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A serious game to provide social skills training  
for people with Asperger's Syndrome/High-  
Functioning Autism

A thesis

submitted in partial fulfilment

of the requirements for the degree

of

**Doctor of Philosophy in Computer Science**

at

**The University of Waikato**

by

**Khadija Bahiss**



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

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# Dedication

*This thesis is dedicated to my father — Shamsuddin Bahiss and my mother—Jamila Bahiss. The Sun and the Moon of my life.*

*No words of gratitude do justice to the sacrifices you have made on our behalf. To prefer others over oneself is a remarkable and rare quality and I am humbled by your unconditional love, support, sacrifices, and prayers.*

*Indeed, all good comes from Allah and I am both grateful and fortunate that I was chosen to be your child for I have learned to love, to live, and to give selflessly from you.*

*Among countless things, I want to Thank you for the gift of knowledge, and for instilling the mindfulness of the Creator rather than the fear of the creation in my heart. Thus, guiding me to find the true purpose of my existence, for indeed life is too short and too precious to be wasted in wander.*

*May you be blessed with the best of both Worlds, and may we be united in Jannat-ul-Firdous through His Divine Mercy. I pray I can be the half the parent you are, for indeed my love, and admiration of you cannot be expressed in words.*

# Abstract

This thesis presents the development and evaluation of a prototype serious computer game to provide social skill training for young adults and adults with High-Functioning Autism.

Autism is a neurodevelopmental condition changing the way people see the world and interact with others. It occurs on a spectrum of severity, with individuals at the less severe end classified as having High-Functioning Autism (HFA). Individuals with HFA present above average intelligence but socio-communicative deficits in non-verbal and verbal behaviour. As individuals with HFA transition into adolescence and adulthood, they struggle to sustain education, employment, and social relationships. Socio-communicative deficits can be positively addressed through social skills training interventions, designed and delivered by behaviour therapists. However, these therapies are not readily available to most individuals due to the intervention costs and shortage of specialized therapists.

Computer interventions designed to address socio-communicative deficits among children, adolescents and adults with HFA show promising results. One style of intervention is the serious game format. Serious games are designed to deliver learning outcomes, but present as games, and so typically have greater appeal than overtly pedagogical software.

A game was created in Unity 3D as a first-person view of a restaurant environment and experience. In the game, the participant walks into a restaurant, interacts with a greeter, is led to a table and seated, and is joined for dinner by a friend. The game integrates features from social skill training interventions with the interactive experience, addressing multiple social skills.

Evaluation of the game for its effectiveness and usefulness for social skills training showed that it provided a plausible learning environment, in that it raised awareness of skills and neurotypical behaviour, and it reduced anticipated anxiety for most trial participants towards future situations in which the social skills might be needed. The level of realism achieved was not demonstrated to be sufficient to provide a fully immersive experience particularly with respect to the skill of making and maintaining eye contact. Further work is required to make the serious game sufficiently realistic to provide a complete training experience, and to find out if the training it offers can be transferred into real world interactions.

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I want to thank Allah for blessing me with this opportunity to pursue this journey of seeking and applying knowledge, granting me the strength and stamina to embrace it and persevere at the face of all the obstacles over its course. I have completed this journey with a sense of accomplishment as Life threw enough challenges my way for me to give up many a times. I will not be where I am today if I were not blessed with those around me who advised me, held my hand, and wiped my tears when I felt broken and unworthy, and reminded me that I can do this, I just need to keep going. Therefore, I rightfully want to acknowledge them.

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# 1 Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that affects cognitive, sensory, and social processing, changing the way people see the world and interact with others. It is no longer regarded as a mental illness, but rather a neurological difference. The number of children diagnosed with Autism has increased since 2000, with approximately 1 in 68 children being given a diagnosis of Autism in 2016 (Khowaja, 2017). Autism is variable and complex and occurs on a scale or spectrum that is based on the degree of severity and variety of manifestations, hence the label Autism Spectrum Disorder. Informally, elements of the Autism spectrum are referred to as including severe, moderate, mild, and High-Functioning Autism (HFA). Classic Autism is the name given to severe Autism, and Asperger's Syndrome is on the mild (High-Functioning) end of the Spectrum (Jones & Meldal, 2001). People on the Autism spectrum may also exhibit physical and/or intellectual disability; however, these are not directly associated with Autism. A combination of the following traits categorizes Autism: social-communicative deficits in verbal behaviour, non-verbal behaviour, and assertive behaviour; fixation on a topic of interest; repetitive motor movements; insisting on routine; resisting change; and being hyper- or hypo-reactive to sensory stimuli (Noor et al., 2012).

As a neurological difference, Autism is not treated with medication; however, several systems designed to address different traits have proven to be effective in improving the overall quality of life for people on the Autism spectrum. These systems include Applied Behaviour Analysis (ABA), Occupational Therapy (OP), Social Skills Training (SST), and Speech Therapy (Kurtz, 2008). These systems are most effective when introduced early in life; therefore, research has been mainly focused on intervention for children. Every individual on the spectrum is unique, so behaviour therapists personalize systems to their clients' needs (Wilkinson & Canter, 1982).

Since people with Autism do not exhibit any physical traits, it is sometimes difficult to identify individuals with Asperger's Syndrome/High-Functioning Autism (HFA). Excellence in their area of interest or education may also contribute to this difficulty. The lack of physical identifiers combined with the social-communicative deficits leads to peer rejection, social isolation, anxiety disorders, depression, low self-esteem, which in turn can lead to a lower overall quality of life (Attwood, 2000; Bellini, 2004; Irish, 2013; Tse et al., 2007). This situation is particularly

devastating for high functioning young adults and adults as they struggle to navigate daily social life and live independently. The New Zealand government provides the Ongoing Resources Scheme (ORS) funding to schools to support students with the highest level of need for special education. Children on the Autism spectrum with severe to mild learning difficulty qualify for early intervention through such schemes; however, children with HFA display coping mechanisms and do not meet the criterion for learning support. There is little to no funded support for adults with HFA. Therapies for Autism are costly (Georgescu et al., 2014). People on the Autism spectrum may not be able to maintain a job due to social skills deficits, resulting in an inability to afford therapies. There is a need for affordable alternative therapies.

One of the shared traits among people on the Autism spectrum is their interest in and attraction to computing, particularly to computer games (Georgescu et al., 2014). For the general population computing game environments are already widely used in teaching several subjects; such programs are referred to as serious games. Serious games “have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining” (Noor et al., 2012, p.647). Serious games vary from simple to complex, depending on the target group and required learning outcomes. The popular serious game genres for young adults and adults use 3D immersive environments on screen or with virtual reality head-mounted equipment. Such computer games are fun and highly engaging; they immerse people in alternate worlds, intrinsically provide motivation for participation, and improve critical thinking (Annetta et al., 2010; Hirumi, 2010; Stichter et al., 2014).

The review of previous research presented in Section 2.3 shows that serious games can be effective in positively addressing several autistic traits in children, young adults, and adults with Autism. It shows that most studies explore social and communication skills and focus on children with Autism. There are several advantages that the computer game format has towards addressing social and communication skills. The first and foremost advantage is that it provides the opportunity for experimenting with social situations by removing factors of social anxiety and fear that are associated with real world or real face-to-face interactions (Cappadocia & Weiss, 2011; Serret et al., 2014). A single player computer game is a virtual training environment; hence both self-consciousness and worry of failure are minimised. It can encourage lateral and strategic thinking

for solving complex problems by training the user to make effective decisions in stressful situations, while considering the moral and ethical implications of those decisions. It allows users to focus on achieving the set goals by removing distractions, controlling external stimuli, putting the user in charge of the situation (i.e., noise level control), and supporting repeated experimentation with social situations. It provides the right balance between challenges and skills, by training the user to learn and apply newly acquired skills in an appropriate time frame (removing time pressure), and is cost-effective (eliminating the cost attached to a therapy session). Last but not least, it provides immediate feedback, a vital component of the success of any training that is otherwise costly to achieve (Hirumi, 2010).

## **1.1 Research question**

The existing social skills training research for people with Autism successfully addresses several autistic traits through computer games, and is designed for diverse age groups. Most of the existing research is focused on socio-communicative skills and is primarily conducted with children who have Autism. There is some funding available for relevant therapies for children with High-Functioning Autism (HFA) through the educational sector. As these individuals' transition into adulthood, they no longer qualify for funding due to their high functioning nature and exiting the educational sector. In adulthood these individuals are required to form meaningful relationships in their personal and professional life and are expected to conduct themselves in socially acceptable manner. This expectation in adulthood amplifies the need for relevant therapies especially for social conduct and are underserved. The programs designed in childhood do not necessarily apply in adulthood as people's needs change. Furthermore, several individuals with HFA do not receive a diagnosis in childhood as they exhibit mild symptoms and display coping mechanisms. Therefore, these individuals miss out on any available therapy for children. For the individuals who get an early diagnosis and participate in the therapies, there is a need for more training beyond that available to them as children as their situation differs from when they were young. The training may be like the training designed for children or more likely customised to be situated in similar social experiences that they are likely to have as adults.

This customisation of therapy/training is comparable to the adult literacy programs where they are not the same as the literacy programs for children. The differences between younger populations and adults to account for when designing literacy program includes: "(1) adults may experience

age-related neurocognitive declines that affect reading and writing processes and speed of learning, and (2) adults have varied and more substantial life experiences and knowledge and different motivations for learning that need attention in instructional design.” (National Research Council, 2012, p. 243). Similarly, these differences apply in designing therapy/training for adults with HFA as their needs differ from that of children.

Studies with young adults and adults with Autism show that Autism negatively impacts the quality of life of adults with HFA (Attwood, 2000; Bellini, 2004; Irish, 2013; Tse et al., 2007). Furthermore, studies with young adults and adults with HFA show that they feel socially isolated and want support with their social skills (Müller et al., 2008). Hence, there is limited research for young adults and adults with HFA.

Limitations of existing studies are detailed in Chapter 2. Existing research successfully addresses various socio-communicative deficits with virtual reality technologies. The virtual reality technologies include desktop-based virtual reality, virtual reality with head-mounted device, and 3D game-based virtual reality (refer to Section 2.4 for further details). The variation among the social skills addressed is due to the novel factor of the use of such platforms. More research is focused on emotion recognition and appropriate behaviours, and less focuses on practical and cognitive skills. Therefore, there is need for a single complete design that targets the most necessary/significant social skills for people with Autism (Thai & Nathan-Roberts, 2018).

Some literature involves the end-users or the Autism behaviour therapists/experts in the design process, some don't, and some have not reported engaging with either (Tsikinas & Xinogalos, 2019). It is widely recognised that engaging the end-users or the professionals in system design is essential to maximise the likelihood that the final product meets the users' needs (Motti, 2019; Preece et al., 1994; Tsikinas & Xinogalos, 2019). As most computer researchers are not qualified in the field of Autism, the active involvement of Autism therapists or experts in the design and analysis process greatly enhances the accuracy of the research. Therefore, there is a need for engaging end-users and Autism experts in designing a system.

The studies predominantly use either quantitative or qualitative measures for analysis but not both. Qualitative measures (i.e., questionnaires, interviews) report on the participants' perceived performance and their experience. Quantitative measures enable objective analysis of the

participants' performance. The use of both measures allows analysis of the usefulness and effectiveness of a given system hence both measures should be used in analysis.

In summary, the identified limitations are the lack of a single complete design that targets the most necessary/significant social skills for people with Autism; the need for engaging both the end-users and the Autism expert in the design process; and the need for using both qualitative and quantitative measures in the analysis.

The aforementioned led to the fundamental question that this study investigates:

**To what extent could a serious game based on existing social skill training strategies address the identified limitations of existing research in providing a plausible alternative to real life training for young adults and adults with HFA?**

The research reported in this thesis set out to answer this question by building and evaluating a prototype serious game. The following objectives were used to direct this research.

1. Identification of the social skill training strategies/methods for young adults/adults with HFA that are suitable for use in a serious game.
2. Engagement of end-users and an Autism expert to prototype a single complete design to address the most necessary and significant social skills for people with Autism.
3. Implementation of the game design components, including the design framework, design approach, design considerations, and design decisions to incorporate 1 and 2 into a serious game.
4. Development of an evaluation approach to use both qualitative and quantitative analysis measures and evaluate how useful and effective the implemented serious game is in providing training.

These objectives were addressed in the order given. The first objective requires an analysis of existing evidence-based social skills training strategies/methods and identification of effective methods for use in the game (Chapter 2). The second objective necessitated working with end-users and an Autism expert to determine the most necessary and important social skills for people with HFA, towards creating a single complete design system (Chapter 3). The third objective builds on the findings from steps one and two. Its purpose is to develop a design and effectively implement the social skills training strategies for the identified social skills into a serious game

(Chapter 5). Aspects of the design to be considered are determining a serious game design framework with relevant components; engagement of end users and the Autism expert; design considerations for implementing the training; and the design decisions for providing useful user experience of virtual training (Chapter 4). The fourth and final objective is the evaluation approach to use both qualitative and quantitative analysis measures, to determine the usefulness and effectiveness of the serious game as a learning platform for the addressed social skills (Chapter 6). The data gathered through the evaluation approach is analysed to draw the overall conclusion of whether the designed serious game provided a plausible alternative to real life training for young adults and adults with HFA (Chapter 7). Because the system design incorporates training methods supported by current research and practice in the field, it is not necessary to do an end to end educational evaluation. The evaluation assumes that the underlying training methods work and have value for end users. It therefore seeks only to determine whether the serious game developed in this work does present the ideas to, and measure the responses of users in a way that is useful and effective.

## **1.2 Contributions of the Thesis**

The research presented in this thesis makes the following original contributions:

- An analysis of evidence-based social skills training strategies and methods used by HFA therapists, together with the selection from these of suitable strategies for use in a social skill training serious game.
- Identification of the elements of social skills training, and mechanisms in games for representing them. This includes the design and use of proxies for training elements that are difficult to simulate.
- Prototype a serious game following the identification of an integrated single complete social skills system with the most necessary and significant social skills, grounded in a human-centred design thinking approach.
- Design and construction of a prototype serious game.
- Development of evaluation methods for such a system.
- The outcome of the evaluation of the game with an appropriate group of participants.

### **1.3 Thesis structure**

Chapter 2 reviews existing research in the field of Autism and Computing. It explores facets of social deficit that are innate to HFA and investigates the training strategies used by Autism experts to address them. It outlines the role of computing in teaching and learning for those on the Autism spectrum and identifies studies that have explored similar questions. It describes the limitations of existing research and provides evidence to support the investigation proposed in this research study.

Chapter 3 explores the first limitation identified in Chapter 2: the lack of a single complete design with the most necessary/significant social skills for Autism. It details the process of social skills identification using a design approach that engages end users and an Autism expert, thus addressing the third limitation as well. It presents the prototype for a single complete design with the most necessary and significant social skills for people with Autism. It is complete as it integrates social skills from multiple social behaviours.

Chapter 4 outlines a game design that incorporates the prototype for a single complete design with the most necessary and significant social skills for people with Autism—identified in Chapter 3, into the social skills training strategies—identified in Chapter 2. It describes the design framework, game components and the design approach. It discusses the design considerations and design decisions for determining what is implementable, and how to implement the aspects that are otherwise difficult to achieve. Finally, it presents the evaluation design.

Chapter 5 presents the method used to develop a game prototype following the design proposal in Chapter 4. It outlines the development process, the expert review process, and the updated software.

Chapter 6 details the game evaluation process and provides the qualitative and quantitative measures for evaluating the game's usefulness and effectiveness. It explores the research questions, informs the participant recruitment process, defines a user study format, and presents the data gathering techniques throughout the study.

Chapter 7 describes the data analysis process and provides the results of the data analysis for each of the evaluation aspects presented in Chapter 6.

Chapter 8 revisits the research question and the process, to present a discussion of the study and its findings. It draws relevant conclusions and proposes a direction for future work.

Figure 1 provides an overview of the chapters and outlines the studies that involved participants.

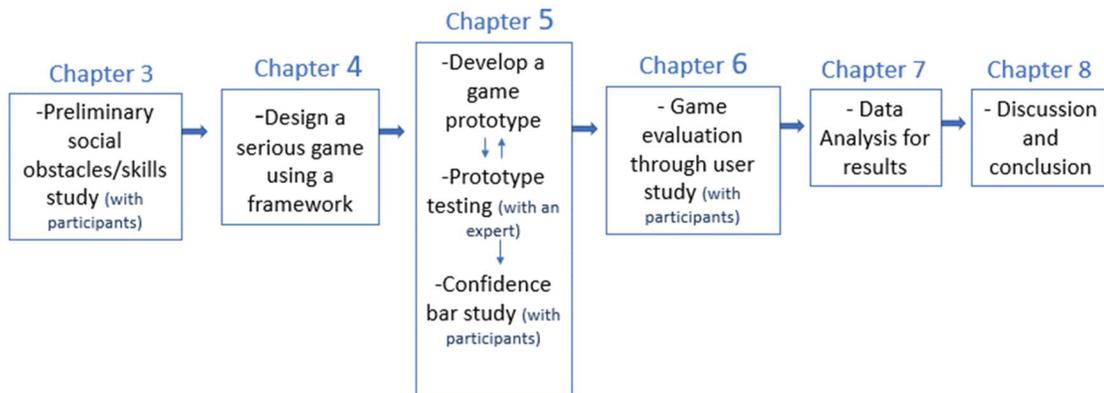


Figure 1.1: Thesis chapters overview.

## 2 Background

Autism Spectrum is a pervasive developmental disorder characterized by several deficits, including verbal and/or non-verbal communication deficits, social interaction deficits and difficulties, and unusual or abnormal idiosyncratic sensory behaviour (Mattila et al., 2011). It is a neurodevelopmental condition, and its effects vary in degree of severity in each individual. The common types of Autism are Autistic Disorder (AD), Pervasive Developmental Disorder –Not Otherwise Specified (PDD-NOS), Childhood Disintegrated Disorder, Rett's Syndrome, and Asperger's Syndrome or High-Functioning Autism (HFA) (Noor et al., 2012). Asperger's Syndrome or HFA are those individuals with Autism who retain high Intelligent Quotient (IQ) levels and who are identified by the socio-communicative deficits in non-verbal behaviours, verbal behaviours, and assertive behaviour. Significant research exists for the treatment and therapy of socio-communicative deficits for individuals with Autism. These assistive treatments/therapy, called social skills training interventions/programs, are designed and used by behavioural therapists and educators. The traditional social skills training interventions/programs consist of social stories, comic strip conversations, direct instruction, video modelling, and group social skills training (Attwood, 2007).

People with Autism commonly have a social phobia that is an anxiety disorder and is often untreated as the sufferers hesitate to attend face-to-face therapies. Assistive therapy is crucial in positively addressing the socio-communicative deficits among people with Asperger's Syndrome and HFA; however, it is not readily available to most individuals due to the "intervention costs and a lack of specialized therapists" (Georgescu et al., 2014, p.10). Research shows evidence that teens and young adults with social phobia frequently search online for social interaction and self-help information (Chen et al., 2011; Erwin et al., 2004; Lehenbauer et al., 2013), so it is clear that people with Autism have an interest in improving their socio-communicative deficits.

Individuals with Autism tend to show a keen interest in electronic media and devices. It is known that virtual environments and characters provide a safe environment to practice real life social interaction dynamically (Smith et al., 2014). Smith et al. also observed that such environments could be provided at a reduced cost because therapist time can be reduced or eliminated, and with easy access, possibly at home.

A virtual environment possesses several advantages "that offers unique potential for individuals with HFA" (Georgescu et al., 2014, p.10) and Asperger's Syndrome. The advantages identified by (Georgescu et al., 2014) are:

- *Control*: the user can directly control and manipulate the virtual environment, supporting repeatable practice opportunities in adjustable, life-like situations.
- *Flexibility*: the virtual program can be modified and customized by therapists or software developers according to the individual's needs.
- *Error-free learning*: Georgescu et al. (2014), use this term to describe the ability to remove competing or distracting stimuli from the training setting, to record the user's performance, and to reduce fear of failure/mistakes/rejection.
- *Independent practice*: the user can engage in self-guided exploration in a safe training environment, knowing that they are in active control of their experience.
- *Ecological validity*: the design can accurately reflect the real world and offer "naturalistic performance measures with real-time performance feedback" (Georgescu et al., 2014, p.11).
- *Affinity with computers*: an interest in, and affinity towards, computers is common among people with Asperger's Syndrome and HFA, as computers are predictable, consistent and enable repetition.

Annetta et al. (2010), in their research on serious games in education, conclude that "game technology has a great potential to be useful in getting people to learn and think in important social, cognitive, and moral domains" (p.31).

Thus, there is support in the literature for incorporating established social skill training strategies for individuals with Autism into virtual reality/computer game environments provides the potential for effective therapy and training. These environments reduce social anxiety and fear, support experimentation with social situations, and are cost-effective.

## **2.1 Autism**

Autism is categorized as a Pervasive Developmental Disorder (PDD) (Jones & Meldal, 2001). Autism is variable, complex, and occurs on a scale or spectrum based on the degree of severity and variety of manifestations, ranging from severe to mild therefore labelled Autism Spectrum Disorders. Classic Autism was the name given to severe Autism, and on the mild end of the

spectrum was High-Functioning Autism (HFA), also known as Asperger's Syndrome (Jones & Meldal, 2001; Preece et al., 2004). However, over the last decade, Autism research has evolved drastically as the Diagnostic and Statistical Manual of Mental Disorders-V (DSM-V) introduced changes to the Autism diagnostic criteria. These changes involved the elimination of some of the individual Autism categories, specifically Asperger's Syndrome, Pervasive Developmental Disorder–Not Otherwise Specified and Autistic Disorder, and their replacement by Social (pragmatic) Communication Disorder. The change has led to a reduction in recognition of people with Autism, especially those with less severe forms of Autism Spectrum Disorder (Sturme & Dalfer, 2014).

In the meantime, an autistic rights movement (also known as the Neurodiversity movement) mobilized in the late twentieth century. They advocated the idea that “‘Neurodiversity’ is a concept that implies that neurological difference is best understood as an inherent and valuable part of the range of human variation, rather than a pathological form of difference.” (Dyck & Russell, 2020, p.170). The movement called for acceptance of neurological variation by advocating for the removal of the label "disorders" as that term "implies a pathological state, with negative and stigmatising connotations" (Dyck & Russell, 2020, p.178) and “replacing it with conditions” (Leveto, 2018, p.3). Respecting this view, this thesis uses the terms “Autism” or “Autism spectrum” to refer to Autism spectrum conditions. Although the Autism spectrum covers a range of categories, the focus of this study is people with High-Functioning Autism (HFA) or Asperger's Syndrome. It is noted that at the time this research was written, Asperger's Syndrome was eliminated from Autism; therefore, the similarities and differences between Asperger's Syndrome and HFA are analysed next to direct the focus group for this study.

### **2.1.1 Asperger's Syndrome and High-Functioning Autism**

In 1944 Dr Hans Asperger, a paediatrician, noticed a group of children under his treatments who displayed some common characteristics: "delayed social maturity and social reasoning with unusual social abilities at any stage of development; use of pedantic language with unusual tone, pitch, and rhythm of speech; possibly advanced grammar and vocabulary use yet lacked age-appropriate discussion; impaired communication and emotional control with a tendency to intellectualize feelings; immature empathy compared to the child's intellectual abilities; preoccupation with a specific topic or interest; learning problems and difficulty maintaining

attention in class" (Attwood, 2007, p.25); difficulty forming a friendship and often suffering from peer bullying; impaired verbal and non-verbal communication, particularly in conversations and sensitivity to particular sounds, aromas, textures, and touch. He argued that such characteristics were commonly found in either parent of the child; therefore, the condition was likely to be "genetic or neurological rather than psychological or environmental" (Attwood, 2007, p.25). After observing these particular children for over three decades, he concluded this to be a life-long and stable personality type. Hans Asperger referred to this with the term *Autistische Psychopathen im Kindesalter*, translated as Autistic Psychopathy (Attwood, 2007). Lorna Wing continued Dr Asperger's research in 1981 and started referring to it as Asperger's Syndrome. Further investigation led to the diagnostic criteria for Asperger's Syndrome in the year 1989, and consequently, Asperger's Syndrome appeared in the DSM-IV within the PDD category. The diagnosis of Asperger's Syndrome requires the individual to exhibit impairment in social interaction, "behavioural and interest restriction, normal cognitive functioning, and an absence of language delay" (de Giambattista et al., 2019, p.139).

Infantile Autism was named and described as a Syndrome by Leo Kanner in 1943. DeMyer et al. (1981) were the first child psychiatrists to use the term High-Functioning Autism (HFA) to refer to a group of children diagnosed with infantile Autism in early childhood. However, later cognitive skills testing revealed they displayed higher intellectual abilities, social and adaptive behaviour, and communication skills than expected in children with Autism (DeMyer et al., 1981). HFA is the term used to describe people on the Autism spectrum with mild Autism and average or above-average IQ (Irish, 2013).

Before the release of DSM-V, the terms Asperger's Syndrome and HFA were frequently used interchangeably by researchers. Taddei & Contenna argue that "AS (Asperger's Syndrome) differs from autistic disorder because of the absence of cognitive and language delay and its onset before the age of three" (Taddei & Contenna, 2013, p.2977). However, as mentioned earlier, the DSM-V eliminated Asperger's Syndrome, merging it into Autism, "characterized by impairment in communication (verbal and nonverbal), social interaction, restricted or repetitive patterns of behaviour" (Khowaja & Salim, 2019, p.1). These similarities have led to considerable research over the neuropsychological and neurobiological differences between the two; most highlighted the similarities between them, while others were stressing the importance of treating them as

different clinical entities (de Giambattista et al., 2019). Although DSM-V eliminated the term Asperger's Syndrome, the change was not to apply to individuals who received a diagnosis of Asperger's Syndrome before DSM-V. Thus, individuals diagnosed before DSM-V maintain the diagnosis of Asperger's Syndrome. Despite the change proposed by DSM-V, researchers often use the term Asperger's Syndrome and HFA interchangeably to refer to those individuals that meet the criterion.

This study will use the terms of Asperger's Syndrome/HFA interchangeably to refer to the group of interest. It was imperative to outline the ever-evolving terminology used in the field of Autism research to refer to individuals that display impaired social interaction and communication skills.

### **2.1.2 Social interaction and communication deficits**

The defining characteristics in adults with Asperger's Syndrome/HFA include impaired social interaction and communication, inflexible behaviours, resistance to change, restricted interests, (Attwood, 2007; Irish, 2013; Kaartinen et al., 2012; Magiati, 2016) subsequently difficulties sustaining education, employment, or social relationships. These traits may be accompanied by other characteristics such as neurodevelopmental delay, mental disorder, or learning disability; however, the latter are not defining characteristics of Asperger's Syndrome/HFA. Instead, they are possible symptoms that led to a diagnosis in the first place (Magiati, 2016). The outstanding criterion for Asperger's Syndrome/HFA is socio-communicative deficits as presented in DSM-V. Socio-communicative deficits or social interaction and communication deficits are divided into three behaviour types: Non-Verbal, Verbal, and Assertive/Self-expression. Non-verbal behaviours consist of facial expression, gaze (eye contact), posture, gait, gesture (waving), proximity (personal distance), touch (hug, slap, etc.), personal appearance (appropriate), and vocal cues (speed and pitch). Verbal behaviours consist of elements of speech (comments, questions, commands/instructions, suggestions) and conversational skills (listening, talking, opening a conversation, maintaining a conversation, ending a conversation). Assertive behaviour or self-expression includes standing up for your rights/not being cheated, making a request/asking someone out, coping with refusal, showing appreciation (compliments), and making apologies (Wilkinson & Canter, 1982). A successful social interaction entails the appropriate use of all three behaviours.

