating. A response to this may be that the older person withdraws, offering less, becoming less motivated and being less likely to be available for further work with the younger researcher / designer.

- **Communication style**

  The way we as younger people speak to older people can lead to failures in communication. Younger people can be observed adopting two styles of speech that do not suit older people. Either they make no allowances for the older person's age and inexperience and talk to them as they would to younger people leading to overloading the older person with jargon and a too rapid flow of new concepts. Alternately younger people can adopt a form of baby talk known as "Elderspeak" which is not simply demeaning but also has been shown to be confusing for the older recipients. The younger researcher / designer walks a thin line between being seen as patronizing and being incomprehensible. Either situation destroys the effective two way communication that is needed to support realistic development for older people.

- **Time issues**

  Tasks, especially unfamiliar tasks can be expected to take longer for older people. If older people are asked to hurry on tasks they are likely to show a drop in performance that is larger than younger people facing a similar request to speed things up. This can lead to problems where the younger researcher / designer is insufficiently aware of these issues and plans such things as testing sessions on a time scale suited for younger people or where the younger researcher / designer is tempted to rush some part of an encounter with older people.

- **Information gathering**

  The standard methods of information gathering have some particular problems when used with older people. Interviews can be badly affected by the issue of power imbalance and may in addition constrain the researcher from venturing outside of a set range of topics. Questionnaires may stumble on the lack of a shared vocabulary for technical matters between younger researchers / designers and older people. Focus groups with older people have been reported to be hard to conduct in a way that stays on topic and avoids frustrating the rest of the group, Barret (2000).

- **Care of older people**

  Older people may have more difficulty in coping with unfamiliar environments with respect to route finding and access issues. Asking older people to drive to a campus and then find their way to a usability lab can add extra stress that potentially may impact performance. Problems anticipated by older would-be volunteers in this regard may affect the self-selection of those who end up volunteering, see the next section.

- **Sampling issues**

  There are two common problems in getting representative older people. In general the people who volunteer for all types of research are usually better educated and of higher status than the population average. This selection bias effect may be increased with older people in that the older people more affected by age may be; less able to get themselves to the research setting, less likely to hear about research requests for volunteers, more likely to see themselves as unworthy or to feel that they would perform poorly. Yet as found in the FileTutor study the less able older volunteers made a disproportionately valuable contribution. The overall effect of this sort of sampling bias is that researchers and designers interested in working on interface requirements for older people are likely to miss the very volunteers who will be most useful.

  The other issue is that the older population is not a single, simple, normally distributed population. Age is a surrogate variable and the effects of aging are loosely associated with actual age and with each other. So the older population is actually many sub-populations ranging on different disabilities and these populations overlap with some older people having no major disabilities, some having only a single significant age related disability and some having more than one such problem. Given that each different disability can have different implications for interface design it will not be easy to sample a range of older people representing all or most of the levels of disability in the older population.

8.4 Appropriate ways of working with older people

A younger designer for older users needs to work with older people during needs analysis, during product development and during product evaluation. A younger researcher may be involved with older people in similar areas or in more general information gathering. This section looks at ways in which working with older people was facilitated in the current study. I have tried a variety of ways of working with the older people who participated in the study, some appeared to be productive and resulted in cheerful participation by the older people, some did not. This section is an attempt to report on how I have worked in a way that allows other people to benefit from my experience. We will look at the following points:

- Working with older people as if they came from a separate culture.
- Issues of establishing a framework where the older people see themselves as respected.
- Questions of the balance of power between researcher and older participants.
- Concerns about communication styles used.
- The problems in building time constraints into work with older people.
- Appropriate techniques of information gathering.
- Care of older participants.
- Approaches to sampling when acquiring groups of older participants.

8.4.1 Differing experience – older people as a separate culture

The first issue in working with older people is that the older person is operating from a basis of a different experience of being a person that the younger one. Younger professionals usually do not have experience of personally coping with a degree of memory loss, learning disabilities, bodily discomfort, reduced ability to direct attention, restricted manipulative skills, poor hearing and poor vision combined with limits to one's cognitive ability when venturing outside familiar situations. Nor are younger professionals yet realistically engaged with having a limited lifespan and a general expectation of decline. Nor are they likely to exist in a situation where reduced respect occurs because of stereotyping.

While gaining experience of older users may be difficult to fit into a development budget it is important in forming realistic expectations. It appears that simply being told of older people's issues does not have sufficient impact. Newell et al (2005) found that telling professional and competent interface designers about the difficulties faced by older people did not adjust the designers' expectations to a realistic view of what older people could cope with. Newell's group arranged for the designers to meet with and observe older people who were representative of the group being designed for and recorded the designers' vocal amazement at the gap between the older people and the users the designers usually worked with, "…they know absolutely nothing..". In fact the behavior that the designers observed corresponded well with the behavior that Newell's group had told the designers to expect, but the designers had discounted the advice in favor of their experiences with younger, more competent users.

One of the problems that younger computer professionals or even friends and relatives may bring to dialog with older people is that the younger people are embedded in a culture where personal respect can be gained (or lost) by their level of understanding of computer terms and techniques. This is a potential barrier to being accepting of older people when they display much lesser skill levels. In the Unitec classes it appeared that, without directly communicating the viewpoint, both students and tutors shared the view that the older users were unsuited for learning computer skills. This blinded those involved to the potential for simple technical interventions to alter and improve the learning situation.

Because the world of older people is very different from that of the researcher or designer there is a need to explore the nature of the area and the desired tasks and achievements that it contains from the perspective of the potential older users. There is a need to go "out into the field" so that older people are observed in a realistic environment. In my own research this exploration was carried out personally by the researcher, it was not delegated to research assistants. One of the aims of the design methodology is to give the researcher/developer direct and personal engagement with older users. Actually visiting older people and seeing (as well as talking about) how they worked with computers in their homes was useful.

My experience is that there is a difference in the way that older people behave among other older people compared with the way that older people behave with younger people. As one of my informants said, discussing memory lapses, “its embarrassing to have younger people know about my memory, my older friends just take it as normal”. One of the approaches I have used extensively is to work with groups of older people. This has, I believe, several effects. The older people can be seen interacting with each other in a way that is more natural. The older people are also in the majority during the interaction and so the younger researcher is more likely to adapt to the temporary majority culture rather than dominate it. There may also be advantages in being somewhat more accepted by older people if one is a late middle aged and graying researcher, I was in my mid to late fifties while this research was undertaken.

As part of gaining a wider background experience of older people there is value in talking with those who are associated with older people, such as relations and supporters, tutors who specialize in training older users and rest home staff. I found there was also considerable benefit in observing people who were not especially sympathetic to older people, in situations where they needed to work with older people, such as the Unitec tutors.

It is not enough to simply ask that interface developers get involved with potential older users. There are a number of pitfalls that skilled computer professionals are likely to fall into when trying to work with older users that can make the experience unproductive. Newell’s group has tried to address this by using academics who are already skilled in working with older users to effectively act as middlemen between older research participants and industrial developers. This is a useful approach but may not be readily available to all developers who want to develop for older users.

8.4.2 Issues of respect

Older people are coping with a significant change from their younger selves. While some cultures such as traditional Chinese or Maori culture regard older people as automatically deserving of respect, current Western culture is less respectful. Older people are facing a shift to a less respected role, some of the loss of respect is external and some of the loss of respect is internal. Assuming that their competence has declined and coping with threats to their internal self respect can lead to older people adopting a number of strategies that can affect useful communication. These include deference and apology. Older people are likely to “go along” with opinions that they receive from the higher status young researcher/designer. Older people are also likely to give false assurances about the value of the design because the designer “ought” to be rewarded for having put in, “all that work for older people”.

Older people are likely to apologize for their perceived incompetence, what I refer to as the “silly old me” syndrome. One result of allowing this form of behavior is that the older person is likely to underestimate their potential ability and to interpret not knowing some key fact as evidence of general incompetence rather than evidence of the much more neutral point that they have not yet learnt the particular skill or concept. There is a value in gently challenging “silly old me” responses and both reframing the issue as a need to learn a specific item and getting the older person to try out actions on the computer rather than living in their expectations of what might happen. As an illustration of redirecting older people’s self perception, in the FileTutor study almost none of the participants had installed software. As part of the study they needed to take a copy of the program home and install it on their home machines. None of the participants initially felt that they would be able to do this. In each of the groups involved I asked who felt least confident about doing this. I then got this person to sit down at a PC and follow a set of printed instructions with guidance from me, (installation was actually very simple). After this first experience of succeeding I got the same person to repeat the installation without guidance and to do this again if necessary while the rest of the group watched. My assumption is that the other members of the group both saw repeated examples of how to do the installation and that they also revised their expectations of their own ability in terms of “If she can do it then I can”. The end result was that all of the participants in the FileTutor study successfully installed the program at home.

Failures on assigned tasks with prototypes can potentially be seen, by the older person attempting the task, as evidence of their own incompetence. Giving the older participant a single prototype and asking them to complete a task seemed to feed into the older person’s expectation of failure. This was in spite of emphasizing that the test was of the software, not the user. A better approach was to present alternative design fragments and ask the older participants to try them so as to see which one was better for them.

This focused the source of the problem on the interface design rather than on the older person's limitations.

In small group situations individual failures seemed to be handled more robustly with the older people using humor to note the fact that they were having problems and then using group support and suggestions to either try other approaches or to suggest that the problem lay with the current version of the software. Older people observed working alone tended to explore less and to give up at an earlier stage. The presence of multiple older people does not, however, automatically constitute a supportive group. An example of this was that in the Unitec classes the older people were effectively isolated by a situation where talking with each other would have been "talking in class". Testing or exploration sessions with small groups need to be explicitly structured so that interaction and mutual support among the older participants are seen as approved activities.

There is a need to show the older people involved that they are valued and that there is a strong possibility that their ideas and understandings of their experience with the test software or with computing in general are going to be valued, understood and acted on. There was a very positive response when older participants found that suggestions that they had made in a previous session had a) been acted on and b) that the changes turned out to make their use of the software easier. Again the older in-house testers were motivated when they saw their suggestions taken up.

Respect and acceptance of the older participants seems to be a necessary stance. Computer professionals tend to be competitive with respect to the depth of computer knowledge that they possess. In addition there are reports of developers blaming "stupid" users for difficulties found with interfaces, Knight and Jefsioutine (2002). Older people can represent extreme cases of uninformed users and could potentially trigger strongly negative responses from developers with respect to the gaps in the older people's computing knowledge. One should expect older people to be fairly accurate in evaluating the underlying attitude of the researcher over prolonged periods of informal interaction so that even politely disguised rejection will be counter-productive. My personal stance is one of understanding the extent of the learning problem older people face, respect for their making the attempt, empathic pleasure when they succeed and respect and patience in the face of even prolonged difficulties. I can still expect things that are currently beyond the older person I am working with, become impatient or expect knowledge that is not present but overall I do not find that these responses are a major feature of my interaction with older people. It appears to be the case that with more exposure to a wide variety of older people attempting to work with computers the amount of respect I have for them has increased. Generally I found I liked being in the company of the older people who have taken part in these studies and that this attitude improved my work with them.

8.4.3 Balance of power and deference

Interactions between younger researchers / designers and older people typically have an obvious imbalance in power in favor of the younger person, especially if the conversation is defined in terms of technology transfer. Apart form the ethical concern about lack of empowerment there is a practical concern since the imbalance of power is likely to put the older person in a passive role where they react to suggestions by the younger researcher / designer but do little volunteering. This raises some issues, given the younger researcher's / designer's lack of deep experience of aging, they are in a poor position to guide a two way conversation that is really about aging in combination with technology transfer. Again the aim of the investigation is to elicit understanding of how the older person will behave with the technology in their own environment, and this environment does not include a dominant younger researcher / designer . Finally one of the characteristics of power imbalance in communication is deference.

The problem where older people defer to the younger researcher / designer is that this distorts the information provided. In situations of deference the subordinate person is less likely to volunteer information. They are also more likely to self-censure and to support the expressed views of the dominant person even when these run counter to the views and experiences of the person doing the deferring. In part older people can be grateful to the younger researcher / designer for regarding them (the older person) as useful and worth talking to and for being concerned with the worthy aim of helping older people. In part the older people may censure negative responses as being ungrateful or indicators that the older person has failed to understand things yet again and the younger researcher / designer should not be pestered with this. So older people working with a younger researcher / designer can tell them what it is thought that they want to hear, "this is a wonderful design, its very clever and it should be very good for older people” (<unspoken> “except for silly old me”). Since this is in fact exactly what I do want to hear, as distinct from what I need to hear, this message is seductive.

It seems useful to reframe the way of looking at an interaction between a younger researcher/designer and an older person. A person with deep experience of technology is talking with someone who conspicuously lacks that experience. Simultaneously a person who lacks direct experience of being old is talking with a person who has deep knowledge of being old. In both cases a knowledgeable and experienced person is talking with a much less competent person. I made it plain to the older people I worked with that I did not know as much as I needed about what it was like to be old and that I was looking to them for guidance.

Working with small groups of older people became a key technique in my research. The enjoyment that the older people took in being part of a small group trying new software or learning new skills was evident. It seemed that they found the experience socially rewarding. It could also be said that by being in a group the older participants were empowered judging by the increased willingness to voice criticisms and to try out new actions with the software. The older participants seemed to benefit from working in a setting where the limitations of aging were accepted and understood.

Small groups had been used in the Dual Task pilot study and it was apparent that it was important to the volunteers to have other older people as company and moral support during the sessions. The presence of other older users also encouraged informal comments that helped understand how the participants were experiencing the interfaces being tested. Small groups were used again in the FileTutor study evaluation and in the development (but not evaluation) of SeniorMail.

8.4.4 Communication style

Younger people seem to find difficulty in finding an appropriate style of talking with older people. For example the common experience that older participants referred to was of relatives and friends who intended to be helpful but who left the older people bewildered and feeling inadequate. The key points made were that such “helpers” went too fast, introduced too many new ideas, did demonstrations the older people got lost in, missed explaining key steps, were impatient, did not give the older person time to practice, became frustrated when the older person made mistakes, assumed that the older people knew terms and concepts that in fact they did not and assumed that what was simple to the "helper" was automatically simple to the older person. I tended to joke about this with older participants, using what we ended up calling the "flying fingers" situation. The "helper" sits in front of the screen, the older person looks awkwardly over their shoulder and the "helper" proceeds with a rapid hands on run through of the task involved saying, "you see, you do this, then this and you follow it with this, there, its simple". The "helper" thus overwhelms the older person with actions performed at a pace deriving from the "helper's" near automated performance of the task (and by the nature of automated performance leaving out explanations of significant aspects of that performance), then the "helper" ends with a statement that double binds the older person by stating that the incomprehensible task just seen is simple and implying that the older person should also see it as simple. The sad thing was that <u>all</u> of the older people I talked with said that this situation was familiar.

Although the focus of section 8.3 is on communication that facilitates development, because of the frequent gaps in older people's computing knowledge some of a developer's time in working with older people will involve training the older people in simple (to the younger researcher / designer) procedures. Effective communication in training older users, in my experience, must not be rushed and must not be flavored by the attitude that the younger researcher / designer thinks the point is trivial. My approach in training older users involves a very basic explanation of the intended aim, followed by talking through a slow, step by step demonstration of the technique. This demonstration is done sitting beside the older person in such a way that the older person is directly in front of the screen. This is followed by a guided hands on repetition of the task by the older person after which the older person attempts the task with minimal and reducing levels of guidance, possibly several times. It was very common that the older people would then ask to make notes of what they had covered. Several of these older people made the statement that it was important to them that these notes be in their own words.

Particularly in the Unitec classes for teaching older people computer skills it was apparent that some of the material that gave the older beginners difficulty was introduced because the tutors had a somewhat rigid concept of what people "should" know about computing. One of the tutors characterized such knowledge as needed to have a "respectable" understanding of computing. A more useful approach is to ask whether particular pieces of computing knowledge are actually needed to support useful (and basic) computing behavior by older people. If not needed, extra knowledge is a distraction and a source of confusion for older beginners. The success of the “minimal manual” approach of the FileTutor study points to the positive benefits of stripping non operational knowledge from any syllabus for older people.

When communication with older people feels difficult younger people may mistakenly attempt to fix matters by unconsciously adopting a communication pattern described under the name “Elderspeak”, see Kemper et al (1998a). Older people report that they find elderspeak demeaning. In general elderspeak consists of a pattern of language where the younger speaker

- Uses a singsong voice, with changing pitch and tone and exaggerating key words.
- Speaks more slowly.
- Uses terms like "honey" or "dear."
- Uses statements that sound like questions but which in fact coerce the older person. “We are ready for our dinner aren’t we dear”
- Uses limited (childish) vocabulary.
- Simplifies the length and complexity of sentences.
- Repeats or paraphrases what has just been said by the older person but in a way that puts the older speaker in a role as an incompetent communicator.

Elderspeak appears to be more common when dealing with frail elderly people. It is noteworthy that older people do not use it with each other. One of the key messages that appears to emerge from elderspeak is that there is a significant difficulty in communicating with the older person and that this difficulty is the older person’s fault.

It appears that elderspeak actually impairs communication, see Kemper et al (1998b). Experiments where older people were paired with younger partners in a map reading task and the older partners were instructed not to ask the younger partner to adjust their communication style two points were observed. The younger partners tended to lapse into elderspeak and the older people (who had in fact found the required map location) expressed uncertainty as to whether they had really found the place of interest to the younger partner.

The latter three components of elderspeak may in fact be helpful if used in ways that accommodate to the older person rather than belittling them and without the patronizing baggage of the first four aspects listed, see Kemper. and Harden (1999).

- Using limited and simplified (but not childish) vocabulary (with respect to jargon).
- Simplifying the length and complexity of sentences.
- Repeating or paraphrasing what has just been said with an explicit aim of allowing the older person to correct or amplify the younger person's understanding.

When talking with older people or with older groups I found that I needed to be cautious in not rushing older people to conclusions and to allow time for them to clarify their statements or to allow the older group to amplify and re-interpret comments before I did.

Extended analogy and conceptual explanation are not regarded as useful in skill training for older adults, Morrell et al. (2000), but I found that limited analogies taken from the presumed experiences of the older generation did appear to be useful in explaining things from the role of prototypes. As an example to explain the limited functionality of prototypes an analogy to the false shop fronts used in Western movies worked well. As another example when explaining the role of folders in email systems, "Suppose you use some shoeboxes to store your mail. You go out and get the mail and come back in and drop it in a shoe box, that's your In Box. Then you go through and read the mail and put anything you want to keep in a second shoebox, that's your Saved Emails". However I found that there was always a danger of my explanations becoming over involved and I needed to be aware of indications of disengagement or lack of comprehension from my older listeners.

8.4.5 Time issues

Older people are slower to complete activities, especially novel activities. It is also suggested that the performance of older people is detrimentally affected by pressure to complete tasks under time restrictions. However younger researchers /designers who are not aware of these issues may in fact both upset the older participants and obtain unrealistically low levels of performance, by setting schedules of activities with older participants that are suited to younger people. This sort of effect was evident in the

Unitec classes where tutors essentially abandoned those older people who could not keep up.

My approach to reducing time pressure was to schedule multiple sessions with the same older participants so that there was less pressure on me or the older people to achieve a particular piece of testing in a particular session. Although the literature is ambiguous on the ability of older people to maintain long periods of sustained attention, the people in the Dual Task study complained that they had been worked too hard for too long so that testing sessions were redesigned in the subsequent research. This redesign involved much less in the way of formal protocols. There were shorter periods on any one activity, breaks for refreshment and discussion and the older people were allowed to both self time and to talk with other older people engaged on the same task.

8.4.6 Information gathering

The standard forms of information gathering, interviews, questionnaires and focus groups have been developed with a focus on adult and task or domain competent respondents. For a variety of reasons when used with older people these techniques appear to require some modifications.

Interviews

One problem with one-on-one interviews is that the power imbalance between the researcher/designer and the older person, combined with the researcher/designer's lack of knowledge of the older person's culture, can lead to interviews missing important information and to the older person not taking opportunities to expand on some of their concerns. Although I engaged in informal discussions with almost any older person I could find I made the decision that in formal interview situations my existing views would be too likely to dominate the exchange. Discussions with groups of older people replaced interviews in my research.

Questionnaires

Questionnaires can be problematic when used with older people to gain computer related information. Because of the difficulty of clearly expressing computer concepts in ways that will be understood by people without some knowledge of computer jargon and computer function it is likely that questions will receive unintended interpretations both when answered by older people and again when the answers are being considered by the researcher. It is also likely that because of the difficulty with the question framer's obtaining a realistic overview of the context within which the older person will answer the questions useful information will be missed.

Questionnaires were used face to face often as a warm up activity for groups of older people. One of the observations from this was that the assumptions that the older people initially brought to the questions were often distinct from the intention intended by the researcher. This was despite pretesting of the questions. Discussion of the questions (and of why they were so easy to miss-interpret) by the group tended to add extra information. This matches the experience and recommendations of Eisma et al. (2003). In addition the discussion of what the questions (and answers) should be, shifted the power balance so that the older people felt encouraged to speak out. One factor contributing to this effect was that the researcher's wishes as (miss-)represented by the questions were seen to be much more flexible than the older people had imagined. Another factor is that within groups of older people there is a culture of greater tolerance and support for the mishaps of old age, given group support there was less concern as to whether the researcher approved of an answer or disapproved of a misinterpretation. The older people initially seemed to focus on there being a right or wrong answer and to be stuck when they did not know how to make the question fit with their own experience. My impression is that the older people were uncomfortable if the question could not be answered literally. "How often do you use the internet per day", could cause anxiety in older people who used the internet possibly once a week or many times on one day and not on others, the question in effect forced them to make a wrong answer. Remember that making mistakes has been found to have a greater effect on older people than on younger people. Older people faced with a series of forced errors such as this are unlikely to find a self-administered questionnaire a good beginning to a usability session.

Focus groups

It has been noted that focus groups with older people are difficult to run effectively, see Barret (2000) for a summary of the problems and possible responses. The problems reported are that it is difficult to keep the group to the intended topics and that some older persons are insensitive about the effects of their communication on other people so that long and irrelevant communications may alienate the other people attending the group.

However in the focus groups I tried, working with independent home living older people and with rest home volunteers, these themes were minor. One possible difference was that the focus groups were carried out after the participants had all undertaken a similar activity, either the dual task study experiments, the FileTutor evaluation sessions or had listened to a rest home presentation on email. It seems possible that the common experience and the fact that one of the main themes of the focus group was to discuss and evaluate that experience meant that there was mutual interest in what other people had to say and that the participants all had recent experience that was relevant to the discussion. This may have explained the observation that they were less likely to make irrelevant contributions. Again in the rest home situation the group of older people already knew each other and may have developed suitable patterns for workable communication.