People with Asperger's Syndrome and HFA tend to struggle with "spontaneously producing, interpreting, and responding to non-verbal cues" (Georgescu et al., 2014, p.1), i.e., eye gaze, facial expressions, or gestures (Cappadocia & Weiss, 2011; Pudło & Pisula, 2018). They display atypical detection and interpretations of such cues, therefore, struggle to form adequate impressions of others.

The most prominent non-verbal communication skill deficit is the absence or lack of appropriate eye contact. Eye contact is vital in social functioning as "it provides information, regulates interaction, expresses intimacy, mediates social control, and enhances communication and cooperation" (Kartinen et al., 2012, p.1917). Engagement in eye contact among typically developing children is reported to be an inherently rewarding task; thus, they are motivated to engage in it. However, children with Autism "do not find eye contact rewarding" (Kartinen et al., 2012, p.1925), so they tend to avoid it. The research established through skin conductance response studies that individuals with impaired social skills exhibit increased levels of arousal while processing emotional stimuli such as facial expression and so they avoid eye contact to sustain the comfortable level of arousal (Bellini, 2004; Kartinen et al., 2012; Pudło & Pisula, 2018). Therefore, they tend to avoid eye contact, negatively impacting the overall quality of social interaction with another person. These points are summarised in Figure 2.1.

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| <p><b>High-Functioning Autism Key Characteristics:</b></p> <ol style="list-style-type: none"><li>1. Higher intellectual abilities, displaying average or above average IQ</li><li>2. Impaired social interaction and communication in all the three behaviour categories:<ol style="list-style-type: none"><li>i) Non-verbal behaviours: facial expression, gaze (eye contact), posture, gait, gesture (waving), proximity (personal distance), touch (hug, slap, etc.), personal appearance (appropriate), and vocal cues (speed and pitch).</li><li>ii) Verbal behaviours: elements of speech (comments, questions, commands/instructions, suggestions) and conversational skills (listening, talking, opening a conversation, maintaining a conversation, ending a conversation).</li><li>iii) Assertive behaviour or self-expression: standing up for your rights/not being cheated, making a request/asking someone out, coping with refusal, showing appreciation (compliments), and making apologies</li></ol></li><li>3. Inflexible/repetitive or restricted patterns of behaviour</li><li>4. Resistance to change</li><li>5. Restricted interest.</li></ol> |
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**Figure 2.1: Key characteristics of High-Functioning Autism**

According to Müller et al. (2008) people with Asperger's Syndrome/HFA become more aware of their social differences from typical peers in adolescence and adulthood, and their interest in social interaction increases. Furthermore, the lack of social competence leads to peer rejection, social isolation, and possible experience of bullying at adolescence, often resulting in anxiety disorders, depression, and low self-esteem (Attwood, 2000; Bellini, 2004; Irish, 2013; Tse et al., 2007). A study conducted by (Müller et al., 2008) with adults with Asperger's Syndrome/HFA about their perspective on social challenges and support confirmed that they experience severe social challenges. The participants identified six major themes of social challenges that they experienced:

- *Intense social isolation*: Participants described this as true throughout childhood and adulthood, with some associating this isolation with a feeling of depression and anxiety and stating that the sense of isolation increased as they grew older.
- The second theme was difficulty in initiating social interactions: participants reported not knowing how to start interactions or that initiating interactions led to tremendous anxiety and stress.
- The third theme was related to communication; it included impromptu conversation, understanding implicit and explicit messages, deciphering and adopting the tone of voice and gestures appropriately, and interpreting emotional and social cues. This struggle is either with coordinating non-verbal cues with verbal language as one participant was quoted "*I can't pick up on body language or hidden meanings, or what people are really saying when they're saying that in-between-the-lines stuff*" (Müller et al., 2008, p.179) or struggle of engagement in small talk as some participants reported dreading engaging "in 'chit chat' with colleagues, schoolmates" (Müller et al., 2008, p.179) due to the unpredictable set of rules.
- The fourth identified social challenge was the longing for intimacy and social connectedness, as evident from the reported need for having a significant other and deeper friendships and the lack of this causing emotional stress.
- The fifth identified social challenge was the desire to contribute to the wider society through different volunteering opportunities and the social difficulties interfering with it.
- Every individual with Asperger's Syndrome and HFA exhibit varying degree of social skill challenges, and the last theme was the effort to develop social/self-awareness by

identifying one's area of social impairment and actively working towards improving in these areas through reading, engaging in support and social skills training groups (Müller et al., 2008).

It can be concluded that the core impaired social skill that encompasses all the above-identified social skills is that of successful interaction and communication with another person. Furthermore, the participants reported that impairment in social skills among people with Asperger's Syndrome and HFA caused feelings of anxiety, stress, and in some cases, depression (Bellini, 2004).

Individuals with Asperger's Syndrome/HFA tend to suffer from varying degrees of social phobia/social anxiety disorder. Social phobia/social anxiety disorder is defined by the distress caused by fear of failure in social situations, leading to avoidance of social situations (Kuusikko et al., 2008). It is particularly common among young adults and adults with Asperger's Syndrome and HFA as they become more aware of their impairment in social skills, leading to self-consciousness, apprehension, and concern about their level of social competence (Attwood, 2007). Adolescents with Asperger's Syndrome/HFA reported clinically significant social anxiety levels and, as a result, reported behavioural avoidance/avoiding engaging in social behaviour (Bellini, 2004; Kuusikko et al., 2008). Bellini (2004) also established the correlation between social anxiety and impaired social functioning: impairment in social functioning causes social anxiety, and similarly, social anxiety causes impairment in social functioning by reducing the motivation to initiate and engage in social interactions.

Social anxiety is measured and evaluated through clinician-administered and self-report instruments (Wong et al., 2016). For measuring social anxiety levels among adults, the two most common clinician-administered scales are the Liebowitz Social Anxiety Scale and the Brief Social Phobia Scale where the respondents are presented with scale anchors to rate the fear of, and avoidance of the social situations described by the clinician. Several self-report measures are used with adults i.e., the Social Interaction Anxiety Scale, the Social Phobia Scale, the Social Phobia and Anxiety Inventory, the Social Anxiety Inventory, and the Liebowitz Social Anxiety Scale-Self Report (Wong et al., 2016). Both the clinician-administered and the self-report measures consist of varied number of items and require the respondents to select option that best represents them on the presented Likert scale.

In summary, individuals with Asperger's Syndrome/HFA present discrepancies between their high intellectual skills and their low social competency e.g., inability to independently look after themselves, communicate or relate to others (Magiati, 2016). The low social competence is embedded in impairment in non-verbal, verbal, and assertive behaviour. Consequently, they are vulnerable to experiencing emotional and behavioural difficulties, impacting their overall quality of life (Magiati, 2016), and causing social anxiety that negatively impacts their social functioning. Recommendations were made for strategies to address social integration (Attwood, 2000), and several social skills training interventions have been implemented with some reporting a higher success rate for individuals with Asperger's Syndrome/HFA. These are further discussed next.

## **2.2 Social skills training strategies**

Social skills training is neither a novel intervention nor a unique treatment (White, 2011); rather it is a standard treatment method for adolescents with Autism (Laugeson et al, 2014). It is used to increase awareness of social situations by providing a variety of behaviour alternatives, enriching the participant's skill knowledge base, and offering practice opportunities (Wilkinson & Canter, 1982).

Social skills training programs are designed in one of two formats: individualized or standardized. Individualized programs are planned according to the client's specific goals. They are carried out in either one-on-one sessions or integrated into a group session, emphasizing each client's particular social goals. The length of an individualized program varies and is mainly dependent on the need of the individual. The sessions may be short and frequent or long and less frequent with homework tasks. Standardized programs are generally designed to systematically address social skills deficits, progressing from simple to complex social behaviours (generally non-verbal to verbal). They can also be delivered on a one-on-one basis or in a group setting. The length of the standardized programs also varies and can be adapted to meet clients' needs; with able clients, 12 sessions with intensive training delivered over several weeks have been reported to have produced the desired outcomes (Wilkinson & Canter, 1982).

Social skills training programs may consist of one or more of social stories (Attwood, 2000; Boujarwah et al., 2012; Tse et al., 2007), comic strips (Attwood, 2000; Tse et al., 2007); direct instruction (Banda & Hart, 2010); video modelling (Charlop et al., 2010; Hart, 2010); and social

skills group training (Cappadocia & Weiss, 2011; Laugeson et al., 2014; Tse et al., 2007; White et al., 2010).

*Social stories* were developed by Carol Gray in 1991 (Attwood, 2007) and aim to address the appropriate/expected behaviour in the participant's life for a given real or hypothetical situations, through the development of sequential stories (Boujarwah et al., 2012). These are written in collaboration with the participant from the participant's perspective, within their reading and comprehension level and in an age and skill-appropriate manner, with emphasis on describing the situation, describing their thoughts and feelings in that situation, defining the expected response, and identifying strategies for clarifying and responding to the case (Attwood, 2000; Attwood, 2007). Aldabas (2019) has established that social stories are effective in reducing inappropriate social behaviour and Qi et al. (2018) that they are effective in improving social skills (Qi et al., 2018).

*Comic strip conversations*, also by Carol Gray, were developed and used with students with Asperger's Syndrome/HFA (Attwood, 2000; Attwood, 2007). The comic strips consist of stick figure drawings with speech and thought bubbles, to present an event or sequence of events in story format to the participant. The participant writes in the thought bubble the perceived emotional state of the speaker in the given situation, using specified colours for the emotions. These are analysed by the therapist and discussed with the participant. Comic strip conversations are particularly helpful for people with Asperger's Syndrome/HFA as it enables them to review their response and understand emotions differently from the way they initially perceived them (Attwood, 2000; Attwood, 2007; Leaf et al., 2020). Comic strip conversations have been shown to be effective in improving desired social skills (Ahmed-Husain & Dunsmuir, 2014) and in increasing social satisfaction among people with Asperger's Syndrome and HFA (Pierson & Glaeser, 2007)

The *direct instruction social skills training* strategy consists of teacher modelling, student practice, feedback, and error correction as required (Banda & Hart, 2010). This method is used in combination with neurotypical peer training, where neurotypical peers are taught desired behaviour when interacting with those with Autism. It is reported to enhance social skills and increase initiation of conversations and sharing behaviours (Banda & Hart, 2010). A study conducted with adolescents with Autism at school by Laugeson et al. (2014) used "teacher-facilitated social skills instruction through Program for Educational and Enrichment of Relational

Skills (PEERS)" (Laugeson et al., 2014, p.2247). The teachers reported improvement in all aspects of social functioning, including motivation, awareness, responsiveness, communication, and a decrease in autistic mannerisms. Participants' self-reports indicated significantly improved social knowledge and their parents reported decreased social anxiety among participants (Laugeson et al., 2014).

*Video modelling* is a strategy that requires the participant to watch a pre-recorded video performance of the desired social task in a sequence of steps, followed by performing/practicing those steps (Charlop et al., 2010; Gardner & Wolfe, 2013; Shukla-Mehta et al., 2010). People with Asperger's Syndrome and HFA tend to be good at imitation (Attwood, 2000) and video modelling has been established to be effective as a tool to teach various skills to individuals with Autism (Charlop et al., 2010; Gardner & Wolfe, 2013; Shukla-Mehta et al., 2010).

*Social skills group intervention/training* allows people to meet others to role-play social situations (Attwood, 2000). It is often recommended for people with Autism (White, 2011) and is reported to be more effective in improving social skills than individualized programs for adolescents with Asperger's Syndrome/HFA. A session typically consists of direct instruction, modelling, role-playing, and feedback (Minihan et al., 2011; Wilkinson & Canter, 1982). Group social skills training conducted with individuals with HFA in an outpatient community mental health centre reported significantly improved social skills. It suggested skill generalization, and in a three-month follow-up study, reported maintenance of the positive effects (Deckers et al., 2016). Similarly, studies using group training carried out with verbal adolescents with Autism reported improved comfort and confidence in social interactions (Tse et al., 2007).

While Cappadocia & Weiss (2011) reported improvement from most social skills training group interventions, Spain & Blainey (2015) reported group training to be effective in enhancing knowledge and understanding of social skills rather than increasing performance of social skills among adults with HFA.

Ke et al. (2018) conducted a review of 42 studies on social skills interventions used with youth and adults with Autism. Fourteen studies used the single-case research design, and twenty-eight studies used the group design. The single-case design studies reported an average of three participants, with an average age of 16 across the studies. The target behaviours varied with most targeting multiple social behaviours, i.e., social interactions, initiations, response, and social engagement. The studies were assigned to one of three categories: direct instruction, naturalistic

interventions, and technology-based instruction. Direct instruction interventions included modelling, role-play/rehearsal, and feedback; naturalistic interventions included peer-mediated activities; and technology-based interventions included virtual reality and computer emotion recognition software.

The group design studies documented 800 participants with varied participant count (6-73 participants) and age range from 10-65. The interventions varied with the use of direct instruction, mindfulness-based therapy, cognitive behavioural therapy, supportive environments for social activity participation, naturalistic interventions, semi-structured social experience, interactive agents (peers), and technology-based learning systems. These studies were further categorized as using either single case research design or group design strategies. The authors reported that the single case research design strategies effectively promoted social behaviour with at least some gain in all cases. Similarly, the comparison studies for the group design "provided statistical evidence supporting the effectiveness of the interventions in promoting diverse social learning outcomes" (Ke et al., 2018, p.32).

For youth with Autism, White (2011) made the following recommendations for promoting better social skills and improving skill performance: "a high level of structure and routine, an adequate dosage of the intervention, a safe nurturing environment" (White, 2011, p.46), the involvement of peers, matching skills training to the deficit areas, and the use of the natural environment. Individuals with Asperger's Syndrome and Autism made the following recommendations for social support: external groups, communication support, self-initiated help, and attitudinal support. External groups enable engagement with others through structured and facilitated social opportunities. Communication supports refer to alternative communication techniques, direct instruction for social cues, and clear communication. Self-initiated supports enable coping with daily social stressors, e.g., "creative and improvisational outlets; physical and/or outdoor activity; spiritual practice and/or organized religion; mediating objects; and alone time" (Müller et al., 2008, p.184).

In summary, a wide variety of social skills training strategies have been developed, and it has been established that these strategies are effective in addressing social skills deficits among people with Autism. Social skills training programs include Social stories, Comic strip conversations, direct instruction, Video modelling, and Social skills group training. Young adults and adults with

Asperger's Syndrome and HFA are aware of their social challenges, look for strategies to improve their social functioning, and can benefit from social skills training programs.

The literature on the role of play/games in learning is discussed next, followed by a review of the computer-mediated interventions in Autism research.

### **2.3 Games for learning**

Walz & Deterding (2014) argue that play and games are derived from the playfulness mindset. The sharing of this playfulness socially frames it, emerging play. The codified version of the shared form is called games. “Video games provide well-crafted experiences through which players explore learning, being expert, and changing the world.” (p.161); while enabling exploration of the emergent properties of the game; and supporting immersion into the game experience (Squire & Jenkins, 2011).

Social games clarify the rules of the game and social world, while demonstrating that rules can be changed. Furthermore, pervasive games use this “to create alternate worlds, in the midst of the shared reality, but usually these games have been staged in order for the players to have fun—or at least have meaningful experience.” (Walz & Deterding, 2014, p.215).

Apperley (2011) states that although digital game play—a serious game— potentially offers several segues into real world activities, they are not entirely smooth, and are dependent on game context and play condition. He further argues that there is both ambiguity and tension between training and practice, as more emphasis is placed on training. He reported regarding skill transfer, that several interviewees believed they could effectively transfer the knowledge of gameplay to various games, hence equipping the player with mobility and flexibility in using wider game variety (Apperley, 2011). Although game research supports the transfer of skills from one game to another, the evidence for enacting “social or societal change has been rare” (Walz & Deterding, 2014, p.215).

### **2.4 Computer-mediated interventions**

The computer-mediated intervention for teaching and training includes virtual reality technologies. Virtual reality is defined as “an advanced form of human computer interface that allows the user to interact with and become immersed in a computer-generated environment in a naturalistic fashion” (Trahan et al., 2019, p.1). Virtual reality simulates the real world or allows the creation

of new worlds and enables real world like experiences (Bellani et al., 2011). It includes technologies such as desktop-based virtual reality, virtual reality with head-mounted devices and 3D game-based virtual reality, among others. Desktop-based virtual reality uses desktop screen to display 3D virtual world, achieves interactivity with the use of mouse and keyboard, and is not supported by use of any tracking equipment. “It relies on the users’ spatial and perception abilities to experience what happens around them. As the technology only relies on the use of monitors, keyboard, and mouse, it is considered to be relatively cheap when compared with other technologies.” (Wang et al., 2018, p.5). In contrast to desktop-based virtual reality, virtual reality with head-mounted devices requires the use of special hardware including head-mounted displays and sensor gloves to further withdraw users from the physical world and provide an even more immersive environment. “Spatial immersion is created by surrounding with images, sounds or other virtual scenarios, user can feel the virtual world is “authentic” and “real.” (Wang et al., 2018, p.6). Whereas 3D game-based virtual reality refers to “computer-based game-like training scenes through integrating visual, interactive, network and multi-user operating technologies and so forth. Other than focusing merely on the immersive effect, game-based VR focuses more on game objects’ interactions.” (Wang et al., 2018, p.6). As is used in training literature (Bellani et al., 2011; Bradley & Newbutt, 2018; Kandalaf, 2013; Smith et al., 2014; Thai & Nathan-Roberts, 2018), this thesis will use the term ‘virtual reality’ to refer to all virtual reality particularly desktop-based virtual reality. The term ‘virtual reality with a head-mounted display (VR-HMD)’ is used where there is need to be more specific.

Computer interventions addressing socio-communicative skills include virtual reality based systems (Bellani et al., 2011). The socio-communicative deficits of individuals with Autism and the potential for the role of virtual reality and serious games in improving quality of life for individuals with social challenges led to evolving research in the role/use of such interventions as educational and therapeutic tools for people with Autism. Many advantages have been reported by several authors for using virtual reality and serious games as tools for teaching social skills to individuals with Autism, who are known to exhibit deficits in verbal and/or non-verbal communication, social communication and interactions, and unusual or abnormal idiosyncratic sensory behaviour to some degree (Mattila et al., 2011; Stichter et al., 2014). The first advantage is that virtual reality and serious games provide an opportunity for experimenting with social situations (Trepagnier et al., 2011) without the social anxiety that is associated with the real world

or real face-to-face interactions (Cappadocia & Weiss, 2011; Serret et al., 2014; Stichter et al., 2014). Because the training is virtual both self-consciousness and worry of failure disappear (Trepagnier et al., 2011). Such training can allow a user to focus on achieving the set goals by removing distractions, minimizing external stimuli and putting the user in charge of the situation, e.g., noise level control (Bellani et al., 2011). Serious games can provide a balance between challenge and skill by training the user to learn and apply newly acquired skills promptly. They encourage lateral and strategic thinking for solving difficult problems. They prepare the user to make effective decisions in stressful situations while considering the moral and ethical implications of those decisions. Computing enables dynamic and real world social interactions in the form of virtual reality or a computer-based simulation (Kandalaf et al., 2013). Finally, they provide the immediate feedback that is a vital component of any training's success but is otherwise costly if it must be provided by a therapist (Hirumi, 2010).

Georgescu et al. (2014) established that non-verbal behaviour is characterized by high processing and high dimensional complexity, as it is context-dependent, has simultaneous multichannel activity, and requires an understanding of the dynamic aspects of facial expression and body movements. They also recognized that investigating such behaviour presents "several basic methodological challenges, some inherent in the nature of the stimulus (i.e., experimental control) and others caused by technical restrictions (i.e., ecological validity)" (Georgescu et al., 2014, p.2). They argued that these challenges could be overcome when using anthropomorphic virtual characters as systems can replicate realistic behaviour while enabling systematic manipulation, simultaneously increasing experimental control and 'ecological validity'. For this reason, Georgescu et al. (2014) investigated the role of virtual characters in assessing and training non-verbal communication through a review of the literature. The work identified the following limitations: the "tradeoff between ecological validity and experimental control" (Georgescu et al., 2014, p.12); the influence of users' prior exposure to such environments on their expectations of and experience with them; possible effect of user's age on their reaction to the stimuli, setting and social situations; and the need for multi-disciplinary collaboration in building and using such systems making them costly in time and effort. It concluded that virtual reality/environment and characters hold great potential for experimental models of social cognition, as they provide "tools to grasp the full extent of the social world in a well-controlled manner" (Georgescu et al., 2014, p.12). It identified the advantages of such platforms in delivering a social experience, including

the observation that virtual environments provide efficient solutions for real-time social interaction, which overcome common methodological problems. They enable detailed and systematic examination of social interaction, thus enabling reverse engineering of social cognition. They allow the identification of typical and atypical human social cognition. They are valuable in supportive therapy and social skills training as "they provide a safe, repeatable and diversifiable learning environment" (Georgescu et al., 2014, p.13).

A computer game is an artificially constructed competitive, goal-oriented platform where the user follows a set of rules and uses provided tools in conjunction with problem-solving skills to achieve a goal (Annetta et al., 2010; Hirumi, 2010). Computer games are fun and highly engaging; they immerse people in alternate worlds, intrinsically provide motivation for participation and contribute to domain knowledge (Annetta et al., 2010; Hirumi, 2010; Stichter et al., 2014). A game that simulates the real world can be used to acquire skills and to teach abstract and out-of-reach concepts in context. Such games are referred to as simulations (Hirumi, 2010; Noor et al., 2012). A serious game is a game developed with a teaching purpose that supports learning through the use of interactive media; it may use simulation. Serious games that support three-dimensional (3D), computer-generated virtual environments enable players to interact and communicate more intimately while encouraging risk-free experimentation with different situations otherwise unachievable in the real world (Annetta et al., 2010; Hirumi, 2010; Noor et al., 2012). People who struggle with initiating and maintaining friendships in real life tend to feel happier in their virtual lives as they overcome shyness and fear of speaking, by interacting through avatars (Hirumi, 2010).

In reporting on their development of a serious game to teach emotions to people with Autism, Serret et al. (2014) cited advantages in using information and communication technologies; that they can provide "clear, structured, and unambiguous information" by using "predictable rules" without "complex socio-emotional expectations" (Serret et al., 2014, p.2). Serrat et al (2014) and Cappadocia & Weiss (2011) further assert that such platforms can aid self-paced learning, provide immediate feedback by using virtual or synthetic environments hence providing an opportunity for experimentation with social situations without the social anxiety that is associated with real world or real face-to-face interactions.

Thus, the potential role of virtual reality technologies in addressing socio-communicative deficits is established. The next section discusses studies reporting on virtual reality and serious games for training children with Autism, followed by virtual reality and serious games for adolescents and adults with Autism and, finally, virtual reality with a head-mounted devices .

#### **2.4.1 Children and virtual reality**

Virtual reality systems have the advantage over VR-HMD systems of being more affordable, running on readily available equipment, and leaving users "less susceptible to symptoms of cyber-sickness" (Bellani et al., 2011, p.3). They enable a user to navigate the virtual world through their avatar. Users have reported, "a sense of being immersed in another world" (p.418) and perceiving the meshing of their bodies with their avatars (Stichter et al., 2014).

Collaborative virtual environments (CVE)s support multiple simultaneous users who "interact with each other via their avatars, and use their voices to speak to each other" (Stichter et al., 2014, p.418). The users collaborate despite not being physically located in the same space (Stichter et al., 2014). Studies that examined emotion recognition and social interaction (manifesting emotion and understanding other's feelings) where a therapist interacted with participants using CVEs reported improvement in identifying emotions and better social performance after the intervention (Georgescu et al., 2014; Bellani et al., 2011).

Stichter et al. (2014), established that children with Autism learn targeted social skills (enhanced empathy, emotion recognition, eye contact, and attending) from 3D Virtual Learning Environment (VLE)s and generalize social appropriateness as such environments are reported "to be highly engaging and motivating" (Stichter et al., 2014, p.419). Consequently, they investigated the use of 3D VLE for youth with Asperger's Syndrome and HFA. They implemented an iSocial 3D VLE where a highly trained educator, located in a university lab, guided students through the social competence intervention for adolescents (SCI-A) curriculum. The extensive conversation around lesson planning and system prototyping between the SCI-A team and the iSocial team led to the development of a working prototype. The prototype was further analysed and refined to support reciprocal interaction between the student and online teacher and enable the teacher to facilitate and manage social behaviour. The study concluded that the student progress, their social efficacy data, the program acceptance by students and parents, combined with their overwhelmingly positive support for the program, presents significant promise (Stichter et al., 2014).

A review conducted by Sasikumar et al. (2017) of computer and virtual based interventions for children with Autism, focused on interventions that address "Eye tracking, eye contact, and facial expression detection, teaching using games, learning with peers, emotional understanding, rehabilitation, relearning and software application based therapy" (Sasikumar et al., 2017, p.2777). The studies that addressed eye tracking and eye contact interventions reported establishing an improved understanding of the child's (participant's) concentration, attention span, and their understanding and interest in the activity. The studies that addressed facial expressions argued its importance in social recognition and functioning and devised methods for teaching it. The authors demonstrated that game-based interventions received a better response than other therapeutic interventions and that learning with peers through an interactive platform improved peer interaction and understanding. The authors concluded that computer-based interventions enable easy incorporation of different scenarios and that children with Autism are attracted to technologically advanced interventions (Sasikumar et al., 2017).

Zakari et al. (2014) conducted a review of 40 serious games for children with Autism. Each game was classified based on the technology delivery platform, e.g., desktop, mobile, Xbox, etc.; the user interaction methods, i.e., Input/output (I/O) devices; the learning objective; the gaming aspect; and the computer graphics, i.e., two-dimensional 2D and three-dimensional 3D. The reviewed serious games for Autism mainly focused on education and therapies. The most popular goal addressed through the games was that of improving social and communication skills, with 54% of research focused on this. These games commonly enabled users to select a virtual character (avatar) at the beginning of the study (boy, girl, or alien). It was reported that the users chose an avatar corresponding to their real life identity, i.e., the males chose a boy avatar, and females chose a girl avatar. The games used different difficulty levels to enable recognition of children's achievement. The second most addressed skills through games were those of social conversation, learning words, and speech therapy, with 26% games addressing these. The least addressed skills included improving imaginative play, learning first aid, and overcoming sensory processing disorders. The analyses of technology delivery platforms revealed that Personal Computers (PCs) and laptops were most popular, with 70% of games designed for them. The authors pointed out that smartphones, iPads, and tablets are becoming more popular as the small screen size helps with attention, and touch screen enables more intuitive interaction. The authors reported at the time of

the review that 22% of the games they analysed used smartphones or tablets and that large screens, tabletops, and game consoles were used in about 3% of the games.

Regarding the modes of interaction, (Zakari et al., 2014) reported that 45% of the games analysed in the review used the ordinary I/O of keyboard and mouse. The touchscreen was the second most used. Although a touchscreen was used by 27% of games, the authors acknowledged that it is reported to be more effective than interacting with a mouse it allows a user to directly manipulate objects in the game environment. About 13% of the studies used a camera-based interface, and 10% of reviews used multiple modes of interaction, i.e., a "digital camera to capture body movement, and also a tangible device" (Zakari et al., 2014, p.101) to interact with the system. About 5% of the studies used a brain-computer interface, i.e., electroencephalography (EEG).

The last element that was analysed was the gaming aspect. The authors established that gaming aspects in the games for children with Autism comprised of shape matching/filling/constructing, levelling up, multiplayer, object collection, object beating, and picture puzzle.

Finally, the review showed that 80% of the games were designed as playing or assisting applications, and 19% tested or analysed the educational and therapeutic use of existing games in children with Autism. In the conclusion of the review, the authors argued that there was a lack of research in addressing sensory processing disorders through serious games, as these are a ubiquitous feature among children with Autism, the authors recommended further research in this domain. They urged the use of customization mechanisms that can be manipulated by parents or teachers, and games to provide "data analysis or visualization tools which presents the progress and development of the child's skills" (Zakari et al., 2014, p.103).

Bellani et al. (2011) report that children with Autism promptly learn to use equipment and acquire information from the virtual reality/environment. Their research showed that participants displayed improvement in understanding of the social skill and, after a few trials in the virtual environment, presented significantly improved performance (Bellani et al., 2011). The research focused on social cognition reported gains with higher scores on the theory of mind (recognizing and responding to other's thoughts and desires), better judgments of appropriate behaviour, and improved emotional recognition (recognizing other's feelings and tone of voice) of facial expressions (Trepagnier et al., 2011). Another study reported significantly increased scores on

some measures of theory of mind, verbal and non-verbal recognition after ten sessions in a virtual environment created in Second Life that addressed several social scenarios (Kandalaft et al., 2013).

Khowaja (2017) conducted research to identify a serious game design framework for vocabulary learning for children with Autism. He conducted an extensive review of serious game design frameworks, serious game attributes, and theories of Autism specific learning and psychology, to enable the identification of game components that form the framework. The proposed design framework underwent an iterative review process with 7 experts in the serious game design. The modified and revised design framework was tested with children with Autism through vocabulary learning application, and experimental evaluation reported improved performance among the users. The design framework by Khowaja is used in the research conducted for this thesis, as discussed in Section 4.1.

The next section will review research on virtual reality for adolescents and adults with Autism.

#### **2.4.2 Adolescents, adults and virtual reality**

Trepagnier et al. (2011) conducted a study with 16 adults with HFA and investigated the validity of using a virtual conversation partner prototype. They used a pre-recorded video to represent the virtual conversational partner. For each conversation, the participant was given a list of responses to choose from. The participant communicated their choice by reading their response aloud, and it then generated conversation according to the answer. The participants reported that their experience with the simulation was beneficial, it increased their interest in talking with people, and some mentioned it was less stressful than real world interaction (Trepagnier et al., 2011).

Smith et al. (2014) researched virtual reality job interview training for adults with Autism, analysing its feasibility and efficacy. Their program used a similar interface to Trepagnier et al. (2011) mentioned above. It also used pre-recorded videos of an actor posing as a Human Resource representative who asked questions. The participant was given a list of responses to choose from and read out their selected response. The system used speech recognition to identify the participant's chosen response. The notable difference is that this program used hierarchical learning with three difficulty levels: easy, medium, and hard, with the wording of the questions based on the level. At the easy level, the non-player character Molly was friendly; at the medium level, she was business-oriented; and at a hard level, she was brusque. This emotional realism

provided "a comprehensive and interactive learning experience" (Smith et al., 2014, p.2453) for training. The comparison of the job interview skills between the baseline and the follow-up showed a significant improvement, and the participants reported increased self-confidence (Smith et al., 2014).

Another study by Glenwright & Agbayewa (2012) created a computer-mediated communication platform to assess irony comprehension in conversations among older children and adolescents with HFA, "followed by forced-choice verbal questions" (p.629). The aim was to assess the execution of a social task by reducing social demands and providing assistive feedback, i.e., one-word replies to questions or a simple rating scale. The results showed that within the computer-mediated platform, all 14 young people with HFA successfully comprehended irony. This contradicted previous reports that irony comprehension was compromised among people with HFA. The authors concluded that methods that minimise demands of "social skills and/or verbal skills offer a promising avenue for examining pragmatics in people with HFA" (Glenwright & Agbayewa, 2012, p.637).

Irish (2013) conducted a literature review that examined the use of single-user virtual environments in supporting the learning of social communication skills among adolescents with Autism and concluded that such technology helped the participants in learning social skills. In these studies, the participants relied on a facilitator or teacher to help them with the interaction; thus, the argument arose that the source of the progress may not have been entirely from the computer program. The author pointed out that none of the studies had examined the effects of this training on real world interactions. Overall, the study concluded that such technology presented promising outcomes in teaching social skills to adolescents with Autism (Irish, 2013).

A review of the virtual reality systems for individuals with Autism with social skills focus was conducted by Thai & Nathan-Roberts (2018). They found that five out of the twelve studies focused on emotion recognition/facial expression and appropriate behaviours/responses in social situations. They discovered that more of these studies focused on dealing with a bully than on introducing oneself to a peer. They argued that based on the characteristics of Autism, research should be more focused on necessary social skills, i.e., introducing oneself to another person, rather than skills that fall "farther in the range of necessary social skills" (Thai & Nathan-Roberts, 2018, p.1471). They reported that two of the studies focused on reducing anxiety in social situations.

Minimizing stress shifts the focus from uncomfortable and distracting feelings to learning, enabling increased understanding, thus resulting in a higher likelihood of information transfer from virtual reality into real world interaction. The authors argued that it was perplexing that this was not a more commonly researched topic. The authors reported that joint attention was addressed in only one study even though it is an essential indicator that a person is aware of and engaged in social interaction with another person. Although the authors reported a study looking at the use of imagination, they noted it was not a fundamental skill; hence it made sense to have only one study on it. The authors argued that the lack of unanimity among the researched social skills through the medium of virtual reality shows that this is a newer technology. They stated that the research focused on the assessment of usability rather than the effectiveness of the social intervention. Therefore, they recommend that future research focus on measuring effectiveness rather than usability.

Furthermore, they suggested that most studies used questionnaires and short interviews as participant measures and that these expose the participant's experiences and perceived performance, but they do not measure operationalized knowledge. Observing a participant's facial expression while they engaged with software was another means of assessment that some studies used for measuring satisfaction and engagement. They conclude that such measures are valuable if the goal of the evaluation is to assess enjoyment. However, they recommend using objective measures for measuring performance: participant's body movement, gestures, eye-gaze pattern, and facial expression. The authors concluded that virtual reality had shown promise in teaching/learning social skills; however, consensus on the social skills and participant measures needs careful consideration when designing a virtual reality training system for people with Autism. They argue that although addressing a variety of skills enables training for many social skills, there is a need for "a single complete design that truly targets all of the most necessary social skills to teach individuals with ASD" (Thai & Nathan-Roberts, 2018, p.1473).

Another literature review of the effects of serious computer games on people with intellectual disabilities or Autism was conducted by Tsikinas & Xingalos (2019). Although their review covered two distinct categories, here, we will focus on the findings relating to Autism. The authors reviewed 37 studies related to Autism. They reported that most research for people with Autism addressed interpersonal skills (social interactions, emotion recognition, and facial expressions),

and others addressed conceptual skills (language and literacy; practical skills and cognitive skills). The authors reported that in the studies reviewed, the serious games improved the skills and enhanced the learning process for people with Autism. They argued that most studies were focused on social and communicational skills as these are among the fundamental deficits among people with Autism; however, this resulted in limited research on conceptual and practical skills.

For the 37 studies related to Autism reviewed by Tsikinas & Xingalos (2019), the most used design methodologies were participatory design, user-centred design, and learner-centred design. Specifically, as used in those reviewed papers participatory design involved engaging potential system users—young people on the Autism spectrum and possibly other stakeholders—in system design, development, and testing. Projects following the user-centred design methodology engaged a special education professional with strong insight into the motivations and behaviours of people on the Autism spectrum (in the reviewed papers, a psychologist) in the design process to define the learning goals and game elements and to conduct usability testing of the prototype. The reported learner-centred approach actively engaged the end-users (the students and teachers) in the development of the serious games and have roles in the design and testing phases. Overall, the review reports a consensus that design methodologies involving end-users or relevant professionals should be used. They do not report a consensus as to which design methodology is best.

The authors reported that personal computers (PCs) are the most familiar device for target users and researchers; therefore, it was the prevailing digital device for hosting serious games in the literature review (Tsikinas & Xinogalos, 2019).

Boujarwah (2012) researched the use of technology by adolescents and adults with HFA to practice social skills. She created the Refl-ex (Reflection and experience) prototype based on the social stories training approach to address three interactive scenarios: unlocking a door, going to a movie, and going to a new restaurant. Each scenario had two sections: the experience section and the reflection section. The experience section presented the user with the scenario, the obstacle, and three decision options. Each selected decision option was explained, and if the undesirable option were chosen then the user could go back and re-think. The reflection section consisted of a storyboard and the options for the steps for correct behaviour. The users were asked to create the story for a successful interaction based on their experience. This approach was called obstacle-

based branching. The study reported that obstacle—based branching approach was useful in teaching social skills and the participants reported that they found this approach to be useful and appropriate. The research was further extended to use crowdsourcing techniques to create human ‘computed’ social scripts for a social experience at a fast-food restaurant. Crowdsourcing is "...the notion of asking many people to complete a task that could not as easily or cheaply be done by a single person..." (Boujarwah, 2012, p.16). Section 3.1 discusses Boujarwah’s work in more detail because her data is used in this thesis.

### **2.4.3 Virtual reality with a head-mounted display (VR-HMD)**

Another popular game interface used in recent years is that of the head-mounted displays for virtual reality. Virtual reality with a head-mounted display VR-HMD not only simulates the real world but amplifies the experience or feeling of immersion of the user by engaging their auditory and visual senses (Bellani et al., 2011).

A pilot study of the use of a virtual reality headset in Autism populations (Bradley & Newbutt, 2018) was conducted to explore the willingness, acceptance, sense of presence and immersion of Autistic participants (Newbutt et al., 2016). Their focus was the potential for head-mounted displays to enhance user experience. The pilot study was conducted with 29 adults with an average age of 32 years and with a diagnosis of Autism, and almost half the participants had a "co-occurring intellectual disability (IQ score < 70)" (Newbutt et al., 2016, p.3167). Three short and straightforward scenarios (a virtual cinema, a virtual café, and a virtual safari) were chosen for Phase 1, and two longer (15-20 mins) and intense virtual reality scenarios (an Apollo 11 mission and a village in Tuscany) were selected for Phase 2. The participants "reported higher spatial presence, engagement and ecological validity within the VR environment and lower levels of negative effects" (Newbutt et al., 2016, p.3173). The study reported no increase in sensory issues or anxiety levels, and the users said their experience was "authentic and could feasibly happen in real life" (Bradley & Newbutt, 2018, p.105). The problems observed were the feeling of dizziness, reports that wearing VR-HMD was uncomfortable and that the computer-generated graphics were not smooth. Although participants reported many positive experiences, the authors mention that "a few participants wanted to discontinue the HMD VR experience" (Newbutt et al., 2016, p.3173).

Bradley & Newbutt (2018) conducted a literature review on the use of virtual reality with a head-mounted displays (VR-HMD) for both children and adults with Autism. The authors report that

Autism research has established that virtual reality provides a safe avenue for practicing interactions and behaviours in a realistic environment by minimizing sensory and social inputs. They enable immersion into alternate worlds, customization, rehearsal, repetition of social scenarios, provide motivation for learning, and thus potentially enable the generalization of learned social skills into real life interactions. The authors argue that the positive findings of the use of virtual reality by people with Autism has led to growing interest in the potential use of VR-HMD to assist people with Autism. This interest is strengthened by recent developments making the displays more user-friendly (small and lightweight), easily accessible, affordable and they carry the advantage of magnifying immersion by increasing the user's field of view and sensory stimuli. The review covered six studies conducted in this area. Each study was analysed based on the focus behaviours, diagnosis/Autism characteristics, setting/context, study design/methodology, equipment, negative/side effects, and main findings. The focus behaviours were the reported acceptance and enjoyment of the experience, the ability to pay attention, task completion, safety of use, information processing during joint attention, non-verbal communication, social initiations, and cognition, vocational training and distracters, and effects of virtual supermarket training on real world performance. All six studies reported that VR-HMD showed potential for learning and assessment of people with Autism. The authors argued that the limitations of VR-HMD identified in earlier research work (i.e., cost and comfort), have been overcome with advances in the technology. They report that these studies conducted do not enable broader conclusions, as they were limited in number, executed with small groups of participants (2, 29, 32, 3, 9, and 9 respectively), and most of them lacked a control group (neurotypical) for comparison.

Furthermore, these studies focused on individuals with above average IQ. There was a consistency between the limitations identified in the studies with the Autism research. The review reported that the studies lacked involvement from behavioural therapists and that only one measured the effect of virtual training on real world performance. The authors reported that only two studies sought expert feedback about interventions, whereas this is valuable information for the design of robust educational technologies. Furthermore, the participants' role was predominantly passive, with their experience measured on quantitative data. Qualitative measures (i.e., interviews) were absent, thus not providing insight into the participants' perception of their experiences with VR-HMD. Therefore, the authors recommend engaging therapists/experts in the design and analysis processes. The studies presented varied responses to VR-HMD applications and experiences.

Although the general response to VR-HMD applications was positive, some negative results were reported, and the study concluded with recommendation for further research.

Regarding the two main concerns raised about the use of VR-HMD (cyber-sickness and discomfort), only three of six studies captured the adverse effects, and only one study specifically asked the participants to report back on the comfort. The authors recommend "developing ethical approaches/frameworks for using VR-HMDs with autistic populations" (Bradley & Newbutt, 2018, p.109), due to their potentially intensified sensory issues. In conclusion, the authors reported that the potential of VR-HMD for people with Autism requires further investigation; they recommend using existing educational approaches and engaging experts in Autism learning to advise the creators of systems (Bradley & Newbutt, 2018).

To summarize, the use of head-mounted displays with the neurotypical population had led to high levels of cyber-sickness in participants that negatively impacted their attitude towards learning and led to withdrawals from studies; therefore, researchers cautioned against the use of technology that potentially causes cyber-sickness when training through virtual environments. Bradley & Newbutt (2018) reported that VR-HMD showed potential for learning and assessment of people with Autism; however, VR-HMD are more costly, less comfortable and may cause 'cyber-sickness,' i.e., nausea, vomiting, headache, drowsiness, loss of balance and altered eye-hand coordination (Bellani et al., 2011). The authors acknowledge the potential concerns of sensory problems (intensified visual/auditory stimuli) and cyber-sickness among this population and recommend further investigation to ensure they are addressed appropriately. The authors recommend extending existing virtual reality research to use VR-HMD to identify the potential, possibilities, and educational benefits and highlight the knowledge gaps (Bradley & Newbutt, 2018).

## **2.5 Summary**

Socio-communicative deficits can negatively impact the quality of life of individuals with Autism. Individuals with Autism become more aware of their social skills deficits as they enter adolescence and adulthood and look for strategies to improve their social functioning. Social skills training strategies/methods consist of social stories, comic strip conversations, direct instruction, video modelling, and group social skills training. It has been established that these are effective in addressing social challenges and improving the target social skills among children, adolescents, and adults with Autism; however, they are costly and not readily available. Research has also

established that computer assistive technology, especially virtual reality/virtual environments, has been useful as teaching/learning tool in the socially anxious population. Virtual environments that target social skills challenges among both children and adults with Autism produced promising results; however, the literature reported limitations of the existing research and made recommendations for the design and analysis of future studies.

These recommendations include: engaging the behaviour therapist/expert in the design/analysis process; using a human-centered design thinking approach by engaging the end-users in the design process; creating a single complete design that targets the most necessary/significant social skills for people with Asperger's Syndrome/HFA, and using both qualitative and quantitative measures of analysis in evaluation. These recommendations motivate creating a serious game that provides social skills training for people with Asperger's Syndrome/HFA. The next chapter will provide detail of the research conducted towards the creation of a single complete design that targets the most necessary/significant social skills following the recommendations.

### **3 Research: Preliminary social obstacles study**

Chapter 2 discussed social skills training strategies and existing software used for addressing social deficits in people with Autism. It concluded that a serious game has the potential for providing a feasible social skills training opportunity. It identified limitations in the existing research and made design recommendations for social skills training programs/software for people with Autism. The recommendations were: creating a single complete design to address the most significant social skills; engaging both an Autism professional/expert and end users in the process of program design; and using qualitative and quantitative measures of analysis.

Both research and interventions exist for children with Autism. Less research has been done and fewer interventions have been created for young adults and adults with Asperger's Syndrome/High-Functioning Autism (HFA) as those with HFA are physically and mentally capable. However, these individuals could still benefit from special interventions to support their social behaviour as they transition into adulthood and are expected to adhere to social norms. Section 2.1.1 outlined that social skills deficit/lack of social competence in young adults and adults with Asperger's Syndrome/HFA leads to difficulty in sustaining education and employment, peer rejection and social isolation, often resulting in low self-esteem, depression, and anxiety disorders. This research focusses on young adults and adults with Asperger's Syndrome/HFA.

Section 2.3.2 established that social skills deficits in people with Autism cover a wide range of social skills and that although existing research addressed a variety of skills, there was a lack of a complete system design that targeted the most significant skills. The preliminary research presented in this chapter, attempted to apply the recommendations established in Chapter 2 to generate a complete design system to target the most significant social skills and engage an Autism professional/expert and end users in the design process. To achieve this, the researcher contacted a New Zealand Autism social support group and proposed engaging the members and the group organizer (an Autism expert) in the design process of identifying the most significant social skills. The group organizer is a qualified psychologist with expertise and experience in Autism. In this research, she has two roles, that of the group organizer and the Autism expert therefore she will be referred to as one or the other as is appropriate according to the role she is playing in the given situation. Before the study to identify social skills with the participants, the researcher had to

identify the social context and the social obstacles to use as a baseline for the study. An ideal social context provides opportunity for structured and non-structured interaction with others where the social skills overlap with several social scenarios. The social context for this study was proposed to be a restaurant experience as dining out is the norm for socializing among young adults and adults in New Zealand and it includes opportunities for structured and non-structured interaction. Furthermore, Boujarwah et al. (2012) had conducted research on human computation of social scripts for the task of eating lunch at a fast food restaurant and reported the potential role of these scripts in creating social scenarios for people with Autism, thus strengthening the argument for using the social context of a restaurant scenario/experience. This is discussed in detail in Section 3.1.

The methodology adopted in this research study towards creation of a complete design encompassing the most significant social skills consisted of four crucial stages in sequence: the computed social scripts' retrieval and analysis, participant recruitment, design, and completion of the survey, and finally a post-study de-briefing with participants. The findings were analysed and matched against literature reviewed in chapter 2, to finalize the social skills that are significant in a complete design system for a restaurant experience and applicable in other similar social scenarios.

### **3.1 Data retrieval and analysis**

Dr Fatima Boujarwah conducted research titled 'Facilitating the authoring of multimedia social problem-solving skills instructional modules' that used iterative crowdsourcing techniques to compute social scripts for the task of eating lunch at a fast food restaurant (Boujarwah, 2012). She used crowdsourcing techniques to collect data that might be used to describe the fast food restaurant experience. Crowdsourcing is "...the notion of asking many people to complete a task that could not as easily or cheaply be done by a single person..." (Boujarwah, 2012, p.16). Boujarwah used this technique to elicit three types of data from the crowd: the steps for going to a restaurant, the possible obstacles that may arise, and possible solutions to those obstacles. Her research concluded that "the use of this approach enables the creation of models for complex and interesting social scenarios" (Boujarwah et al., 2012, p.1995) that could be used to author/create social skills instructional modules for people with HFA.

The initial data gathering stage for this study involved accumulating data on perceived relevant obstacles for the purpose of a restaurant experience. The researcher contacted Dr Fatima Boujarwah, explained her study intent and requested access to the raw data she had gathered for the restaurant experience. Dr Fatima Boujarwah kindly agreed to share this data with the researcher. The researcher created a computer program to convert this raw data into readable format and analysed it to remove data that was irrelevant. Irrelevant data in this situation refers to behaviours that strictly applies only to a fast food restaurant experience – e.g., take my food to an empty table; throw the garbage away and put back the tray; collect napkins and ketchup if needed; etc. A subset of Boujarwah’s steps and obstacles relevant to a New Zealand restaurant experience was created. This subset was presented to the Autism expert who was requested to give feedback on the relevance of the identified social obstacles for people with Asperger’s Syndrome/HFA. The subset approved by the Autism expert was used as the basis for the survey that is discussed in Section 3.3.

## **3.2 Participant recruitment**

The participation criteria for this study were decided to be individuals aged 16 years and older with a diagnosis of Asperger’s Syndrome/HFA. As discussed in Section 2.1, Asperger’s Syndrome is not a recognized diagnostic according to DSM-V and HFA is used to define those with Asperger’s Syndrome, however the individuals who received an initial diagnosis of Asperger’s Syndrome are exempt from re-diagnosis and can adhere to the Asperger’s Syndrome following DSM-V recommendation. The study was conducted with approval of and in accordance with the policies of the University of Waikato ethics committee. Please refer to Appendix A for a copy of the ethics application and letter of approval from the ethics committee for this study.

The participants for this study were recruited from the New Zealand Autism social support group. For recruitment, the researcher met the organizer of the New Zealand Autism social support group, introduced the study intent, and provided her with the study information sheet. Upon the organizer’s agreement to take part in the study, the researcher provided her with consent form. The researcher was advised to attend a social gathering held for this group in the presence of the group organizer prior to conducting any study with the group members. This was to enable the prospective participants to meet the researcher and decide whether they would like to be part of the study or not. Following the organizer’s instructions, the researcher attended one of the social

gatherings of the New Zealand Autism social support group and verbally informed the group members (prospective participants) about the intent of the study and the expected participation. Concerns were raised about the time commitment and location of the study. The researcher informed them that participants who wanted to take part in the study would be given a period of two weeks to complete the survey and as it was a paper survey completed in the absence of the researcher, they could complete it at any location of their choice. The researcher gave the group organizer copies of the participant information sheet, research data and consent form and the organizer passed them on to the interested participants to take home and to complete at their discretion. The reason the researcher preferred to ask the group organizer to pass the forms and survey to prospective participants after the initial meeting with them, was to avoid influencing the participants' decision by her presence and to ensure they had enough time to reflect before agreeing or not agreeing to take part.

Nine adults elected to participate in this study, 5 males and 4 females. During the post survey debriefing, it was discovered that one of the male participants had a diagnosis of Pervasive Developmental Disorder -Not Otherwise Specified (PDD-NOS), and therefore did not meet the study criterion of Asperger's Syndrome/HFA. To keep the results consistent, the data collected from that participant was discarded for the purpose of this study and the results were based on eight participants with a 1:1 male to female ratio.

### **3.3 Study design**

The aim of the study was to retrieve information from the participants about the social obstacles that they identify with as being significant in their social experience or anticipated social experience at a restaurant. Section 3.1 described the process of retrieving social scripts data and creating a subset of data relevant to a New Zealand restaurant experience. It further reported that the subset containing the steps and social obstacles was presented to the Autism expert for confirmation of the relevance of the social obstacles for people with Asperger's Syndrome/HFA. The subset was presented in the form of a list of the possible steps in restaurant dining experience and with each step was presented a sub-list of possible social obstacles for that step. The approved subset was used as the survey to be presented to the participants. Figure 3.1 shows a snippet of examples from the survey with steps and possible obstacles. For the complete survey, please refer to Appendix B: Survey for evaluating social obstacles.

|   |   |
|---|---|
| <ul style="list-style-type: none"> <li>❖ Walk into the restaurant <ul style="list-style-type: none"> <li>➤ The door to the restaurant is jammed</li> <li>➤ The restaurant is too crowded</li> <li>➤ Someone is leaving at the same time you are entering</li> <li>➤ the electricity goes out</li> <li>➤ The restaurant is closed</li> <li>➤ you slip and fall</li> <li>➤ The door I chose to use has a sign saying to use another entrance.</li> <li>➤ There is extremely loud music, many people talking interfering with concentration.</li> <li>➤ People on the other side of the door are standing against it not allowing the door to open.</li> <li>➤ There might be someone you don't like there.</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>❖ enjoy conversation <ul style="list-style-type: none"> <li>➤ The restaurant is so noisy you can't hear what other people are saying to you.</li> <li>➤ You don't know if it is appropriate to talk to other people in the restaurant or just to your companions.</li> <li>➤ the other person has food between their teeth</li> <li>➤ the other person gets up and leaves</li> <li>➤ people stare and make comments</li> <li>➤ you do not grasp that a remark is a joke</li> <li>➤ you do not understand your friend's body language</li> <li>➤ you feel like you are interrupting too much</li> <li>➤ You want to use the restroom but don't want to tell someone and be overheard by other diners.</li> <li>➤ Make comments unrelated to conversation.</li> <li>➤ Idioms are used that you do not grasp</li> </ul> </li> </ul> |
|---|---|

**Figure 3.1: Examples of step and social obstacles from the survey.**

Following the participant recruitment presented in Section 3.2, interested participants were presented with: a participant information sheet, an ethics consent form, and the survey containing instructions for survey completion and the list of steps and the possible social obstacles in a restaurant experience. The survey asked participants to select the obstacles most relevant to them, based on their personal experience and/or assumption of what they perceived to be relevant in a restaurant experience. It also allowed and encouraged the participant to add comments and/or other possible obstacle(s) that they considered relevant in a restaurant experience. Consent for the study was obtained from all participants and they were given the instructions and the survey to take with them and complete at their convenience, in accordance with the ethics guidelines of the University of Waikato (New Zealand). This study was independent of the effects of the physical location and the participants completed the survey at their discretion thus the locations varied. After the completion of the survey, the participants returned the completed information to the group organizer, who then passed them back to the researcher for analysis.

### **3.3.1 Data analysis design**

This study is focused on social aspect of Asperger's Syndrome/HFA, so each obstacle was categorized into one or up to three of six possible types of environments as with the recommendation of the Autism expert. These environments were: Emotional/Individual Environment (caused by individual or emotional response to the obstacle), Sensory Environment, Social Environment-Staff (caused by the interaction with staff member), Social Environment-Group (caused by interaction with other group members/diners), Social Environment-Other Patrons (caused by interaction with other people at a restaurant), and Physical Environment. This allowed the researcher to analyse what environment caused the most distress in a restaurant experience for the participants.

The results obtained from the survey were organized based on the frequency of selection of each obstacle from most frequently selected to least selected by participants and are discussed in Section 3.5.

After the survey, it became apparent to the researcher that one-on-one debriefing was required to come to a better understanding of obstacle selection and the comments entered by participants. Consent was obtained from the Ethics committee, and subsequently from participants for the one-on-one debriefing.