It may be worth considering the personality of the younger researcher / designer when looking at how easy the researcher finds it to control a focus group of older people. I am a somewhat authoritarian middle-aged male with considerable experience in managing discussions in small classes of adult students.

Informal group work

Groups of older people, especially groups comprised of existing friends can help overcome the typical deference to the researcher/designer. They may also create a situation where the researcher/designer more readily adapts to the majority culture within the group. The pattern used in much of the research was to work with groups of two to four older people rather than individuals. Several times this was done by having “Computerware” parties where an older couple would invite another couple to their home and the four would work as a group using laptops on the dining room table to evaluate alternative software features. These were found to be enjoyable social events and productive in establishing better alternatives or in critiquing software features. Note that acceptance of home visits is culture dependant, another researcher working in North England pointed out that inviting another person into one’s home was uncommon in a North England context and it seemed likely that older people in that culture would feel uncomfortable doing so, Zajicek (2004). However for Zajicek, gatherings of older people in social centers that were already part of their everyday lives served a similar purpose.

Usability sessions with older people were structured so that afternoon or morning tea breaks occurred in the middle of the sessions and the researcher later made notes on any informal discussion in these breaks that added information about the participants responses in the evaluation sessions.

When working with groups of older people there is an issue for the researcher of paying attention to multiple users. I used a number of techniques to work around this. The participants were given an explicit role in pointing problems out to the researcher. In addition when people encountered problems and asked other participants for help, the shift from working alone at a task to discussion was easy to notice. It was then acceptable to change position and join the discussion, usually after allowing enough time to pass so that the older people had formed their own clear idea of what was wrong and possible solutions if any. This worked well. Applications and design fragments had been already examined by the older in-house testers and modified in response to their views. This reduced the rate at which new problems were discovered. The interface development and testing was broken up into testing of small fragments and sections of the software rather than testing the whole application at once. The testing was repeated on different groups so that for example in the FileTutor study there were 8 groups (a total of 25 people) involved in the testing. Group size was kept small, ranging from 2 to 4 and in a single case 5. My experience was that groups of 3 or 4 were optimum.

Given these techniques one observer could cope with the amount of data generated. For example in the FileTutor study, the interactive tutorial was already partly "debugged", it had been informally tested as the screens were developed on the in-house testers and on any available person over 50 and this reduced the rate at which problems were found during usability testing. Up to 30 problems were reported in a two hour group session , but many were simple, or repeats of problems found earlier by other volunteers so that recording problems and assisting the student to progress was not time consuming. It was found that a single observer was able to cope reasonably well. Notes taken during each session were revised at the end of the session. Understanding of the problems recorded was checked against the FileTutor screen involved. There was usually a fair amount of time between problems so that there was time to observe ordinary interaction and to intervene to ask participants what they understood at particular points.

8.4.7 Care of older people

Some older people will have, or may expect, difficulties with getting to new venues. They may have difficulty way finding in new areas of a city, following complex directions can be a problem, walking may be restricted to short distances, there may be problems in activities such as climbing stairs. Bladder control may be such that easy access to a toilet is important. Remembering to keep appointments made well in advance may also be an issue. Maintaining task focus over long periods of time may be unpleasant. Some older people may have expectations of getting lost and a lack of confidence in new surroundings. The key point is that issues that may seem non-issues to the more able younger researcher / designer can be significant for older participants and require the younger researcher / designer to think (yet again) outside of their usual assumptions.

Meeting strange people in strange surroundings may disconcert some older people. I made a point of making initial phone contact with the older volunteer and explaining what was intended, how they would find the place where research was going to be done, ask about any difficulties they might have, for example a non-driver might need to be picked up from a bus stop or a volunteer may need reassuring that there is lift rather than stair access. If there is a signage trail (recommended) from the parking area to the site this can be explained at this point. This initial conversation serves to provide the older volunteer with a realistic expectation of what is involved and thus defuse worry but it also serves as a social icebreaker, in that the older person now has had a friendly interaction with the researcher / designer. Finding a particularly clear signage trail from car park to lab resulted in older people who arrived feeling pleased, cared for and in an environment that the researcher was willing to adapt to cater for them as older people.

I also used the initial phone contact to describe what the volunteer was going to do and check (without being patronizing) that this was understood by the older person. I also checked the older person’s existing computer experience if the particular project assumed pre-existing computer knowledge. An example was the FileTutor usability studies, twice against my better judgment I was persuaded by an older volunteer to let them take part when it was clear they had minimal experience. In both cases the older person had a miserable experience and with hindsight should not have been included.

It is obviously desirable that older users are comfortable and feel cared for during sessions. Part of this lies in looking after a number of simple nuts and bolts issues. When participants were accepted onto the project they were sent a letter or email confirming the location, times and dates of their 3 sessions as well as a further explanation of what was involved in the project and a statement that they would be given a reminder shortly before their sessions were due.

A lot of attention was given to providing advance information, giving reminders as sessions approached, accessibility, booking nearby parking and signage trails. Reception staff around a large and scattered campus were alerted to approach and direct participants if they got lost. The research area was new, tidy and well furnished and attention was paid to lighting and adjusting seating, keyboard and screen position. Nearby toilet locations were pointed out at the start of sessions. Some of this may sound trivial or nit-picking but the points listed do address older people's issues in attending new venues and the result was happy and co-operative participants. The older people also noticed the care taken and stated that they appreciated it.

Home visits are another solution and can add depth to the information gathered. It was easy to obtain information from discussion groups that email was not a major part of my participants' lives and that they were tentative about computer use. However this information was strongly reinforced when seeing the relative lack of importance indicated by the location of their computers in their homes and the proliferation of small notes that were needed as tools to guide them in remembering the steps needed for all but the most frequent tasks. In the SeniorMail evaluation using older CAB workers the study was done in a spare room of the CAB offices so that the older people were in an environment with which they were already familiar and traveled to regularly. Another solution to getting field experience with older people might be to get co-operation from older people's social clubs and to carry out research in such settings. If the clubs used were not exclusively intellectual in pursuits this might have the effect of extending the range of older people who could be sampled.

To summarize the following points should be considered when ensuring that older participants are cared for in the research or design process.

Housekeeping issues - Pre session

- Ensure clear prior understanding of what is involved.
    - I had a short telephone conversation with each volunteer to check that they met the project criteria and understood what was involved.
    - I told them I would send an email confirming the details
- Be firm about excluding people who do not meet the criteria
- Some older people forget easily.
    - Send confirming information giving clear written information given about dates and locations and contact information
    - Send a reminder shortly before cycle begins
- Session times set to avoid traffic peaks

Housekeeping issues - Session format

- New locations are difficult for seniors. Accessibility, nearby reserved parking and signage trails are important. Reception staff were alerted to direct participants if they got lost.
- Session times 50 min then tea break then another 50 min
- The research area was new, tidy and well furnished
- Attention was paid to lighting and adjusting seating, keyboard and screen position. Mice were cleaned and checked.
- Nearby toilet locations were pointed out at the start of sessions.
- Tea breaks provided a varied choice of good quality biscuits. Range of cup sizes.

For another discussion that provides extensive support for these points see Chisnell et al. (2004).

8.4.8 Sampling issues

Older people consist of multiple overlapping populations of persons with differing degrees and types of age related difficulties. In addition these difficulties are such that they are likely to amplify selection effects in sampling. Selection bias is one of the known areas of difficulty in research on older people, Hertzog (1996). Rosenthal and Rosnow (1975), note that volunteers for any form of research project tend to be more intelligent, of higher status and more self-confident than the community average. This effect may be strengthened with older volunteers by factors such as the need to cope with city driving and the greater range of ability in the older population. From the point of view of interface designers or researchers this means a systematic shift of the sample group towards people who are more able than the target population the designer is aiming at.

Acquiring a "more average" group seems particularly valuable in evaluating how a design will fare. Volunteers in the FileTutor study were generally of higher status and had high levels of educational achievement but because the project offered instruction that was genuinely in demand, and because some of the initial volunteers encouraged other friends to enrol with them, there were 7 volunteers who appeared more typical of the general community. They were less educated, had lower past occupational status and were less self confident. This "more average" group had more difficulties and were of considerable value in showing areas in which FileTutor could be improved. The "above average" volunteers made a useful but different contribution. They were more able to cope with problems in the earlier versions of FileTutor but they were happy to adopt a role of identifying things that they felt might cause difficulties for other older people. However the "above average" group did not spot many of the pitfalls that the "more average" participants exposed. This should be borne in mind when selecting older users for product evaluation.

How many older people are needed? Nielsen and Landauer (1993) argue that usability testing with around 5 people is enough to find all the significant problems in a version. Various authors have argued that this is simplistic and depends on the complexity of the application under test and the likelihood of any individual detecting the errors needing to be found, see Woolrych and Cockton (2001), Spool and Schroeder (2001). Older people are more variable than the younger population so we might continue to get useful results with more test subjects than if our participants were younger. In the FileTutor project there were three main usability cycles, one in December (6 people) and two in January 2001 (9, 10 people) . All reported problems were fixed before the start of the next cycle. However people continued to find problems in material from previous cycles. My argument from this is that if testing is aimed at older users 5 people is likely to be insufficient. My tentative recommendation is for around 8 older users based on the point that 8 people formed the core group for testing during the development of SeniorMail and that this seemed sufficient to produce an acceptable application. Again in the

FileTutor study the most realistic testing came from the "average ability" group and there were in fact only 7 in this group scattered through the three usability cycles.

There is the question of why an unrepresentative sample works at all. It is clear that a group of 6 – 8 older people who are self supporting and willing to take part in research about computers is unlikely to be representative of the older population. Further the initial development with WinTutor, FileTutor and SeniorMail depended on the in-house testers who were in their mid fifties and showed mild visual impairment and some problems remembering information. Yet the designs that finally emerged were greeted as exceptionally good when presented to a wide group of older people. There are two possible arguments; firstly that the study of the possible implications of aging on interface design reported in Chapter 2 (the literature review) helped guide the designer in suitable directions. The second argument is that most older people in fact have age related deficits in a number of areas but that these deficits are sufficiently small that the older people are able to compensate for the effects and maintain normal functioning. However in this scenario the process of maintaining such compensations takes effort and so older people will choose design alternatives that reduce the amount of effort required for compensating age related deficits that are not obvious. Salthouse (1996) has made a similar point with respect to vision in older adults where older people who tested in the normal range for visual acuity could be shown to have significant decline in vision when tested under conditions that were deliberately less ideal than the standard test conditions.

In pursuit of a quasi experimental approach this study recruited people who had difficulty with using standard applications. This focuses research and design on a useful group of participants. This meant that the group chosen were either selected by their care givers as unable to use an application effectively or they self-reported themselves as “poor” users of the application. However it seems worth asking the question of how competent are older people who report that they can use Word or MSOE? There may be useful information to be gained from exploring the behaviour of self described “competent” users.

8.5 Developing applications with older people

The overall research has involved developing three applications for older people that have been well received by the target group. Within those applications nearly 200 screens suitable for older users have been developed in conjunction with older people. This section takes that experience and looks at modifications to the development process that allowed me to usefully involve older people in the shaping (and eventual success) of the designs produced.

8.5.1 Needs analysis

Newell and his group have been working largely in the area of new products for older people. However my research has focused on redesign of standard applications for the needs of older users. One of the differences between the two approaches is that, when imagining new products, the driver is features that are unique to the product and appropriate to older users. In contrast when providing a redesign of a standard application such as email for older users, the emphasis is on restricting features to those actually of use to older people and then redesigning those features to be age appropriate. There are two benefits to restricting features, the older user has fewer things to learn and the interface designer, given a simpler feature set, has more scope to focus the interface on design that suits older people's abilities. Note the further difference from developing new versions for younger people. In developing new versions of standard products for younger users, the driver is to provide new and extra features not provided by competing versions.

In doing needs analysis for older people I have found several steps useful. The start is a background investigation that asks what are the key features of an application such as email that older people will use and need. This involves discussions with groups of older potential users covering their likely needs, their concerns and any experiences they may have had with standard software. There is discussion and observation with older people who are users of standard applications in the area chosen, such as older people using MS Outlook Express, the focus here is on what features are actually used, what things are difficult and what features does the older person want to use but finds too hard. There can also be an interest in the frequency with which various features are used. My current focus is to use this part of the background investigation to counter my own expectations of what makes a worthwhile application in this area (my personal preferred list of features if I were the intended user.)

Another aspect of the needs analysis when designing for older users is discussion with the older people's supporters. As an example the SeniorMail study included a series of focus groups with relatives of older people, part of the longer term investigation of SeniorMail included discussions with rest home staff. Here the concern is only partly with the older person's needs and difficulties as seen by the supporters. A useful topic in discussion with supporters is details of the supporter's role in assisting the older person's software use. This not only indicates features of current software that the older person may be unable to use unaided but it also indicates possibilities for the new design in alleviating some of the tasks currently undertaken by supporters and thus relieving the burden that support places on supporters. In passing, my experience so far is that supporters find supporting an older computer user of standard software a much larger task than they initially expected and that reducing the size of the support task is not a matter of removing a welcome link between middle aged children and their parents but a matter of making the support job manageable and removing a largely unacknowledged and unexpected source of overload, duty, guilt and exasperation.

It is also useful to consider the supporters' technical competence in computing or in the specific application area under consideration. One of the potential tricks for providing older people with a highly simplified application is to design some of the setup tasks so that they are intended to be done by the older person's supporters. Obviously obtaining a feel for the skill level of the supporters is helpful.

Another aspect of interest in working with supporters is the supporter's own views on what makes a desirable application for themselves in the application area. One can also consider how willing the supporters are to modify these views with respect to a different version of the application for older people. One design problem is that supporters are potential gatekeepers for older people's software acquisitions and may reject software that does not meet their own preferred feature set even though that feature set may not in fact be needed by the older people they support.

A further resource when looking at design for older people is the existence of training organizations devoted to teaching older people computing topics. Both talking with tutors and observing classes can be informative almost irrespective of whether the training organization does a good or bad job of addressing older people's needs. As a younger researcher / designer you should simply be cautious about accepting the organization's own claim to be a good training provider until you have evaluated the evidence for this.

8.5.2 Creating the basic design

Newell and Gregor (2002) argue that user centered design contains inbuilt assumptions that the user is reasonably similar to the designer and that the users form a relatively uniform group. Both those assumptions can also be seen in task centered design as described by Cooper (1995). Given those assumptions it is possible to proceed from the knowledge of the user's situation, needs and tasks to produce an outline of a workable design. To an extent what the designer does is to use their knowledge of the user to put themselves in the user's place and create initial designs that seem to allow the target users to carry out the identified tasks. The product is typically a low fidelity prototype and this is then refined in design sessions with the users.

When designing for older users this process runs into difficulties. In my experience older users can be sufficiently different from younger people in ability and in computer experience that the designer will have considerable difficulty putting themselves in the older person's place. Additionally older people have difficulties working effectively with low fidelity prototypes. However if the designer wishes to have an on-going relationship with a group of older people in the course of product development then what the older people work with must carry sufficient promise of a credible design for older users that the older people are not alienated.

A partial solution involves:

1. Intensifying the initial investigation of the older user's difficulties with existing software so that the first designs presented to older people clearly solve some real and common issues. A concern here is that, in the initial work presented to older people, the observed benefits outweigh the inevitable shortcomings so that the older people are willing to remain involved with the project.

2. Using knowledge of the effects of aging to inform design. It can be said that each finding on the effects of aging represents a departure from the assumptions that a designer could reasonably make about what would work for younger users. The problem is that the findings on aging are much less specific on how an interface design should compensate for the effects of aging or about when particular effects of aging come into play.
3. Using high fidelity prototypes and abandoning the considerable advantages of low fidelity prototyping. This puts a number of costs on the development process but it does allow older people to give realistic responses.
4. Building in almost daily consultation with representative older people into the design process so that the designer's assumptions about what is feasible for older users are checked sufficiently frequently so that errors in these assumptions do not snowball.
5. This requirement means that selected older people need to be readily available as part of the day to day design activity. In effect some older people are needed as part of the design team.

The older contributors to the designs

I was fortunate in that I had available two people in their mid fifties who were working close to where I worked and who needed to learn computer skills but who had found themselves surprisingly unable to do so. They were competent, intelligent individuals in semi-professional occupations but computers were a remarkable and enduring blind spot. They came close to fitting the stereotype of "perpetual newbies". They had virtually no knowledge of elementary computing conventions. They did not understand basic concepts, the "file thingy" was used in a way that did not distinguish between the file icon, the (lost) data on the disk and the program that allowed display of the data. They had considerable difficulty in interpreting screens and appeared blind to features that are taken for granted by even minimally experienced users such as an [OK] button. One of them had bifocal lenses that allowed good reading and distance vision but were unable to provide good resolution at the intermediate distance represented by the computer screen. Further they had considerable difficulty in retaining information about either procedural steps or about concepts. In short, despite being relatively young, they showed many of the characteristics of older beginners. They have since become competent computer users. I owe them a considerable debt of gratitude that they were willing to allow me to carry out endless impromptu tests of design fragments as I was developing them.

The SeniorMail project was the third application developed in my research and by this time my in-house testers had benefited from their involvement with the interactive tutorial projects and while they still could not use email they were too knowledgeable to act as older beginners. While I still used the in-house older testers as a resource I also recruited a group of 9 much older people who were unable to learn email using MSOE. The drawback here was that they often lived some distance away (up to 50 kilometers) and so organizing and going to testing sessions was time consuming. Another problem was that there would often be a backlog of features that I wanted to test, this delayed progress and threatened to overload my volunteers when test sessions were organized. (Remember that testing needed to be relaxed, exploratory and done in a group context, this meant that testing of any feature was relatively slow.) My opinion, based on the number of problems found in my initial designs, is that without the contribution of these older people and the in-house testers I would not have produced suitable designs for older users. Finding a suitable, convenient and ethical way of making older people part of the development project remains an issue. Working with residents in a nearby rest home was examined but there were difficulties in finding enough people who were interested and who were sufficiently unimpaired to make computer use feasible.

Prototyping

Developing low fidelity prototypes with older users was tried and it was found that they had considerable difficulty with relating to paper prototypes as precursors to a screen design. Not only were there problems of conceiving of a paper design as a stand in for a screen design but it also emerged that a number of the issues that affected older users were in the actual implementation of a design on a screen, font sizes, colors, precise layout etc. The question became how could older people usefully participate in the development of the design? The approach that was finally adopted was to build high fidelity prototypes of several alternative design fragments at points where there was uncertainty as to what older people would want as a design choice or I was unsure of the validity of the responses of my older in house testers or they disagreed with each other. These fragments included working code as it was found that older people tended to be disrupted by explanations from the usability tester of what would happen after they performed an action on a zero code prototype. As a group the older people were more comfortable if the intended response from the prototype actually occurred, instead of being talked through by the researcher or demonstrated by the researcher intervening and displaying new screens. I found older participants could become quite worried where effects depended on the researcher doing a quick alteration. The response was confusion as to what steps they themselves would be expected to do as distinct from those carried out by the researcher. If I had made an intervention such as swapping to a new screen representing a view of the prototype after an action by the older user, I persistently encountered a belief that in the real application they would need to carry out extra steps similar to those I had just done. This belief appeared to be resistant to my explaining that in the real system action A by them would be automatically followed by appearance B. No, they had seen that I needed to follow action A by some complex or fast fiddling before appearance B eventuated and they wanted no part of it. This did not mean that the prototype had to be a full featured final version but that for the parts of the prototype under test, the sequence of action and response needed to be believable. In addition the way of reaching the part of the application being tested, either with the researcher’s verbal preamble or the test participant's actions needed to effectively set the context within which the part of the application under test was relevant to the older participant's understanding of what they wanted to achieve.

These alternative design fragments were then presented to groups of older people and to the older in-house testers. I got the older users to carry out simple scenarios with the design fragments while I observed. They were then asked for preferences. This allowed us to choose the preferred approach for selected design issues and often to consider ways in which the approaches developed to that point could be improved.

I found in early work with older people that their continued interest in participating depended strongly on their belief that the outcome would be useful. Shown a prototype with major features they found unworkable, their response was to disengage rather than to discuss improvements and maintain engagement until the improved version was available. As an aside I wonder if this is because the older people I chose to work with were people who had had repeated experience with unsatisfactory computer systems and so were quick to place poor prototypes into the category of, "yet another computer program I can’t use"? So my aim was to build a working and credible prototype as a starting point for involving older users in making major contributions to the final design. In building a preliminary credible prototype of an entire system I worked from the emerging design principles for older users, from identification of the older user's needs and wants and from trialing various specific pieces of the prototype with older users. I also relied on ongoing involvement from my two in-house testers who were able to devote considerable time to trying out preliminary versions of the parts of the various systems I developed without becoming discouraged. Thus by the time I looked at the usability of the systems with groups of older people I had developed prototypes that were seen by the older participants as already usable and meeting more of their needs than other systems that they had tried. They then found no difficulty with using the preliminary credible prototype as a basis for suggesting numerous improvements and for discussing why such changes would represent improvements to them.

This is a fairly radical change from the orthodox recommendations for participant design when working with younger groups. The use of prototypes based on high fidelity design fragments with working code is recognized as having several problems, it tends to slow the pace of development, it gives less flexibility for discovering alternative designs than the rapid modifications available with low fidelity prototypes. Again high fidelity prototyping leads the designer to be egoistically involved in designs given the level of work and skill required to build them. This reduces the willingness to make radical changes as does the designer / developer's awareness of the coding costs of re-design as opposed to cosmetic changes. All of these points are forcefully covered by Cooper (1994) where he argues for the highly desirable nature of paper prototyping over code based prototyping. Cooper in fact suggests that there should be complete separation between coder and interface designer on the very reasonable grounds that the job of the interface designer is to solve the user's problems rather than design to ease the programmer's workload.

I acknowledge these issues but argue that, for the reasons discussed above, the drawbacks do not outweigh the advantages of having working hi-fidelity, code based prototypes as a basis of participant development with older people. In particular the extra focus on the older user's needs and problems and the increased personal involvement of the researcher / developer / designer with the older users are seen as techniques that off-set the concerns with ego capture and capture by programming convenience identified by Cooper. Certainly the work with the in-house testers repeatedly found aspects of my designs that were unworkable in spite of my hopes for the design. Because I was working in close conjunction with the older in-house testers I had to do three things to preserve the relationship. I needed to accept that the design was wrong when their behavior with the prototype and their comments showed that the prototype did not work as intended, if one wants to have an ongoing relationship with a messenger, shooting them or denying what they say is unproductive. I needed to show responsiveness to their concerns and to value the work they put in if I wanted ongoing involvement from my in-house testers. If this meant a major redesign then that was better than asking them to allow me to ignore the original design failings, implying that I was not really taking them seriously. I also discussed the intended direction of a re-design with the in-house testers and then had them re-check the final result. Thus there was a check on the tendency of a designer / developer towards both wishful thinking and laziness in facing coding difficulties when working with high fidelity prototypes. This was also the way to maintain an effective relationship with well-motivated in-house testers.

In a number of situations it was not simple to see what should go into a credible prototype in spite of having access to in-house testers, partly because any manageable number of in-house testers is going to under represent the variety of combinations of disability in the aging population. There could be uncertainties as to what would be desirable trade offs as they would affect a wider group of older users. There could be questions about the usability of particular techniques. At times there were concerns that the in-house testers had acquired too much knowledge or too high a level of skill. At times I doubted the suggestions of my in-house testers or they each had different responses or they themselves were uncertain, at other times I had a simple gut feeling of caution. There were also questions of the proper interpretation of the research literature on aging when extending the findings beyond the original studies in order to apply them to an interface issue.

In these situations the approach was to construct several functional versions of the design that captured different responses to the uncertain issues. These were then presented to the informal backup pool of older people who were observed trialing the alternative designs, made comments on how usable they found them and gave opinions as to their design preferences. Usually a preference emerged or a new and better solution emerged from observation and reflection.

8.5.3 Usability test cycles

One of the key aspects of the way in which I worked was that the older users were supported by other older users as they did the usability tests or explored the design alternatives. In passing, my experience does not support the claim that presenting a high fidelity prototype always tends to stifle discussion. Where the older users worked with groups of other older people in using the prototypes, when they found problems in the designs they were very able to identify the difficulties and to discuss what changes could address these. In contrast the final evaluation of the SeniorMail system was done by older people working alone with the researcher and here it was noticeable that although people still encountered difficulties, they were less likely to discuss them or to suggest improvements.

To allow a broad scope for examining what was happening, most of the research projects involved periods during which the participants could discuss their experiences with each other as well as with the researcher, both during tea breaks within the testing sessions and in focus groups held in separate sessions occurring after the testing sessions. These focus groups combined older people from several testing sessions. This allowed for lively discussion of the benefits and failings of the system being examined in terms of how each individual experienced their own aging. As noted above the final evaluation of SeniorMail did not fit this pattern and this is felt to be a drawback, although earlier work on SeniorMail included and benefited from considerable group discussion by older users.

8.5.4 Long term use

As pointed out by Salthouse (1996) one of the significant limitations of laboratory investigation of older people is that the rates at which behaviors change and at which new behaviors are established are much slower in older people. Salthouse suggests that some of the important changes we need to observe in older people's adaptation to situations will occur outside the timescale that is available to a laboratory study. A full scale follow up study involving repeated observations would be an ideal although one needs to be cautious about the training effects due to the intervention effect of the follow up evaluations themselves. Baltes and Willis (1982) showed that relatively small amounts of training (in effective memory techniques) had effects that showed in retesting five years later, it seems possible that even the knowledge that evaluations would happen in the future could affect the course of an older person's skill development with a system. In the research for this thesis the two interactive tutorial systems that were intended for relatively brief use by older users as they learnt computing skills were never the less capable of being placed in a situation of long term use and evaluation by making them available to New Zealand SeniorNet branches and obtaining feedback as tutors gained more experience of using the tutorials and tracking sales to confirm that branches continued to find the products useful, instead of having had a first flush of enthusiasm that died on further acquaintance with the tutorials. Similarly for SeniorMail which is a product intended for long term use, although the usability testing was short term and did not really address long term suitability, a small pool of long term users was established to check if they would continue to find the product desirable.

Long term involvement with a product means that users are likely to engage in a wider variety of actions and to try to satisfy a wider variety of needs. This gives further opportunities for the developer / researcher to obtain information about what works, what needs changing and what level of enthusiasm about the design is sustained in the long run. It is seen as important that this feedback does in fact reach the developer / researcher. One of the tools for making this happen is to respond positively with new versions of the product that address any issues raised by the long term users. Another technique is to arrange visits to the long term users and discuss the product with them and observe their current patterns of using it and levels of enthusiasm for it. Standardized evaluation forms were not used with these long term evaluations as there was a strong aspect of the older users being pleased to receive ongoing attention and to want to reciprocate by pleasing the researcher. It was felt that it would be harder to maintain an artificial level of approval in discussion and so the long term users' satisfaction was rated on this basis. Which does lead to some rather unorthodox items indicating approval and that the system under test is important to the user, such as baking a cake as thanks for promptly resolving a bug, gifts of fruit and vintage wine or a wish to come to the researcher's graduation.

8.6 Ethical issues in working with older people

This section arises from reflections on ethical issues that arose during the course of the study. I do not want to increase the difficulty of obtaining ethics consent for research in design for older people but with hindsight there appear to be some ethical issues specific to working with older people that are not typically addressed in the framework of standard ethics consent procedures. Designers as well will want to look at ways of working that treat the older people they work with fairly. So this section looks at some of the ethical pitfalls in working with design for older people and considers ways in which these can be avoided or minimized.

Let us quickly recap the responses from older participants that illustrate the ethical issues around the study for this thesis. In the Dual Task study, interface and problem solving conditions were used that meant that the older volunteers failed in around half of the apparently simple tasks they attempted. Instructions to participants were that we were looking at conditions that made it harder for users to succeed. This made the participants passive recipients of bad design while setting them up to try and succeed. The volunteers disliked the experience, ascribed blame for poor performance to their own failings as older people and were not highly motivated. Participants who initially saw themselves as reasonably competent computer users had their self confidence reduced. In the same study participants also looked at a range of fonts to see what was readable. Here good and bad seemed to be ascribed to the fonts used and the volunteers were interested and motivated.

In contrast the FileTutor project was designed to maximise success while placing a positive construction on difficulties. Participants found that they were understanding things that they had previously puzzled over. They also saw themselves as actively taking part in improving the design. When they failed to understand a point they more often saw it as due to their discovery of a problem in FileTutor rather than their own weakness. They saw themselves as making a useful contribution in pointing out where they became stuck. On coming to later sessions they could in fact see that improvements had been made based on the problems they had identified. Participants reported that their self confidence was boosted.

In the SeniorMail study the in-house testers, the long term users and the people who contributed to the “ComputerWare” parties all showed clearly that they appreciated involvement in the study and found it personally rewarding. However in the later usability testing with the CAB volunteers, remembering that this was not done in a group situation, a number of the people involved appeared to have come because this new email system was part of a possible change to the way the CAB was run. While they succeeded in using the program it is hard to argue that all of them saw this as a preferred use of their time. In addition the email program at that time still had some periodic bugs that made it harder to support and so it was not possible to provide the participants with their own simplified email as a reward for participating.

With this background let us look at some of the more general concerns about ethical treatment of older participants in research. Levy (1996) has done provocative work on the effects of activating negative self stereotypes in older people. These include significant physiological stress and negative influences on long term decision making. In the light of this putting older people in front of a screen and having them fail may breach the ethical commitment to protect the volunteers' personal welfare. This is in spite of the apparently harmless nature of the computer activity. A problem here is older people's apparent use of self blame (the "silly old me" syndrome) as a coping mechanism. At the very least the study's orientation, design and de-briefing procedures must help volunteers to ascribe blame to the experimental set-up rather themselves. However note that positive debriefing has not been established as effective in protecting older people, Levy (1996). It is my impression that the pattern adopted in the three studies following the Dual task study led to the older participants maintaining a positive view of themselves and their role in the research. The key aspects were a mix of the following:

- Providing older participants with rapid responses to their suggestions
- Using alternative design fragments where the question becomes, “Which do you prefer?” rather than, “Can you do this?”
- Working with an initial credible prototype so that there were reasonably high levels of initial success.

Aging is a time when previous views of one’s competence as a person are challenged. It seems dubious ethically to put older people in situations where they are likely to conclude from their experience that they are less worthwhile as functioning members of society than they had assumed. Levy (1996) suggests that there can be long term consequences from such experiences. Such a possibility in working with older people and computers is that their experiences may lead them to incorrectly decide that they are unsuited for using computers and to avoid further experiences with what could possibly be a useful tool for them. In work by Hess et al (2004), older, but not younger people showed altered performance on memory tasks when exposed to implicit versus explicit priming with aging stereotypes. Implicit priming with positive stereotypes led to improved memory recall while implicit priming with negative stereotypes led to decreased recall. When explicit priming was used there was an effect due to the strength of the stereotypes. With exposure to subtle stereotypes older people showed little effect but blatant stereotype exposure led to decreased performance irrespective of whether the primes were positive or negative stereotypes. A possible implication of this work is that older people will be able to cope with minor inadvertent prejudice on the part of the researcher or designer but will be negatively affected by exposure to stronger prejudice. It also seems possible to interpret Hess et al's work as implying that a falsely positive presentation of the researcher's attitude to older people is detected and will in fact activate negative self stereotyping. However anxiety was not associated with poorer motor performance in older adults in a study by Horgan (2003).

Work by Claude Steele (see Steele 1997, Aronson et al. 1999) explores a related concept of stereotype threat. Steele suggests that more needs to be done to create social settings in which people can function as a comfortable part of the whole. Organizations can have features - ways of being organized, group compositions, philosophies about diversity - that can cue people to worry about whether they may be disadvantaged by their social identity - their gender, age, race, religion, nationality, profession and sexual orientation. This social identity threat can be significant enough to interfere with their performance in such a setting. Most recently, Steele's research has focused on identifying ways that these settings can be made more "identity safe" - that is, reducing the social identity threat people can feel. Since, when working with older people, we do not want to subject them to demeaning experiences, considering the possibility of, and countering, any stereotype threat is important. The experience gained in the research for the thesis is that older people being placed in situations where they were “objects” of study because they were old were more likely to show depressed performance than when such situations were reframed as ones where the older people were taking active steps to find out what suited older people. Again the use of group situations was seen as providing a situation where the older people had more of a role in constructing a social situation in which being old was seen as normal and accepted and thus reducing effects from stereotype threat.

In developing the conceptual underpinning of Universal Usability, Schneiderman (2000) has argued against dumbing down applications for older users partly on the grounds that this is an ethical stance. Dumbed down applications, Schneiderman argues, could well be seen as patronizing and hence demeaning to the older users. The older people I raised this issue with were dismissive, simple software was seen as useful rather than demeaning and there were so many more significant demeaning issues from the effects of aging that concern for one size fits all software was seen as irrelevant. This does not rule out the possibility of cultural differences, with older people in a culture outside New Zealand being more concerned about universality, but this does suggest that the ethical approach to this issue is to allow older people (and younger people) to make decisions for themselves as to what best suits their software needs. At the least this argues for the availability of "dumbed down" versions, if these are simpler to construct and hence more readily available, and is neutral about the desirability of universal versions until the reactions of potential users of all ages are considered.

Norman Alm (1994) in a paper on the ethical issues for researchers engaged in Augmentative and Alternative Communication research (AAC) noted that there are several issues that arise when working with people who are unable to communicate effectively by reason of such conditions as cerebral palsy. Alm and co-workers were looking at technological approaches for improving aspects of their ability to communicate with other people. This was intensely significant to these people as where the interventions succeeded the temporary freeing from being "locked in" was very important. Since the devices being tested were prototypes that could not be supported for the volunteers after the research ended the loss of such communication assistance could be upsetting. From this background Alm wrote a searching paper on the ethical issues involved. In what follows I have selected issues from Alm's paper that in my experience also apply to work with older people. Where appropriate I have translated Alms wording relating to communication impaired people to wording related to older people. Alm cautions that there are two areas in which the participants need to have their expectations managed. If the device or software being tested can only be made available to the participant during the course of the research then this needs to be made very clear to the participants in advance. Again Alm notes that in working with people who suffer from extreme communication disadvantages it is likely that the participants will receive a lot of attention and interest from the researcher. This, Alm points out, can raise false expectations of friendship and long term links with the researchers and the participants may feel let down when the researchers withdraw at the end of the project. A similar effect can happen when working with older people where loneliness may be alleviated by the researcher's involvement, only to return when the researcher withdraws at the end of the project.

Other issues that Alm has raised include:

- If a person has limited time remaining in their lives is participating in the research a good use of that time? Where studies of older people involve group work with enjoyable social aspects it is easier to answer this positively.
- Videos of older people's difficulties can be excellent for communicating older people's needs to developers but such videos may expose levels of incompetence that are demeaning to the individual older participant. Newell's team has suggested using actors to portray older users. There is no immediate equivalent in my own work, but there is the question of individuals exposing such incompetence in front of the group of people they are working with and the researcher. What appeared to happen is that in a group of older people individuals felt (and were) supported by their peers. Further since the designs did not present insurmountable tasks the results of exposing difficulty was usually assistance followed by success. Supporting the expectation that exposing difficulty or incompetence, would be followed by achieving competence and congratulations from the group, does change the nature of such exposure inside the group. However Newell's proposed use of actors seems valid in response to displaying lack of competence outside a supportive group.
- Claims of eventual benefit for "older people in general" so that the older person sees their contribution as philanthropical are dubious in that the actual benefit to the researched group is uncertain and may also be considerably delayed. In addition such a claim draws attention away from the personal benefits to the researcher in terms of career and grants (and in my case software sales).
- Alm makes the point that if older people are to be paid, if for example they are contributing to commercial development as in-house testers, it is important for

those paying the older people to consider the effect of any such payments on the older people's entitlement to retirement benefits or continuity of such benefits

- The designer or researcher needs to consider how to deal ethically with imbalances of power between the researcher and the older person. These may be subtle. For example, older people get tired, get bored and are strong believers in being polite and cooperative. When using in-house older testers there is a risk of exploitation of tester's good will, “Look while we are here can we test just this one extra feature?”

Ethical approval tends to miss important issues in working with older people. It has been traditional to evaluate harm on a strictly physical basis. In such a view there is little possible harm in sitting in front of a computer for an hour and trying to complete a variety of tasks. However for people whose belief in their own competency is threatened placing them in situations where they fail on tasks, such an experience can lead to these people making inappropriate long term decisions based on an under-estimation of their own ability induced by the experiment. For those tempted to say that this can be tidied up by talking to the participants at the end of their participation, I repeat Levy's (1996) point that positive debriefing has not been established as effective in protecting older people.

My impression is that research consent forms tend to be filled in without the older people really being willing to apply the safeguards that are offered. In no case have I had older people request that they withdraw from a testing situation but there have been several cases where older people have appeared to be uncomfortable with the testing situation and where at times they have opted for superficial involvement. It is worth noting that these cases with one exception occurred in situations where the older people were working one on one with the researcher. The exception involved a person who appeared to make very limited communication with the two other older people working alongside.

Note that the quasi experimental approach used in this research assists in achieving an ethical stance with respect to older participants in that it does not require a control situation in which older people demonstrate fresh examples of poor performance. As practiced in this research, the quasi experimental approach provides ways of alleviating past failure and in fact re-casting past failure as a useful source of knowledge for increasing the coping ability of the older participants.

8.7 Conclusions

This chapter has taken the stance that in order to design for older people, or to research appropriate design for older people, one needs to interact with older people frequently during the design/research process. The chapter has suggested that traditional forms of research need modification of the pattern of interaction between researcher and subject in order to achieve improved access to information. Examples of such modification that worked well in this research have been discussed. It has also been suggested that where the designer or researcher is considerably younger than the group to be researched there are a number of difficulties in communicating and working with older people that may be insufficiently appreciated by the younger person but which can be surmounted by adopting different forms of study design. In the chapter that follows we will look at the remarkably similar approaches to research on older people that have emerged from the work of Newell’s team at the University of Dundee.

Chapter 9 Comparisons with the UTOPIA Approaches

9.1 Design for Dynamic Diversity and User Sensitive Inclusive Design

This section examines the methodology that has come from the work of the UTOPIA project led by Newell with a team centered at Dundee University. UTOPIA stands for “Usable Technology for Older People, Inclusive and Appropriate”. The correspondence of the UTOPIA approach and my own work is of interest since while my own approach was developed independently there are considerable similarities between the two approaches and these similarities provide for a degree of mutual support between the two. The main themes of their work will be outlined in this section and then, in the following section, a comparison will be made with the approach that has been used in my own research.

There are an increasing number of web and interface design guidelines for including the needs of older and disabled users within mainstream products. These approaches come under names such as "universal design", "design for all", "accessible design", and "inclusive design". However, as Eisma, et al. (2003) note, there are relatively few guidelines for the successful involvement of older users in the development of systems for their use.

User Sensitive Inclusive Design as described by Newell and Gregor (2000), is a methodology aimed specifically at describing how to usefully include older and disabled people in research product development intended to meet their needs. User Sensitive Inclusive Design has numerous parallels to the methodological approach developed for, and used in, my own research. User Sensitive Inclusive Design (USID) was developed to provide a methodology that supports the Design for Dynamic Diversity (D3) paradigm described by Gregor and Newell (2001). In the D3 paradigm the concern is to develop systems that are appropriate for users whose abilities are different from those of the mainstream population and from each other (hence Diversity) and whose abilities are subject to change in both the users' development over their lifespan but also in their daily good and worse times, (hence Dynamic). Gregor and Newell (2001) and Newell and

Gregor (2002) describe Design for Dynamic Diversity (D3) as a more feasible approach to the concerns of universal usability. In these papers, although they acknowledge the usefulness of wide access to computing services by most of the disabled population, they see a need to relax the absolutism implied by the strict definition of universal usability. Hence D3 is offered as an alternative to the initial universal usability argument proposed by Schneiderman (2000) that every application should be available to all users irrespective of age or disability. This attitude is captured in the slogan, "Anyone, anywhere, at any time" but not, perhaps, realized in practice. Newell and Gregor argue that, in the approach identified under the name of Design for Dynamic Diversity, not only should some activities be seen as inappropriate for some users but also a conflict should be acknowledged in that features imposed on a design to adequately compensate for particular aspects of one sort of disability may restrict the usefulness of the design for users without disability or with different disabilities. Hence under D3 it is not proposed that all designs should suit all users, however there is the hope that when designing for disability there should be some level of acceptance of the resulting products by the general population, (except for designs aimed at extreme disability). It is also intended that some of the insights gained in developing products for older or disabled users can be used to alter mainstream applications so as to increase the range of users that they address.

The User Sensitive Inclusive Design methodology developed by Newell and co-workers at the University of Dundee is aimed at supporting the development of systems under the D3 approach. Although the first published description of the methodology is in Newell and Gregor (2000), the methodology draws on a considerable period of experience in working with disabled people in the research done at Dundee on development of assistive systems. Newell himself traces it back to a keynote speech given in 1993, (Newell 1993), where he agued that the full diversity of the whole user population should be taken into account when undertaking interface design. USID is seen by Newell and Gregor as a necessary adaptation of User Centered Design (UCD) that is required to cope with the characteristics of older and disabled people. In Newell and Gregor's view, UCD assumes relatively homogenous standard users with shared needs, similar abilities, competent communication skills and the ability to undertake informed consent. These standard users are assumed to adequately represent the general user population which is seen as being similarly homogenous.

In contrast USID is aimed at approaching users for whom there is a much wider range of characteristics and abilities. This is not simply a population with a broader distribution around a central tendency, rather it is a population containing many diverse clusters whose characteristics are different in kind from those of other clusters. Because of this USID needs to cope with the probability that any particular user sample is likely to be unrepresentative. Again because of the diversity of sources of impairments, USID, unlike UCD, needs to consider that designs that accommodate the needs of a sub-group of users (one form of disability), may in fact increase the level of difficulty for other sub-groups of the intended user population (those with different disabilities and needs).

USID should probably not be seen as a fixed definition of an appropriate methodology but rather as an evolving statement of the ways in which the workers at Dundee and those associated with them are finding ways to usefully capture the realities of the older and disabled people who are the focus and the intended primary beneficiaries of their research. Thus the UTOPIA project is both offered as an example of USID and also provides an ongoing enquiry into refining the methodology needed to work with older people, see Dickenson et al. (2002).

One of the key features of USID is that the relationship of test subject with researcher and designer is seen as problematic.

a. The users are very different from the researchers so that the researcher's own experiences as a user give a poor model for understanding the old or disabled user's needs, experiences and issues.
b. This leads to a much increased need for observation of the intended users, by the researcher, in the context within which they will eventually use the system.
c. The user is not always an adequate source of information on their own needs and abilities, it becomes necessary to incorporate expertise on aging or disability into the research team. However the inclusion of disability specialists does not diminish the importance of the information provided by the older participants, it supplements it and assists in interpreting it.
d. The users may in fact have levels of diminished competence where they have difficulty offering informed consent or adequately expressing or conceptualizing their needs.

There are several key ways in which USID seeks to resolve the problems noted in the preceding bullet points. Firstly the usual formal distance between the researcher and the test subject is reduced. Selected user representatives are formally recruited as research team members and at the same time there is a considerable effort to use methods that provide insights into the context of the lives of the older people who are potential users of the proposed systems. Thus while questionnaires may be used, Goodman et al. (2003), who work with Newell, point out the value of the extra information available if the questionnaires are completed face to face and if comments and discussion are encouraged to capture the wider issues raised by the questions. Researchers working at Dundee and in co-operation with Dundee use a variety of methods that allow observation of the unplanned. Focus groups and discussion are encouraged, visiting and observing older users in their homes or at older person's centers is seen as necessary and informal "hands on" sessions where groups of older users are encouraged to explore new technology are found to be useful. In general there is a concern in USID with a high level of personal contact with the older or disabled people who participate in the research. Note however this emphasis on involving the older or disabled users occurs for specific phases of the research such as needs elaboration or product refinement, in other phases, such as code development, older users are unlikely to be involved.

Although this leads to less formal and less quantified results there is a strong argument made by the researchers in the emerging USID tradition that the richness, and capability to surprise, of the information gained in this way makes this reduced rigor an acceptable payoff in the short term. There is a statement in Eisma et al. (2003) to the effect that the approach is concerned with allowing the chance for older people to provide answers to questions the researchers did not know should be asked. This is in complete agreement with the approach I have taken. Eisma et al. (2003) also propose a concept "mutual inspiration" where the older people who take part in testing, discussion and "hands on" sessions are inspired with new understanding of the opportunities that potential and existing systems can offer them as well as gaining an understanding of the nature and needs of the design process to which they are contributing. At the same time the researchers are inspired to frame more accurate research questions and design solutions by a fuller, more accurate and empathic understanding of the users' lives and needs. Note that Eisma et al. (2003) make the point that sessions involving groups of older participants can be socially rewarding, and are part of positioning older users so that they are less in awe of the researchers or designers, this facilitates fuller discussion. Eisma et al. also suggest that one of many payoffs from combining observation of older people actually using systems with their verbal reports of their use and capabilities is that they found that verbal reports often did not correspond to what was actually observed. This could involve observation showing unreported difficulties but could also involve older users displaying greater enjoyment and involvement than they had predicted.