### **3.4 One-on-one study debriefing**

The aim of this study was to create a complete design system with the most significant social skills from the perspective of end users and an Autism expert. Therefore, debriefing was proposed to provide insight into the participants' identified or suggested significant social obstacles and to ensure the finally selected social skills are representative of them. It focused on finding answers to the following three questions: does the participant go to restaurant with family or friends; which social obstacles bother the participant most (from the list and any other ones); and are the selected obstacles bothersome enough to stop the participant from going to the restaurant or is it just an uncomfortable situation?

The debriefing was carried out at a time and venue suggested by the participant. The researcher verbally presented the three questions to the participant (focusing on one question at a time) and wrote their responses on paper. The debriefing led to a better understanding of the participant's

motive for making each selection and comment, hence clarifying any confusion. The debriefing provided the participants with an opportunity to ask the researcher questions and to make suggestions on what they consider may be a beneficial approach for this study. Some good suggestions resulted from the debriefing. These are reported in Section 3.5.1. The researcher is grateful to the participants for their contribution.

### **3.5 Results**

This study provided the researcher with the opportunity to view the restaurant experience from the participant's point of view hence making the study user centric.

The obstacles that were selected by at least four participants were selected for further consideration as four was fifty percent of the participant population. As explained in Section 3.3.1, the data was categorized into 6 social environment categories. Some data fell into multiple categories. In those cases, the data was then categorized based on the strength of the category as being the first, second or third category, e.g., "The restaurant is so noisy you can't hear what other people are saying to you" falls under the Physical Environment as it is the restaurant environment that is creating the obstacle, and then the Sensory Environment.

The frequency of occurrence/selection of obstacles in each environment type was calculated. This was to identify those obstacles that were considered significant by most participants. One obstacle was identified to be significant by all eight participants, 3 obstacles were identified to be significant by seven participants, 5 obstacles were identified to be significant by six participants, 21 obstacles were identified to be significant by five participants and 42 obstacles were identified to be significant by four participants.

Figure 3.2 shows that the most popular first choice category for obstacles is the Physical Environment and the most popular second choice category is Emotional/Individual Environment.

Each significant obstacle was then analysed for relevance to the study and potential for accurate implementation. It was then compared against the findings from the debriefing to ensure it was from the most significant social skills. The results from the debriefing are discussed next.

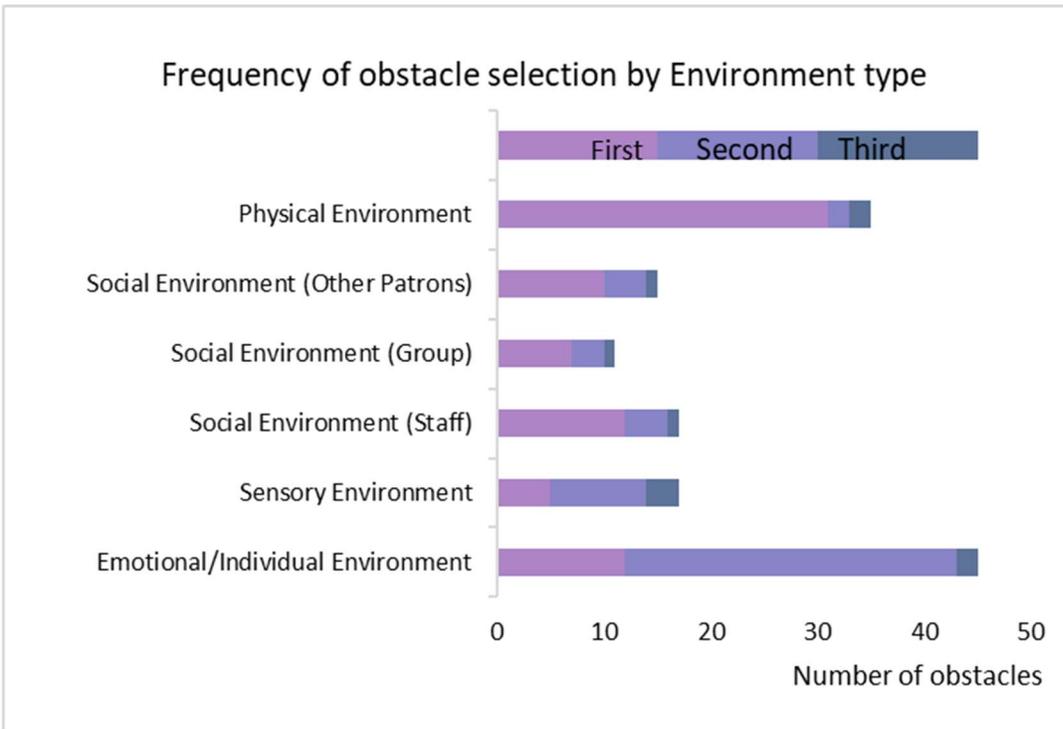


Figure 3.2: Participant’s selected data categorised into environments based on choice occurrence

### 3.5.1 Debriefing results

The debriefing session was designed to provide insight into the social obstacles that the participants identified as being significant in a restaurant experience. The session was designed to be informal as it was an opportunity for the participants to report on their personal experiences and seek feedback from them. Six participants chose to conduct the debrief session at the University of Waikato with the researcher, and three participants chose to conduct it at their home. The sessions varied in length, with the shortest session lasting 30 minutes to the longest session lasting 3 hours. In the debriefing, the researcher would ask the participant a question and allow the participant to share as little or as much information as they pleased.

The session began with the researcher presenting to the participant the intent of the project, the role of the survey in the project, and the role of the debrief. The participant was walked through the participant information sheet and reminded of their right to withdraw from the study if they wish to do so. Once the participant agreed to proceed with the study, they were requested to sign the consent form and the debrief began.

The researcher opened the debrief by discussing with the participant any restaurant visits they might have had. Next the researcher handed the participant a condensed list of the social obstacles they had selected in the survey, asking them to rank and compare the identified obstacles. Handwritten notes were taken during the session. After the participant discussed their selection and its significance, the researcher asked the participant if there were any social obstacles that were significant to them but were not included in the survey. At the end of the debrief, the researcher asked the participant whether the social obstacles identified and/or proposed represented uncomfortable but tolerable situations or if they were significant enough to spoil their experience. Five participants reported regularly going to restaurants (once a week or more), and three participants reported only going occasionally (once a month). No participant reported never going to a restaurant. No participant reported going to a restaurant alone, instead they reported going with family and friends, or with the Autism support group. All participants reported that social obstacles presented uncomfortable situations and negatively impacted their interest in going to restaurants.

The participants discussed their selection and made comments/recommendations. The participants' comments/recommendations included: 'how to start a conversation with someone you don't know', 'initiating/starting conversation', 'starting a conversation (how to?)', 'strategies for engaging in conversation', 'understanding another person's perspective', 'a program that addresses the issues of how to engage in conversation will weigh more for people with Asperger's Syndrome than Physical Environment thing like no toilet paper', 'deciding what to talk about and who to talk to', 'not interested in what I am saying – when people talk over you and make it look like your input wasn't important or even acknowledge it', 'how to make relaxed/frequent eye contact', 'how to make good eye contact', 'no quiet tables – if this is missing then there won't be a conversation', and 'will be put off by there being no quiet tables and loud areas to the point that will leave'. The participants' reported social skills belonged to one of three groups: the concerns related to the verbal behaviour of engaging in small talk/conversation; the concerns related to the non-verbal behaviour of eye contact, and concerns related to the physical environment.

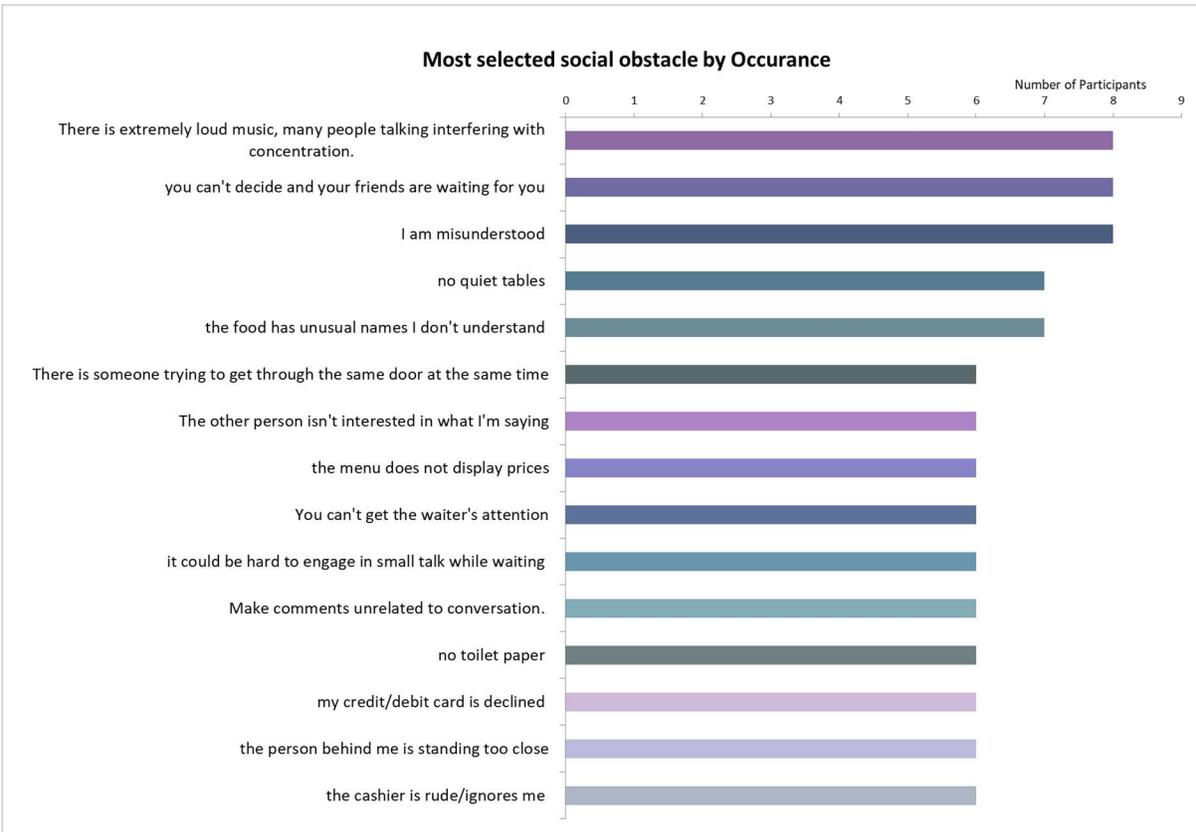
The participants also made suggestions about the design of the program during the debriefing. These were: 'use pictures/images for body language and scenarios', 'clips from movies to tell them about cues for sarcasm', 'audio input, computer reads the thought bubble', 'give feedback on why the selection was right or not', 'Click on option by others and it's read to you... good for

reading difficulty’, and ‘no troll or people who are abusive’. These suggestions assisted the design of the serious game presented in the next chapter.

### **3.6 Final social skills/obstacles for implementation**

To create a complete design system for the most significant social skills/obstacles, and implement it in the serious game prototype, the researcher proposed selection of four social skills/obstacles. Several aspects were considered for obstacle selection process. First and foremost, a standardized approach was taken with regards to obstacle selection. A standardized program aims to accommodate a large group of people and is focused on their core (common) deficits; it uses a systematic approach by moving from simple to more complex social routines (Wilkinson & Canter, 1982). The second level of importance was taken from the frequency of selection of the obstacle; hence those obstacles that were selected by most participants were considered for further analysis. The third aspect that contributed to the selection of the obstacles was the practicality of implementing the obstacle for maximum virtual experience, for example: “the person behind me is standing too close” cannot be simulated with maximum effect as the sensory stimuli from the other person’s body in real world cannot be replicated in the virtual world. The final aspect of selection was the emphasis that the participants placed on the obstacles in the debriefing. Figure 3.3 shows the social obstacles identified to be significant by 4 or more participants.

The four obstacles below were considered to meet the selection criteria for being from the core/common social deficits, identified to be significant by most participants in the survey and implementable in the virtual world. Each obstacle is accompanied by arguments for its significance. Finally, the list is further analysed against the findings from debriefing in Section 3.4.5.



**Figure 3.3: The social obstacles identified by more than 50% of the participants as significant.**

### 3.6.1 First social obstacle

The first obstacle that was selected for this study was the obstacle that all eight participants recognized as significant. It was “There is extremely loud music, many people talking interfering with concentration”. This obstacle is categorized to first fall into Emotional/Individual Environment as the main concern is the inability to concentrate on the conversation, which is caused by Physical Environment and Social Environment-Patrons (people talking). This obstacle is a standard problem as it is common among people with Asperger’s Syndrome/HFA, and in the training program the obstacle can potentially progress from easy scenario where one environment is addressed to more advanced where all three environments are implemented.

### **3.6.2 Second social obstacle**

The second obstacle that was selected for this study is “I am misunderstood”. This obstacle was identified to be significant by seven participants. It is categorized to be from the Social Environment. Being misunderstood during conversation is a generic social problem for people with Asperger’s Syndrome, so it provides a good base for being part of the social skills system.

### **3.6.3 Third social obstacle**

The third obstacle that was considered for implementation was “the restaurant is crowded, there are no quiet tables”. This obstacle falls under the Physical Environment and Social Environment-Patrons categories. This was acknowledged by six participants as being a significant obstacle. The training for this scenario would cover basis for several other scenarios, e.g., shopping in crowded mall hence it is selected for further analysis.

### **3.6.4 Fourth social obstacle**

The fourth obstacle identified for the purpose of this study was “it could be hard to engage in small talk while waiting”. This is a core social skill deficit among people with Asperger’s Syndrome/HFA. Although five participants selected this obstacle and other obstacles were more frequently selected by participants compared to this one, the debriefing thoroughly supported the identification of this among the most significant social skills.

Each selected obstacle was analysed against the findings from debriefing to form the final system design. This is discussed in the following section.

### **3.6.5 Analysis and final obstacles**

The first obstacle identified to be significant covered sensory issues of sound and chatter affecting concentration. Although all participants reported it was significant in the survey, in the debriefing no participant reported it to be among the most significant social obstacles. Therefore, it was not selected to be among the most significant social skills.

The second identified obstacle concerns verbal communication being misunderstood. In debriefing, most participants identified engaging in verbal behaviour to be significant, although this specific one had not been among their reported most significant social obstacles in the survey.

Therefore, engaging in verbal communication was selected to be among the most significant social skills.

The third identified obstacle covered Physical Environment of crowded restaurant and no quiet tables. In the debriefing, some participant reported the no quiet tables to be significant thus social skill to address this was identified to be among the complete system of most significant social skills.

The fourth identified obstacle was that of small talk, in the debriefing the issue of small talk and engaging in conversation was a recurring theme among the participants, therefore it was selected to be among the most significant social skills.

Although the first and second obstacle are not selected to be among the most significant social skills at this stage, an extended version of the serious game could address these skills as an advanced stage to which users can progress.

The debriefing results showed that the participants placed the most emphasis on engaging in non-verbal behaviour/skill of eye contact and verbal behaviour/skill of engaging in conversation. The non-verbal behaviour/skill of eye contact is established to be impaired among people with Asperger's Syndrome/HFA (Attwood, 2007; Kaartinen et al., 2012; Motti, 2019; Thai & Nathan-Roberts, 2018) and is among the core social skills deficits for people with HFA. This combined with the emphasis the participants placed on eye contact in the debrief interview, and advice from the Autism expert, resulted in it being selected for the study. Similarly, the verbal behaviour/skill of initiating/starting conversation, maintaining/sustaining conversation, and ending conversation (Attwood, 2007; Khowaja, 2017; White, 2011) are among the core social skills deficits for people with Asperger's syndrome/HFA as is established in Section 2.1.2. Their importance was supported by the study with participants, and hence were selected for the study and presented to the Autism expert for further discussion. The non-verbal social skill of eye contact is vital to engaging in successful interaction with another person and the social skill of engaging in conversation covers verbal behaviour as well as assertive behaviour of initiating/starting conversation. Thus, the skill

of engaging in <sup>1</sup>small talk/conversation itself has three sub-sections of initiating/starting conversation, maintaining conversation, and ending conversation. The argument a system that gives precedence to social environment was supported by the comment of one participant in the debriefing who stated, ‘a program that addresses the issues of how to engage in conversation will weigh more for people with Asperger’s Syndrome than Physical Environment thing, like no toilet paper’. This proposal was presented to the Autism Expert who agreed that these were the most significant social skills for any social interaction and in this case for a restaurant experience. Therefore, a single complete design to address most significant social skills consisted of the skill of eye contact and engaging in small talk/conversation with its three skills of starting a conversation, maintaining a conversation, and ending a conversation.

### **3.7 Conclusion**

The aim of the social skills study was to identify and prototype a single complete design system that addresses the most necessary/significant social skills for people with Asperger’s Syndrome/HFA. In the context of this thesis, it refers to a system prototype that integrates social skills from multiple social behaviours therefore giving the user experience of a wide spectrum of social conduct. This was done with human-centred design thinking approach by engaging the Autism expert and end users in the decision making. The complete design system prototype contains the social skills of eye contact, initiating/starting conversation, maintaining conversation, and ending conversation. Each of these skills consist of its subskills. Figure 3.4 outlines them.

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<sup>1</sup> Small talk – “Light talk or conversation, esp. polite conversation about unimportant or uncontroversial matters, as engaged in on social occasions.” (The Oxford English Dictionary accessed January 2021, <https://www.oed.com/>). In the context of the serious game, the term small talk is used to refer to light conversation that covers both structured interaction with the greeter and the unstructured interactions with the friend.

| Social skill                     | Sub-skills   |
|----------------------------------|--|
| Eye contact                      | <ol style="list-style-type: none"> <li>1. Getting in line of vision</li> <li>2. Using body language to get attention</li> <li>3. Making appropriate eye contact</li> </ol>           |
| Initiating/starting conversation | <ol style="list-style-type: none"> <li>1. Stand at reasonable distance (proximity)</li> <li>2. Ask relevant questions</li> </ol>   |
| Maintaining conversation         | <ol style="list-style-type: none"> <li>1. Adopting listening position</li> <li>2. Showing an interest in what other is saying</li> <li>3. Turn taking during conversation</li> </ol> |
| Ending conversation              | <ol style="list-style-type: none"> <li>1. Appropriate time and appropriate method for ending conversation</li> </ol>   |

**Figure 3.4: Selected social skills with a list of its subskills.**

These skills are vital for any social interaction and once equipped with them, an individual can successfully manage several social obstacles, therefore the proposed social skills training program consists of these skills. After the identification of the most necessary/significant social skills, the next step was to develop the design for the serious game to provide social skills training for people with Asperger’s Syndrome/HFA as presented in the next chapter.

## **4 Design: Serious game for social skills training**

The literature review in Chapter 2 described the social skills deficits among people with Asperger's Syndrome/High-Functioning Autism (HFA). It elaborated on the potential of addressing social skills training for them through serious games. The design framework proposed (Khowaja, 2017) for serious games for people with Autism was explored, and the relevant game components were identified for our purpose. These game components were clustered together based on their functionality, and a structure for the design components for our serious game prototype was proposed. It is discussed in Section 4.1. The established recommendation by Wilkinson & Canter (1982) for social skills training programs for people with Autism, highlighted the importance of engaging the prospective users and the professional/expert in the design process as detailed in Chapter 2.

Consequently, this study proposed using a human-centred design thinking approach and engaging the professional/expert and prospective users in the design process, as presented in Section 4.2. Section 4.3 discusses the design considerations, and Section 4.4 the design decisions made based on the finding in Chapter 2 and the design suggestions offered by participants in Section 3.3.1, that formed the basis of the game prototype. Section 4.5 presents the evaluation design, and Section 4.6 presents a summary of the serious game design proposal.

### **4.1 Serious game design framework**

Growing research interest in serious games over the recent years led to research into specialized serious games design frameworks to assist game developers. Khowaja (2017) proposed a serious game design framework for people with Autism, as presented in Section 2.3.1. The proposed serious game design framework was analysed to identify the game components from this that were relevant to our research. Due to the complex nature of our proposed serious game, all the proposed game components were identified to be valuable to our design. However, the game components were grouped according to their functionality in the game design process, forming eight main segments of game components. These segments were then placed in a sequential design structure to assist the design process for our purpose, as shown in Figure 4.1. Each segment and its contribution to our serious game design is discussed in the following section.

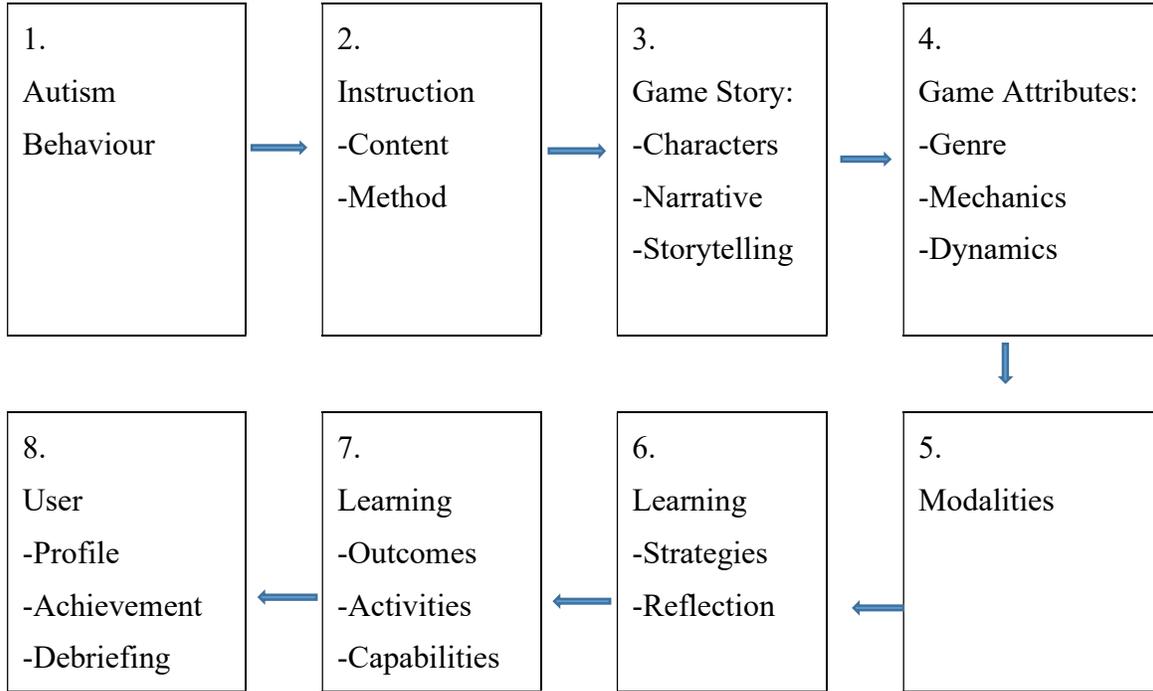


Figure 4.1: Game components design structure.

### 4.1.1 Autism behaviour

Individuals with Autism exhibit varying degrees of autistic traits and behaviours. The one-size-fits-all design is not feasible when dealing with diverse individuals and behaviours. White (2011) suggested identifying social skill deficits and matching them to training; therefore, the most important decision before designing a serious game is to identify the behaviours that will be addressed through the serious game. These behaviours form the foundation of the serious game as it dictates the instructional contents and learning activities.

For our purpose, a study of the social obstacles was conducted with prospective participants as detailed in Chapter 3, for the development of a complete system that encompasses necessary/significant social skills from all three social behaviour categories: non-verbal, verbal, and assertive. The identification of social skill to be among the most significant was influenced by the following criteria: whether the skill was among the core/common deficits, whether it was identified by participants to be significant in the survey, whether it was implementable into a

practical virtual experience, and whether it was identified to be significant in the debriefing. The process for selection of the social tasks and the outcome was discussed in detail in Section 3.6. The main identified social skills were that of eye contact and small talk skills, along with the sub-skills. The skill of eye contact consisted of the sub-skills: getting in the line of vision of the other person, if required using body language to get attention, and making eye contact and maintaining eye contact. The small talk consists of the skill of starting a conversation, maintaining a conversation, and ending a conversation. The skill of starting a conversation is divided into two subskills: moving to the appropriate/acceptable distance from the other person for conversation and starting a conversation with appropriate conversation starters. The skill of maintaining a conversation has three subskills: adopting a listening position, showing an interest in what other is saying and turn-taking during the conversation. The last skill in this category consists of knowing the appropriate time and method for ending conversation. The next step in the design structure was to identify the instructional components for the serious game; these are discussed next.

#### **4.1.2 Instruction**

The two components used in the process of designing interventions for teaching social skills and enabling learning opportunities are the instructional method and instructional content.

##### *Method*

The instructional method refers to “evidence-based methods that have proven to be effective for some individuals on the spectrum” (Khowaja, 2017, p.134). The instructional method for this study consisted of reviewing evidence-based social skills training interventions/strategies and identifying the effective method or methods to promote learning of the target skills among users. The social skills training method that stood out in the review was that of group social skills training, as presented in Section 2.2. Group social skills training is advantageous to the individual’s training as it provides efficient, immediate, and natural opportunities for practicing newly learned social skills (Berry et al., 2003). The techniques used for social skill training resembles teaching any other skill, where the task is broken down into smaller steps and taught systematically, starting with easy and moving on to the complex. Each step consists of direct instruction, modelling, role-playing, shaping, feedback, and reinforcement of positive interaction, followed by

homework tasks to practice the newly acquired skill. Some research with younger children is inclusive of parental training to reinforce the skill training; however, as this program is designed for high functioning young adults/adults, parental reinforcement was not considered in the program design.

The social skills training modules for this study were carefully selected. The attributes that assisted the selection of the training modules were first and foremost the effectiveness of the training module in real life training, the possibility of virtual implementation of the training module, and the possible effect on overall training if the training module is absent. The social skill design proposal consisted of skill instruction, modelling, role-playing, reinforcement, and feedback. These elements are vital for social skills training, are implementable, and leaving them out will reduce the overall impact of the social experience, thus negatively impacting the participant's learning. In a real world training session, these are carried out by an instructor; therefore, virtual design alternatives were proposed for each of these training steps. These are further discussed next.

### ***Instructional Content***

The instructional content refers to “the specific contents or subject matter that player can learn through the serious game” (Khowaja, 2017, p.132). The instructional content categories proposed for this game design consisted of concept, procedure, and principle. *The concept* refers to the promotion of basic understanding of the target skill, the *procedure* is the sequential performance of the tasks, and *principle* refers to the cause-effect relationship between the behaviour and its application.

The proposed design for the concept was to create instructional information for each identified skill and sub-skill based on training concepts presented by Jed Baker in ‘The social skills picture book: For high school and beyond’ (Baker, 2006) and Alison Schroeder in ‘Socially speaking: A pragmatic social skills program for primary pupils’ (Schroeder, 2000). The proposed design for the procedure consisted of a step-by-step system for each skill and sub-skill, moving in a natural sequence. The non-verbal skill of eye contact was to be addressed first with all its sub-skills, followed by the assertive and verbal skill of initiating/starting conversation, then the skill of maintaining conversation with all the verbal and non-verbal sub-skills in sequential order and ending a conversation. The

proposed design for principle was to enable the carryover of skills from one task to another in sequential order, i.e., the skill of eye contact was to be addressed first and when the tasks for small talk starts, this task is reiterated in it thus outlining the cause-effect of eye contact on skills of small talk.

### **4.1.3 Game story**

The game story/setting presents the overall context of the game and is comprised of three components, the game characters, the narrative, and the storytelling. The first step in the game story was to identify the context and theme for gameplay.

White (2011) recommended the use of a natural environment for promoting social skills, hence, the proposed context for the serious game was a restaurant environment and the theme were interaction with the restaurant staff and a friend that came to dine with the user, as presented in Chapter 3. A restaurant scenario was chosen as it is an environment that enforces both structured and non-structured interaction. The structured interaction was the social experience that takes place between the diner (player) and the restaurant staff. It had a series of steps that were likely to occur in a restaurant experience. The non-structured interaction was the interaction that takes place between the diner (player) and the friend—Non-Player-Character (NPC). The social skills were addressed in the restaurant context however the skills might be applicable to other social situations, e.g., at the hospital, in the supermarket (if you need to find out about where a particular item is placed, you have to follow the steps of eye contact and small talk skills with the reception/greeter by using the non-verbal skill of moving in the line of vision, making eye contact, maintaining eye contact, approaching them once they have your attention, keeping the acceptable distance when communicating, engaging in conversation, understanding when to speak, maintaining the listening position when being spoken to and ending conversation), etc. As the target users were young adults and/or adults, it was deemed appropriate to set the virtual training in a social context like restaurant as they are likely to be engaging in real life restaurant experience either personally or with family and friends thus the social context will be familiar and realistic from the user perspective. The three game story components: characters, narrative and storytelling are further elaborated.

### *Characters*

The characters refer to the non-player character in the game. The non-player characters are controlled from within the game through scripting. The proposed design for characters in the game consists of the greeter/waiter, the friend, and the other diners. The greeter and the friend will engage in the proposed social skills tasks with the player. The other diners will not engage in direct interaction with the player, however their existence in the game is vital for presenting realistic restaurant environment to the player.

### *Narrative*

The narrative/story refers to the sequence of events that sets the motivation behind the gameplay. It can be presented in written words, spoken words, or moving pictures. The narrative for the gameplay is proposed to occur on multiple occasions. First, at the initial start-up of the game before the player enters the game to provide an overview of the expectations and motivate engagement from the player. Narratives are further proposed to be used in the training phase. After the skill introduction and social skill modelling video, as in the training strategy, skill practice is intended to present the player with a narrative/scenario to enable skill application.

### *Storytelling*

Storytelling refers to the resulting story of the designer's account with the player's decisions during gameplay. The design for storytelling is dependent on the stories the designer wants the player to experience hence designing the story/setting, character, and narrative around this. The proposed design of storytelling for this game consists of presenting the player with interaction choices, especially conversational choices for each skill and sub-skill task that leads to relevant experience.

#### **4.1.4 Game attributes**

The game attributes refer to the application of established teaching practices into the serious game to support effective learning and engagement. The social skill training strategy consisted of skill/direct instruction, modelling (social skill modelling video), role-playing/practice opportunity, and feedback. The design proposed game scenario creation based on the training strategy for each skill and sub-skill to support learning, critical thinking, and engagement.

The game scenario led to a design decision about the game mode. The main factor of influence for game mode is the objective of a given game idea. The proposed game aimed to provide social skills training in an ‘effectively’ immersive environment. An effective immersive environment refers to a simulation that offers real life like environment and experiences without over stimulating hypersensitivities and social stressors. In determining an ‘effective’ immersive environment, two general game modes were considered. The two general game modes that are used for serious game design are virtual reality and the 3D virtual game, as discussed in Section 2.3.

The first proposed game mode was a virtual reality with a head-mounted display. Virtual reality with a head-mounted display involves the use of headgear, earpiece, and the controller handle and is known to provide vivid real life like experiences. Section 2.3.3 established that when working with people with Autism, it is advisable to avoid the use of any restraining or uncomfortable equipment as that may affect the overall user experience. It also presented the argument that virtual reality with a head-mounted display has the potential of causing cyber-sickness and heightening sensory (visual/auditory) stimuli, thus enhancing the social stressors, and negatively impacting the user’s social experience. Therefore, virtual reality with a head-mounted display was not the selected platform for this study.

The second game mode that was considered for this study was a first or third-person camera in a simulated three dimensional (3D) environment. Section 2.3 established that 3D environments have the potential to provide an immersion into the social environment/experience and address socio-communicative deficits. 3D environments are cost-effective; they do not cause cyber-sickness or heighten sensory stimuli; thus, a 3D environment was reported to be the best platform for our purposes.

For presenting the serious game to participants, the Personal Computers PCs were reported to be the most familiar device for users and researchers (Section 2.3.2). Thus, to reduce discomfort, the serious game was designed to be presented on a 42-inch screen Television (TV) using its audio output, thus avoiding the use of any headsets or other devices attached to the player. The design decisions regarding the game genre, game mechanics, and game dynamics are discussed next.

### ***Genre***

The game genre is defined by the challenges that the gameplay presents (Khowaja, 2017). The game genre proposed to complement the game story, in this case, is role-play in a simulated restaurant environment.

### ***Mechanics***

The game mechanics specifies the player's interaction with the game world through a set of actions, behaviours, and control mechanisms. The game controls/elements used for interaction with the system consisted of the mainstream 3D virtual reality game controls/elements. The standard game control of WASD was proposed to be used for forward/backward and sideways movement. 3D games generally use the mouse movement for rotation of the first-person player; however, this game proposal required the participant to interact with active objects in the environment, i.e., door, buttons, menu, checkboxes at various stages as will be further discussed in later paragraphs, thus mouse movement was proposed to be detached from rotation and instead used for interaction with the user interface. The rotation of the first-person controller/player was offered to be done through the arrow keys on the keyboard as they are directional keys hence viable for this purpose.

### ***Dynamics***

The game dynamics refer to the player's emergent behaviour during gameplay as it promotes enjoyment and engagement. The proposed game dynamics used a progressive learning framework. This design recommended starting the participant with tasks in a <sup>2</sup>static environment to allow them to get familiar with the game aura and mechanics, then moving them onto the social skills training program. The training stage is proposed to be followed by free flow/practice mode that provides the user with assistive feedback. It is to be followed by the test mode stage, where the assistive feedback is proposed to be withdrawn. These stages were designed to increase enjoyment and engagement.

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<sup>2</sup> Static environment - the mode of virtual environment gameplay at the start of the program where distractions such as background noise, greeter, other diners are inactive (paused), to allow the user to focus on the task at hand.

#### **4.1.5 Modalities**

Modalities refer to the communication channel used for conveying or acquiring information. The integration of “more than two modalities are known as multimodal games” (Khowaja & Salim, 2019, p.25). This serious game design proposed the use of a multimodal feedback system. Müller et al. (2008) recommended the use of direct instruction to promote explicit and clear communication; thus, instructions were to be delivered through on-screen text accompanied by audio playback. Following the participant recommendation to make use of clips from movies to teach about the social cues (Section 3.3.1), the skill modelling was to be delivered through social skill modelling video; role-playing was to be delivered through mini virtual tasks that enabled skill practice opportunity; reinforcement was to be implemented through the in-game scenario best-worst selection survey immediately post skill training, and immediate feedback was delivered post best-worst survey attempt and through the use of proxies. This strategy was proposed as the best virtual alternative for real world group training. Although in group training the feedback is provided by the instructors and possibly peers, the game design proposed a virtual feedback mechanism where feedback was provided through audio and text upon successful completion of a social skill that was practiced. It was complemented with the stars system that enabled the recognition of successful completion of social skills tasks that were grouped together upon its completion.

#### **4.1.6 Learning facilitators**

Learning facilitators assist learning objectives of gameplay and comprise strategies and reflection. These are discussed in the following sections.

##### ***Strategies***

The proposed design strategies included visual changes during training and gameplay. The strategies refer to techniques used to support instructional methods by getting the user’s attention, engaging them in learning, and stimulating their thinking skills. The visual changes were to be presented in the form of freeze-frame where the scene and all the game objects and distractors, e.g., non-player characters, the player character, the background noise, and the TV were paused and blurred. They were to be obscured but not entirely removed from player view. It was to be done to draw attention to the learning activities

that consisted of instructions presented in written text over an extended text display and with audio playback, presented one by one to enable thinking and grasping of information before building on it. The social skill modelling video presentation decisions were proposed to display minimal instructional text for significant tasks alongside the zoom/focus feature to draw attention to the specific behaviour.

### ***Reflection***

Reflection refers to techniques used to promote strategic thinking of the learning activities and its application in the next activities (Khowaja, 2017). As with the skill training design proposal, the training is comprised of skill instructional information, social skill modelling video, and practice scenarios within the training, followed by feedback. The practice scenarios are proposed to use the best-worst evaluation methodology. Best-worst evaluation methodology refers to evaluating a set of given options to find the best and the worst option in the given context. It promotes critical thinking, as unlike the evaluation methods where the participant is required to select the best option, the best-worst technique enforces further evaluation of the given option to identify the two extremes for the given context. The participants in Section 3.3.1 recommended giving the user ‘feedback on why the selection was right or not’; therefore, this is proposed to be followed by a review of each presented option and its implication in the given context.

### **4.1.7 Learning**

Serious games are designed with the intent of specific learning through the gameplay (Khowaja, 2017). The proposed framework uses three components of learning: learning outcomes, learning activities, and desired capabilities.

#### ***Outcomes***

The learning outcome refers to the goals that are set for the player to achieve through gameplay (Khowaja, 2017). The learning outcomes for this design was proposed to be social skills and sub-skills. The social skills and sub-skills were taught using the proposed social skills training program. The free-flow/practice mode and test mode offered to provide on-screen skill evaluation survey for each taught social skill enabling the player to recall the learning from the training session to answer the skill-specific questions correctly

and use it in the game to progress to the next activity. The player's responses are recorded and presented to them in the debriefing, as is detailed in Debriefing (Section 4.1.8).

### *Activities*

Learning activities refer to the tasks that promote player engagement and immersion into the game environment (Khowaja, 2017). Important design consideration for learning activities is to ensure the activities match the player's competency level, so the design proposed adopting a systematically progressive model where the activities start with easy and move onto harder tasks, thus providing an adequate dose of intervention as recommended by White (2011). This model is to be reflected in the whole system and the social skills training activities. The player is to start with a static environment and engage in easy tasks, then is moved to training mode to learn about the skill, then to free flow/practice mode with the feedback mechanism, and finally, to test mode where assistance is withdrawn. The training activities are to provide mini tasks for the addressed skill post training followed by the best-worst evaluation and the free-flow/practice mode; and test mode is to present the post skill evaluation enabling recollection of the training.

### *Capabilities*

The capabilities refer to the development of the desired cognitive, psychomotor, and affective skills due to gameplay (Khowaja, 2017). These refer to the player's ability to recall, analyse, evaluate, identify, adopt appropriate attitudes, thus promoting well-time task execution. The post skill on-screen skill evaluation surveys are proposed to promote recall, and analysis of the addressed social skills. The proposed design for free flow/practice mode is to encourage the identification and adoption of appropriate actions/attitudes while providing immediate feedback where the participant may attempt the inappropriate behaviour. Whereas the test mode is proposed to withdraw assistive feedback and promote analysis of affective skill through evaluation of the player's behaviour as they engage in social skills during gameplay. The proposed focus for the test mode is the analysis of the player's engagement in eye contact, distance recognition from the other person, the speaking time, and conversational decisions.

#### **4.1.8 User data**

User data refers to components that enable personalization and customization of the user experience (Khowaja, 2017). It is achieved by setting up a user profile and recording user achievement. This information assists in debriefing the player on their game performance. Each of the three elements and their implication in the game design is discussed below.

##### ***Profile***

The serious game framework proposed the use of user profile at set up, where the user records their necessary information into the system and updates this information as needed (Khowaja, 2017). The serious game design proposes storing the player's username/given name for the game prototype.

##### ***Achievement***

User achievement refers to the successful accomplishment of the set game activities and tasks. The game design proposes recording the player's responses to the post skill on-screen skill evaluation survey, recording the percentage of successful eye contact during gameplay, recording the count of times the player interrupts the conversation, and fiddles with game controls while the other person speaks.

##### ***Debriefing***

Debriefing refers to providing the player with information on their game performance at the end of the gameplay (Khowaja, 2017). It assists their understanding of their overall performance and outlines the areas that they did well in and the ones that need improvement. The debriefing can be particularly helpful for returning players as they can analyse their performance improvement. For this study, the proposed debriefing consists of the profile information with their achievement information displayed as the transition screen between free flow/practice mode to test mode and then as the end window from test mode to exit the game. It is to allow the participant to view their performance difference in the two environments post skill training.

It concludes the design proposal for the game components and the game structure of serious games for people with Autism. The literature review in Section 2.3.2 highlighted the importance of

engaging professional/expert and end-user in the design process; thus, the next section elaborates on the design approach to achieve this.

## **4.2 Design approach**

The limitations and recommendations identified in the literature explored in Section 2.4.2, included the need for engaging end-users or Autism professionals/experts in the design process. The approaches that are commonly used for engaging users and experts in design processes include participatory design, user-centred design, and human-centred design thinking.

Motti (2019) reported that designing effective technology for neurodiverse users requires the use of inclusive and participatory design to allow iterative engagement of and decision making by the participants from the early stages of the design process. This design approach is known as participatory design. It uses dedicated methods to provide “appropriate support, and guidance to understand the needs of neurodiverse users and involve them” (Motti, 2019, p.3).

Preece et al. (1994) defined user-centred design as “an approach which views knowledge about users and their involvement in the design process as a central concern” (p.722). This requires integration of knowledge and expertise from different disciplines, and continuous user engagement to influence the design. A researcher collects information from the user and secondary sources, to learn about the user’s needs and transfers this information to the designer/design team. This information is used to prototype the design and an iterative testing process is used with the user to ensure the design meets their needs (Abrams et al., 2004; Sanders, 2002). Hence, a researcher acts as an interface between the user and the designer/design team (Sanders, 2002).

The main distinction between user-centred design and participatory design is that in participatory design, the user is directly and proactively engaged in the design development process (Abrams et al., 2004; Sanders, 2002).

Human-centred design is derived from user-centred design, using many of the same techniques for requirements elicitation, design, iterative prototyping, and testing. The main distinction is that human-centred design extends the process of addressing the concerns, values, and perceptions of other stakeholders in the design as well as those typically considered as users (Harte et al., 2017; Zachry & Spyridakis, 2016).

Human-centred design thinking is the term used in design literature to address these issues. Its stated goal is to solve problems by matching people's needs with technologically and logistically viable solutions. It is documented as a five-step process, the d.school model (Sakama et al., 2018). This process was used by Fabri & Andrews (2016) for applying the human-centred design thinking approach to working with university students with Autism. In selecting this approach, they argue that true innovation emerges when empathy, creativity and analytical processes are combined.

The five steps of the d.school model are:

- Empathise: gain a deep understanding of user needs through surveys and interviews with emphasis on real life events.
- Define: identify the users' needs: what, why, and which context.
- Ideate: generate ideas for meeting the identified needs through engaging with all the stakeholders.
- Prototype: iterative process of prototype design.
- Test: iterative process of obtaining feedback on design from end users.

The human-centred design thinking approach as used by Fabri & Andrews (2016) was chosen as the approach to develop the serious game prototype for this present thesis.

In applying this approach, the stakeholders involved during development were young adults and adults with High-Functioning Autism and an Autism Expert (and leader of the New Zealand Autism support group). Young adults and adults with High-Functioning Autism may use the serious game as a training program or as part of a training program. Autism behavioural therapists/experts may use the serious game to supplement their programs.

The extent to which the study adhered to the d.school model human-centred design thinking approach is detailed below:

- Empathise: the researcher engaged with members of a New Zealand Autism support group through a survey of social obstacles in restaurants and an extensive debriefing interview with each participant, to identify the social obstacles that were important to them, as detailed in Sections 3.3 and 3.4.
- Define: the researcher analysed the social obstacles identified by support group members to determine the most significant needs, why they were significant and in which context

they mattered. Findings were discussed with the Autism expert to verify the identified needs. This work is presented in Sections 3.5 to 3.7.

- Ideate: ideas were generated as to how to meet the users' needs (Chapter 3). Design suggestions by participants, as presented in Section 3.5.1, were considered and the researcher engaged with the Autism expert for feedback on game design decisions.
- Prototype: a prototype system was developed, but there was a limited iteration of the design, as access to users was limited and involving participants in the iterative prototype process would have compromised their value for testing. Thus, a complete iterative prototype process was not conducted with the whole system; rather a limited iteration was conducted on paper for parts of the design, as reported in Section 5.5.1.
- Test: it was not possible to do iterations of testing with users due to the small pool of participants available. However, evaluation of usability was done with an expert in the field of Human Computer Interaction as reported in Section 5.4 and Section 5.5, and a single major evaluation of the serious game was undertaken with members of the Autism support group (Chapters 6 and 7).

### **4.3 Design considerations**

Hirumi (2010) emphasized the importance of gameplay in the design of a serious game. The gameplay takes precedence over the physical game environment as it is the deciding factor of the engagement and immersion of the user. The gameplay consists of goals, decisions, pacing, balance, and other elements that make the experience enjoyable, as presented in Section 4.1.7.

The game design uses levelling up method where the successful completion of a step leads to a higher/more advanced level. This game uses this strategy as the focus is on one skill at a time, and upon its completion, another is introduced as discussed in Learning Activities (Section 4.1.7).

The design considerations for the serious game proposed by Motti (2019) consisted of clear instructions; multimodal feedback; customization of the sensory output; damage and bias prevention during user study; detection of distractions, distress, disengagement and propose interventions accordingly; provide stress-free space and reduce discomfort due to the devices; minimise stress sources such as fully immersive VR and sensory overload; positive feedback,

encouragement, and rewards; allow customization of interventions, text, feedback, and sensory outputs. The design considerations and their implication in the serious game are further discussed. The serious game proposed the use of SiSoMo (sight, sound, motion) (Hirumi, 2010) approach to enhance user interaction and promote the emotional experience. Participants suggested the use of ‘audio input, computer reads the thought bubble’ (Section 3.3.1); therefore, the proposed design uses a combination of text and audio playback of automated and timed instructions of the users as presented in Section 4.1.5. Emotional engagement with learning enhances the learning experience and retention.

Müller et al. (2008) reported the recommendation made by people with Asperger’s Syndrome/HFA to provide facilitated and structured social engagement opportunities with others, thus, the serious game was carefully designed to provide virtual experience with sufficient realism while avoiding stress caused by sensory overload in virtual reality with a head-mounted display.

The game provided customization of the audio by providing the sound off button. The interaction devices for the game were limited to mouse and keyboard input. White (2011) recommended providing a safe, nurturing environment, and the participants suggested preventing trolls and abusive people from accessing the social interaction medium (Section 3.3.1). Thus, to offer a stress-free and safe environment, the game did not allow networking, and the communication and interaction took place between the participant and script generated character models.

The game used a multimodal feedback system where verbal and text positive feedback was provided upon successful completion of a social skill that was taught. It was complemented with a star’s system that enabled the recognition of successful completion of social skills tasks that were grouped together upon its completion, as presented in Section 4.1.5.

As this was a serious game for social skills training, it was not viable to allow customization of interventions. However, the feedback after each user study provided the game performance report with the participant’s name was thus customized as discussed in Debriefing (Section 4.1.8).

#### **4.4 Design decisions**

The serious game was carefully designed to incorporate the social skills training simulation for the social skills and sub-skills of interest into a virtual system where its strengths were utilized to

provide users with effective realism. The main design concern was translating the aspects of real world training into effective virtual training. Several game controls/elements and proxies were designed for this purpose.

The game controls/elements used for interaction with the system consisted of the mainstream 3D virtual reality game controls/elements. The game controls proposed were: WASD keys for player movement; arrow keys for player rotation; and mouse movement and clicking for interaction with active objects.

The game was proposed to contain assistive features should the player need to use them. The game, by default, uses the first-person view; however, it enabled the player to swap between first-person and third-person perspective with the click of a button. Another assistive feature proposed was pop-up written assistive instructions during gameplay, i.e., when the player gets to the door, a pop-up message says, 'Click on the door to open it.'

It was proposed to play music inside the restaurant alongside people chatter sounds as that is expected noise in the environment. To assist the user with hypersensitivity to noise, the game provides background audio-off options that will be displayed in the control bar, should they need to use them.

The proposed social skill training program consisted of skill instruction, modelling, role-playing of the skill of interest, reinforcement, and feedback. The proxy for real world skill instruction was by written text accompanied by audio playback. The skill modelling was to be proxied with a pre-recorded modelling video of the skill. The role-playing was to be conducted in the game by creating a scenario and allowing the player to respond using the newly introduced skill instruction and modelling. The reinforcement was proxied using a built-in in-game survey. Feedback was given in two places; one was by stars after each major skill and at the end of each successful attempt at the training through the player performance report.

The proposed serious game aimed to address the social skills of making eye contact, and small talk skills. Proxies were proposed for the implementation of these social skills and the sub-tasks in the serious game.

The first skill of eye contact consists of getting in the line of vision of the person of interest, getting their attention by making eye contact, and maintaining eye contact. In this game development

context used, the simulation is not capable of measuring the eye gaze behaviour of the participant and their area of interest in the game. The user of the game is represented in the game through an avatar, and the proxy for eye contact is the alignment of the facial axes of the user's avatar and the person of interest as shown in Figure 5.13. Note that the user's in-game presence is referred to as the 'avatar' in both the third-person and the first-person views, even though the avatar is mostly not visible on screen in the latter case. The initial view presented to the user is the first-person view as is common in a 3D game, however, the game provides the user with the option of switching to a third-person view during game play. This is to assist visualisation for the user (they see themselves in the scene) and to make the experience more relatable for those who are new to virtual games. In the third-person view, the alignment of axes is visually clear. In the first-person view, the avatar's line of sight is assumed to be the axis of the screen.

The game provides additional visual feedback on eye contact to the user through the appearance of coloured halos, and the maintenance of these halos when appropriate contact is sustained. A white halo will appear on the screen when the participant gets in the line of vision of the other person. When the player gets to the appropriate distance, the halo will change colour to green, thus providing feedback that the player is standing at the appropriate distance. When the player stands too close to the other person, the halo turns red, thus giving visual feedback. In contrast, if the player character looks away or breaks eye contact, the breaking of the eye contact results in the disappearance of the halo, thus providing the player with visual feedback that the eye contact has been compromised.

The second task of small talk consists of the sub-tasks of starting a conversation by moving to the appropriate/acceptable distance from the other person and with appropriate conversation starters; maintaining conversation by adopting a listening position, showing interest in what others are saying and turn-taking during a conversation; and ending/suspending conversation appropriately. The proxy proposed for the player to communicate with the system consisted of the combination of using a button to tell the program they were ready to speak that led to the list with possible options to choose. During the training phase, a scenario was to be presented to the player alongside a list of interaction and conversation options and requested to choose the best option for the given scenario and the worst option for the given scenario. The best-worst evaluation BWE enforces individual analysis of each presented option and is thus a good method for making the user think

beyond the best option. After the participant's selection, the program goes through each option and discusses its validity and ramifications in the context of the given scenario. It is inspired by the behaviour strategy used in Baker (2006), where an individual is taught the right way and wrong way of behaving in a social scene. The game mode and test mode did not use the BWE rather it enabled the player to experiment with the conversation by pressing on the "Speak Now" button that proceeds to a list of three conversation options. The three conversation options comprise of one best option according to the training/conversation, one acceptable option, and one wrong option. The system is proposed to keep track of the participant's selection and inform them at the end regarding how well they did.

#### **4.5 Evaluation design**

Thai & Nathan-Roberts (2018) recommended evaluating the effectiveness of social skills training virtual systems for people with Autism. Wilkinson & Canter (1982) and Tsikinas & Xinogalos (2019) recommend employing assessment methods before, during, and after training to evaluate the effectiveness of a given social skills training program. The two analysis approaches employed in research are based on qualitative and quantitative measures, as they both "serve certain aspects of research; they have specific strengths and weaknesses, and in the best cases are complementary" (Bölte, 2014, p.1). Qualitative measures include interviews and observations, to enable a deeper understanding of the users' needs and perceptions (Wilkinson & Canter, 1982; Bölte, 2014). Quantitative measures assist objective analysis of the hypotheses and enable generalisability of the findings to larger populations (Bölte, 2014).

For our purpose, the researcher identified the user study research questions to enable evaluation of both the usefulness and the effectiveness of the game, as presented in Section 6.1. A systematic assessment approach was used, where the study was divided to be conducted in five sessions (pre-study, static, training, free flow/practice, test, and debriefing), as presented in Section 6.3. Several techniques were used to retrieve qualitative and quantitative data from the study. Questionnaires were developed to obtain qualitative and quantitative data on the participants' perceptions and experiences, using Likert scales where appropriate to allow participants to quantify their responses. Further qualitative data was obtained from observations of and interviews with participants during the study. Further quantitative data was obtained from instrumentation within the serious game itself.

The effectiveness and usefulness were measured through the above recommendation where data is gathered from the participant before the study (Section 4.6.1), during the study (Section 4.6.2; Section 4.6.3; Section 4.6.4) and at the end (Section 4.6.5) and qualitative information was gathered through observation and debriefing as presented in Section 4.6.6.

An important consideration for the evaluation user study was the hardware, and software sturdiness to prevent damage and the user environment to prevent hindering the data collection. To prevent damage and ensure the user environment is consistent and does not hinder the findings or bias the results, the experiments were conducted inside the usability lab at the School of Computer Science, University of Waikato.

Other design considerations were the awareness of possible distraction, distress, and disengagement by the participant; thus, the researcher was advised to detect the signs during the evaluation/user study, and when necessary, intervene to end the session or regain the participant's focus. The serious game was carefully designed to engage the participants with an automated intervention opportunity at the end of each study session. The interventions allowed for breaks, but the decision of taking the break and the length of the break was handed to the participants, to prevent fatigue and minimise unnecessary distraction. The aim of proposing interventions at the end of each study was to reinforce the idea that breaks were available if the participant needed to take them.

## **4.6 Summary**

The design process described here uses the framework proposed by Khowaja (2017) for designing serious games for people with Autism. The game components in the framework were grouped into eight segments and were structured based on the design process. These were Autism behaviour, instruction (content, method), game story (characters, narrative, storytelling), game attributes (genre, mechanics, dynamics), modalities, learning facilitators (strategies, reflection), learning (outcomes, activities, capabilities) and user (profile, achievement, debriefing).

The design employed the use of human-centered design thinking approach and the engagement of a professional/expert in the design and evaluation decisions throughout the game design process.

Section 4.3 outlined the design considerations, and Section 4.4 detailed the proposed design decisions to enrich the player's overall game experience. The following chapter explores the game implementation process and discusses the game prototype.

# 5 Implementation

Chapter 4 established the design for a serious game to address the social skills training system derived from the research conducted with participants in Chapter 3. This chapter details the implementation process of a serious game for people with HFA based on the general design framework for serious games for people with Autism by Khowaja (2017) as discussed in Section 4.1.

## 5.1 Overview

The implementation process is presented in Figure 5.2. It consists of the development of the game prototype, followed by a prototype review with an expert in user experience. The resulting modification recommendations were implemented, and the software was then presented for a second expert review. Questions raised about the validity of the control bar led to a user study of its design; the new suggestions were taken into consideration and all the results were then implemented into the final game. Figure 5.1 presents the overview of the game flow in detail, which is discussed in Section 5.2.