Explicit in these papers is a level of personal involvement in the lives of the older participants, a building of trust and of understanding. Newell and Gregor note that the close ties between researchers and the research participants creates a need in USID for careful management of the relationship. In particular they insist on clear separation between the roles of researcher and usability participant although they do select some carefully chosen disabled people for formal membership of their research teams where they are able to provide a "test pilot" role that gives quick feedback on feasibility during system development as well as informed comment on research and development proposals. Newell and his research team also insist that the researchers are responsible for driving the direction of the research, they do not accept the position of some members of the Participant Action Research school that the crucial choices should be driven by the aged or disabled users to avoid any suggestion of patronizing the people the research is aimed at assisting. Another area that Newell and co-workers note needs care is in the management of the expectations of test users of successful assistive designs. For a variety of reasons ranging from cost to the availability of adequate technical support it is unlikely that test systems will continue to be available after the project is concluded and this can be very disappointing for test users if the system has proved beneficial. This is especially so given the deliberately personal nature of the relationship between researcher and participant encouraged by the USID approach. Newell notes the responsibility of the research team to make it very clear to test participants what the duration of system availability will be. This issue is of particular importance to Newell and co-workers since they have maintained an interest in "blue sky" research where the approaches they use are not limited by the availability of currently available affordable technology. Newell argues that to constrict research into what is currently practical and easily affordable represents a crippling of the long term potential to assist older people.

Newell and Gregor note that they do not reject formal, experimental approaches but that they wish to see a synthesis of the strengths of both informal and formal investigation of the needs and solutions for older and disabled users. They note that one of the key aims of D3 and of USID is to provide motivation for change in the people who design commercial products for older users. To this end they propose that firstly USID should be seen as a mindset rather than a set of rules suitable for mechanical application to design issues. What they would like to create is a "culture change" within the developer community. Secondly they suggest that the way in which results are conveyed might be in the form of a story telling metaphor which, they argue, is better suited to convey the particular solutions developed for older and disabled users as exemplars of using the personal understanding of these users that underpins the USID mindset. To quote Newell and Gregor (2002), "The narrative methodology is designed to provide useful information to designers in a form that they will find easy to assimilate and act on". Similarly Zajicek (2003), in discussing the use of a pattern approach to offering guidelines when developing for older users, is concerned with the need to make the reasoning and experience on which design principles are based, accessible to designers through the inclusion of pattern examples. More recently the UTOPIA project has made some videos that use actors to portray older people and the problems they bring to computer use. This emerged from the experience of the UTOPIA team with the Portal project where industry designers with a background in UCD signally failed to come to terms with the needs of older users from verbal descriptions of their issues presented by experienced academics. Until confronted with older people attempting to use computers, experienced industry designers persisted in designing for conceptual users who were much closer to the designers own abilities than the reality of older people, see Eisma et al. (2004).

9.2 A comparison of methodological approaches

This section is aimed at examining the way in which the methodology developed for the current research echoes and diverges from the approaches developed by Newell's team at Dundee.

9.2.1 The range of older users addressed

In Gregor and Newell's (2001) description of Design for Dynamic Diversity (D3) they look at the range of users who are targeted as consisting of people who fit the criteria in Table 9.1.

Table 9.1. The range of abilities targeted in Design for Dynamic Diversity

1. Able, but with some diminished capabilities
2. Frail, where reduction in capabilities noticeably limits what they can do
3. Disabled, with severely limited capabilities in some areas

My own research looks at designing for a slightly more limited group of older people indicated as classes 2,3 and 4 in the following list. Some of Newell's category 3 would fall into my category five and be outside my target population and some of Newell's category 1 would fall into my (excluded) category 1 and some into my (included) category 2. As Newell (2003) points out in practice these distinctions are somewhat arbitrary and there will be blurred cutoff points between my included categories and my excluded extremes. Newell also takes the position that even old, able users are in fact likely to have some age related restrictions but are at this point in their aging process able to compensate for them. Hence my findings can be seen as having some relevance to all of Newell's groups while the groupings I include or exclude primarily reflect my recruitment of participants.

Table 9.2 Range of users included and excluded in the current research

1. (Excluded) Old, able, users of mainstream applications
2. (Included) Old, slightly restricted, can use mainstream applications with some effort
3. (Included) Old, moderately restricted, mainstream applications require too much effort to achieve useful results

4. (Included) Old, moderately to noticeably restricted, cannot use mainstream applications
5. (Excluded) Old, very restricted, cannot use applications designed for moderately age restricted older people

9.2.2 Responses to the diversity of older users

Under a D3 model it is important to consider a mix of disabilities and a range of the severity of these disabilities, both within individuals and across the user group. In addition, Newell and his fellow workers use the word "Dynamic" to make the point that for any individual their capabilities will shift with time of day, with general health, with unexplained good and bad days and potentially with the progression (or remission) of the underlying conditions that cause the disabilities.

My work focuses on age as a source of various disabilities. I have made an arbitrary division into those older users who can cope well with mainstream software and those who have difficulty doing so. Newell et al. tend to argue for more of a continuum from able to moderately disabled, so they would argue that the older apparently able group do in fact have some reductions in ability due to aging. This implies that there is a case for altering mainstream design in ways that will improve the access of current older users and potentially increase the number of older users who can use mainstream products as well as extending the time during which older users can continue to make use of applications that they have learnt as younger people. I accept this argument and suggest that this means that there are two valid areas for research on user interface design for older users, one on desirable adaptations to aging within mainstream designs and the other on design for those older people who cannot use mainstream designs or are not comfortable with doing do. Although I have focused on the latter area I do not discount the usefulness of the former. I also see a considerable potential for cross fertilization between the two approaches.

Newell et al's statement of "Dynamic" diversity implies that individuals' capabilities are fluid and hence that the categories they use are heuristic rather than fixed. I did not originally incorporate the dynamic aspect of D3 into my methodology but I think it should be supported. Interestingly work reviewed by Monk (2005) on circadian rhythms suggests that there is a payoff from testing older people in the afternoons when they are at a generally lower level of ability than in the mornings and by accident much of the testing in my projects was done in the afternoons.

9.2.3 Adaptive software versus multi-compensating software

Gregor and Newell (2001) in their paper outlining D3 argue for the ability of the system to adapt to accommodate the user. I on the other hand note that older users tend to have difficulty finding out how to customize an application or remembering how to do so. I tend to consider choosing the level of the adaptations to a particular diminished capability such that an application is not irritating for users with minimal disadvantage in that area. Hence I have aimed to attempt designs that cope with a fairly wide range of age related disability with as little customization as possible. Thus for example I have tried to establish not simply a minimum font size for a suitable default font for older users but I have also tried to establish a maximum comfortable font size for older users with acute vision to check that they will be able to work with the suggested default font size in reasonable comfort.

I am not automatically against adaptive applications as such but rather my aim is for relatively quick and easy solutions to older people's current needs. I do however suggest a note of caution in avoiding adaptive software that noticeably alters the way in which an application functions, I believe that older users function best in an apparently unchanging system model and should not be exposed to what could be the equivalent of mode problems as adaptive software sets different levels of assistance.

9.2.4 The need to extend standard design methods

Newell sees USID as an extension to User Centered Design (UCD). The methodology used in my research began as an extension of Task Centered Design as defined by Cooper (1994) and Cooper and Reimann (2003), but it should be noted that Task Centered Design is in itself an extension of User Centered Design. Newell argues that the need for extending user centered design is based on the fact that the differences in the groups he is dealing with are too great to be accommodated by the assumptions of UCD. USID aims to accommodate a much greater variability of user characteristics and capabilities than current mainstream applications or the range of users considered in traditional user centered design. Although my work focuses on older people, rather than disability in general, I share with Newell the view that the older group in itself is highly variable and that methodology aimed at working with this group needs to be based on allowing for this variability in the techniques used.

Again because significant aspects of this diversity are dynamic, responding to changes in age related ability or to changes in context, a less formal and more extensive investigation of older people's use of artifacts that have been designed for them is demanded. Thus Newell's teams use projects that seek to evaluate realistic prototypes in the context of the potential older user's everyday lives. Again this matches the approach used by the current research where the aim has been for naturalistic investigation using realistic prototypes rather than the laboratory based usability sessions initially using low fidelity prototypes that typifies more conventional User Centered Design.

9.2.5 Responding to the variability of older people

As noted older people form a highly diverse group. One of the issues that Newell highlights in this respect is the fact that working with a highly variable population needs additional concern about the way in which participants are recruited. Where User Centered Design tends to assume fairly homogeneous users, who can be readily sampled, working with older or disabled people means that the population variability makes obtaining truly representative samples very difficult. I have covered my approach to the issue of recruitment in Hawthorn (2001) and in Chapter 8 on how to work with older users. I have specifically wanted to avoid recruiting confident older computer users, although exploring their strengths and weaknesses could be valuable in research with a different focus. I have looked for people who are showing age related problems and so I have tended to recruit people who have tried and failed at other approaches to performing computer related tasks or learning. I suggest measures like this are needed so that sample bias can be actively countered given that the people who volunteer as research subjects tend to be unrepresentative of the general population. The FileTutor study still showed a tendency to draw in volunteers who were better educated and had higher social status, but this study also illustrated the benefits of getting non-traditional volunteers who are less cognitively able, less self confident, and presumably more representative of the general older population.

9.2.6 Stance with respect to Universal Design

USID offers a relaxation of the aims of Universal Design as given by Schneiderman (2000) and others, suggesting that truly universal design may be such a difficult target that it would prevent progress on effective but separate design for disabled users. I tend to go further arguing that there is a case that effective design for those older people who cannot cope with mainstream designs may be inherently unattractive to younger users. My position is that designing for a range that includes fully able users is a very much a secondary consideration and as such is much less important than effective design for older users who fall outside the mainstream. As I have argued in the discussion of the SeniorMail project (Chapter 6), some of the aspects of good design for older people actually conflict with the standard tools used by interface designers to provide rapid access to a large feature set. Where younger users want access to more features and to make use of more densely presented information, I suggest that they will be frustrated by systems intended specifically for older users. I do not claim that it is necessarily impossible to design applications that satisfy both able mainstream users and older (less able) users but I do argue that this is more difficult and that it should not be used as a reason for delaying the rapid design of systems specifically aimed at older people. In a similar vein, arguing against using the ideal of Universal Usability as a reason for not attempting less than universal designs, Newell quotes Watson-Watt, the British inventor of radar, to the effect that, "the excellent is the enemy of the good".

Some proponents of Universal Design argue that having systems that are specifically designed for older people are stigmatizing and so should be avoided. Some older people may object to using applications that are publicly acknowledged as being for older users, however the older New Zealand people I talked with were rather derisive about attempts to sanitize old age or to go to extremes of tact regarding the disabilities old age brings. What they wanted were things they could use. There may be a genuine cultural difference with the older American population or it might even be that concerns as to politically acceptable expression may have isolated Universal Design advocates from what older Americans actually want.

Newell and Gregor (2000) make the point that there will be situations where "design for all" is simply not appropriate, their example is that one should not promote a right to car driving for the blind. They also make the point that there will be situations where design for one type of disability can actually make the design harder to use for people with a different type of disability. To provide an example, very large fonts for the partially sighted will mean that blind people need to traverse larger areas to explore the information on a screen while people with poor concentration, reduced effective visual field or impaired short term memory may find the greater spatial distances between the concepts presented make relating the concepts harder.

9.2.7 Role of older people in research

In USID Newell at al. examine the desirable roles of disabled people in project development. Newell argues that there are very important benefits from gaining wide ranging input from the target user group. Newell's team has found that observation and discussion are much more productive than are questionnaires and surveys, a view that I support. We also agree on the importance of meeting the older people in context, so that home visits and observation of older people in environments that they would normally use become important.

Newell (2003) notes a concern within one school of the participant design movement that argues that the designer should be subordinate to the disabled people. This in theory allows the disabled person to maintain an equitable power relationship, in this view they should dominate decisions about things they will eventually be the users of. Newell fairly bluntly rejects this, arguing that at times disabled people lack the breadth of knowledge or even competence that would allow them to see the potential of what might be created for them. After trying to elicit ideas for email design from older people I agree with Newell on the researcher shaping the overall direction of the design project. The older people tend to have too little understanding of the possibilities available in potential designs to be able to direct the decisions that form a new design. The role for older participants in my own research that has been found to be more appropriate, is to respond to concrete examples of design possibilities rather than to initiate them. This is not to say that issues of power are irrelevant in working with disabled or older users. I have explicitly opted for working with groups of older users in order to provide settings that empower the older participants with respect to the researcher and the UTOPIA team also makes extensive use of groups in product evaluation.

9.2.8 Role of older "in house" testers

It is interesting that in the UTOPIA project a few carefully chosen disabled people are in paid roles as project consultants and they make initial usability assessments before the version of a product is tried with disabled users who are strictly in the role of testers, not project members. This closely parallels the way in which I used a few selected older people to get quick initial feedback and then proceeded to get usability information from a wider group. Both the UTOPIA team and I have found this to be an excellent way of bridging the considerable gap between sympathetic but able researcher and the disabled target audience. There are so many design decisions in the course of a project that the availability of quick feedback is essential and this becomes more important when the difference between designer and user increases as is the case with both aging and disability. This "concentrated investigation with small groups of extreme users" is also strongly supported by Gheerawo and Lebbon (2002) who argue for becoming a trusted part of the user's life with whom the user can have very frank discussions of their needs, difficulties and aspirations. Gheerawo and Lebbon also argue for the inclusion of an empathic dimension to the researcher's relationship with the users. They argue that this can "open up a creative space" that will facilitate innovation and I tend to agree. In a similar vein Eisma et al. (2003) suggest a concept of "mutual inspiration" for deepening the relationship between designers and older people and hence increasing the value and depth of the resulting communication.

Newell made a much clearer distinction than I did between disabled consultants who were formally part of the organization and test participants whose involvement was restricted to aspects of providing information about their lives and testing designs. As noted above I had two late middle aged volunteers who provided substantial immediate input but I also tended to form longer term relationships with usability test participants who were interested in the projects and insightful. In the case of SeniorMail, a relatively few people became long term users though this raises problems in terms of providing sufficient long term support.

9.2.9 Role of experts and supporters of older users in research

Newell also argues that there should be contribution from the people supporting the target disabled group including clinicians, care givers and disability experts. The aim is to increase the expertise in understanding the conditions under which older or disabled people operate. In setting out the principles of USID, Newell and Gregor (2000) do not explicitly make the case for a strong reliance on the literature on cognitive and physical aging while I tend to see it as a keystone of my approach. However they do argue for a clear knowledge of the characteristics of the user group and they do employ experts in disability as part of the research teams. Further if one examines work by members of Newell's team, one finds examples of penetrating analysis of the implications of the literature on cognitive and physical aging, see for example Carmichael (1999) in the first chapters of his style guide for interactive TV design for older people.

Newell makes the point that experts in disability are likely to resist research directions that challenge the current orthodoxy of the area and this limits the freedom to make useful innovations, and hence at times experts must be overridden. A point that Newell makes strongly is that overall control of the direction of the research and the shape of products produced in the course of the research should remain with the HCI researchers. To this end Newell makes the point that the clinicians involved in the UTOPIA team need to be aware of and to accept such a research focus.

After trying to elicit ideas for email design from both older people, their family supporters and from rest home care givers who assisted older residents make emails, I agree with Newell on the researcher shaping the overall direction of the project. The older people tend to have too little understanding of the possibilities, family members often appear to want the older people to perform like themselves and care givers can have difficulty seeing the possibilities of independent action by older people. I have dealt mainly with independently living older people so I have not looked for input from official care givers or clinicians but I have no doubt that this would be valuable as the level of disability one is designing for increases. What I have done is emphasis the role of family supporters as both a source of information and as people who can benefit from design that considers the role that they play in an older person's software use. However I am willing to override some of the prescriptions of family supporters, just as Newell has at times overridden the views of the clinicians in his projects. Supporters of older users, in my experience, as well as being helpful, can adopt one of two non-productive roles in suggesting what is needed in a design for the older people they support. They are either too limiting on the potential of the older users, "Father could never handle that" or what they want is in effect a clone of the systems that they themselves use and they appear to be projecting their own likes and wants onto the older person.

9.2.10 The appropriate research focus

Newell argues for a focus on a long term perspective on the future needs of the elderly rather than looking to a short term product perspective. He argues that the project should remain research focused and not lose that focus to aim simply for constructing assistive devices. I do not disagree but I do suggest that there is, as well, a place for examining what can be done to improve current mainstream applications for older users using simple off the shelf technology.

I have had a dual focus in my research, aiming to expand and understand principles of design for older users at the same time as constructing software that was of immediate use and could be made available as commercial products. This gave me ready co-operation from older people who needed easier software and gave a stronger test of my designs, however it also stretched me in that coding for a robust application involved considerable time that was not directly related to my research aims. I tend to look more to an understanding that will support short term product development though, as I point out, I see my emphasis on the way my recommendations are grounded in the literature of aging as a way of relating my recommendations to future generations of older users who will have more initial computer knowledge, but similar patterns of aging.

Both Newell and I are concerned that a methodology for working with an impaired group should set out a proper way of relating to members of this group. This is discussed in more detail in Chapter 8 on how to work with older people. For the present is worth noting that Newell and I independently decided that it is inappropriate to treat the older people involved as subjects, the term "participants" seems to better capture the desirable relationship.

9.3 Conclusions

In short two sets of researchers have independently developed very similar ways of developing products for people who because of age or disability are unable to use mainstream products. The degree of correspondence between the two approaches is striking. Representatives of the disadvantaged groups become key players in the design team and provide frequent and ongoing evaluation as product features are developed. Expertise in the nature of the disabilities catered for is also incorporated into the design team. Evaluation of products focuses on informal observation and placing the product evaluation in the context of groups of older people working in their own environments. The design effort aims to inclusively meet the needs of a variety of types and levels of disability. There is a tendency to take a pragmatic approach to providing software that works rather than achieving universal design. The needs of the disabled users are evaluated informally and face to face allowing for the emergence of unexpected issues and clearer communication. Finally the key source of initial designs comes from the researchers, not from suggestions by the disabled participants who are seen as lacking sufficient design expertise to create initial designs but as being very capable in making suggestions about what does and does not work.

This close correspondence between two approaches developed without reference to each other on opposite sides of the globe and the degree of design success that both approaches have achieved, offers useful support for the overall approach.

Chapter 10 Conclusions

10.1 Introduction

This thesis has examined ways of designing user interfaces that suit older people. In the course of this research three applications (two interactive tutorials and an email system) have been built that older people report as being unusually suited to them as older people. Testing has shown that older people who have had little success with standard approaches to learning computer skills or emailing have succeeded in using these systems. It would be nice if we could then conclude that if an interface designer does A, B and C, they will then obtain effective applications for older users. However what emerges from the study is that successful interface design for older people depends on consideration of a number of issues that are not entirely simple to incorporate into interface design. This concluding chapter will provide an overview of the issues that the research found to be relevant, it will note how identification of these issues was arrived at, and will point to the ways that responses to these issues were used to create interfaces that suited older people.

The chapter will begin with an overview of the conclusions reached in this research. The question of the relevance of the findings for the current and future older generations will be considered. It will then proceed to look at the way each of the aspects of the research contributes to these conclusions. The role of the literature survey as a resource for designers will be discussed. The way in which the Dual Task pilot study and the experience of observing the Unitec classes for older people shaped a re-direction of the thesis will be reviewed. Then the chapter will look at the contributions of each of the three interface design case studies that provided successful examples of design for older users. After exploring the contributions of the WinTutor, FileTutor and SeniorMail studies this chapter will then look at the derivation of the research methodology with a view to making the thinking behind the choice of methodology accessible to other workers in this area so that they can make informed decisions as to which aspects may suit their own research. From here the chapter briefly looks at the concerns that need to be addressed when working with older people in such a way that they make useful (and ethical) contributions to a design project. Having noted that the designer needs the competencies in relating to older people that are explored in Chapter 8 the conclusions chapter moves on to examine the relationship between the thesis and the similar theoretical perspective developed at Dundee. The chapter has then reached a position where it is possible to look at the extent to which the thesis has achieved its aims. The final sections of this chapter look at possible directions for future research and attempts to sum up the overall thrust of the thesis.

10.2 Overview of the conclusions.

There are areas of the aging process that give rise to concerns about the ability of older users to use software that is designed for the mainstream population. With the expansion of the older section of the population and the expansion of the role of computing in society the problem of poor design for older people takes on particular relevance. By creating interface designs that take account of age related changes in vision, motor control, memory, attention, intelligence and learning abilities it is possible to improve the performance of older users well beyond the performance seen when these same users attempt to use standard software. However the creation of such age appropriate designs is not a simple matter of translating a fixed set of age based guidelines into interface practice. Rather the degree of difference between young or even middle aged designers is such that it becomes essential to incorporate older people into the design process from the beginning and to obtain frequent feedback from them to guide the design. In doing so the designer needs to adapt and alter practices that suit younger people involved in participant design, useful and ethical interaction with older people is not something that can be taken for granted but becomes another skill that designers in this area should acquire. In addition designers aiming at older people need a background of increased understanding of the aging process. With this combined knowledge base and skill set, the thesis has shown that it is possible to construct useful and successful software for older people that older people appreciate and benefit from.

The thesis documents a shift in attitude with the experience gained over several projects where products were developed for older people. At the start of the research my expectation was that from the literature survey and some experimental work the research could produce a set of strong recommendations for designing for older people.

With experience my emphasis changed from a view of design for older people as something that could be expressed in terms of rule based guidelines, to a view of design for older people as a process that involved older people within each design, that used knowledge of aging and previous examples of design for older people as resources rather than rules and which altered the traditional skills and role of the designer.

An overview of the issues that are seen as relevant to designing for older people is given in the following list. These points come from a variety of sources and do not originate solely with my research, but what my research has done is to find a variety of techniques for incorporating these points into both the interface designs produced and into the process of interface design for older people.

1. Older people are subject to a wide range of age related effects. Each change due to age represents a departure from what a designer could reasonably assume about the capabilities of people of similar age to the designer.
2. Older people are not uniform in the effects of aging. People of similar ages will have widely varying types and degrees of age related disability and the extent to which individuals are affected by age will vary over both the long and the short term.
3. Any interface design for older users should be restricted and simplified so as to fall within the perceptual, manipulative and cognitive capabilities of as wide range of older users as possible.
4. There are significant gaps between a younger designer's assumptions about people, even older people, and the reality of the actual limitations of older people. It seems that these gaps are difficult for younger designers to adapt to except by exposure to older people.
5. Older people from the current older generation who learnt computing skills as older adults are likely to have unexpected (to a younger designer) gaps in their computing skills and knowledge.
6. Part of achieving suitable restriction and simplification comes from working with older people as part of the design team.
7. Older people form a different culture and it is not simple for younger designers to communicate well across the cultural gap.

8. Older people are slower to learn and more likely to forget during extended periods of learning.
9. Older people have generally fewer needs that they wish to meet by using computer systems, they are likely to be less frequent and less intensive computer users than younger users, this in turn impacts the frequency of opportunities they have for cementing learning.