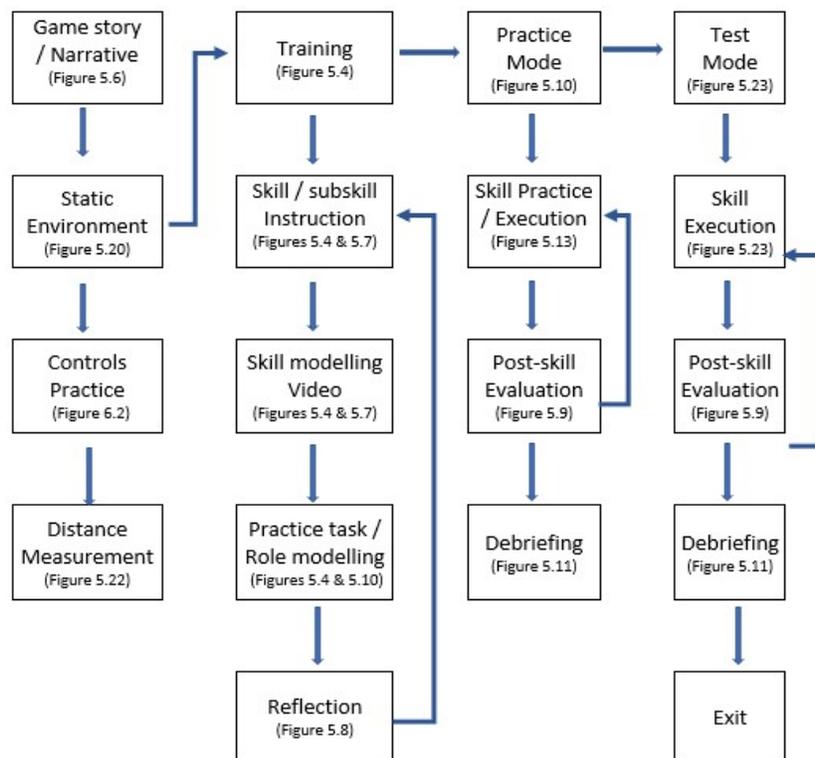


Figure 5.1: The game flow overview.



Figure 5.2: Game prototype implementation process.

## 5.2 Game components

The game design proposal analysed the commended design framework components of Khowaja (2017), to identify their prospective roles in the game, and recommended the method of incorporating these into the serious game as described in Section 4.1. A step by step plan was created for the implementation of the recommended game components in the prototype (Figure 4.1). The following sub-sections describe the implementation of each of these steps into the game.

### 5.2.1 Autism behaviour

Chapter 3 described the research undertaken for the design of a complete system that would address the significant social deficits/challenges for the prospective users of the serious game. The system covers behaviours from all three social skills categories (non-verbal, assertive, and verbal), where each behaviour complements the others and lays down the foundation for social interaction. The non-verbal behaviour is the skill of eye contact, specifically strategies for making and maintaining eye contact. The assertive and verbal skill identified was that of starting or initiating conversation, and the verbal behaviours were those of maintaining and ending a conversation. These social skills, and their related sub-skills, dictate the instructional content and the learning activities of the serious game.

Figure 5.3 lists the behaviours and the sub-behaviours selected for implementation in this study.

| <b>Social skill</b>              | <b>Possible sub-skills</b>  |
|----------------------------------|---|
| Eye contact                      | Getting in line of vision<br>Using body language to get attention<br>Making appropriate eye contact           |
| Initiating/starting conversation | Stand at reasonable distance (proximity)<br>Ask relevant questions  |
| Maintaining conversation         | Adopting listening position<br>Showing an interest in what other is saying<br>Turn taking during conversation |
| Ending conversation              | Appropriate time and appropriate method for ending conversation   |

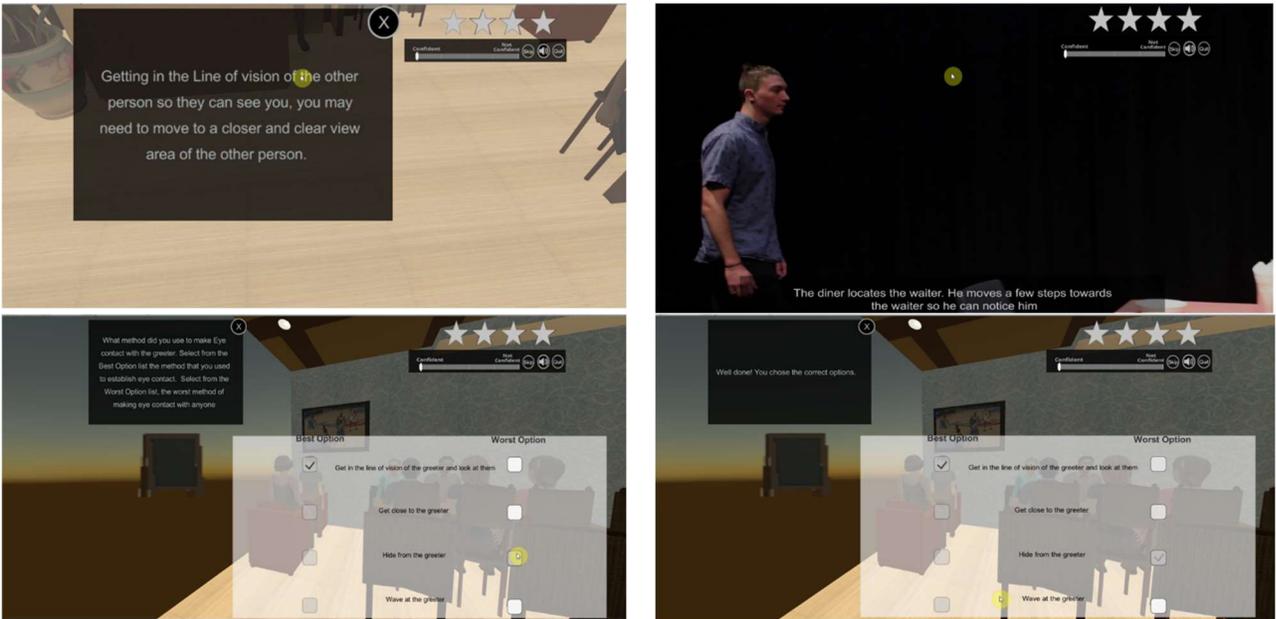
**Figure 5.3: Social skills and its subskills for implementation.**

## **5.2.2 Instruction**

The design components used in presenting social skills, and providing learning opportunity, are instructional method and instructional content. The implementation of each of these is discussed in the following sub-sections.

### ***Method***

This game uses a combination of evidence-based social skills training strategies. It uses the social skills group training format as the overall training grounds for the game, where it combines direct instruction for providing information, social skill modelling videos for enabling skill modelling, in-game practice opportunity for role modelling, and a combination of on-screen skill analysis survey and star reward system to provide feedback.



**Figure 5.4: Eye contact; (a) skill/task instructions using direct instruction method, (b) social skill modelling video, (c) practicing the skill/task, and (d) feedback.**

### *Content*

The social skills training content implemented in this game uses a combination of concept, procedure, and principle as detailed in Section 4.1.2. The game uses concepts about the social skills to create instructional information, i.e., for the social skills and possible sub-skills as presented in Figure 5.5, the instructional information is created based on the social skills training concepts described by Baker (2006) and Schroeder (2000). This involves a procedure where the learning is implemented with a step-by-step sequence, focusing on one skill or sub-skill at a time, and then building on it (e.g., eye contact skill and sub-skills are taught first, then the skills and sub-skills for initiating/starting conversation, then the skills and sub-skills for maintaining conversation and lastly the skills and subskills for ending conversation). This principle promotes the carryover of one addressed social skill into another, e.g., the skill of eye contact is addressed first and when the tasks related to conversation are addressed, the skill of eye contact is reiterated.

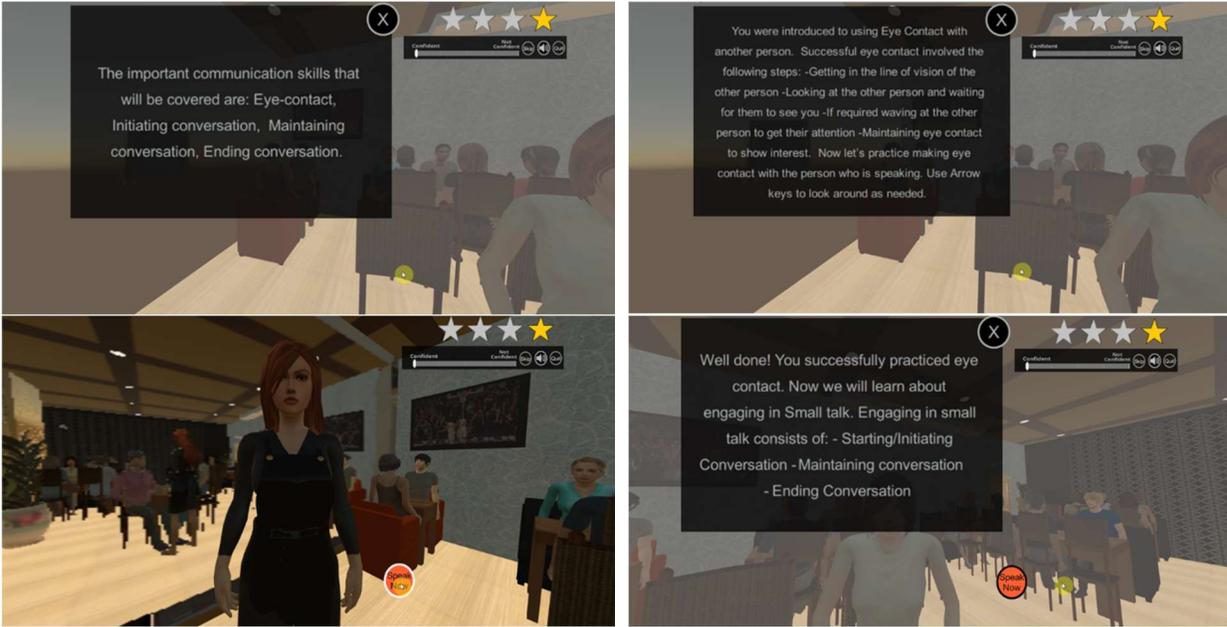


Figure 5.5: Training for eye contact followed by small talk/conversation; (a) concept - skill/task instructions, (b) procedure: step by step learning, (c) practicing the task, and (d) principle - skill/task carry over to next task.

### 5.2.3 Game story

Chapter 4 proposed that the game should simulate a real life like environment and experience using a restaurant scenario. All three components of the game story are used in this game prototype as described in Section 4.1.3 and presented in Figure 5.6. These are detailed under the following relevant sub-headings.

#### *Characters*

The non-player characters (NPC) in the game comprise the greeter/waiter, the friend, and other diners. Interactions are designed to take place between the player and the greeter/waiter, the player and the friend, and the greeter/waiter and the friend. Although animated, the other diners in the restaurant do not directly interact with the player but are vital in creating a restaurant-like atmosphere.

#### *Narrative*

The game uses narrative at the beginning of the gameplay to set the atmosphere. It informs the player that their task is to undergo a restaurant experience where a friend joins them for dinner. During training sessions, the player is presented with anecdotes for a possible

scenario and asked to make relevant choices based on the training that precedes this practice opportunity, and thus assists the social skill exploration in the game.

### *Storytelling*

The training mode, practice mode, and test mode, all use storytelling, with the on-screen choices enabling the story to proceed according to the player's choice. In this manner, the designer's story is built with the player's interaction choices resulting in storytelling.

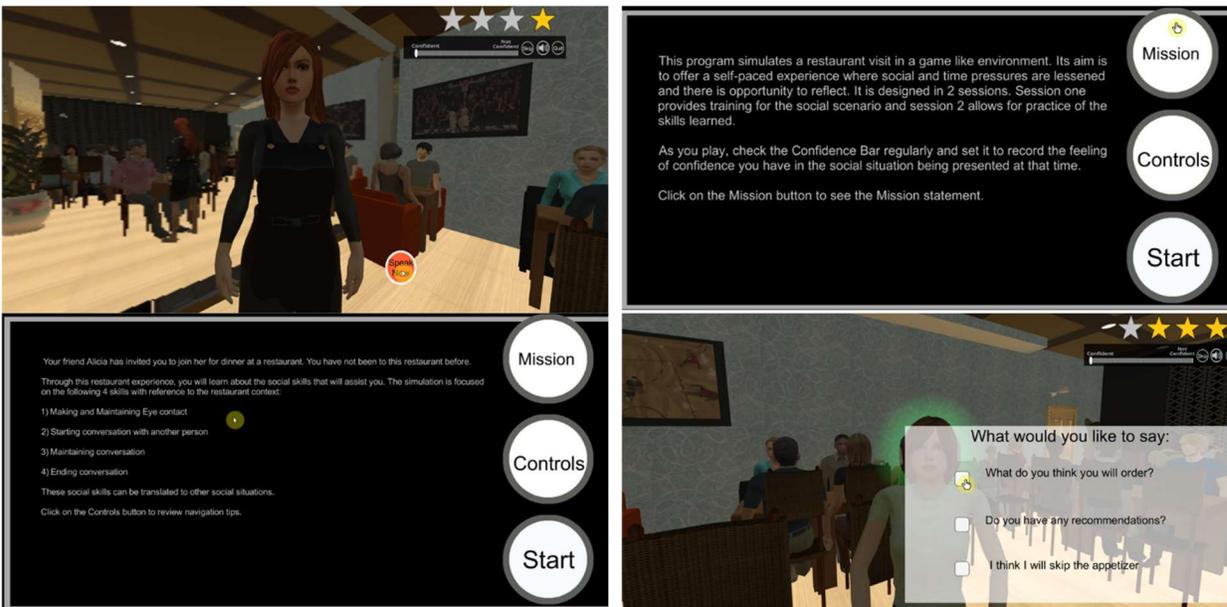


Figure 5.6: Game story components: (a) greeter and other non-player characters NPC, (b) introductory game window, (c) game narrative, and (d) example of storytelling.

## 5.2.4 Game attributes

The game attributes used in the implementation comprise established social skills training practices such as direct instruction, video modelling, practice opportunity, and feedback. The game scenarios are carefully designed to support and engage the user in learning and critical thinking. The implementation process included decisions regarding the game genre, game mechanics and game dynamics, which are discussed in the following sub-sections.

### *Genre*

Game genre is categorized according to the interaction requirement between player and gameplay (Khowaja, 2017). The game genre is role-play in a simulated environment.

### *Mechanics*

The game mechanics enable the player to interact with the game. In this game implementation, the player uses a PC with a 42-inch screen TV. The I/O used for the interaction in game is a keyboard and mouse combination. These selections are discussed in Section 4.1.4.

### *Dynamics*

The game dynamics uses progressive learning as discussed in Dynamics in Section 4.1.4. The game starts with a static environment in which the user gains familiarity with the game. Next, the play moves to the training mode, where the social skill training takes place. It then progresses to free flow/practice mode where the user undergoes the social skills experience with the presence of proxies/assistive feedback and withdrawal of training information. The user is then moved to the test mode where assistive feedback is also withdrawn. All these stages were carefully thought through to increase engagement and enjoyment. Section 5.8 discusses this in detail.

## **5.2.5 Modalities**

The game implementation uses a multimodal model for input/output as proposed in Section 4.1.5. The modalities include text accompanied with audio playback, video models, virtual characters, and forced options.

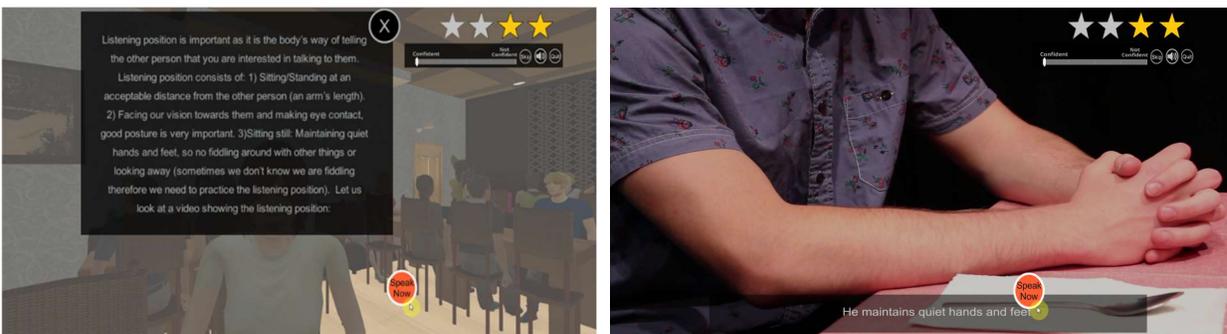
## **5.2.6 Learning facilitators**

The learning facilitators that the game uses are learning strategies and reflection. Their implementation is described in the following sub-sections.

### *Strategies*

The strategies used to get the user's attention, engage them in learning, and stimulate their thinking skills, were visual changes during training and gameplay, e.g., use of Freeze-frame

with prompts and presentation decisions of the social skill modelling videos. The Freeze-frame consisted of freezing/pausing the screen, freezing/pausing the distractors (i.e., background noises, TV), blurring the background while keeping it in view, extending the instructional text display with accompanied audio play-back of the text, and presenting instructions one-by-one to enable thinking and grasping of information before building on it. The design decisions made for the social skill modelling videos consists of adding minimal text of the important instructions and using the zoom/focus feature to draw attention to the skill performance by the actor. Figure 5.7 shows examples of the Freeze-frame and social skill modelling videos.



**Figure 5.7: Learning strategies: (a) Freeze-frame with instruction for Listening position, and (b) video presenting instruction on listening position.**

### *Reflection*

Reflection promotes strategic thinking of the learning activities and enables its application in the following tasks (Khowaja, 2017). The program creates practice scenarios within the training context, that are preceded by instructional information and the social skill modelling video. The practice scenarios use the best/worst evaluation methodology to promote critical thinking. The user is presented with an on-screen skill evaluation survey and requested to select one best and one worst option for the social scenario/anecdote, thus promoting analysis of each given option rather than just choosing the best one. The user's selection is followed by a review of each option presented in the given context. Figure 5.8 shows an example of reflection.

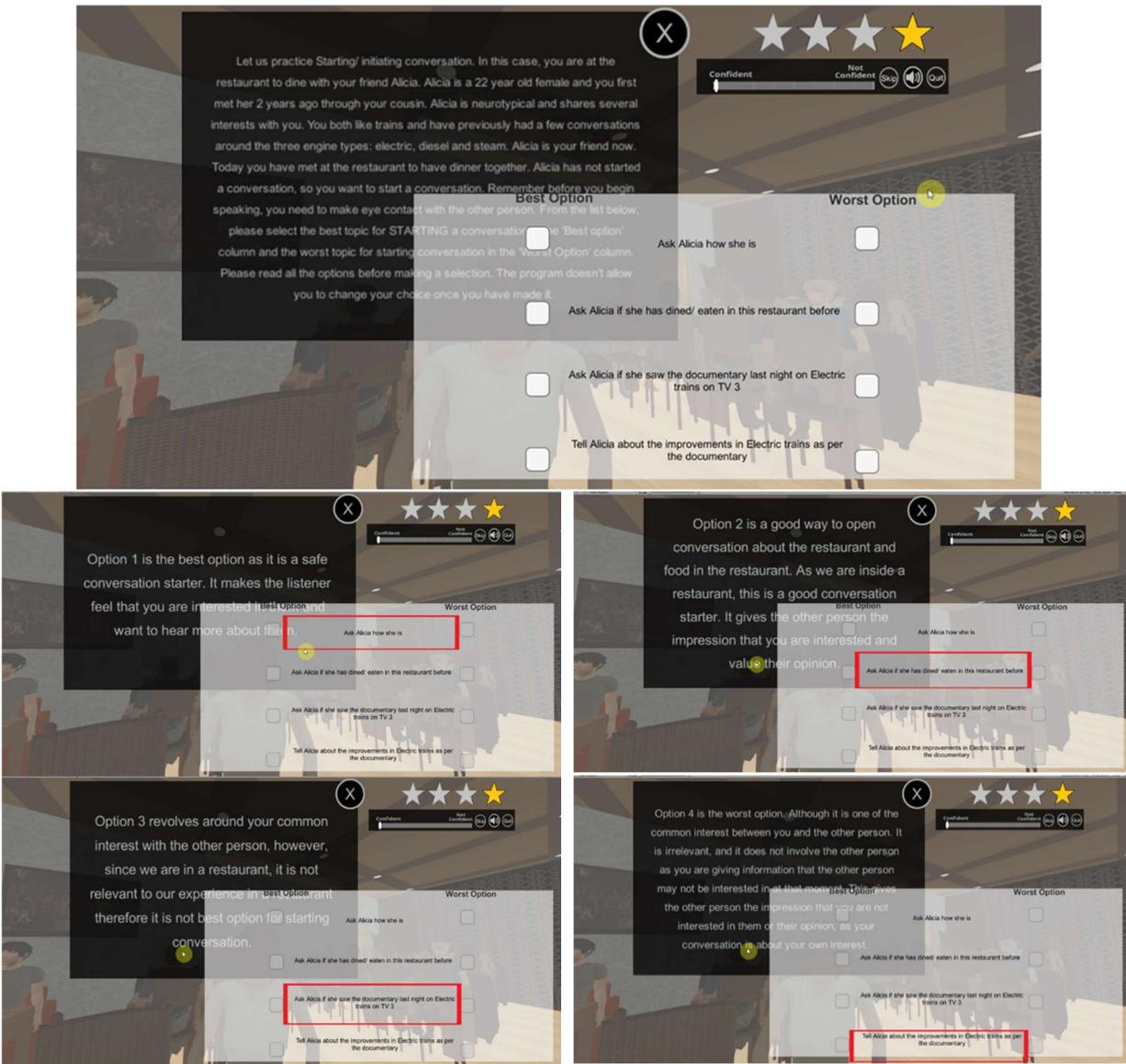


Figure 5.8: Reflection for skill/task of initiating/starting conversation with step by step option review; (a) practice scenario with best-worst evaluation, (b) review of option 1, (c) review of option 2, (d) review of option 3, and (e) review of option 4.

## 5.2.7 Learning

Serious games are intended to promote learning through gameplay (Khowaja, 2017). Learning potential is discussed in the following sections under the headings: learning outcomes, learning activities and the desired capabilities.

## Outcomes

The learning outcome refers to the goal that the user is attempting to achieve. The learning outcome in this study is social skills specific and is analysed post skill training completion in the practice mode, and then again in the test mode. A form of on-screen skill evaluation survey is used, where the user is asked to recall the learning that took place in training, to use that skill in the game to progress to the next activity, and to answer the addressed social skill specific questions appropriately. Figure 5.9 shows the evaluation attempt by one participant in the practice mode and then in the test mode, for the social skill of maintaining conversation. The participant's responses were the same for both questionnaires, successfully indicating carry-over for the learning.

Figure 5.9 consists of two side-by-side screenshots of a skill evaluation form. Both screenshots show the same form with the following content:

**Left Column: Please select 3 strategies that are used for Maintaining Conversation**

- Speaking even if the other person is talking
- Adopting quiet hands and feet
- Maintaining Eye contact with the other person
- Waiting for a pause and then asking relevant question
- Sharing your thoughts about global warming with them

**Right Column: Select the Best option that describes the method YOU used for maintaining conversation with the other person. Select the worst option from the given list for maintaining conversation.**

| Used Option  | Worst Option                        |
|--|-------------------------------------|
| <input type="checkbox"/> Interrupted friend to ask them a question   | <input checked="" type="checkbox"/> |
| <input type="checkbox"/> Looked at TV when friend was speaking   | <input type="checkbox"/>            |
| <input checked="" type="checkbox"/> Looked at friend, maintained quiet hands and feet and once there was pause followed their statement with relevant question | <input type="checkbox"/>            |
| <input type="checkbox"/> Read the menu while friend was speaking   | <input type="checkbox"/>            |

Both screenshots have a "Submit Response" button at the bottom right.

Figure 5.9: Measuring learning outcomes for the skill of maintaining conversation; (a) skill evaluation form post free flow/practice mode, and (b) skill evaluation form post-test mode.

## Activities

Several different learning activities are designed to promote engagement: progression of learning from static mode, to training mode, to practice mode, then to test mode; task progression from one social skill to the next relevant social skill within the game context; training instructions followed by practice tasks, followed by best-worst evaluation; and post skill on-screen skill evaluation survey. Figure 5.5 shows the different games modes and an example of the progression of social skill to the next relevant one. Figure 5.7 shows training instructions, Figure 5.8 shows practice tasks and best-worst evaluation, and Figure 5.9 shows post skill evaluation.

### *Capabilities*

The cognitive, psychomotor, and affective skills that the user is attempting to develop through the gameplay are the ability to recall, analyse, evaluate, identify, adopt, and apply the appropriate behaviours, to assist well-timed task execution in game (Khowaja, 2017). The post skill on-screen skill evaluation survey, as shown in Figure 5.8, promotes recall and analysis of the social skills addressed through this study. The free-flow/practice mode promotes the identification and adoption of appropriate actions/attitudes, while providing immediate feedback if the participant takes the wrong action (e.g., when the user interrupts the other person during conversation, they are reminded to wait until the other person finishes speaking). The test mode withdraws assistive feedback to promote analysis of affective skills by checking whether the user identified and adopted appropriate behaviour as they engaged in social skills during gameplay, e.g., do they maintain eye contact after the proxies (halos) are withdrawn. The focus in test mode is to check whether the user engages in eye contact appropriately, whether they stand at the appropriate distance from the other person, whether they speak at the appropriate time and make appropriate conversational decisions.

### **5.2.8 User data**

The game records user information and achievement, as explained in the following sections. This user data is stored as the user profile and achievement and is used in game for debriefing the user about their performance.