10.3 Relevance

Part of the special relevance of the needs of older people attempting to use computers is that they represent a group whose vulnerability is exposed through the convergence of two major trends. The rate of demographic change towards an older population is at a rate and a level not experienced since the Black Death in Europe. At the same time we are at the beginning of a change in the way that information is used and disseminated through society that is akin to the magnitude of the eventual impact of Gutenberg's printing press. As with literacy given the existence of printing, we can expect that the skills of computer literacy will move from being desirable to being assumed and necessary for adequate participation in what our society will become. The current generation of older users faces special problems caused by the need to learn basic computing skills and concepts while old. Despite the Flynn effect, and somewhat better medical treatment of aging, future older generations will still face problems due to declining abilities. As social security systems struggle to cope with the demographic shift, older people are likely to need to engage in employment for longer in order to maintain sufficient income and that employment will increasingly require computer skill, again applications that are usable for older users will ease this situation. The current thesis is aimed at a Windows application style of interaction whereas much of the emphasis of HCI research has shifted to Web and mobile design. However with increasing bandwidth and the rise of web services, the more fully featured style of interaction available in Windows applications seems likely to return to relevance, especially where meaningful employment tasks are involved.

It was pointed out in the introduction that the aim of the thesis is relevant to older people over a time scale beyond the current older generation. There will continue to be a gap between applications that suit younger users and applications that suit older users. The next generation of older users who come to old age with existing computer skills will still suffer from the perceptual, manipulative and cognitive declines of age, forms of interface design that lessen the effect of these age related effects will be relevant to their needs. In addition they will be vulnerable to technological shifts that erode the relevance of the computer knowledge they learnt when younger. The findings on the narrow ranges within which expertise is maintained in old age and the findings on the role of crystallized rather than fluid intelligence in older people's performance suggest that future generations of older people will still not cope well with changes in what is expected in terms of computer knowledge.

Although we are moving into an age where the next wave of retirees will include many computer literate people, the new recruits to the older generation will not all posses computer skills and the computer skills they do possess may be relatively narrow and work related. It seems reasonable to suggest that the less educated among the people who will soon be retiring will include numbers of people with minimal computer skill so that for some time to come the older generation as a whole will have a majority of people who do not possess adequate (or in some cases, any) computer skills and yet may be forced to try to come to terms with computers because of the increasing advantages of computer based interaction with the world. The findings on intelligence and age link the extent of previous education with ability to maintain intellectual functioning into old age. This suggests that if computer use becomes important as a way of obtaining access to services for a wider section of the population, then this potentially exposes an older less educated section of the population to requirements which they may find difficult.

10.4 The contributions from the literature survey

The literature survey documents a wide range of effects of aging that can be argued to be likely to have implications for interface design for older people. Another way of looking at this is to see each of the differences that aging makes between younger and older people as another break in the in-built assumptions of (younger) designers that they are designing for someone who is generally similar to themselves. As it stands the literature review has identified over one hundred and fifty such departures from similarity between the younger designer and older users. This is before gaps in older people's specific computing or operating system knowledge are considered. It should also be remembered that the literature survey is not exhaustive given the volume of current research on aging. In addition, research on aging is continuing to produce new findings at a considerable pace.

It is also the case that these findings do not apply to all older people equally, the older population is far more diverse than the populations from younger age groups. This means that a designer is going to be performing a balancing act in which features in an application intended to cope with one form of aging disability may be strongly relevant for only a section of the product's target group, may be mildly beneficial for other potential users and may be irrelevant or an active disadvantage for others in the target group whose individual pattern of aging does not include the particular effect of aging at issue. It is even the case that individuals vary in the degree to which they are age impaired over the course of the day.

On the face of it design for older users is an apparently impossible task. It also raises the question of why users of WinTutor, FileTutor, SeniorMail and even the test software constructed for the Dual Task study stated that they found the software particularly easy to use and well suited to themselves as older people and that they wished that other software could be like this. All these designs were designed with extensive input from older people, but why should the relatively few older people providing the input give rise to software designs that were widely accepted by older people? Several possibilities exist but this is an area where further research could be highly productive. There may be a core group of age related disabilities that are more likely in many aged individuals. There may also be a situation where age related disability on these core problems is widespread in most aged individuals but that this is masked by the adaptations to aging that people learn to make as they age. In this view the older population may be more uniform than is currently thought. What is not uniform is the breakdown of the ability to cope with disability that occurs as various forms of disability worsen or as the conditions being coped with, such as the complexity of a problem, become more difficult. The assumption in relating this view to interface design for older people is that maintaining adaptations for age related problems takes effort and that where an application design does something simple such as providing large fonts, the people who benefit include those older people who are apparently coping well with normal sized lettering. This is highly speculative and the eventual answer may be quite different, but the question exists as to why an apparently wide range of older people appreciate the application designs that have resulted from this research where the designs are made up of features that accommodate specific age related difficulties that are not apparently major difficulties for the test subjects?

Another issue raised by the literature survey is the difficulty of obtaining experimentally verified confirmation of the implications that have been drawn. We have some one hundred and fifty age related effects, they are general findings saying such things, as older people find greater difficulties with motor control. They do not easily translate into findings on specific interface skills and features such as difficultly positioning a cursor in small text or the inadvisability of using Windows style menus with a broad structure of sub-menus. Even where we have research that is directly related to interface features, such as a finding that older people read more slowly when reading colored text compared with black text on a white background, Charness (1988), we can guess that colored text requires more effort for the older person to read but we do not know the range of conditions under which this is true. It appears from the fonts used in WinTutor and FileTutor that older people cope well with colored text if the font size is large, the color is relatively dark (navy and maroon were used) and there is a high level of contrast between letter color and background but this is impression, not an established finding. The problem is that given the vast range of aging effects and the potential subtleties of the implications that can be drawn from them there will never be enough time to experimentally verify the full range of interface adaptations for aging.

Given the range of aging effects, even if interface design for older people was suddenly and improbably given NASA levels of funding, if what resulted was a mass of interface rules, there would be so many rules and the rules would be so detailed as to overwhelm any real and human designer. To allow real products with appropriate interface design for older users to emerge in a reasonable time frame there simply has to be some use of design work based on impressions of what works well for older users. What I suggest is that the role of the literature on aging and the implications that have been drawn from it in this thesis is to provide a framework for considering possible problems, checking that proposed solutions are reasonable and, importantly, for interpreting observations on older people's problems and successes with interface features. As such the information on aging provided here does not function independently but as part of a design process that depends on closely working with older people. Interface designers require a way of coming to terms with the breadth of the findings on aging, what has been shown in this research is that combining a general knowledge of aging with the close involvement of older people in design development allows this.

10.5 The Dual Task Pilot Study Contributions

One of the interesting questions about the dual task study is why the findings were negative. We know that older people have difficulty in managing dual task situations, there is no reason to suppose that such difficulties will not be present when older people manage an interface task and a substantive task at the same time. We know from the work on automated responses in older people that such responses are more difficult to form when old and so older people are more likely to need to pay conscious attention to the steps involved in many interface tasks. The handwritten notes, giving step by step instructions on how to do computing tasks, that are found around older people's computers, are no accident. However in the dual task study a deliberately difficult interface did not lead to poorer substantive task performance. Are some forms of task pairing such as vision and comprehension more resistant to dual task effects or do dual task effects depend on fine details of such things as timing, or are some as yet unconsidered effects in play? At some stage in the future understanding more about whether and when interface tasks compete with substantive tasks seems likely to allow improvements in interfaces for older people.

The focus groups that formed part of the dual task study indicated that there was considerable information to be gained about older people and computing from interaction with them outside the setting of a laboratory study. The dual task study also opened the issue of what did ethical treatment of older volunteers consisted of? The standard ethical guidelines for younger people indicated that research was ethical if it did not cause any physical harm, therefore sitting in front of a computer trying tasks and failing on some of them was physically harmless and thus if the study gave the subjects suitable compensation and offered a chance for useful knowledge it was ethical. It became apparent that guidelines of this sort are not suited to older volunteers. Because of older people's tendency to self stereotype they were likely to generalize the experience of failure to conclusions about their computer competency and to thus view themselves as less worthwhile. It was also noticeable that failing on the comprehension tasks surprised the older people and distressed them by presenting a more negative view of how intellectually able they were. Without some sensitivity to issues of aging and self identity, researchers new to the field and non-specialized ethics committees are unlikely to pick up these issues. This is not to rule out laboratory studies with older people, including those that use computer displays for presenting tasks, but it does raise serious questions about studies of older people which are designed to lead to task failure on tasks that are important to the older volunteers' self concept. In this context it should be noted that there is no evidence that de-briefing older people after such experiences undoes the effect.

The dual task study also raised the issue of whether laboratory studies of older people would lead to the older people performing with realistic levels of engagement and motivation. Obviously if we are trying to obtain information relevant to older people's computer use outside the laboratory we would like levels of performance that are similar to those the older people apply to their own private computer use. What was found in the dual task study was that the older people tended to disengage under three conditions; if the experimental trials went on for too long, if they were distressed by failure and if they did not see the tasks as interesting and relevant to themselves.

Again the dual task study gave a first indication of the usefulness of social interaction and the use of small groups in working with older people. In the focus groups and in the refreshment breaks it was evident that getting together with other older people was in itself rewarding. It seemed that focus groups with older people who had shared a common recent experience were relatively easy to manage, some of the issues other authors noted as difficulties in using focus groups with older people such as insensitivity to what other people were saying were observed but not frequent and did not cause major problems. My interpretation was that the common shared experience in the group members' recent past (taking part in the dual task study) gave the group enough common ground to improve the group's functioning.

Obtaining basic personal information at the start of the dual task study drew attention to the way that asking for volunteers for a research project was leading to a sample that appeared to be considerably better educated and to have had higher status previous careers than the general older population. This raised the issue of sample bias for later consideration.

10.6 The WinTutor Study Contributions

With hindsight, studying the difficulties faced by older beginners in the Unitec teaching observations, was an excellent contribution to the overall research. As was made clear in the chapter on the WinTutor project, the decision to develop a tutorial for older beginners arose from a personal response to the unhappiness that was observed when older people tried to take classes intended for young and middle aged people. However the experience of designing the tutorial with the in-house testers led to an appreciation of the extent of the difference between older beginners and the users a designer might expect. One shot learning was almost non-existent, learning could take weeks or months and some older people appeared to be likely to remain as perpetual novices. Apparently elementary skills and concepts were missing, a designer could in fact assume that if something was completely obvious and basic then some of the older target group would not have learnt about it. Some older people appeared to proceed by using a few rote rules, sometimes learnt but often written on pieces of paper so that carrying out a computer task at home involved stops to find the right bit of paper and further work in trying to remember what their instructions to themselves meant. The older people seemed likely to learn at a concrete level and to be slow to form underlying concepts that allowed them to generalize learning to somewhat similar interface features and to different settings. Although the older beginners did learn from WinTutor and from the intervention tutorial they were slow to apply their skills to other applications and there were frequent cases of fragile learning. It appears that in order to make a design widely available to older people, a designer needs to design in a way that makes the design usable by beginners and does not make the assumption that all of those beginners will change status to become experienced users. A designer should assume that partial skill sets will continue to typify some of today's older users. It also seems likely that later generations of older users will have partial skill sets for computing paradigms that emerge after they have reached old age. How to anticipate and to accommodate a partial skill set will continue to be a valuable ability for designers aiming at older users. As an extension to this it seems valuable for any designer for older people to gain face to face experience with older beginners.

The WinTutor study identified a set of difficulties and needed skills that apply to the current older generation's beginners. It also included training features that seem appropriate for older people such as reasonably entertaining hands on activities, designing activities so beginners could achieve a high level of success and having very easy and consistent ways of restarting exercises.

The WinTutor study suffers from its lack of formal evaluation, but if the continuing use of the product by SeniorNet and the more formally evaluated success of the similar FileTutor tutorial are accepted as evidence, it seems as if WinTutor provides a suitable method of training older people in computer skills. I am cautious about evaluating this as general support for interactive tutorials as a method of teaching older people. It is my position that, in this research, interactive tutorials have been shown to be a format for teaching that can suitably contain solutions to the problems that older people have been observed to have with standard training formats designed for younger people. Interactive tutorials can offer easy solutions to providing hands on active learning and to integrating instructions with the hands on activity and to providing a format that suits small group and self paced learning. On the evidence presented in this research, this does not rule out other training formats as containers for such solutions, nor does it suggest that interactive tutorials are automatically a good idea for training older users. Rather the conclusion from the two studies involving interactive tutorials is that the success of these designs comes from carefully evaluating the problems that older people have with needed concepts and skills and then formulating interventions that aim to build knowledge towards providing the needed concepts and skills in a carefully built sequence where each step provides the needed knowledge and practical hands on experience for subsequent steps. It is also concluded that in order to effectively provide such step by step progress, the content, activities and the presentation need to be developed in close cooperation with inexperienced older people working as part of the development team.

In addition to being a training program, WinTutor is an example of an application that was designed to be used by older beginners. As such it provides other designers with an example of a program that older beginners found easy to work with. It makes use of a variety of recommendations from other authors and from the literature survey and while the study design is unable to offer experimental support for individual interface features, it does appear that the combined design features used in WinTutor led to an application that older beginners use well.

10.7 The FileTutor Study Contributions

One of the aims of the FileTutor study was to provide retrospective support for the WinTutor study. An interactive tutorial that was very similar to the interactive tutorial used in WinTutor was given more formal evaluation and proved to be effective in training older people on computer skills. It was noticeable that as the amount of conceptual material increased the interactive tutorial format was stretched. The older students' memory and comprehension issues meant that they struggled to relate a textual screen introducing concepts to a succeeding screen where the concepts were put into practice. The older students needed more assistance from the tutor and more encouragement to persist with the tutorial in the sections that had higher levels of cognitive content. After they had persisted they saw the tutorial as very helpful but, particularly for complex material, interactive tutorials may be better used in conjunction with support from a tutor. There is also the possibility that interactive tutorial design could be improved by including skilled teachers of older students on the development team.

With those provisos the FileTutor project demonstrated that it is possible to use appropriate interface design for older people, combined with appropriate interaction with older people, to improve training for older people to the point where the older people succeed in spite of being previously unable to gain adequate understanding on other forms of training. This is an important finding in the area of computing and older users. It offers a research based finding to counter views of how limited older people will be in their computer use, it also offers an alternative approach to creating interface designs specifically for older users. If there are situations where it is not immediately practical to redesign software to suit older users, or where the job demands are irreducibly complex, it seems that specialized training that takes account of older people's abilities can allow them to succeed in using applications that would be impossible or difficult to learn without such training. My personal view is that it is more desirable to produce versions of applications where the interface is designed specifically to be accessible by older people, if however this does not happen, for whatever reason, one should not write off the possibility of training older people to use software designed for younger people. The reservations are threefold. Firstly a training approach should not be used as an excuse for not making suitable software for older people. Secondly that providing appropriate training and training materials such as FileTutor is itself a large task. Finally the FileTutor project does not tell us where the training approach will break down as the target application's complexity and prevalence of age unfriendly features increase.

The FileTutor project provided a number of specific recommendations for making interactive tutorials suit older learners. These recommendations will not be repeated here in the conclusions but they are seen as being worth studying by any person intending to create such a tutorial. In addition the FileTutor project demonstrated that Carroll's work on restricting initial training to a minimal set of core application features and providing hands on experience with these features is suited to older learners as well as the younger learners that his team worked with.

It should also be noted that the FileTutor project provided a second demonstration of a successful interface arising from a development process that relied on the input of the older in-house testers. Two other themes started to emerge in the course of the FileTutor project that would be extended in the SeniorMail project that followed and would form part of the overall set of ideas on productive work with older people that the thesis contributes. The first was the idea of obtaining design input from older people by having them interact with a high fidelity working prototype that was suitable to their needs as older users. As reported in Chapter 5 the in-house testers worked with each individual screen of the FileTutor and WinTutor tutorials. These screens were presented as code based prototypes, the in-house testers were observed trying to use them and comments were collected. New screen versions were then produced and the cycle continued until the issues raised by the in-house testers had been resolved. By the time the usability testing was done FileTutor was a relatively well working program that had been repeatedly altered until it answered the needs of the in-house testers and the problems found by observing the in-house testers try and work with, and understand, files and folders. It was apparent from the responses of the usability testers that they had feared yet another computer program that they would struggle with and that finding a program that was generally suited to them as older users was both novel and welcome.

The other emerging theme was the use of group work in product evaluation and in eliciting comments about usability. It may be remembered that the FileTutor usability testing was done with small groups where although each person had their own computer running FileTutor there were other older people using FileTutor sitting alongside and the researcher allowed the test participants to interact with each other and discuss what they were doing, provided they brought usability problems to the researcher's attention. What I was doing here was modeling the situation in which FileTutor was intended to be used, the SeniorNet classes for older people. What emerged was that this was an effective way of finding usability problems. Given an initial credible prototype where the frequency of problems was low a single researcher could record and discus the issues found. What also emerged was generally an atmosphere of pleased, interested and lively engagement with the product and the other participants. This was an extraordinary contrast to the bored and sometimes distressed task compliance found in the Dual Task study as well as to the uncommunicative misery of the older adults failing to learn in the Unitec teaching environment. It was also observed that the participants in the FileTutor testing did not defer to the researcher/designer in the way that had been found in the Dual Task study. Remember that I, as designer, was conducting prolonged evaluations of the product that I had designed. Being human, in a few cases I slipped into trying to justify my design choices, to get sharp reminders in the form of, "Oh I didn't like that either". This is not to say that the relationship with the researcher was adversarial, it was much more that the participants had bought into the idea of contributing to improving the product and that they accepted the idea that their difficulties were valid data and that the researcher/designer was one member of a team trying to achieve improvements. My personal response was that I was challenged by, and I intensely enjoyed, most of the testing sessions.

Two other possibilities emerge from the FileTutor study. Firstly given that this tutorial format appears suited to older users it should be possible and useful to include such tutorials, alongside or embedded within, applications that are aimed at older users. In fact the SeniorMail email application did have an embedded tutorial that in effect provided Carroll's concept of minimal instruction for the SeniorMail system. This was used in training some of the long term users of the system in conjunction with a tutor and appears to be helpful but has not been extensively evaluated.

As a second approach the format used in FileTutor could well be used for either applications that older people use infrequently or for older users whose aging process is such that they struggle to remember sets of procedures. In a sense this is a way of modeling the working environment that older people were observed to repeatedly create for themselves. When I visited older computer users I made it a point to observe the computing environment they used. An almost universal feature was that they relied on hand written notes giving the steps for all but the most common tasks. The conclusion is that older people do not hold a mental working version of the procedural steps of infrequently performed computer tasks and that it is probably unrealistic to expect them to do so. Suppose the older user needs to copy a file or do a backup. An application similar to the second menu screen on FileTutor could present a set of buttons giving choices of typical file management actions. The user chooses [Copy a file] and then goes to a screen that provides step by step notes of how to carry out the procedure together with an embedded tool for doing the task, very similar in appearance and concept to the screen in FileTutor where a learner practices the file copying exercise. The differences from the FileTutor concept are that the application is intended for actual work, rather than learning and the embedded tool for file management in this case does not need to be a reproduction of a standard tool such as Windows Explorer but could be a file management tool specifically designed to suit older users. It might be possible to allow the older user to divert into a refresher course on some aspect of file management if they required but the main thrust of the application would be to allow the user to carry out basic file management tasks with clear step by step procedural notes positioned alongside the task. Although the example I use here is for file management the basic concept could well apply to any computer based job that older users need assistance with and where they are unable to retain the procedures needed between uses. The assumption here is that there are computer tasks where older people will choose to trade off the fastest way of performing the task for a longer winded approach that leads to eventual success. My position here is that this is conceptually different from a wizard in that the application provides an overview of the whole task and that the user can use the tool with as much or as little reference to the notes as they choose.

10.8 The SeniorMail Study Contributions

The point has been made that the interactive tutorials developed in the earlier studies are applications and that they require the design of a large number of screens that suit older people. However the task being accomplished by these applications is an internally focused learning task and the system model of each tutorial is relatively simple. The SeniorMail project allowed the research to move to considering whether the design process that had been developed for creating the interactive tutorials would work for an application with an exterior focus on a real world task and a more complex system model. The SeniorMail project took the themes related to design for aging that had emerged in the development of the interactive tutorials and put these themes in the context of development that was clearly application development and was for a moderately complex application. In-house testing using older people who were part of the design team, use of awareness of the effects of aging to inform design, and use of groups of interacting older people in order to test prototypes were all aspects of the earlier design studies. Bringing these themes to a different type of design gave not only a chance to suggest their relevance to application design for older people in general, but also gave a chance to refine the techniques involved as the new design setting exposed new requirements. Hence these earlier themes have been expanded to include firmer support for such aspects as the need for an initial credible prototype, the desirability of code based prototypes as distinct from standard practice, the development of “Computerware” parties to create a socially rewarding and supportive group environment for software exploration and testing, and the provision of alternative design fragments to allow older testers to critique designs without being seen as criticizing the designer and to see more of the variations that design changes allow. These techniques are seen as a significant contribution of the SeniorMail research, they provided an ongoing flow of responses and comments from older people that had a major impact on shaping and improving the SeniorMail design. They significantly increased my own understanding of the human reality behind the term “aging”. These techniques offer methods that can be applied by future designers for older people with useful payoffs for their own projects. The actual details of the techniques will not be repeated here as they are discussed in some depth in Chapter 6 on the SeniorMail project and explored further in Chapter 8 on working with older people.

The report of the SeniorMail project also contributes a number of examples of how design details were arrived at using multiple aspects of the information on the effects of aging further combined with observation. The study design contrasts the overall design of SeniorMail with the other email designs that the older participants used (effectively MSOE) so it is not equipped to make strong findings at the level of the individual features incorporated in the design. However descriptions of the considerations that went into such design features as the modified tool-tips used in SeniorMail are seen as useful to future designers, not as rules that are to be followed, but as exemplars of ways of considering design problems and solutions that are capable of linking what is observed with multiple aspects of aging. Some of the design decisions that are detailed in Appendix E are likely to be useful in future projects. For example if lists of instructions are used, then numbering them, simplifying the wording and making each point in the list deal with only a single simple step is a useful approach. However the support for its usefulness comes from unstructured observation, conversation with older users and apparent congruence with aspects of aging covered in the literature survey. Given the design of the SeniorMail study it may well be that some of the adaptations to aging used in SeniorMail and reported in Appendix E make much less of an impact on the overall design success than others, the success of SeniorMail is support for the overall design and not for every feature of the design, except to the extent that it can be argued that no feature that remained in the design after testing provoked strong difficulties or complaint from the older users. The reader should be aware that it is not known which of the adaptations to aging found in the designs are most or least relevant in SeniorMail or will be most important in future designs.