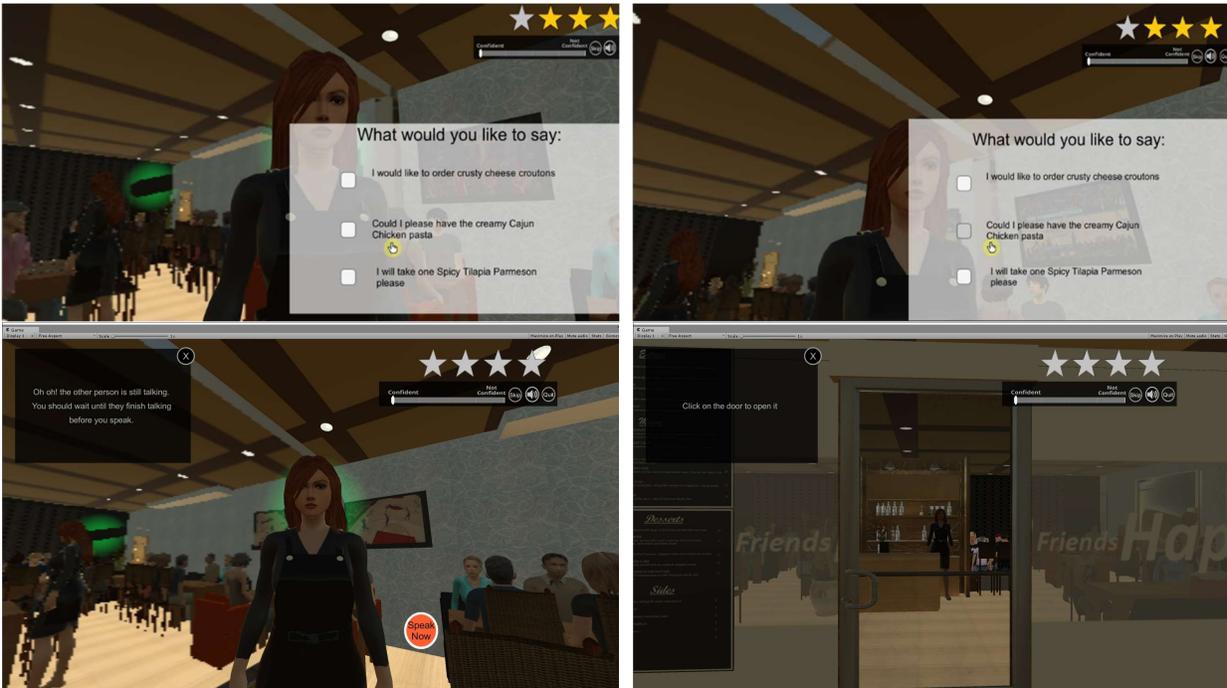
#### *User Profile*

The user profile information for this game is limited to their name/game name. As this game is used with participants in the study, more extensive profile information is not retrieved from users at this stage to protect their privacy.

#### *Achievement*

The achievement in this game includes the user's response to each of the post skill task evaluations, together with the percentage of time the user makes successful eye contact with the person of interest, the count of the times the user interrupts conversation, the number of times they fiddle with game controls while the other person is speaking, and the

count of the times the user reports feeling confident or not confident during gameplay. This information is recorded for each participant during the gameplay of free-flow/practice mode and then for test mode; to enable self-analysis of user performance in the two environments; and assist the analysis of the effect of feedback withdrawal on the user's performance, as discussed in Section 6.3.3.



**Figure 5.10: Learning activity for skill/task of maintaining conversation, task carry over and assistive feedback; (a) placing order practice mode, (b) placing order test mode, (c) assistive feedback during conversation, and (d) assistive feedback during practice mode.**

### *Debriefing*

Debriefing involves reporting on the performance of the user, and for a serious game this is significant, as it enhances the user's learning and experience. In this game, the achievement criteria discussed in Debriefing (Section 5.2.8) is displayed to the user at the end of the free flow/practice mode, and then at the end of test mode. It is presented in the form of a report, with emphasis on each target social skill. Figure 5.11 shows the debriefing

with the user profile and user achievement presented post free flow/practice mode and post-test mode, for one of the users from the evaluation study discussed in Section 6.3.

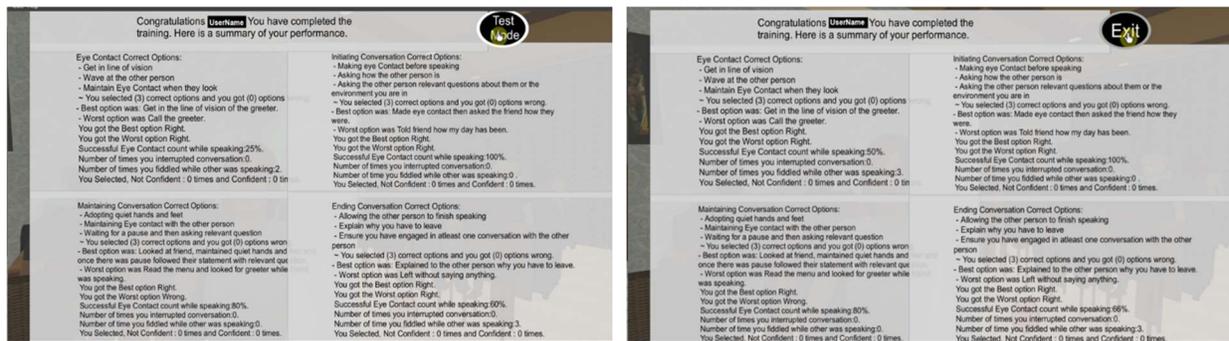


Figure 5.11: Debriefing presenting a user’s data from user study; (a) debriefing post free flow/practice mode, and (b) debriefing post-test mode

### 5.3 Game development process

The game development process began, as detailed in Section 5.2, by selecting an implementation route for each of the relevant game components from Khowaja’s (2017) serious game design framework. The next steps were creating the game scenarios for the identified social obstacles as proposed in Chapter 4, creating social skill modelling videos for each social skill, and finally creating the instruction scripts for the proposed game flow.

#### 5.3.1 Prospective social obstacles scenarios

One of the most important early steps towards game development was the creation of a game story. The game developer’s visualization of the idea through the game story enables the analysis and identification of possible ambiguities in the proposed design. Thus, the implementation of this game began with the design of the game story. As the main game components were established by this stage as described in Section 5.2, the game story focused on presenting the scenarios that would incorporate the game components to provide an immersive and engaging experience of social skills/obstacles to the user. Firstly, the game characters and the game narrative were identified. Based on these, the story was drafted for two major scenarios, one for the skill and sub-skills of eye contact and the other for the skills and sub-skills of small talk which included initiating/starting, maintaining, and ending conversation. The scenarios underwent extensive

review and modification to ensure that the game story flowed and that all the elements/components were incorporated into the story. Refer to Appendix D for the social scenario drafts.

### **5.3.2 Social skills modelling videos**

After the creation of the game scenarios, the next step was to create the social skill modelling videos. This consisted of the two main steps: script writing and video filming. Each of these is described further in the following sub-sections.

#### *Scripts*

Scripts were used to outline the social skill modelling videos. Each script identified the objective of the scene, the characters for the scene, the time and place of the scene, the sequence of actions, and the dialogues. Scripts were created for the tasks associated with eye contact, small talk skills and sub-skills. These scripts are included as Appendix C.

#### *Social skill modelling video production*

The social skill modelling video production included recruitment and specific video instruction/special features. The recruitment process involved recruiting actors and an experienced video editor to carry out the editing work. The actors were recruited through the University of Waikato Screen and Media Studies Department (UoW-SMS). The interested participants (two males and one female) directly contacted the researcher to partake in the study, following information provided by UoW-SMS to students.

The video editor was a summer intern student studying graphic design. His role was to record the videos and edit them to meet the video presentation requirements/special features as set by the researcher (zooming in and/or editing in accompanying text for certain focus behaviours). The social skill modelling videos were recorded at the Theatre studio at the University of Waikato, using the scripts discussed above.

### **5.3.3 Instruction scripts**

This stage of prototype development required the specification of the game story from start to finish. This included: the information to go on the main window, i.e., the introduction, narrative/mission, and controls information; the instruction scripts for operating the program, giving information/feedback to the user; and the instructional content for the training data. At this

stage, the user experience was defined from the start of the program till the last window. It served as a paper prototype for the user experience and enabled the correction of mishaps in the proposed experience. The instruction scripts are included as Appendix G.

### **5.3.4 Game flow**

This section describes the design decisions made to implement the research goals into the game prototype. As this research attempts to simulate a real world environment and experience, it was vital to propose workable/effective representations or proxies of the real world for use in the game.

Although the 3D environment was created based on real world restaurants, further decisions were made to enhance the user experience and promote realism in the scene. For the physical environment, the seating was done according to a real world like setting. The greeter or server was carefully chosen to be a petite female. A dynamic reflection is created on the inside glass window, as would be natural in an evening experience, when it is dark outside, and lights are on inside the venue. Another factor to promote realism was the use of multiple background audio sources in the scene. The background audio sources are of two types. The audio sources assigned to tables with people, playing people chattering with active positional sound, so when the player gets close, the sound increases just as it would in real world, and the second sound type is the background music that is played without positional effects and only within the restaurant environment. Other audio sources include the player's audio source which is used for player dialogues and to receive all the instructional audios and conversation with others in environment. The NPC's in the game (i.e., the greeter and friend characters) each has their own audio source. Their conversation contributions are played through their audio sources to provide real world like features in conversation, e.g., the effect of distance, the direction of conversation etc.

The visual presentation of the environment and scene to the user was researched and discussed. It was concluded that to promote the best field of view and distance for realism, the game would be best presented to the user on a 42-inch screen TV, with the audio being played through the TV audio. The TV was placed on a desk, at which the user was seated on a non-swivel chair (Figure 5.12). This reduced movement opportunity and gave coverage of a large proportion of the user's field of view, and made the NPCs appear roughly life size at 1m distance. The advantage of this was that the user experiences more control (as they are in control of how close or far to sit, and

how loud or slow to play the audio, thus reducing stress caused from sensory stimuli). The playing arrangement avoids reliance on, and restriction of, physical products such as headphones etc.

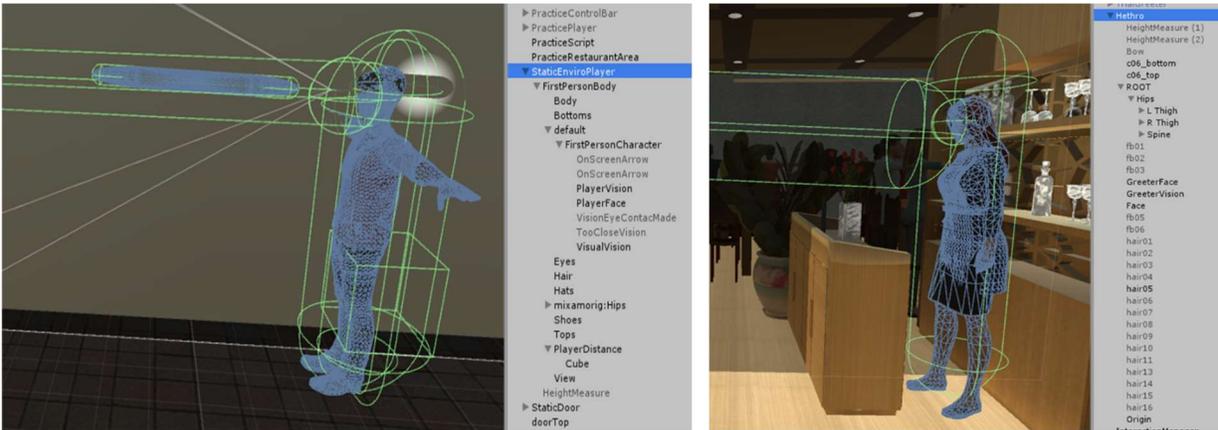


**Figure 5.12: Usability lab; (a) lab set up during user study, and (b) close-up of user seating during user study.**

Distractions were implemented in the game to promote realism. These included a TV screen that is carefully placed in the peripheral vision of the player and kept in view, yet not centred. To pay full attention to the TV, the player must reorient their display, thus breaking eye contact with the friend in the scene. Other diners and their chatter are potential distractors, as is background noise. These are the distractors that are found in real world restaurants.

To implement real world social behaviour such as eye contact and social interaction, several proxies were introduced in the serious game. For eye contact, on-screen coloured halos around the other person's face were used. These are a white halo displayed when the player is in the line of vision of the other person; a red halo when the player stands too close to the other person, and a green halo used when the player has made successful eye contact by standing at an acceptable distance (proximity), looking at the other person and standing in the other person's line of vision. The white halo (line of vision) is implemented by player view game object and player face game object (Figure 5.13). The cylindrical trigger volumes activate the view and face triggers of the other person of interest (greater or friend) without the player's distance cylinder colliding with the other person's body. To convert this to green the white halo condition must be met and in addition, the player's distance cylinder must collide with the other's body. The red halo is activated when

the green halo condition is met and the distance between the player and other person is less than 1 arm's length. Acceptable distance is calculated by measuring 1.5 arm's length (half the length of the player's virtual character) as suggested by training literature. The distance is implemented by using a measurement cone on the body of the player and it is triggered by the body of the other person of interest. The absence of a halo represents absence of eye contact.



**Figure 5.13: Game objects for calculating eye contact; (a) player character with colliders, and (b) greeter character with colliders.**

The proxies used for social interaction comprised a conversational proxy and training proxies. The conversational proxy uses the technique of the user pressing a 'Speak Now' button which opens a window with conversational options to select from. In each case there are three options, comprising two acceptable conversational options and one irrelevant option. Each option leads appropriately to the next scenario. Training proxies consists of social skill modelling videos and practice tasks. Figure 5.14 shows an example of conversational proxies.

Social skill modelling videos with special features (zooming and accompanying text) are used as proxies for modelling ideal behaviour, post instruction, in the training phase, as shown in Figure 5.7. Mini-practice tasks, post instruction, and the social skill modelling video are created as proxies for real world role modelling. Examples are shown in Figure 5.8. These tasks provide feedback to the user to encourage the correct behaviour, e.g., when the other person is speaking, the player's attempt to speak in the game is blocked, and a reminder pops up stating to not interrupt the other person and to wait for them to finish speaking before talking.



Figure 5.14: Free flow/practice mode button click for speak options; three conversational options to choose from.

## 5.4 Game prototype expert review

An expert review of the game prototype was conducted at the early stages of the software development to determine the feasibility of the design. This was undertaken to obtain feedback on the design and making necessary modifications to the software before presenting it for usability testing to the participants.

### 5.4.1 Expert reviewer

The expert review was conducted by a senior New Zealand academic with 20 years of experience in teaching and research in Human Computer Interaction and Usability. The expert also has a long-running research interest in computer gaming.

### 5.4.2 Method

The expert was requested to use think aloud techniques, and the researcher observed the expert throughout the review process and made observations. The study was recorded, further analysed, and conclusions were drawn. A detailed summary of the Expert review has been provided in Appendix E.

### 5.4.3 Expert review observations and software modifications

The prototype review provided insight into the user interface through observations, and a proposed modification were derived from them. Each critical observation, and the consequent modifications, are described as follows:

1. It was proposed that the system should provide the player with instructions on navigation and controls at the beginning of the gameplay to promote ease of use and to provide alternative options for rotation and interaction with active objects in the environment. However, the narrative was reported to be confusing by the reviewer, so some modifications were made. The start/main window now provides the player with the gameplay goal, access to the mission/narrative, the navigation/controls information, and the ability to start play. Figure 5.6 shows the initial window and the mission/narrative window, and Figure 5.15 shows the controls window and the start window of static environment. The initial window guides the user to go to the mission/window and the mission window encourages the user to go to controls window. This is particularly useful to first time players as they are given exposure to the important information before they enter the gameplay.
2. The colour and interface/menu design choice were reported to be busy, uncommon, and complicated, therefore so it was suggested that neutral colours and universal interface design should be used. The reviewer pointed out that the interface lacked consistency in the typography of the text in the scene and the text of other game objects, and it did not convey “restaurant-ness”. It was suggested that formatting should be consistent throughout the start menu and rest of the game to promote a sense of continuity to the player. The modified menu window presents relevant objects only and uses consistent typography. Neutral colours black and white are used in the following manner: white writing on black background for text; black writing on white background for buttons to enable contrast as they are displayed in the same window. The buttons inside the game are displayed on a separate location in the screen than the text display thus using black background with white writing promotes consistency of formatting. The text display formatting is consistent throughout the game. However, two button displays are used inside the game: black button with white writing and orange button with black writing. The orange colour is used to draw attention to the buttons, i.e., the reveal button for distance measurement in the environment and the speak now button throughout game modes: training, free flow/practice, and test mode as presented in Figure 5.15.

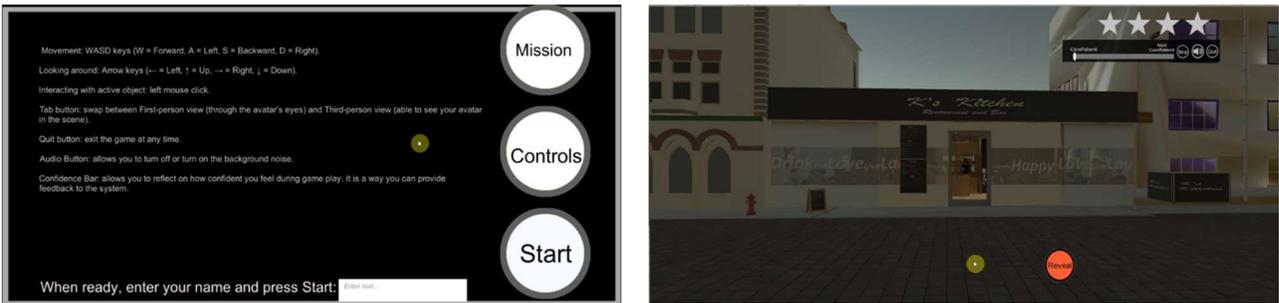


Figure 5.15: Final game display; (a) controls window, and (b) static environment window

- Multiple active objects reportedly performed the same function and did not provide feedback. Reviewer suggested providing one platform per function and consistent representation of the active objects. Therefore, dynamic graphical representation is used to differentiate active objects from inactive objects in the scene. A hand icon appears over the active objects, and in the case of buttons the border colour of button further changes from black to white giving highlighting affect. Figure 5.16 shows the dynamic feedback of hovering over the active object of speak now button and the food menu. This is consistently used throughout the game.

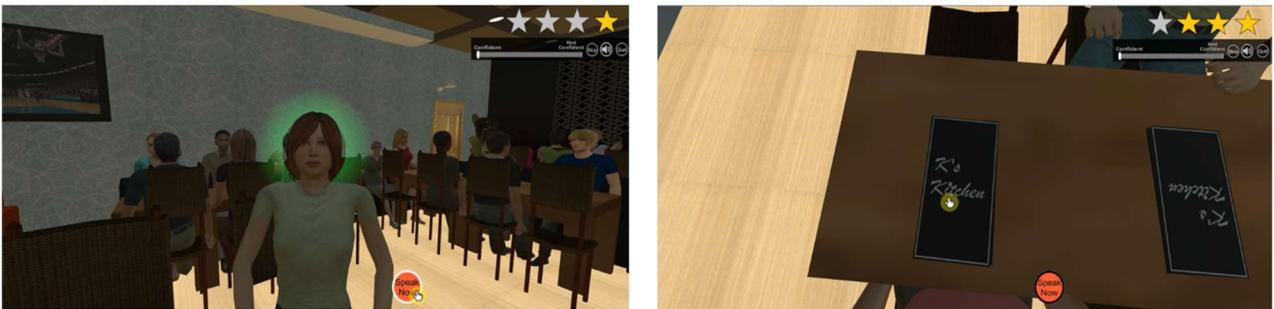


Figure 5.16: Final game dynamic feedback of active objects; (a) hover over effect on button, and (b) hover over effect food Menu.

- The control bar background transparency reportedly interfered with text readability the mood bar/Nervous-Happy scale was reported to represent negative mood. Reviewer recommended starting the player on positive. The control bar transparency is decreased to increase readability. The Nervous-Happy measurement is replaced with Confident-Not Confident measurements to focus on measuring the comfort level of the player not their emotional mood.

The measurement is set to confident by default to start the user on positive mood. Furthermore, stars are added to the control bar to provide user with feedback of their progress. The 4 white stars represent the four social skills/tasks and completion of each task replaces the white star with golden star.

5. The restaurant sound was reported to be audible on the outside. The reviewer suggested restricting the restaurant audio within its structure and enabling sound control via the keyboard sound buttons. The restaurant sound is modified and is audible only when the player is inside the restaurant. The keyboard shortcut is not implemented at this stage as the containment of sound within the restaurant changed the whole dynamics of the need for sound control.
6. The building architecture (roof) intersected the neighbouring buildings in an awkward manner and lacked information about the restaurant, i.e., the name of the restaurant. A graphical glitch was also reported with the reviewer pointing out that any graphical glitches can irritate the player. The structural distortion of the restaurant is resolved as it no longer intersects the neighbouring building. The restaurant displays its name at the top of the building and a chalk board is placed in front of it with specials on it, as is common in real world restaurant settings. The graphical glitch is also resolved.
7. The input instructions were recommended to relate to the action itself and not be random. The input instructions are provided as needed and remain in the scene until the action is completed, e.g., 'Click on door to open it' appears when the player is close to the door and disappears when the player opens it, similarly, the 'Press space button to sit' appears when the player is next to the destination chair and disappears when the player sits.
8. The reviewer reported that the player sat at an unnatural angle and was able to rotate 360 degrees in the chair. The player sitting position is modified to face the opposite chair and the in-chair rotation is restricted to allow the player to rotate 90 degrees only to their left and right.
9. Lastly, reviewer recommended consistency in formatting and alignment of the active objects. The active objects use consistent typography, feedback, and alignment throughout the game interface.

## **5.5 Follow-up expert review**

A follow up expert review was conducted by the same expert, after the improvements described had been completed. The overall experience was positive; however, some important further suggestions were made. The main suggestion from the expert was that the player would benefit from training with controls before starting the gameplay.

This was resolved by creating the static environment. The static environment enhanced the user's experience with controls and learning; the user started gameplay with static environment where they received hands on experience of manoeuvring in the environment and engaging with the game proxies prior to starting the training session.

The other significant finding was that the reviewer questioned the role of the confidence bar, and whether the participants would find it beneficial. This was investigated with the prospective users through a confidence bar study described below.

### **5.5.1 Confidence bar: participant study**

To assess the questions raised about the validity of the use of confidence bar by the prospective participants, the researcher conducted a study to determine whether users consider the confidence bar to be a usable and effective method of communicating with the system. If the participants reported it to not be useful and helpful, the researcher proposed to explore alternatives, otherwise the confidence bar would remain in the program.

#### ***Ethical Consent***

This study was carefully designed to meet the University of Waikato standard of Ethical conduct and was approved by the University's Human Research Ethics Committee (Health).

#### ***Participant recruitment***

The participants for this study were people over the age of 16 years with a diagnosis of Asperger's Syndrome/High-Functioning Autism, who had used computers before and who did not exhibit an intellectual or physical disability that might have impacted their performance. The study was conducted with eleven adults with who were voluntarily members of a social group for individuals with Asperger's Syndrome/HFA. The researcher

had previously conducted the social obstacles study with members of this group (as discussed in Chapter 3). For this study, the researcher contacted the group organizer and send her an invitation for participation, outlining the intent and details of the study. The group organizer contacted the members of the group and invited them to participate. Eleven participants were recruited for this study.

### ***Study design***

The study was conducted in the form of a paper survey with seven yes/no questions. The participants were provided with a copy of the participant information sheet, consent form and the survey, by the group organizer, to take home and complete at their convenience. The participants were requested to look at the screenshot of the program with confidence bar and respond to the seven yes/no questions in the survey. Appendix F contains a copy of the survey.

### ***Study results***

All participants reported that they anticipated finding the confidence bar useful in expressing their confidence level during gameplay, and they anticipated being comfortable with its use. These finding resulted in the retention of the confidence bar in the game.

## **5.6 Final game**

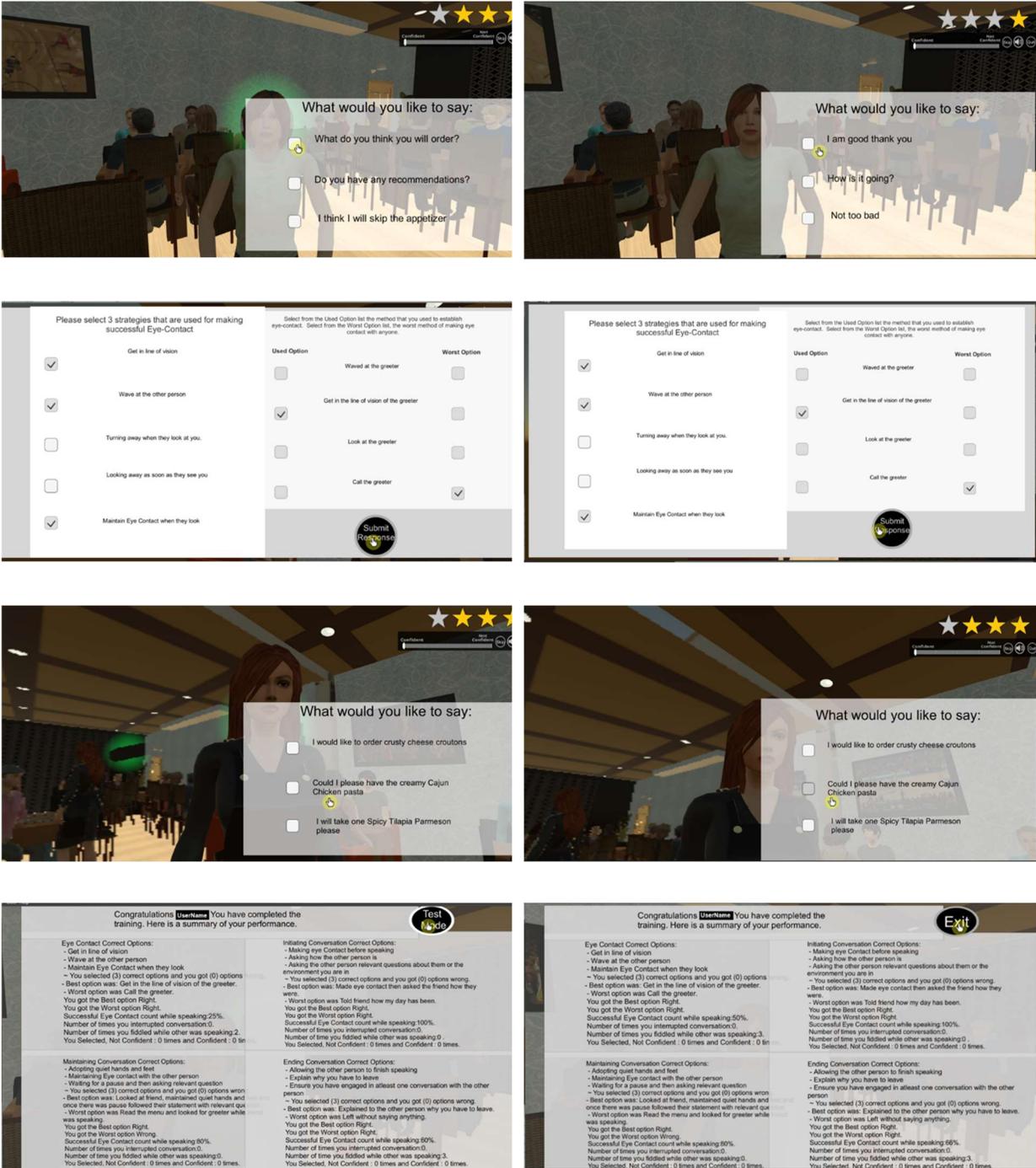
The final game was created to be run in four sessions. The first session is a static environment as all distractors such as background audios, TV and all characters including greeter/waiter, are set on freeze mode to allow the player to focus entirely on the given tasks or movement, rotation, distance measurement and experimentation with eye contact. Figure 5.17 shows the static environment distance measurement tasks against the chair and against the greeter. The static environment tasks enable the participant to get familiar with the game controls, game aura, manoeuvring and player experience. Furthermore, the static environment in the game is useful to identify barriers to operation. This preceded any interaction with the training/learning; therefore, it is aimed to provide the user with experience with controls and distance training, hence overcoming barriers to operation.