The SeniorMail project also highlights the tension between designs for older users and designs for the general computer using population. It was noted that the design techniques used in SeniorMail frequently involved dropping techniques used by designers for younger users that allowed applications to present a high number of features and ready access to these features. Examples would be the decisions to use full screen windows, to avoid Windows style menus, to increase font and button size, to limit the number of toolbar options, to restrict the navigation model and so forth. In order to make the SeniorMail design work for older people, dropping as many email features as possible was an essential prerequisite. The SeniorMail design would not be possible if it tried to incorporate an extended feature set without hiding the extra features as sub-levels of the program along the lines of the [Options] button on the main menu. What has been demonstrated is a way of making a useful and usable basic application. It has been shown that with such an application older people can achieve email tasks they want to achieve whereas they could not achieve those tasks with MSOE. What has not been shown is a technique or a set of techniques that allow a designer to make all of a fully featured modern application available to older people. The core enabler of the approach used is to carefully scrutinize the requirements in the light of what older people actually want and do and to then ruthlessly simplify the feature set offered by the application. This means that the approach used here to make a suitable application for older people is not scalable to complex, highly featured applications.

The trial of SeniorMail with the set of middle aged users that is reported in Chapter 6 was interesting. Older users were generally delighted by SeniorMail, it appeared to be a breakthrough in their experience of applications and their enthusiasm was readily apparent. The middle aged, computer and email experienced users were simply not excited by SeniorMail, yes it worked, yes they could use it, but so what? The older users came from a perspective that what they had previously tried did not allow them as older users to complete basic tasks, an application that did allow this and did not involve stress and frequent errors was a revelation to them. The middle aged users on the other hand took for granted that if something called itself an email application one would be able to achieve basic email tasks on it. What they looked for was the ability to use features that they used and valued in other email applications. When they did not find this in SeniorMail they concluded that it would not be suitable for them. As noted in Chapter 6, the relatively small sample, of 15 middle aged users, showed very little overlap in what they regarded as desirable extensions to the basic feature set. In essence the argument is that what middle aged or younger users want collectively is a fairly feature rich application. The approach used in designing SeniorMail will not extend to this.

This observation was extended at the end of Chapter 6 to consider the question of the Universal Usability movement's concern with full accessibility for all, regardless of age or disability. The argument was made that fully featured applications would be too complex and require too many difficult interface features to be accessible to many older people, nor would the extra features provided necessarily be desired by this older group. The further point was made that it is inequitable to delay older people's access to a basic and workable emailer or other application on the basis that a fully accessible, fully featured version is the desirable starting point. It was noted that there was interest in providing fully featured applications that provided a senior friendly skin with a simplified interface and minimum features. I suggest that the desirability of this approach and its difference from providing older people with usable but "dumbed down" applications is moot if the older people do not venture beyond the skin provided for them. What may be more important is the issue of extensible applications or skins that allow an older user to learn on a basic feature set and then to incorporate some extra features later as desired in such a way that the extra features conform to the gestalt of the initial application. This would be in accordance with the earlier finding as to the suitability of minimal applications for learning on where the WinTutor study extended Carroll's findings to older learners. SeniorMail has attempted this with its provision of categories for saved email and its use of a navigation bar but these features have not been tested with older users, so their utility for older people is yet to be demonstrated.

10.9 The Derivation of the Methodology

This section is a deliberately warts and all description of the way in which the methodology emerged. It is argued that the final methodology is suited to the study aims and it may well be a methodological approach that other researchers in the area could adapt. My concern in describing the reasoning (and difficulties) behind the development of the methodology is to assist any further researchers who adopt it to make their own informed decisions about how fully they use it and what adaptations they might wish to make.

The research methodology had initially been assumed to be a non-issue in the overall research. Research on older people proceeded by way of well constructed experiments and there was little to question by way of wider methodological issues. Methodology therefore was going to be an issue of experimental design, establishing the protocols for carrying out the experimental work and deciding on the appropriate forms of statistical analysis. With hindsight this ignored the extent to which working in an applied area differs from pure research. Because the Dual Task pilot study occurred in conjunction with my observations of teaching at Unitec, I looked not only at the issue of the failure of the study to support the dual task hypothesis but also at issues of the appropriate and ethical treatment of the older subjects, their levels of enjoyment and their motivation to contribute realistic levels of performance. There was also the issue of how much information the Dual Task pilot contributed in comparison with observation of older people in the Unitec setting and in the focus groups following the Dual task sessions and the question of which types of information were more appropriate to the aims of the study in establishing relevant guidelines for interface designers wishing to create software that older people could use well.

I was fortunate in that my background included, as well as a Masters in Information Systems, six additional Masters papers in Sociology with a focus on research methods in the social sciences. This prepared me to consider approaches outside those of hard science. The key question was - how to carry out research that met the thesis aims. It was apparent that the area of <u>applied</u> knowledge of aging was at a level that could be described as pre-scientific. This was true of knowledge about older people’s computer use in particular. The implication was that hypothesis testing as such was premature but that observation and description of what was observed would be appropriate. It was also apparent that observation of older people led to new information. However observation and analysis of those observations did not offer a way of describing how to design for older people, nor did they offer a way of testing the value of such a description if it should emerge. The methodology would need to include examination of attempts to construct interfaces that suited older people.

The success of the rapid intervention tutorial created in response to analyzing the problems observed in the Unitec courses showed that the knowledge gained from observation of older people's problems in a computer use situation could guide successful interface design. The way that I drew on my reading from the literature review in designing the rapid intervention tutorial seemed to indicate that the information contained in the research literature on aging was relevant to informing the designer as they moved from observation of older people's problems to design responses to those observations. What was problematic was that this design was an informal and intuitive process that was hard to describe in a way that would assist other designers.

It would be nice to report that the obvious concept of carrying out repeated case studies was initially a deliberate choice. In fact the first case study, the WinTutor study was carried out as a holding action. I had tried to find a way of framing a form of experimental research that met the objections raised by the Dual Task study, I could not find one, I was, simply, stuck. To engage in useful activity during this phase it seemed useful to create an opportunity to find out more about older users and I had some hopes that this might give me some insight with framing my overall research. What emerged was the WinTutor project and the realization that I was engaging in a design process that seemed to be sufficiently powerful to produce highly appropriate software for older people. In contrast with the process that drove the rapid intervention tutorial, the design process for WinTutor was much more deliberate and allowed time to reflect on how the design choices fitted the findings of the literature review. The design process also included the in-house testers for the first time and it was very clear that the step by step feedback that they provided made a critical difference. It was at this stage that the next major decision in framing the research methodology emerged, that the overall study would consist of repeated case studies of interface design for older users. Again the WinTutor study drove an expansion of the scope of the material covered by the research. Where previously the methodology had been concerned with the relationship between the effects of aging and the interface features that older people could cope with easily, it now became apparent that a designer would also benefit from understanding the likely weaknesses in computing knowledge that typified the older population and including adaptations to such weaknesses both into design and into the designers understanding of the difference between the target group and the designer. So the methodology expanded to include a study of such differences.

With the FileTutor study the obvious shifts were to a methodology that made more systematic use of the case study approach, the use of evaluation by older people who had previously failed to master the area and skill being addressed by the software in evaluation so as to provide a quasi experimental check that the design was in fact better for older people than standard approaches and the use of group activity in the evaluation of the software. The FileTutor study also included the use of in-house testers as part of the development process and returned to a useful aspect of the Dual Task pilot by including focus group discussion so that the older participants in the usability testing could provide a wider picture of their relationship to computing as older people, and so that they could comment on their experiences with the product in a way that allowed information to be obtained that the researcher did not expect or prepare for in the study design. What was also occurring in the context of the FileTutor study was that the design process was becoming seen as a core part of the design principles so that the methodology extended from looking at questions and justifying answers based on, “What features work for older people?” to “How should one work with older people so as to obtain features that work for them?” Another aspect of the methodology that was brought into consideration in the work during the FileTutor study, and particularly during the evaluation phase was the issue of how best to work with the older participants. This was prompted by the obvious contrasts between the happiness and motivation of the FileTutor evaluators and the disengagement and unhappiness of the Dual Task subjects. Thus the case studies expanded to include reflection on how the older people were treated during my work with them and what the results were from the different aspects of my relationships with the older participants. One of the concerns that became part of the methodology was the question of altering power relationships between the older participants and the researcher in such a way that the older people obtained more ethical treatment and the researcher obtained less censored and more realistic responses.

The SeniorMail study was in effect a relatively full realization of the design approach and of the research methodology. The SeniorMail study continued the replication of design cases over different areas of interface design that the research methodology required in order to strengthen the arguments being supported. The study also expanded the role of exploring the context within which older people contributed well to the development of the interface. This led to the use of the “Computerware parties” as a productive tool for managing power issues in the relationship between researcher/designer and older participants as well as a way for the researcher to enter into the culture of the older people who were participating. The pattern of obtaining wider information about older people and computing was continued in focus group discussions within the “Computerware parties” but was also used in the requirements gathering phase with discussions with resthome dwellers and supporters of older users. The results gave continued support for incorporating information on older people from a wide range of sources.

With this background the role of Chapter 7, where the research methodology is described, is not to describe a research methodology that was adopted entire at the start of the overall study but to detail the research methodology that had emerged as a productive way of working during the course of the study, to examine the ways in which the techniques employed can be seen as legitimate borrowings from a variety of research traditions and to make a case for the validity of the methodology used.

10.10 Considerations in working with older people

As will be evident the underlying definition of the guidelines for designing for older users had evolved during the course of the research from “What interface features are suited to older people in the light of the literature review on aging?” to “What design process is useful for designing for older people is such a way that knowledge of aging <u>and</u> experience with older people contribute effectively to designs that are suited to older people?” As a part of this shift it was apparent that one of the key demands of a successful inclusion of older people in the design process was attention to how they were treated within that process. So rather unexpectedly in terms of the initial framing of the thesis, one of the skills that will be useful for designers is the ability to reflect on how one’s interaction with older participants is proceeding and the ability to make improvements to the interaction. Chapter 8 is thus still clearly aimed at using the research done during the thesis in order to contribute to the useful skills and knowledge of designers who are aiming at products for older people.

The areas of concern that are addressed in Chapter 8 cover the following areas; a brief overview of the interface design process for older users, appropriate ways of working with older people, specific techniques for developing applications with older people and ethical considerations with older people.

Under the heading of appropriate ways of working with older people Chapter 8 gives detailed consideration of the following issues, illustrated by experience gained in the course of the thesis research.

- Working with older people as if they came from a separate culture.
- Issues of establishing a framework where the older people see themselves as respected.
- Questions of the balance of power between researcher and older participants.
- Concerns about communication styles used.
- The problems in building time constraints into work with older people.
- Appropriate techniques of information gathering.
- Care of older participants.
- Approaches to sampling when acquiring groups of older participants.

In describing detailed techniques for including older people in application design Chapter 8 examines suggestions for managing the roles of older people in project development under the following headings and again gives examples of experiences from the three cases of interface design in the thesis research.

- Needs analysis
- Creating an initial credible prototype
- Prototyping
- Usability test cycles

The final main section of Chapter 8 explores the ethical issues that can arise during work with older people or indeed any other underprivileged or disabled group. Here more attention is paid to the writings of researchers such as Levy, Steele and Alm but again there is material showing how some of the concerns raised by these writers were experienced during the thesis research and some of the ways in which these concerns were addressed.

Without attention to these issues, simply involving older people in the design process would not have produced the degree of understanding of older people's needs and concerns that underlay the three successful design studies. It is acknowledged that working effectively with older people involves a relatively large skill set and one that may not be part of a typical designer's armory. However the point was made that older people are experienced in making allowances for the lack of skill younger people often display, so that the designer needs to show well intentioned and thoughtful interaction with older people rather than perfection.

10.11 The Relationship of the Thesis Research with the Dundee Research

The thesis has basically advanced the position that because of the gap between the capabilities, experiences and situation of the designer and the capabilities, experiences and situations of older people the designer needs to include older people within the design team. The thesis has also advanced the argument that design for older people is not a case for a design for a fixed set of age related disabilities but design that must work for a range of people who each have individual variations of the combination of losses that aging brings. In the thesis, design for old age is seen as requiring the designer to consider a range of age related effects but also to consider the designer's own relationship to the older people that they work with. Very similar themes are central to the position taken by Newell and co workers in relation to the research undertaken at the University of Dundee related to design for both older people and for people with disabilities. There are differences, Newell and co-workers have been more concerned with the effect of understanding good design for lowered ability on the usability of systems for the general population and in particular the relationship of techniques for reducing the effects of disability on designing systems for use by people from the normal population working in extreme circumstances where such things as environmental difficulties (noise, light etc.), protective clothing or speed of important input, challenge the user's ability to cope. My own work has a basic focus on assisting current older users and has not looked for wider implications. While my work looks at designing for variability in the types and levels of age related disability in the target population, Newell's group makes the correct and additional point that individuals will also vary over a range of timespans covering different levels of need for assistance over hours, months and years.

Despite the differences, when it comes to a practical view of how to work with and for older people the two approaches are very similar. The interesting point is that both approaches have been developed quite independently until 2003 when Alan Newell contacted me after the publication of a paper on SeniorMail. At this point I had completed the three design case studies using and simultaneously developing the methodology as described in the thesis. The extent of the similarities of the two approaches, coupled with their independent derivation and given the clear demonstration of successful products achieved using this design approach provides strong support for the overall approach.

10.12 Has the research achieved its aims?

In one sense it can be argued that the research has clearly achieved the aim of setting out and justifying guidelines for other designers interested in creating interface designs for older people. It has been shown that products can be created using the guidelines that are both usable by older people and are in fact enthusiastically received by them. The thesis in fact goes further by presenting the guidelines in a context of how they were arrived at, so that future designers can reflect on the differences between the design situation within which they are working and the design situations that existed in the case studies used in the thesis. This should have the advantage of allowing informed departure from the guidelines as the circumstances in which they are applied change.

In another sense we will not know if the research has achieved its aims until the findings are used and critiqued by other designers for older users. Personal communications from other researchers who have undertaken design projects for older users, (Aula, Dickinson and Newell) have been positive. When these researchers have seen parts of the overall research they have responded that the findings are in accord with what their experience has shown to be useful in design for older people.

However I am somewhat pessimistic. To quote Newell, “Making accessible interfaces for older people is a unique but many-faceted challenge”. This nicely encapsulates my own view on what I have discovered during this research. The problem is that meeting this unique and many faceted challenge is going to place considerable demands on designers, demands that their training and previous experience will not have prepared them for. Designers working in industry will be under pressure to produce results within a limited timeframe and a limited budget. Adapting design processes to fit older in-house testers who have a finite amount of time and effort that they can reasonably devote to product development per day will not sit easily within such constraints. There are further pressures that will be felt when trying to apply the approach in an industry setting. Retraining the designers themselves in skills of working with older non-computer literate people and gaining a background knowledge of aging takes time and access to providers of such training. Working with code based high fidelity prototypes runs counter to received wisdom in HCI and slows the development pace while increasing development costs and personnel. Further designing by reducing features and discounting appearance to achieve usability runs counter to most of a designer’s experience of what really matters if a designer is to be noticed, respected and promoted. Design for older users may also be hard to defend to a management concerned about budgets and marketers concerned about salability, what is being produced is (hopefully) impressive in terms of its usability but may be visually ordinary. Finally it is not known how great a market exists for products that older people can use. This is something of a chicken and egg situation, at present the Pew reports show that older people remain by far the smallest segment of the computer and internet using population and within that population the older group makes far less intensive use of almost all categories of computer use. Further the initial impressive growth rate of this group has flattened. The bulk of older people are unlikely to move to being frequent computer users until there are suitable products for the less able among them. But until there are a large number of older users who do not like standard available products (a contradiction in itself) there is a limited market for developing products that are suited to age affected older people.

There have been moves to force industry to move towards accessible web sites and products by legislation. However Kelly et al. (2005) among others argue that trying to enforce compliance with accessibility criteria is not a good way to provide older people with usable web sites and applications. Kelly et al. make the point that a system can fully comply with official usability guidelines but still be unusable, giving the example of providing an auditory rendition of a large table, where the spoken list of numbers is impossible to remember or extract relationships from, but is none the less officially accessible. Given this, when industry seeks inexpensive compliance with existing legislation, this is unlikely to radically improve the situation of older and disabled users.

10.13 Future directions for research

Ironically, having spent a rather long time exploring exactly what is needed in designing interfaces for older people and arriving at a description of a relatively slow and intensive process, I suggest that one of the urgent needs in future research is to explore ways of doing quick and dirty design for older people. It would be useful to know how much can be achieved with a relatively few rules and limited exposure to older people, if there is a form of design for older people that can fit more easily within industry development budgets it would be desirable to identify it. As always the aim is to increase the number of people who can make use of applications and web sites rather than to promote strictly ideal design for older people.

Given the difficulties identified in getting industry based designers to adopt the approaches to design for older people, the thesis advocates that is there a place for academic expertise in design for older people to be contracted out to industry. The UTOPIA team at Dundee has made a beginning on looking at this and found that such collaboration was demanding. One of the key issues they identify is convincing industry designers of the quantum leap between the usual people they design for and the reality of older computer novices. Further research on industry / academic collaboration is obviously desirable and this might include further attention to and identification of the factors that make such collaboration difficult.

A related issue lies in identifying what designers currently consider when asked to make designs suitable for older people, are there identifiable misconceptions in the design community that are sufficiently common to be worth developing material specifically to address re-education on these issues? Again the Dundee team has started to look at the use of videos with actors portraying older users, extending this to see how such videos impact the work of actual industry based designers will be difficult but looks to be worthwhile. A related issue is the question of how to make academic findings in the area available to industry. As Dray (2004) points out this is a more general issue where entrenched barriers and differences in perception of what is important, make fruitful communication between academics and industry difficult. Zaijcek (2003) looked at using pattern language for making her work on design for older people available to other designers, the problem here is that it is not certain that designers will be willing to make the effort of working through the rather lengthy format of patterns, especially if as is contended in this thesis, there are a very large number of patterns that are relevant to design for older people. Fisk et al. (2004) in their book “Designing for Older Adults” have taken the radical step (for academics) of writing in a much less academic style and deliberately avoiding endless referencing of the findings they use to make their case. The considerable combined authority of the authors makes this a valid approach. My reading of the book is that it should be readable for non-academic designers but feedback from actual non-academic designers would be useful. This thesis itself attempts to use a style that is accessible to non academics but I have a suspicion that few non-academics will ever read it while the style will be off-putting to a number of academic readers. One of the possibilities that could be of interest is to research suitable formats for design workshops for industry in this area. With the event of the web we appear to have a further decline in the influence of academic HCI as more web designers have career paths that do not include academic instruction in computing or in interface design. If there is going to be good design available for older people, academics will need to reach out, possibly by way of making exemplars of good design for older people available together with clear discussion of why the designs were developed in the manner chosen.

A more theoretical issue that is relevant to the work in this thesis is the question of how much disability is present in apparently well functioning members of the older population. The case studies in the research for the thesis made extensive use of input from the in-house testers. Neither of the in-house testers was apparently age impaired though as mentioned there was persistent difficulty in learning computer skills and concepts and for one of the people a degree of difficulty focusing clearly at the distance involved with computer screens. Nor did the extended testing group of older people used in the SeniorMail project cover examples of significant disability over all forms of age related disability. Why then should their input contribute to designs that older, demonstratably age impaired users were enthusiastic about? Salthouse (1996) and Newell and Gregor (2002) have considered the possibility that apparently well functioning older people do in fact have age related impairment but that under normal circumstances they make successful compensation for their problems. What we tend to think of as the problems of older people are not the onset of age related effects but the onset of the points at which the ability to compensate for age related effects starts to break down. Under this hypothesis, one of the reasons that apparently well functioning older people appreciate well designed software for older users is that they are freed from the effort needed to compensate for aspects of their own aging. It seems useful to see how far this can be confirmed and whether there are aspects of people's compensation for age related effects that can be identified and used to improve design for older people. It also seems useful to explore the related sampling issue of what extra benefits come to a design project if the older people who are recruited for the project come from groups who are more representative of the general older status population than the usually high status and well educated volunteers for research.

Another theoretical issue has already been mentioned in that it seems that older computer users should show some aspects of the general difficulties with dual task performance that have been shown to occur with age. While the Dual Task pilot study did not support this, it does not suggest any convincing reason why the effect should not have been observed and if dual task issues of cognitive resource scarcity do affect how older people benefit from an interface it will be worth while to understand how.

More specifically feature oriented areas for research include looking at how to make visual search easier for older users, suitable icon design for older users and the effective use of senior friendly skins for applications. New interfaces such as virtual reality and force feedback will provide new sets of challenges to older people whose sense of balance is less effective or whose motor control and proprioception (self awareness of body position) is aging. Even simple changes such as the touch mice and glossy screens on newer laptops are areas that may or may not suit older users and could benefit from research. To an extent all the recommendations on the design features that were found to be useful for older users contained in Appendix E can be seen as hypotheses about appropriate design for older users that are awaiting testing. This would include such things as establishing suitable parameters for animation that suits older people.

It was noted at the end of Chapter 5 on the FileTutor design study, that the format used in FileTutor for training older people in the use of the training wheels version of Windows Explorer could be adopted to provide a way of encapsulating an application within sets of notes to guide older users through seldom needed tasks. My observations are that current older users not only have difficulty remembering how to perform tasks but that the low intensity of their computer use means that the problems with remembering tasks are accentuated by having far fewer opportunities to practice tasks in real life than younger, more computer involved, users. Related enquiries could look at the content of the notes that older people currently write to themselves as reminders of how to carry out even basic tasks. In effect what is proposed here is that the equivalent of these notes are embedded with the application, I am reasonably confident that the current scrabbling in boxes, drawers and cubby holes in order to find a note written on scrap paper months ago is not a useful contribution to older people's application use but more seriously older people have stated that they find it important to write the notes on procedure themselves, it needs to be known if this is an important objection to the proposed style of application. Another related issue here is the use of wizards by older people. Here we have an application format that already provides guidance in following the steps in a procedure, is this more suitable than the proposed extension of the FileTutor format? Are there problems that older people find with wizards as they are presently presented and are there ways of addressing such problems?

The thesis has expressed a concern that those working on interface design may conclude that the current problems with older users may become less significant at a more computer experienced generation retires. Rather than take this on faith it seems worthwhile looking at the computing skills in the general middle aged population. How many of this group do in fact possess competent computer skills, how are computer skills distributed with education and income and thus what are the implications for the next older generations? It may be in fact that the numbers of older people for whom usable computer software becomes an important issue will actually grow as inadequately computer experienced people reach retirement age while at the same time the social isolation of being outside the computer literate group increases. Data is needed.

10.14 The overall thrust of the thesis

To sum up the thesis has created and repeatedly demonstrated a design process for creating user interfaces that suit older users. The thesis documents the process and discusses the changes to practice that a designer using the process can expect to make. The thesis has also provided resources to back the design process in the form of; 1.) a survey of the relevant effects of aging and a consideration of its implications. 2.) exemplars of the design process in the form of detailed descriptions of three working products resulting from the design process and discussion of how these products evolved, and 3.) consideration of the issues that designers should be aware of and sensitive to when working with older people within the design process.

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Appendix A Demographic shifts towards an older population

The data presented here is for the United States, U.S. Census Bureau (2004). US data may in fact show a less rapid move to an aging population than Europe or Japan. This is because of the high level of immigration from south of the US border and the high birth rate of the US Hispanic population mean that there is more replacement of younger population groups than in Europe or Japan. None the less the trend is stark. The data can be seen in summary in the following figure A.1. Supporting detail is then supplied in figures A.2 to A6 and tables A.1 and A.2.

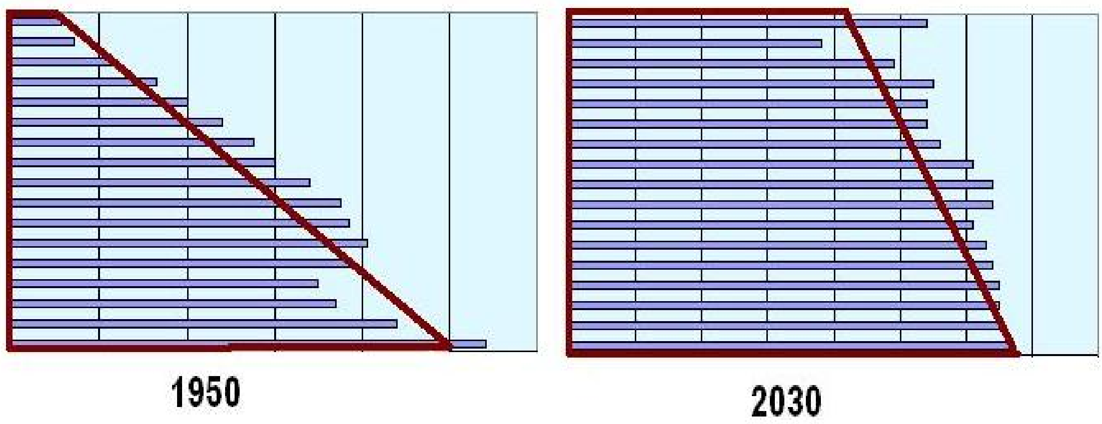

Figure A.1 Contrast in population structure from 1950 to 2030

In Figure E.1 the top band represents the 80+ age group, the bands then descend in 5 year age groupings to age 0 to 4 at the bottom. What is made very obvious in this figure is that there is a very rapid shift occurring from a triangular population structure with a relatively small proportion of the population over 60 (12.1% in 1950) to a population structure that is more nearly rectangular and having a substantial proportion of the population over 60 (a forecast 25% in 2030). In fact a full 30% of the population is predicted to be over 55 years of age in 2030 so the number of people who may benefit from software that includes adaptations to the effects of aging can be expected to be substantial.

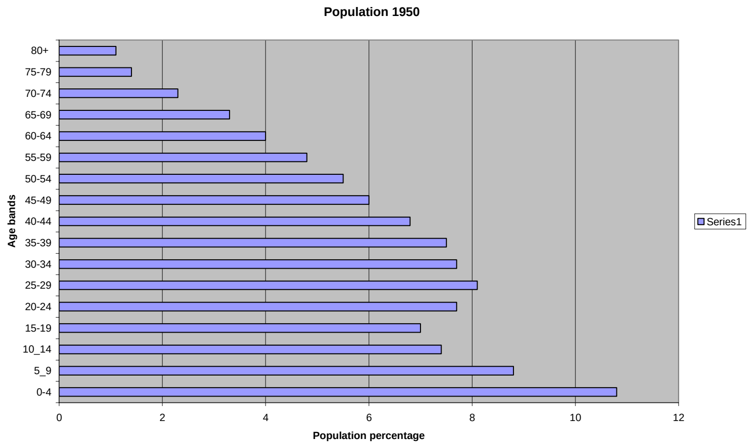

Figure A.2. Percentage of population by age bands for US population 1950

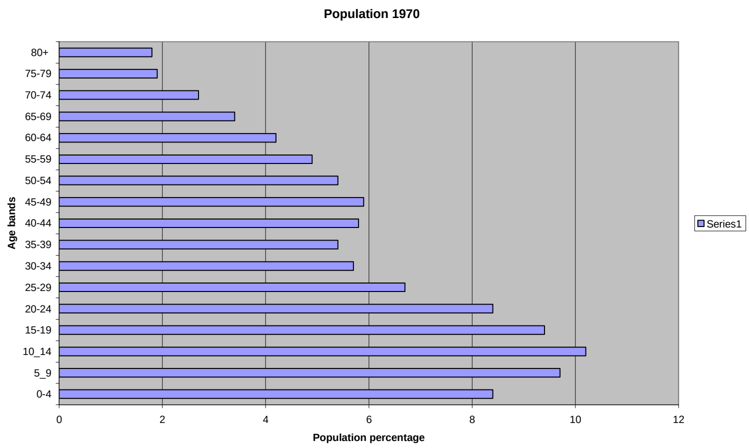

Figure A.3. Percentage of population by age bands for US population 1970

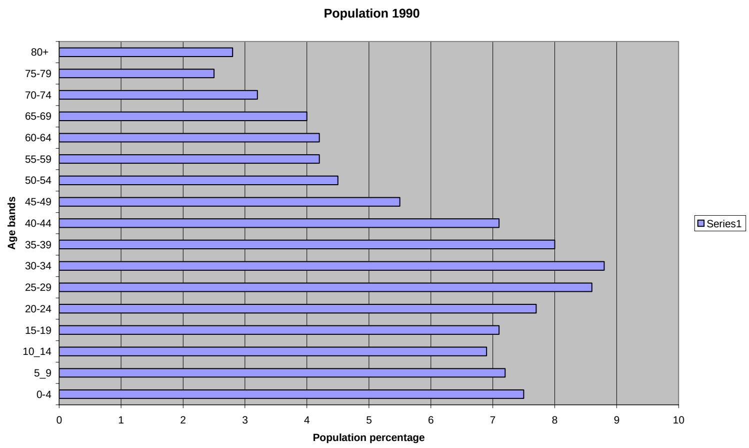

Figure A.4. Percentage of population by age bands for US population 1990

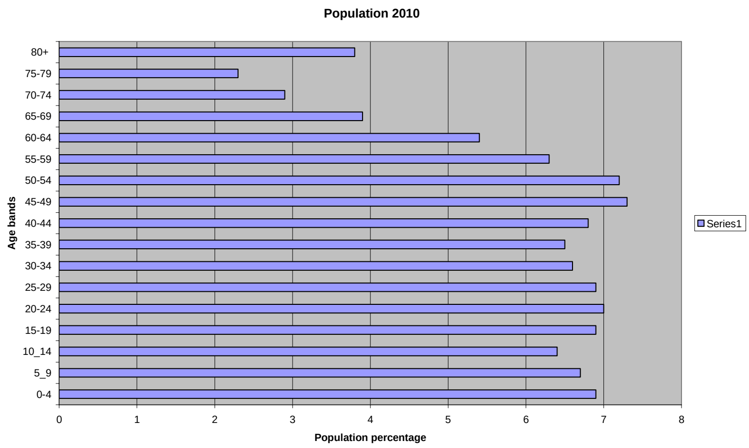

Figure A.5. Percentage of population by age bands for US population 2010

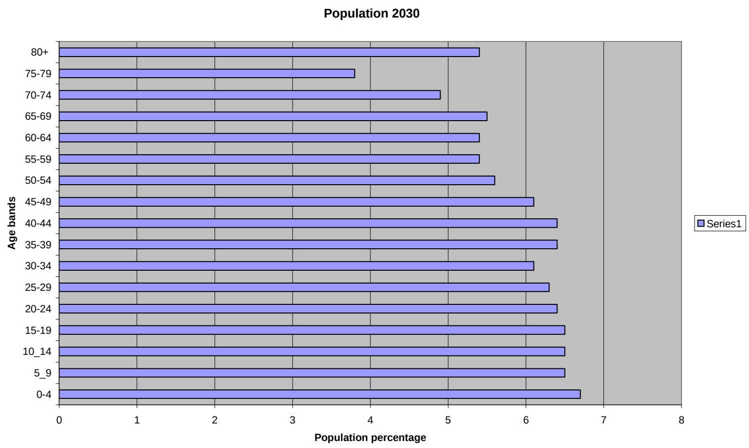

Figure A.6. Percentage of population by age bands for US population 2030

Table A.1 United States Percentage of population in age band by year 1950 - 2030

Year		1950	1960	1970	1980	1990	2000	2010	2020	2030
0-4		10.8	11.3	8.4	7.2	7.5	6.8	6.9	6.8	6.7
5-9		8.8	10.4	9.7	7.3	7.2	7.3	6.7	6.7	6.5
10-14		7.4	9.4	10.2	8.0	6.9	7.3	6.4	6.5	6.5
15-19		7.0	7.4	9.4	9.3	7.1	7.2	6.9	6.4	6.5
20-24		7.7	6.2	8.4	9.5	7.7	6.8	7.0	6.2	6.4
25-29		8.1	6.1	6.7	8.7	8.6	6.8	6.9	6.7	6.3
30-34		7.7	6.6	5.7	7.8	8.8	7.3	6.6	6.8	6.1
35-39		7.5	6.9	5.4	6.2	8.0	8.0	6.5	6.6	6.4
40-44		6.8	6.5	5.8	5.2	7.1	8.0	6.8	6.2	6.4
45-49		6.0	6.0	5.9	4.9	5.5	7.2	7.3	6.0	6.1
50-54		5.5	5.3	5.4	5.1	4.5	6.3	7.2	6.2	5.6
55-59		4.8	4.7	4.9	5.1	4.2	4.8	6.3	6.5	5.4
60-64		4.0	4.0	4.2	4.5	4.2	3.8	5.4	6.2	5.4
65-69		3.3	3.5	3.4	3.9	4.0	3.4	3.9	5.2	5.5
70-74		2.3	2.6	2.7	3.0	3.2	3.1	2.9	4.2	4.9
75-79		1.4	1.7	1.9	2.1	2.5	2.6	2.3	2.8	3.8
80+		1.1	1.4	1.8	2.3	2.8	3.3	3.8	4.0	5.4

Table A.2. United States Percentage of population in combined age bands by year 1950 - 2030

55 – 79		15.8	16.5	17.1	18.6	18.1	17.7	20.8	24.9	25
60 – 79		11	11.8	12.2	13.5	13.9	12.9	14.5	18.4	19.6
55+		16.9	17.9	18.9	20.9	20.9	21	24.6	28.9	30.4
60*		12.1	13.2	14	15.8	16.7	16.2	18.3	22.4	25

Source: U.S. Census Bureau (2004), International Data Base.
http://www.census.gov/cgi-bin/ipc/idbpyrs.pl?cty=US&out=y&ymax=250

accessed November 2005

Appendix B Test protocol used in evaluating the FileTutor study

The following one sheet set of tasks was used to see if the older participants in the FileTutor study could apply the skills learnt to the real world environment outside of file tutor. Subjects worked individually without assisting each other or using notes.

10.15 A check on your file and folder skills

1. Put your name here: ____________________________________

Tick the following jobs off as you complete them.

2. [ ] Start the real Windows Explorer

3. [ ] There is a folder called "**C:\Bills Stuff"** on your computer. Use Windows Explorer to help you draw a map (on paper) of the tree of folders that branches out from **Bill's Stuff**. Use the back of this page, just draw the folders, do not worry about the files.

4. [ ] There are three letters like **"letter to Sally and John 1.txt"** numbered 1, 2, 3. Use Windows Explorer to find the one called
   "letter to Sally and John 3.txt"
   and open it, add another line of text with your name and then save it and close the Notepad window.

5. [ ] Use Windows Explorer to copy a file called "**letter to Sally and John 2.txt**" from the folder called "**C:\Bills Stuff\Family**" to the folder called "**C:\Bills Stuff\Family\Sally and John**"

6. [ ] Use Windows Explorer to make some new folders called “**Bowls**” and “**House**” that are connected to the **“C:\Bills Stuff”** folder

7. [ ] Use Windows Explorer to move files from the “**C:\Bills Stuff\All sorts”** folder to folders that suit the topics. For example the letters about bowls should be moved to the “**Bowls**” folder

8. Show Dan the final result.

Participants were provided with a small folder tree on the C: drive of the computer that they were using. This folder tree had the following form.

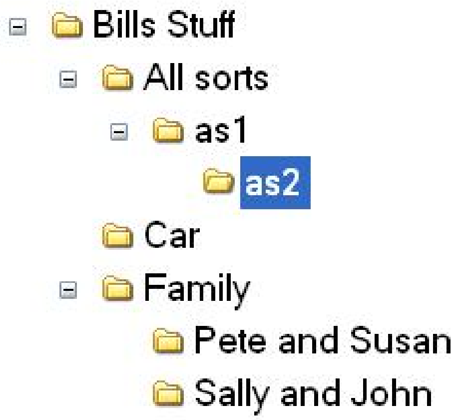

Figure B.1 Bill’s Stuff folder and sub-folders.

Appendix C Test protocol used in evaluating the SeniorMail study

The SeniorMail program was put into practice mode. This allows the simulated reception of first three emails and then a forth email in response to two clicks of the [Check for emails] button. It also allows the user to write dummy emails and send them although no actual emails are transmitted to the ISP.

The following set of scenarios was used with this practice mode setting of SeniorMail. Older users after a short introduction to SeniorMail were observed one on one carrying out the following tasks.

SeniorMail scenarios

1. Find out if there is any new mail

2. Read each of the 3 new messages
    Bob and Mary Shaw - poem suitable for later forwarding
    Jenny Wilson - thankyou for dinner
    Peter Mason - you left a pullover

3. Save the address of Bob and Mary Shaw to your address book

4. Send an email to Ann Smith (Ann is in your Address book) just saying
   "Hi Ann - I will come over tomorrow at 2.30"

5. Find the email from Peter Mason and reply to it saying
   "Thanks, we will pick it up next time we are round'

6. You have a snail-mail letter from a friend Kay Davies in which she says
    "Doug, my son has just set up email for me on my computer, my email address is kaydavies@hotmail.com

can you send me an email so I can send you one back"

Send her an email and save her email address while you are doing so.

7. Find and delete the email from Jenny Wilson

8. Find out if any more inwards mail has arrived while you were doing all this

   There should be 1 new msg from Sally Marsh with an attachment

9. The new message that has come in has a picture sent with it, have a look at the picture then reply to Sally Marsh saying "I liked the birthday card"

10. Pretend that you can't remember if you told Ann Smith the time you were coming over, find the copy of the email you sent to her and check what you said.

11. You want to find a poem that someone sent you several months ago. You have forgotten a lot of the details but you do remember that it contains a line mentioning the High Pyrenees. You decide to use the [Find] option on the main menu and search for any emails that contain the word Pyrenees.

12. You decide that you want to pass on the verse that came in the email from Bob and Mary Shaw to a friend called David Kelly who is in your address book. Find the email from Bob and Mary Shaw and forward it to David Kelly.

13. Use the "Write a new email" button on the main menu and send an email to Sue Travis (she is in your address book) with a picture of a flying pig that you will find in a folder called "My Pictures" when you look at the "Add attachments" tab when you are writing an email.

Questions for people taking part in the study on older people and email

1. Name:____

2. Year of birth: ____________________

3. What best describes your education?

   School Cert UE Some tertiary Bachelors degree Higher degree

   Comment:____

4. What has been (or is) your occupation or main occupations?

5. How do you rate your health?

   Poor health 1 2 3 4 5 Good health

6. Do you wear glasses or contact lenses at the computer?

   Yes / No

7. When you look at the computer screen how clear are the details? (with glasses / lenses if you use them)

   Very blurred 1 2 3 4 5 Perfect

8. How would you describe your typing skill?

   Hunt and peck 1 2 3 4 5 Expert

9. How easy do you find using the mouse?

A struggle	1	2	3	4	5	Easy

10. How frustrating do you find computers to use?

Very frustrating	1	2	3	4	5	Easy

11. Do you like using computers?

Really dislike	1	2	3	4	5	Like a lot

12. Why did you get your first personal computer?

13. Was you first computer bought new, bought second-hand, got for you by family, etc?

14. Which of theses ways were important as you learnt your computer skills?

1 not important – 5 very important

[ ] Self taught
[ ] Books
[ ] SeniorNet classes
[ ] Friends and family
[ ] Work
[ ] Other ______________________________

15. How many years or months have you been using computers?

16. How many years or months have you been using Windows?

17. How many hours a week do you use a computer?

18. How many times a week do you use email?

19. How many times a week do you use the World Wide Web?

20. The most common things I do on my computer are:-

21. Give a list of other things you would like to use your computer for in the future.

22. What has stopped you doing these things so far?

23. What are the most frequent problems you find with using a computer?

24. What do you see as the important issues for older computer users? (good as well as bad)

Appendix D Summary of age related problems

This appendix provides a summary of the age related changes reported in the literature survey from Chapter 2 that are potentially of relevance to an interface designer.

D.1 Changes in Vision for older people

D.2.1 Size and contrast

- Harder to focus at short distances
- Less ability to detect fine detail such as small print. This is worse in dim light, with low contrast and away from the center of the visual field
- Less ability to make out low contrast patterns
- Poorer color discrimination and detection especially in short wave lengths (blue-green)

D.2.1 Searching

- Visual search becomes harder
- Useful field of view declines
- Poorer pattern recognition, less recognition of embedded or incomplete figures
- Older people are less able to filter out irrelevant items
- Less ability to tell if similar objects are the same or different
- Visual search is improved by consistent positioning
- Visual search takes more effort, is more influenced by clutter and the number of irrelevant items, is generally slower and is particularly slow if older people have to check to make sure a target is absent
- Visual search is easier in a one dimensional space rather than a two dimensional space

D.2.1 Speed of perception

- Reading is slower
- Slower to recognize items but this effect is reduced for familiar items
- Ability to detect small movements declines

- Poorer estimates of speed and time of arrival
- It becomes difficult to read moving text
- Ability to detect flicker declines

D.2.1 Lighting and illumination

- More disrupted by glare
- Slower to adapt to changes in illumination

D.2.1 Perception of 3 dimensional information

- Poorer depth perception and estimation
- Poorer perception of 3 dimensional information

D.2 Changes in Speech and Hearing for older people

D.2.1 Speech

- Less distinct pronunciation with age
- More pauses and fillers such as “um”, “err”
- Harder to produce the exact word for precise requirements
- More tip of the tongue episodes where a familiar word cannot be found

D.2.2 Hearing

- High pitched sounds harder to hear
- Some words are lost when listening to speech
- High pitched voices can be harder to understand
- Harder to work out the location of a sound
- Harder to make sense of speech when there is background noise or competing speech
- Less able to deal with fast speech
- May depend on extra information from lip movements to make sense of speech
- Slower to respond to sound cues

D.3 Changes in Motor control for older people

- Response times are slower
- Movement is slower
- There is less control of speed, direction and force
- There are more small movements in a larger movement
- It is harder to track targets or pathways
- It is harder and slower to capture small targets
- There is more likelihood of overshooting targets
- Skilled movement such as typing by experts can be maintained but appears to require more plan ahead strategies
- Older people appear to adapt to poorer movement control by trading accuracy for speed and avoiding risk
- Coordinated movement is harder
- There are more involuntary movements
- Less accuracy in knowing one's own body position
- Poorer balance and more need for visual input to maintain balance
- Possibly less touch sensitivity

D.4 Changes in Memory in older people

D.4.1 Short term memory

- The ability to make use of information in short term memory declines
- Older people are slower to recall information from working memory
- One effect of reduced short term memory is in problems with text comprehension, especially for longer or more complex passages

D.4.2 Recognition and Recall from long term memory

- Deliberate recall of previously encountered material becomes harder with age
- Recognition of previously encountered items is not greatly affected if the items are simple
- Older people are likely to use inadequate strategies for learning new material so that it can be retrieved
- Structuring of memories may be worse in less educated older people

- Problems in using context to prompt recall memory as distinct from recognition
- Less ability to inhibit irrelevant memories
- Attempts to recall information are more affected by anxiety

D.4.3 Specialized forms of long term memory

- Spelling of unusually structured words becomes poorer
- Memory for how to do relatively simple things remains
- Skilled motor performance requires practice to retain
- There can be problems in remembering if a job has been done or is still to do
- There is poorer memory of spatial information and other non-verbal information
- There is poorer memory for where information was found (source memory)
- It becomes harder to remember to do jobs at some later point in time (remembering to remember or prospective memory)

D.5 Changes in Attention in older people

D.7.3 Attention and vigilance

- There are some problems with maintaining focused performance over time but this appears to depend on the type of task

D.7.3 Selective attention

- Poorer ability to inhibit responses to irrelevant items
- Less ability to control an activity with a top-down plan of action

D.7.3 Dual task performance

- Less able to do multiple tasks at once if the tasks are complex
- Problems in dual task situations may paradoxically show on the task that takes less concentration
- Anxiety reduces dual task performance

D.7.3 Automated responses

- New automatic responses are hard to form for older people

- Existing automatic responses are harder to suppress if necessary due to changed circumstances

D.6 Changes in Cognitive performance in older people

- Reasoning ability declines
- Speed of mental processing slows
- There is less ability to recall relevant information through associations with information presented in a problem (associative memory)
- When faced with problems older people rely more on existing knowledge and are less able to work out new solutions, (crystallized versus fluid intelligence).
- The performance of older experts is maintained at levels similar to younger experts but this depends on high levels of practice and does not translate into general ability in areas that relate to the expertise
- Older people are slower and less able at decision making
- While decline is relatively slow if one follows the same individuals over time the gap between today's younger people and older people is wider than the gap between today's older people as they were when young and as they are now. This is due to a well established but not fully explained improvement by each generation in test performance, (the Flynn effect).
- Losses of types of mental functioning are not uniform, they vary widely between older individuals
- Losses of cognitive performance tend to be correlated with losses in visual performance
- Older people adopt a more conservative strategy with regard to risk taking
- Ability to work with spatial problems declines

D.7 Changes in Learning in older people

D.7.3 Difficulties

- Learning takes more effort and takes longer

- Older people can be overwhelmed by younger instructors who go too fast, present too many ideas and tend to be impatient with the slow and uncertain progress typifying older people.
- Older people's learning can be disrupted by the provision of too much information
- Learning may be limited to a minimum or inadequate skill set in some older people
- Older people are likely to blame themselves for learning difficulties
- Where older people see themselves in negative age stereotyped terms this further impairs their ability to perform

D.7.3 Content

- Older people can learn a wide range of new skills
- Older people benefit from learning on a simplified model before using the more complex real world tool
- Older people benefit from a focus on learning a minimum of essential concepts and techniques
- Older people benefit from learning skills as a set of concrete procedures
- Older people benefit from actually performing skills as they learn
- Older people may benefit from simple background information that places their learning in context but they are disadvantaged by a focus on conceptual material
- Learning techniques such as ways of associating new items with categories in order to assist remembering can show continued benefit over years, but older people need encouragement to adopt such techniques

D.7.3 Format

- The speed with which individual older people learn varies widely
- Older people benefit from self paced learning
- There may be a long period during which learnt items are easily forgotten and need to be relearned more than once
- Older people appear to benefit from learning in small (2 – 4) groups rather than individually or in large groups

- There appears to be a benefit in having either an instructor from the same (older) age group or an instructor who has adjusted their style to accommodate older learners

Appendix E Detailed design examples from WinTutor, FileTutor and SeniorMail

This section provides a bullet pointed list of the design recommendations that have been developed from the experience of developing the WinTutor, FileTutor and SeniorMail systems. One of the issues in designing for older users is that the specific design recommendations for a particular application can be related to the effects of age related disabilities with hindsight but are not necessarily predictable in advance. One of the aims of this thesis is to provide not simply a description of how to design for older users but also a feel for the level of detail at which specific design decisions are made. So the rationale for including these descriptions of a wide variety of low level design decisions that are often specific to SeniorMail rather than more generally part of design for older users is to convey something of the feel involved in the process of designing for this group. Design for older users is often a matter of minutiae where different combinations of ideas about older people's needs come into play.
Application design recommendations

Vision

- Blocks of text are easier to read if surrounded by white space and older people benefit from this. However this means that standard multi-line text boxes need a border added at the left and this border needs to preserve the behavior of multi-line text boxes where dragging to the left of a line selects the text in that line. The assumption is that older people will have more trouble adapting to minor inconsistencies in the system model such a whitespace (the left hand border) that behaves differently from other whitespace.
- Blocks of text appear to benefit from a larger font size than short captions, for blocks of text give the user the ability to simply adjust the font to size 16 and to set the font to bold.
- Some older users find bold text an advantage, some do not
- Hints or bubble help should be in a readable font, be simply written and be timed so that there is long enough for older users to read them given slower reading speed and poorer performance under time pressure. However as older users are less able to inhibit distracting information and they are likely to move the mouse

comparatively slowly they may be distracted if hints pop up while they are slowly moving the mouse to a different intended target. Hence - do not have the hint pop up too quickly. And again avoid covering up useful screen information with the hint, remember that older people make less sense of what they see when they can only see part of something.

- Older users were often observed to use the mouse cursor as a pointer to assist them while reading blocks of text. Therefore hints should not be shown in response to a mouse over on blocks of text.
- Use larger than normal icons and keep icon designs distinctive and simple, do not rely on minor changes in color or detail to distinguish icons. As a counter example the Windows Desktop method for showing a selected icon selects the icon's caption and makes the icon's colors much duller and hence harder to distinguish from each other. This makes the icon harder to interpret and on returning to the Desktop makes the supposedly highlighted icon harder to find for older users because it is both duller than the competing icons and it no longer looks like the icon they initially searched for.
- Do not expect many older people to turn on accessibility features such as altering the basic font size, their computer knowledge is usually not up to this, nor is the computer knowledge of the supporters of older users interviewed for this study.
- One consequence of the frequently poor typing skills of older users is that they look at the keyboard instead of the screen while typing and this makes it possible for them to miss that they are not typing within the input area that they intended to type into.
- Using full screen designs with plain backgrounds and no graphics unless the graphics are really relevant to understanding how to use the application is part of the more general rule of avoiding distracting background material.

Visual Search and Reduced effective field of view

- Expect older users to fail to find important screen features that you consider obvious. Older users can be surprisingly blind to parts of the screen away from the areas they usually look at.
- Try and put controls very close to the effects they produce. This helps assist with the reduced effective field of view of some older people.

- Status bar information at the bottom of the screen is likely to be missed by too many older people for it to be useful given their restricted effective field of view.
- When you ask older users to look for the right action, restrict the number of choices because older people are poorer at searching long lists. Ask your older users what features are actually going to be used by your target group.
- Put choices in a list or along a row, avoid two dimensional arrays or random patterns of choices. Older people perform better on searches of short, one dimensional arrays.
- Aim for consistent positioning of controls in each part of your application. Older people are better at searching when there is consistent positioning of search targets.
- "Flat" buttons that only take on the appearance of buttons on a mouse over appear to give older people a less useful cue when they are thinking, "I need to find and click the [Something] <u>button</u>". They also seem to worry older users as they change appearance, where a designer might expect them to welcome confirmation that they were on target. The response I observed was along the lines of "Why has it done that?" rather than "Oh good I have got there". In addition flat toolbar style buttons that only show as a button when the mouse moves over them give a smaller visual target.
- Menus in typical Windows programs offer too many choices for easy searching by older users, keep to very simple menus or avoid menus. Older people are particularly disrupted by large numbers of irrelevant items when searching.
- Older people were observed frequently losing the cursor when it was over a text background. Older people benefit from a larger and bolder cursor, especially over text. The cursors that older people seem to prefer have thicker lines as well as being larger.

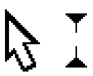

Figure E.1. Examples of enlarged bold cursors used in SeniorMail. The one on the left is the modified default cursor and the one on the right is the modified text cursor.

Manipulation

- Provide large targets. This includes larger buttons but also includes providing large fonts for entering and correcting text or when using listboxes and menus. It is not that older people are unable to capture small targets but that doing so requires concentrated effort that can distract them from the overall task.
- Some controls like radio buttons and check boxes visually imply a very small target area. Provide a larger target area by contrasting the control color with the background and possibly extending the active area at the front of the control with a label that shares the Click response with the radio button or check box.

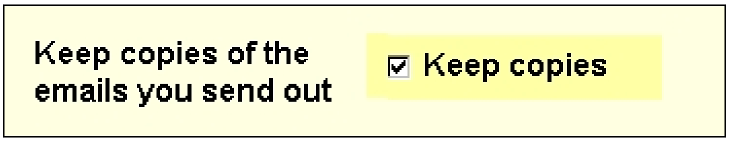

Figure E.2. Enlarging the target area for a checkbox, all the outlined area is clickable.

- Use open listboxes rather than drop down lists because of the small target size of the button that opens the list. It is also likely that some older users will not know the conventions behind the use of drop down listboxes.
- Use full screen windows and a few modal (stay on top) pop-up windows. Experience suggests that older users will be poor at window management tasks such as resizing, the window border is too small a target to acquire and the penalty for clicking off target can be severe, (the whole window vanishes!). Older users are generally in danger of unknowingly clicking on a background window (reduced accuracy in clicking on very small targets) and then being mystified by the fact that the window on which they were working has vanished. Usually their limited knowledge of the application model makes it difficult to get back to a window that has been hidden when another window comes to the front.
- Be wary of requiring drag operations, provide an alternative or avoid drag and drop altogether, especially over long distances. Some older people have difficulty combining mouse movement with holding a button down, this results in inadvertent dropping before the target is reached. For some older people similar inadvertent dropping was seen due to involuntary clicks on the right mouse button while

dragging. Some older users have difficulty in coordinating the mouse position with the timing of the release of the mouse button so that the mouse may have moved off target again when the drop is attempted.

- Do not require double clicking - many older users either cannot do this or cannot do this reliably. Also be aware that repeated single clicks on the captions of some components like icons or list views and tree views can put the caption into edit mode. Older people who cause this effect by slow attempts at double clicking are likely to be bewildered by what they have done and unsure about how to get out of the new mode.
- The need for double clicking means that a desktop icon should not be the only way of making a program for older people available. The points that these icons can be made to respond to single clicks or show an Open option if right clicked are irrelevant as most older people and many of their supporters will be unaware of these alternatives.

Menus and Sub-menus

- Avoiding the use of standard Windows menus and making the home screen a menu of command buttons has two effects, it increases the ease with which some older users can get access to features and it provides the older user with a frequently visited visual map of the core features of the system.

Typing

- Typing remains a major stumbling block for some older users. SeniorMail has not attempted to provide a solution to this.
- Given the slow pace at which older people acquire and consolidate new skills, typing remains a hard task for many of these older struggling typists for years. Given their reduced effectiveness in visual search some older typists can be described as, "hunt, hunt, swear, hunt and peck", and they can be seen going through the same agonizing process for the next occurrence of a letter that they have found only a few seconds before.
- Typing by older users is frequently error prone. In SeniorMail a spelling checker that displayed errors with red wriggly underlines is used. This provides a pop up menu of choices for spelling correction that older users found useful. However it needs to be explained as even those older users in the sample who used MS Word did not know

the meaning of the red underlines or know functionality of this approach to spell checking.

- Problems such as typing mean that creating work is harder for older users and therefore losing what one has done is a bigger loss. Try and design so as to preserve older user's work despite possible errors.

Comprehension

- Reduced complexity is the main way of increasing comprehension.
- Keep the system model simple. There should be as few parts to the system as possible and each part should have a clearly designed task. The aim is to make it very easy for the older user to form a mental model of the application.
- It is possible to go some way towards sheltering older users from the complexities of the operating system and the file management system.
- Layers of options can serve to keep more complex options away from older novices but there is a tradeoff with ease of use for more experienced or more capable users.
- Some simple analogies may help rather than conceptual explanations. Do not rely on users absorbing explanations of the underlying concepts. Older users appear to spend a long time working at a procedural level. Trying to think of the explanation as well as remember the procedural steps may simply give the older person more information than is useful.
- On making an error, older people are likely to be less able to work out what has gone wrong and to recover from the problem. A lot of design work needs to go into designing out errors that show up in prototype testing.
- Older users trying to understand what to do can be very literal in their interpretation of instructions. As an example, an error message read, "Click on the line for an email and then click the [Open] button". The result was that older users attempted to click on the email line and the [Open] button while the modal message box was still displaying. Changing the message to the future tense improved this, "You will need to click on the line for an email and then click the [Open] button". Another approach could have been to change the error dialog box so that it was float on top but not modal so that the older user could in fact respond as instructed while the error message was still displayed.
- In a further example an email address pick list actually showed a list of names rather than email addresses, some older users therefore objected to calling this an

"address list". This was not pedantry, they were worried and a little stressed by the inconsistency. The pick list was renamed "Who is the email going to?".

- Older users may not anticipate the later consequences of actions that they take. As an example older people are more prone to replying to a whole mailing list rather than just the sender as their mental model of "reply" does not seem to easily accommodate that the reply will by default go to more people than the person they intend replying to. A solution in this case was to give a dialog identifying that they were responding to an email from a mailing list and asking if they wanted to reply to the sender (default) or the whole list.
- As another example SeniorMail made it safe to delete emails even if they were later found to be wanted. Deleting moved emails to a recently deleted list.
- Unexpected situations are likely to be interpreted as errors rather than predictable and reversible consequences of past actions. An example from SeniorMail is where a temporary category filter has been placed on an email list, the older user has then left the list, done some other work and later returned to the list. The response is not "Oh, I am only showing bridge club emails" but, "I have lost most of my emails". It was found to be better to turn off filtering when the user left the list so that they returned to an unfiltered list.
- A realistic stress factor when older people are responding to errors is the difficulty older people face in obtaining support. Supporters often live some distance away. Asking for support can be felt to be embarrassing in that it exposes the older user's lack of competence and that it places a further demand on one’s friends or relatives. Depending on the availability of visits from supporters there may be a delay of days or weeks during which the computer is inoperable. Support from computer suppliers is expensive and transporting the computer is a major physical effort coupled with uncertainty as to whether the older user can successfully reconnect the cabling.

Idiomatic knowledge

- Expect older users to have large gaps in their knowledge of basic idioms of the graphical user interface environment they are in. Examples I have met include; not realizing that one was expected to click [OK] to complete interaction with a dialog box, not knowing about column sorting by clicking column headers, not understanding tabbed pages, not understanding the implications of text being selected, not understanding the Windows task bar, not knowing about Alt-Tab form swapping between programs, not understanding windows management skills such as dragging a top most window to a different location by using the title bar and so on.

- A lot of design depends on users seeing a cue such as a button and jumping to the "obvious" conclusion that they should click it. We, as younger users, interpret the screen based on a wide knowledge of standard ways of doing things in our particular graphical user interface. However in designing for older users, expect older people to have a fragmentary knowledge of such standards.
- As an example about 20% of the older users I tested with the email system did not know that the intended response to a dialog box is to click [OK] after entering one's choices. All the other buttons in the email system had colored icons and I found that including similar icons on the [OK] and [Cancel] buttons led the older users to examine them as possible solutions for the next step to take. This may also relate to older user's need for a stronger stimulus if items are to be seen at the edges of the effective field of view and the fact that without knowledge of the standard model for a dialog box the older user was not getting a preparatory cue indicating where they should look for the next step.
- As another example I found older users consistently ignored or were puzzled by very simple tabbed pages with a single row of two or three tabs. See Figures 6.11, 6.12 and 6.13. The older users had very rapidly formed the habit of searching the toolbar for options and ignored the [Add attachments] tab immediately under the toolbar. The solution was to put an [Attach] button on the toolbar that had the effect of opening the [Add attachments] tab.
- As an aside on tabbed pages, they seem to illustrate the weak level at which some older users view the application as an integrated whole rather than as a set of loosely connected parts. Older users would go to a tabbed page in the Editor and successfully choose a file and add it to the email as an attachment. But when they returned to the other tabbed page in the editor where the message text was entered they asked why there was no attachment on the email, this in spite of the attachment tab caption having changed to show the number of attachments made. The solution was to show a prominent drop down list of the attachments that had been added to the email to provide confirmation that what they had done had actually altered the email as seen on the page where the email's text was shown. As

a younger designer my assumption was that conceptually the two tabbed pages should be seen as part of a whole, this did not happen for the older users I tested.

Figure E.3. The tabbed pages of the editor were not understood

Memory

- Radically simplifying the number of choices available reduces the amount to be remembered.
- Making the choices visible instead of hiding them in menus reduces the load of trying to remember where a feature is to be found. For example a row of large toolbar buttons at the top of each screen means that if an older user has forgotten what to do they simply look along the toolbar.
- Do not ask older users to remember material from one screen or page to another, for example in SeniorMail Help information displays in small float on top (non-modal) windows so that the older user can see the aspects of the application that the Help information is referring to and carry out the steps described in the Help. (Microsoft has started providing this form of "Tooltip" help but it would benefit from a larger font.)
- The numbered instruction style developed for the FileTutor tutorial to guide older people through a series of procedural steps without getting lost can be useful in designing Help information for Help systems
- Do not depend on older users remembering to do things. In the email example there is a reminder if an unsent email exists when the user decides to exit the program. There was also a decision not to automatically poll for new emails on the grounds that older people might forget that this kept their connection to the internet live and

thus leave the email program running with the possibility of higher connection charges than they expected.

Learning applications

- Expect older users to try and use applications without having put much time into learning them. Older users, like anyone else, want to get going quickly without a lot of preparation.
- Your applications for older people need to make more of the knowledge needed to run them, "knowledge in the world" rather than, "knowledge in the head".
- One of the areas in which what seems to a designer to be "knowledge in the world" is actually "knowledge in the head" for older users, is when labels and instructions use computer jargon.
- A major area in which older users fail to learn enough to work effectively is in learning to understand the file management system. Expect older users to struggle with file Open and Save dialogs, especially if they are asked to change folders. Also expect older users to have problems finding documents they have previously created. The effects can take a number of forms, I have met older users who basically put all their word processing in one enormous document, that was the one they knew how to find through the recently opened files list in the MS Word menu, so each new bit of writing went at the end of this single document. I have also met older users who put most of their documents onto the desktop with consequent problems with clutter. Other older users have everything in "My documents" but the folder is so full that it is very hard to search and too big to back up.
- Try and design applications for older users so that they minimize the amount of learning required. One technique is to divide the application so that some configuration tasks are off-loaded to the supporters of the older users.
- If older people learn one way of doing something at the start of using an application they will find it very difficult to switch to another more efficient method later. This means that the designer needs to be concerned with what methods for controlling the application get exposed first.
- Another aspect of this is that older people can be blind to things that conflict with their initial learning. Told initially that the functions they needed could be found on the toolbar buttons at the top, older users ignored clearly labeled buttons that were relevant to the task they were attempting and less than 4 cm from the toolbar.

- If there are three standard ways of doing a job then some of your older users will each know only one of these three and the one's that they know will be different. All standard approaches need to be supported. At the same time the older users I have worked with complained strongly if more than one way of doing something was included in the learning instructions. As an example of coping with this, in an email system for older users, when an email needs to be opened, the user clicks on the header line and then clicks on an [Open] button on the toolbar. This is the official instruction given to new learners. However double clicking and pressing the Enter key also open the email, it is simply that they will be used by people who expect these capabilities and will be ignored by other users. As another example I have made my email program available from the Start/Programs menu, from a desktop icon and from the Start/Run option.
- One of the things that older learners will have reliably learnt is that when they use the computer, things go wrong. I find that older users may need reassurance that an action has succeeded, for example a small message, "Please wait, saving the address", that appears and sits in mid screen for a second. Younger people tend to assume that if they clicked the [Save Address] button the address will have been saved. Note that I am not requiring the older users to respond to a message box by clicking an [OK] button, this in itself can be disruptive. Instead the message appears for long enough to be read and then vanishes of its own accord.
- Another thing that older people will have learnt is that Help systems do not give them what they are after. Expect many of your older users to avoid even attempting to find information in Help systems.

Interactive tutorial design for older learners

This section provides a bullet pointed list of the detailed design recommendations that have been developed from the experience of developing the FileTutor and WinTutor interactive tutorials.

Designing for the older user's background - Recommendations

- Provide a high level of success, many older users have previous experience of failure with a variety of learning approaches and this needs to be combated.
- Provide a safe environment for carrying out exercises where mistakes are non damaging and easy to recover from, by the very people who are most likely to

make those mistakes. This can involve providing an easy "Undo" feature and a safe practice area that will not affect the rest of the user's computing environment.

- Allow for self paced learning and the ability to repeat sections of the material. Also provide support for small group learning as a social activity rather than making learning purely machine focused. Make it easy to use tutorials for revision at home.
- The above points imply an easily understood architecture and simple navigation methods for moving around in the tutorial.
- Cater for a wide range of learning styles from highly verbal to largely activity based and from learning of procedural steps to a desire to understand the underlying model.

Visual design for older users - Recommendations

- Graphics should be relevant. They should also be clear, large featured and simple.
- Avoid any visual distractions in the form of purely decorative graphics, wallpaper or animation.
- Make graphic features involved in exercises easy to locate while retaining realism.
- Graphics may change in the course of an exercise or demonstration but this should either be step by step in response to the user's actions or in slowed animation.
- Particularly for older users visual feedback resulting from actions needs to occur close to the site of the action that causes the effect. Graphics should be placed close to any instructions that refer to the graphics.
- Older people can make use of some spatial metaphors but the designer should be careful to user test elements that depend on spatial understanding.
- Do not ask older users to rely on remembering graphic information between screens.

Text instruction format for older users - Recommendations

- The text format that worked in FileTutor matches recommendations by Morrell and Echt (1996, 1997) and Morrow and Leirer (1999). Text used was a dark Arial

12 - 14 point sans-serif font contrasting strongly with a very pale plain cream background chosen to reduce glare. White space was used to help keep items separate.

- Instruction content that worked in FileTutor matches recommendations by Morrell and Echt (1996, 1997) and Morrow and Leirer (1999). Sentence construction and language were kept simple, negatives were avoided, sentences and lines were kept short, instructions were phrased in an active voice.
- Morrow and Leirer (1999) note the advantages of lists for older people for such things as medication instructions, in FileTutor where older users are following sequences of multiple steps to carry out a procedure, numbered lists were found to be better.
- Inserting statements of what has been achieved up to this point may be useful as a way of helping older users understand what they are doing in long lists of procedural steps.
- Do not combine two or more procedures within one point in a list of instructions.
- Provide a consistent layout so that older students know where to expect instructions.
- Place instructions physically close to the point on the screen where they are to be applied.
- Test instructions carefully to remove ambiguity and avoid unexpected results.
- Use concrete examples and language together with supporting and relevant illustrations.
- Instructions that ask users to type some specified text should use a distinctive font to identify what is to be typed, not quotes.

Manipulative design for older users - Recommendations

- Keep the required manipulations simple.
- Provide large, easy to locate targets for manipulation.
- Reduce the need to scroll.
- Avoid requiring double clicks while allowing them for those older users who are comfortable doing so.
- Use of pop-up menus and right clicking is a satisfactory way of avoiding the problems some older users find with double clicking and / or with using main menus distant from the site of the intended action and results.

- Changes to improve manipulation should still maintain the basic behavior of the application being learnt.

Interactive graphics - Recommendations

- Using interactive graphics to integrate explanations, instructions and exercises within the same screen is an important way of designing to accommodate the reduced working memory of (some) older students
- Interaction with interactive graphics should be in terms of a series of exercises that actively develops the older students' skills and understanding.
- Older students benefit from having a working but simplified version of the application being learnt embedded in the interactive graphic.
- Interactive graphics should be driven in single steps by the student's actions with the aim of getting the student to actively explore the topic.
- Make the interactive exercises as quick and easy to perform as possible.

Menus and Sub-menus

- In line with Carroll's "training wheels" and "minimal manual" the menu structure used while older users are learning should be strongly simplified.

Typing

- Typing should be reduced where possible for older users. In particular the effort of typing may compete for cognitive resources and displace material in short term memory thus reducing the effectiveness of older learners.

Comprehension ,Memory and Learning - Recommendations

- Deal only with a core set of essential skills and concepts taking Carroll's "training wheels", "minimal manual" and "active learning" approaches throughout.
- Background material is important to a sub-group of older learners, this should be made available in a way that allows most learners to ignore it.
- Begin from a starting point that should be at simple revision level for most of the older users involved. Be prepared for gaps in understanding of very basic Windows skills.
- Introduce topics and concepts more slowly than for a younger audience, carefully building on a structured development of supporting concepts.

- Use an active approach to learning so that students put their new knowledge into effect as they acquire it. Do not assume that simply telling older users about a concept will allow them to integrate the concept into their mental model. Where possible provide explicit interactive exercises aimed at letting them check their understanding of the concept.
- Concepts and skills developed early in a tutorial should be reinforced and re-emphasized in later topics. Do not assume that because some skills have been covered previously, older students will be able to incorporate these skills into later exercises without further instruction.
- Having older students work with a consistent set of example material can aid building understanding
- The time frame in which (some) older users learn may be much, much longer than one would expect for younger students.