**Figure 5.17: Distance measurement in static environment distance; (a) player distance against chair, and (b) player distance against greeter.**

The static environment experience was followed by the training session. Training was conducted for each of the selected social skills and subskills as shown in Figure 5.3. It was conducted in with the group social skill training format, where direct instruction with text display and audio play back was used for skill introduction, followed by social skill modelling videos with special feature used as proxy for skill modelling (Figure 5.7), mini practice tasks immediately following the social skill modelling videos as proxy for real world skill role modelling/practice (Figure 5.8), and a combination of on-screen skill analysis survey and star reward system to provide feedback as shown in Figures 5.4 and 5.8.

The training session was followed by free flow/practice mode. The practice mode provides opportunity for application of learning/training and uses proxies and feedback to assist the player. The aim of the serious game is to ensure the user learns the taught behaviours, recalls them in the correct context and can apply them appropriately. The test mode, where assistive feedback such as skill support comments and halos are withdrawn, was implemented to analyse the learning capabilities of the player, i.e., to check if the user can carry the learnt behaviour training to free flow/practice mode and then onto test mode. Figure 5.18 shows side by side one participant's performance from user study in practice mode and test mode.



**Figure 5.18: Practice mode performance vs. test mode performance; (a) conversation with friend in practice mode, (b) conversation with friend in test mode, (c) post skill evaluation for making eye contact in practice mode, (d) post skill evaluation for making eye contact in test mode, (e) conversation with greeter in practice mode, (f) conversation with greeter in test mode, debriefing results in practice mode, and (g) debriefing results in test mode**

## **5.7 Summary**

This chapter presented the implementation process of the serious game. It described the implementation of the design framework game components (Section 5.2) as proposed in Chapter 4 and discussed the game development process (Section 5.3) followed by the expert review (Section 5.4 and Appendix E). The expert review observations were then outlined, and the resulting modifications presented (Section 5.4.3). The follow up expert review was discussed, (Section 5.5) and the resulting the confidence bar study and its findings were described (Section 5.5.1). The final game was then presented (Section 5.6). Following game implementation, the next step is to evaluate the serious game, the plan for which is developed in the next chapter.

## 6 Evaluation: User study

Chapter 5 presented the implementation of a serious game for people with Asperger's Syndrome/HFA following the social skills training system design presented in Chapter 4. This chapter describes an evaluation study of the serious game based on the approach proposed in Section 4.5. The evaluation aims to determine if the presented serious game is useful and effective as a learning platform for the addressed social skills.

The evaluation involved first identifying the questions to be addressed (Section 6.1), devising a study to conduct with participants to address those questions (Section 6.3), and finally, planning data gathering techniques (Section 6.4). The participant recruitment process and sample size issues are described in Section 6.2. The data gathering method used quantitative and qualitative measures for data collection. The data is gathered using a combination of direct survey questions and built-in game functionality to record users' responses. The data gathered was intended to make it possible to compare participants' responses to survey questions with their game performance.

### 6.1 Evaluation questions

The evaluation focused on answering questions that fall into one of two categories: effectiveness of the game components, and perceived usefulness of the serious game in providing social skill training.

The evaluation of effectiveness investigated the following questions:

- Were the proxies/feedback used in-game effective as a learning alternative to real life equivalents? (Section 6.4.3; Section 6.4.4; Section 6.4.6)
- Did the game successfully represent real world like environment/experiences? (Section 6.4.3; Section 6.4.4; Section 6.4.5; Section 6.4.6)
- Were there realistic distractions in the environment, e.g., TV, background noise, other patrons? (Section 6.4.6)
- Could the participant identify the features that were the focus of this study in the game prototype, e.g., the mechanism for eye contact identification, etc.? (Section 6.4.3; Section 6.4.4; Section 6.4.6)

- Ease of use: what were the barriers (if any) to the operation of the game prototype? (Section 6.4.2; Section 6.4.6)

The evaluation of the perceived usefulness of virtual social skills training addressed the following questions:

- Was the user aware of social skills being addressed before the study? (Section 6.4.1; Section 6.4.6)
- Did the training provide a feasible practice opportunity for the introduced and modelled social skills? (Section 6.4.3; Section 6.4.4; Section 6.4.6)
- Did the user maintain an awareness of the social skill while they were undertaking the training; was it immersive? (Section 6.4.6)
- Did the user identify the learning objectives and maintain this awareness (practice mode, test mode)? (Section 6.4.4; Section 6.4.5; Section 6.4.6)
- Did the user exhibit and carried forward the addressed social skill when feedback was withdrawn during the test session? (Section 6.4.5; Section 6.4.6)
- Did the program reduce expected anxiety towards future encounters of the addressed social skills? (Section 6.4.5; Section 6.4.6)
- Did the program raise awareness of the expected neurotypical behaviour in a social scenario? (Section 6.4.6)
- Did the program increase awareness of each addressed skill for the participant? (Section 6.4.6)

## **6.2 Participant recruitment**

Sample size is an important aspect of study design. The sample sizes that have been used by other researchers in investigating the effectiveness of interventions vary and are dependent on the research designs used. The two common research design methods used to study people with Autism are the single-subject (also referred to as single-case or single-user) research design and the group-based (also referred to as group) design (Khowaja, 2017). Single-subject research design evaluates the effectiveness of an intervention through repeated measurements with an individual, where the individual/participant is his/her own control (Smith et al., 2007). Group-based research designs assign participants to either an intervention or control group and draw comparisons between the groups to evaluate the effectiveness of the intervention (Smith et al., 2007).

Khowaja states that “the national research council has highlighted that researchers working with children with ASD have frequently used the single-subject research design to provide intervention of some skill” (Khowaja, 2017, p.194)

Sample sizes in research reviewed in this thesis (Section 2.4) involving adolescents/adults with Autism are:

- Fabri & Andrews (2016): 3 participants in first workshop; 5 participants in second workshop, and 4 participants in third workshop
- Boujarwah (2012): 8 participants with High-Functioning Autism
- Georgescu et al. (2014): 8 adults with High-Functioning Autism.
- Kandalaft (2012): 8 adults with High-Functioning Autism.
- Stichter et al. (2014): 11 youth with High-Functioning Autism.

Figure 6.1 shows the number of participants that are reported in literature review of studies addressing social skills interventions for adolescents and adults with Autism. As can be seen, the sample size varied for both research design methods with adolescents or adults with Autism; it ranged anywhere between 1 and 7 participants in single-subject/case research designs and between 6 and 73 participants in group-based designs.

A factor that influences the sample size is the data analysis method used. A study using quantitative measures needs a large sample size to be able to report on the statistical significance of the research and to enable generalisation of the findings to larger populations. A study that uses qualitative measures typically aims at getting a deep understanding of the users’ needs and perceptions and does not need a large sample size (Bölte, 2014).

The serious game designed in this thesis uses the single-subject research design and uses a combination of qualitative and quantitative measures for analysis. This thesis does not draw statistically significant conclusions, rather the quantitative data is used to objectively analyse participants’ actual performance in the game against their perceived performance (qualitative data).

| Literature review                               | Reported studies | Participants size |
|---|------------------|-------------------|
| Irish (2013)                                    | 2                | 6                 |
|   | 1                | 3                 |
|   | 1                | 2                 |
|   | 2                | 12                |
| Ke, Whalon, & Yun (2018)<br>—Single-case design | 2                | 1                 |
|   | 1                | 2                 |
|   | 9                | 3                 |
|   | 1                | 4                 |
|   | 1                | 7                 |
| Ke, Whalon, & Yun (2018)<br>—Group design       | 2                | 6                 |
|   | 1                | 8                 |
|   | 2                | 10                |
|   | 2                | 12                |
|   | 1                | 14                |
|   | 2                | 17                |
|   | 1                | 18                |
|   | 1                | 22                |
|   | 1                | 24                |
|   | 1                | 27                |
|   | 2                | 28                |
|   | 1                | 30                |
|   | 2                | 32                |
|   | 1                | 33                |
|   | 1                | 37                |
|   | 1                | 40                |
|   | 1                | 42                |
|   | 1                | 50                |
|   | 1                | 54                |
|   | 1                | 58                |
| 1   | 67               |                   |
| 1   | 73               |                   |

**Figure 6.1: Participant(s) sample size reported in literature review of studies reporting on social skills interventions for adolescents and adults with Autism .**

This study relied on young adults and adults with High-Functioning Autism. Access to willing participants from this group is difficult as they are often shy individuals who love their routines. Participating in new experiences with new people poses challenges for them. Additionally, researchers from different disciplines engage with them and some potential participants feel that they did not derive expected benefits from prior participation in studies. For these reasons, members of this group can be reluctant to take part in studies.

For the study conducted in this thesis, a participant size range of 6-10 would therefore be consistent with prior research in the field and would address the difficulty in accessing a larger participant group. This will give results with limited generalisability but should be capable of showing whether the serious game works for some users.

This study was carefully designed to meet the University of Waikato standard of Ethical conduct and was approved by the University's Human Research Ethics Committee (Health). Refer to Appendix H for the ethics application and approval letter. To support continuity of the human-centred design thinking approach, the Autism expert and the participants for this study were recruited from the same New Zealand Autism social support group mentioned in Chapter 3, and the participation criteria were the same as presented in Section 3.2. However, as the group had extended extensively since the study in Chapter 3 was conducted, it was important for the researcher to treat this like a new study in terms of providing information to members.

The participation criteria for this study were individuals over the age of 16 years with a diagnosis of Asperger's Syndrome/HFA, who had used computers before and who did not exhibit an intellectual or physical disability that might have impacted their performance.

The study was conducted with nine adults with Asperger's Syndrome/HFA who were voluntary members of a social group for individuals with Asperger's Syndrome/HFA as shown in Figure 6.2. Two of the participants continued from the obstacles study (Chapter 3), whereas the rest were new participants.

The plan for participant recruitment was that the researcher attends a gathering of the social group for individuals with Asperger's Syndrome/HFA to introduce herself and the study intent to the prospective participants, answer questions/queries about the study, and invite them to participate in the study. It was to be followed up with the researcher attending a second gathering to answer

any further questions and collect consent forms from participants who were willing to take part in the study.

The actual recruitment process, however, differed from the plan. Upon the initial contact with the social group organizer to discuss this proposal, the researcher was informed that the group members no longer welcomed researchers to their social gatherings. Furthermore, any study participation request was to be sent by email to the group to enable interested participants to respond in affirmative. Therefore, the researcher contacted the participants through email, detailed the study intent and invited them to participate. Those who responded and showed interest in participation were provided with the participant information sheet and consent form for further consideration. After the participants responded in affirmative to participation, a time convenient for the participant was chosen to conduct the study. The participants were further reminded about their right to opt-out of the study at any stage through verbal declaration or written message of withdrawal before the analysis of the data (two weeks after their session).

|   |      |
|---|------|
| Participants  | 9    |
| Age Range (years):  |      |
| 18 – 24   | 2    |
| 25 – 34   | 3    |
| 35 – 44   | 2    |
| 45 – 54   | 2    |
| 55 – 64   | 0    |
| 65 – 74   | 1    |
| Male: Female  | 6: 3 |
| Diagnosed: Self-diagnosed                                   | 7:2  |
| Anxious: Not anxious (in a restaurant)                      | 5:4  |
| Attended Social Skills Training Program: Not attended       | 1:8  |
| Previously played First-Person Controller Games: Not-played | 6:3  |

**Figure 6.2: Participant demographics.**

### 6.2.1 Actor recruitment

For this study, a real human actor was required to conduct the real world distance measurement and eye contact study with the participant, as presented in Section 6.3.1. The actor was recruited through the University of Waikato Screen and Media Studies Department (UoW-SMS). The

interested actor directly contacted the researcher to take part in the study, following information provided by UoW-SMS to students. The actor used the form in Appendix O to report observations of the participant's eye contact behaviour i.e., got in the line of vision, made eye contact, and maintained eye contact.

### **6.3 Study format**

The location chosen for the user study was a usability laboratory at the University of Waikato. This was intended to provide a quiet environment in which participants would have the opportunity to focus on using the serious game with as little external distraction as possible. The game was played on a 40" monitor with the participant approximately 1.1 meters away, so as to further support engagement by occupying a reasonably wide part of their field of view. In fact, with the chosen set up, approximately 70 degrees of the user's field of view was occupied by the screen. Ideally, the depicted field of view presented by the game would also have been set to 70 degrees. In fact, informal experimentation found that a depicted field of view of 50 degrees (the avatar's field of view) provided the best visual sense of being in the restaurant in the opinion of the researcher and lab colleagues, so that was used. The resulting set up was therefore something of a compromise between angular accuracy and image presentation. Note that videogames typically use 90-120 degree fields of view with smaller screens, so the angular accuracy in the experimental set up is better than in a typical gaming set up.

The design of the user study was that it be conducted in four sessions:

1. Real world and virtual world
2. Virtual social skills training
3. Practice
4. Testing

Figure 6.3 shows all the participants that took part in the obstacles study, the confidence bar study and the user study described in this chapter. It also highlights the two participants that took part in both the obstacle study and the user study.

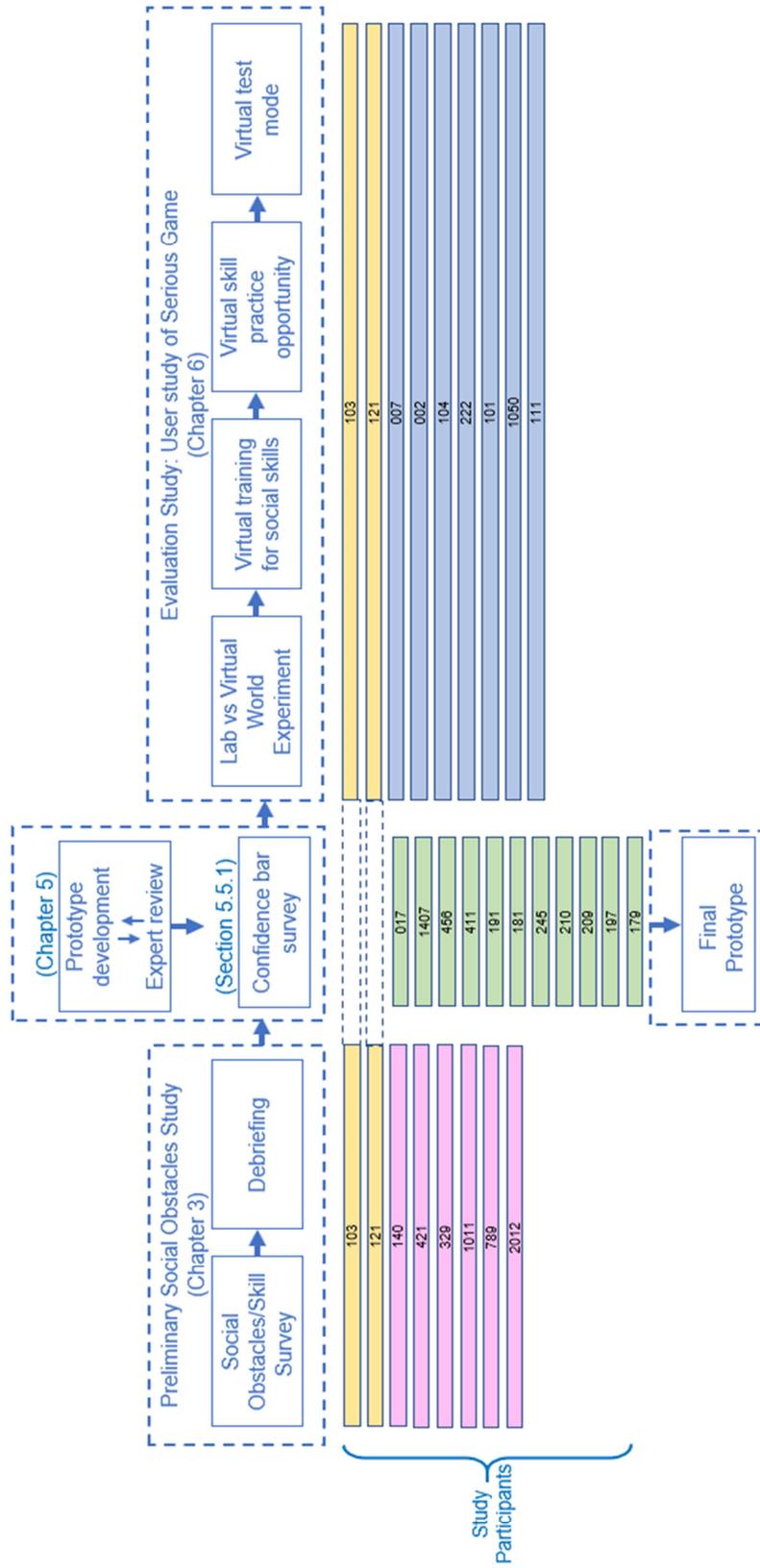


Figure 6.3: Participants with their unique identifier, involved in the three different studies during this research.

The real world and virtual world study were conducted to provide a baseline measurement of the participants estimation of distance in both real world and virtual world, and whether they made and held eye contact in the real world. The term ‘real world’ as used here means a real physical laboratory setting and was chosen to emphasise the contrast to the virtual game environment. The laboratory setting was more appropriate for the measurement than a real restaurant because it avoided distractions. Participants were given similar distance estimation tasks in the game environment, but again to avoid distraction this was done in the static environment mode rather than in the active restaurant simulation. The similarity of the tasks and setting allows comparison of distance estimation between the worlds (Section 6.3.1). A secondary objective of the first session was to familiarise participants with the controls and environment of the serious game (as recommended by the usability expert). The virtual social skill training focused on the skills and sub-skills related to eye contact, starting a conversation, maintaining conversation, and ending a conversation (Section 6.3.2). These were selected as described in Chapter 3, to be part of the system design as they were the most significant social skills for prospective users. The practice session used the serious game with the dynamic feedback (Section 6.3.3), and in the test mode the feedback was withdrawn (Section 6.3.4).

This section reiterates the most significant social skills and sub-skills. It describes the study format starting with the real world and virtual world study, followed by the introduction of the training session, the introduction of the practice session, and finally, the introduction of the testing session. Each segments’ introduction provides a reference to the sub-section that further discusses it.

Successful eye contact entailed three sub-skills, as presented in Section 4.1.1: Getting in the line of vision of the other person, if required using body language, moving to the appropriate/acceptable distance from the other person, and making and maintaining eye contact. Section 5.3.4 presented the implementation of these into the game. Each of these is vital for eye contact; thus, it was important to ensure that participants familiarized themselves with each step.

Successful engagement in small talk/conversation consisted of three crucial social skills: starting a conversation, maintaining conversation, and ending a conversation. As presented in Section 4.1.1, initiating/starting conversation consisted of the sub-skills of standing at a reasonable

distance and starting a conversation with appropriate conversation starters. Maintaining conversation included three sub-skills: adopting the listening position, showing interest in what others are saying, and turn-taking during a conversation. Ending conversation consisted of identifying the appropriate time and method for ending a conversation, specifically: allowing the other person to finish talking, explaining the reason for leaving, and saying goodbye. Section 5.3.4 presented the implementation strategy for the skills and sub-skills of engaging in small talk/conversation.

The training session was designed to be conducted post familiarisation. It followed the effective social skills training method of direct instruction/introduction of the skill, including social skill modelling videos, practice opportunities, and feedback on learning. Section 6.3.2 elaborates on the game methodology of social skills training, as discussed in Section 4.4.

The practice session was designed and accompanied by a relevant skill questionnaire. This session aimed to enable participants to report back on their experience with virtual training for the given social skill as soon as possible. Section 6.3.3 details the study methodology for eye contact and small talk study.

Test mode was designed to analyse whether the participant managed to identify the main learning objectives of the study and to carry over the learned behaviour when feedback was withdrawn. Section 6.3.4 details the study methodology for this session.

### **6.3.1 <sup>3</sup>Real world and <sup>4</sup>virtual world study**

At the beginning of the user study, the participant was given the opportunity to read the participant information sheet and sign the consent form for taking part in this study. After signing the consent form, they were presented with the pre-study questionnaire, as detailed in Section 6.4.1.

The study was conducted in both the real world and the virtual world, under the guidance of the researcher, where the researcher was actively engaged in giving instructions to the participant and

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<sup>3</sup> Real world in this context refers to a real physical laboratory setting where measurements were taken against real life objects—door, chair, and a real human actor, as defined on Page 107.

<sup>4</sup> Virtual world in this context refers to the static environment game mode as defined on Page 58.

observing the participant's response. The presence of the researcher aided the participant as they received dynamic feedback and assistance when required.

The study enabled the researcher to measure a participant's perception of distance and to compare their eye contact related behaviour in the real world with their behaviour in the virtual world. Distance perception /proximity to people and objects and eye contact related behaviour such as getting in the line of vision and making eye contact are vital parts of the social skills training incorporated in the serious game prototype. This study enabled the researcher to find similarities and/or differences of the participant's perceived distance and eye contact behaviour in both worlds to determine whether the serious game provided a satisfactory environment for practicing the social skill.

It also provided the participant with the opportunity to become acquainted with game controls for movement and rotation; understand the game atmosphere and become familiar with system features that simulate eye contact i.e., halos. This step of the study was intended to provide the participant with the opportunity to get familiar with the system before proceeding to the social skill training and identify barriers to the operation of the prototype.

### ***Real world***

The participant was requested to complete a series of steps in the real world. Instructions were explained one at a time by the researcher, who observed the participant's progress and clarified instructions where necessary. The steps were as follows:

1. Locate the chair and stand at what you consider to be three arm's lengths from the chair.
2. Stand at what you consider to be two arm's lengths from the chair.
3. Stand at what you consider to be one arm's length from the chair.
4. Locate the door and stand at what you consider to be three arm's lengths from the door.
5. Stand at what you consider to be two arm's lengths from the door.
6. Stand at what you consider to be arm's length from the door.
7. Look at your sharp left (90 degrees).
8. Look at your sharp right (90 degrees).
9. Look at the ceiling.

10. Look at your feet.
11. Get in the line of vision of the actor.
12. Stand at 3 arm's lengths from the actor.
13. Stand at 2 arm's lengths from the actor.
14. Stand at an arm's length from the actor.

After the participant completed each step, the researcher marked their location appropriately with marked duct tape so that distances could be measured after the experiment. Understanding and showing eye contact is part of the training of an actor. Therefore, a human actor was used to observe whether the participant satisfied instruction 11 and provide further details on whether the participant established and maintained eye contact with him. The actor recorded results on the observation sheet (Appendix O). Figure 6.4 shows post-study images of location markers for each of the three different measurements against the three objects of interest after one of the participants had completed the familiarisation study. The markers shown are for distance measurements against the chair for 2 arm's lengths and 3 arm's lengths, distance measure against the door for 3 arm's lengths, and distance measure against the actor for 1 arm's length. For privacy reasons, the photos were taken post-study, multiple marking can be seen in the pictures. There is also a marker showing the actor where to stand.

After the real world study, the participant was given the real world questionnaire to complete, as discussed further in Section 6.4.2.

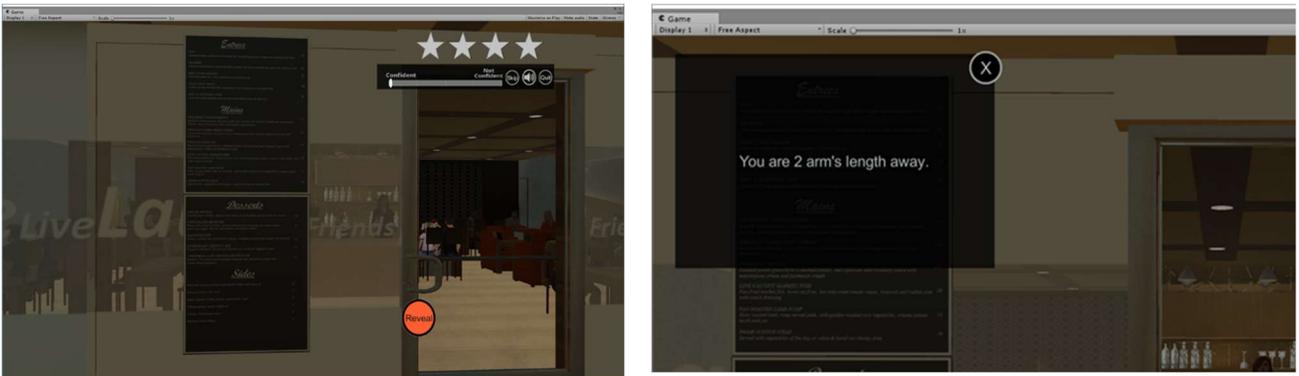


**Figure 6.4: Real world distance measurement; (a) 2 arm's lengths-(Chair), (b) 3 arm's lengths- (Chair), (3 arm's lengths-(Door), and 1 arm's length- (Actor).**

### *Virtual world*

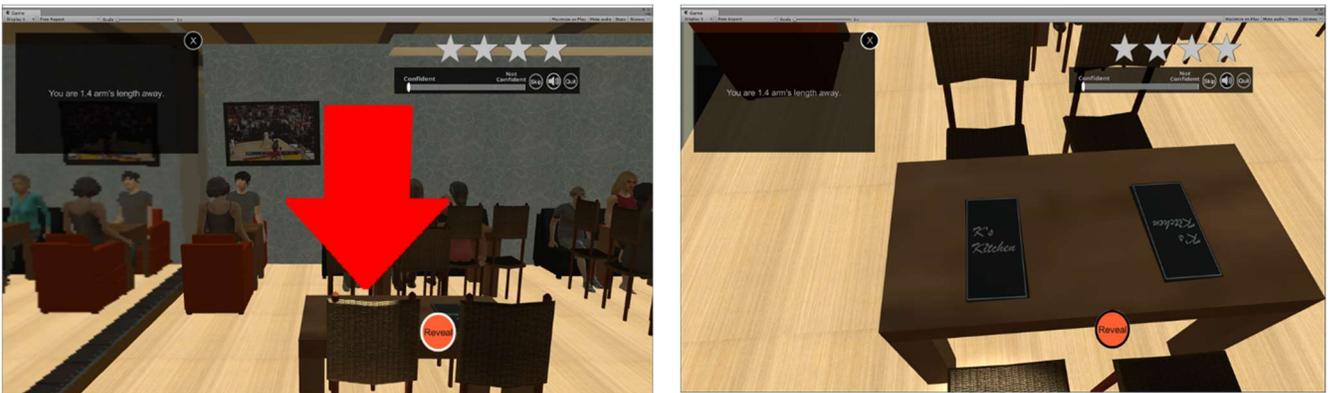
The participant was requested to complete a series of steps in the virtual static environment. Instructions were explained one at a time by the researcher, who observed the participant's progress and clarified instructions where necessary. The steps were as follows:

1. Locate the Menu poster on the restaurant wall and walk towards it.
2. Once by the Menu, look to your sharp left (90 degrees).
3. Look to your sharp right (90 degrees).
4. Move away from the Menu and get to the restaurant door.
5. Stand at what you think is about two arm's lengths from the door.
6. Press the Reveal button to see the distance between you and the door.
7. If you are not at two arm's lengths, move to two arm's lengths from the door.
8. Do you feel you are two arm's lengths from the door?
9. Keeping the distance displayed for two arm's lengths in mind, stand at what you consider to be about one arm's length from the door. Press Reveal to see your distance from the door.
10. Click on the door to open it.



**Figure 6.5: virtual world task execution; (a) standing by the Menu, and (b) displayed distance: 2 arm's lengths from the door**

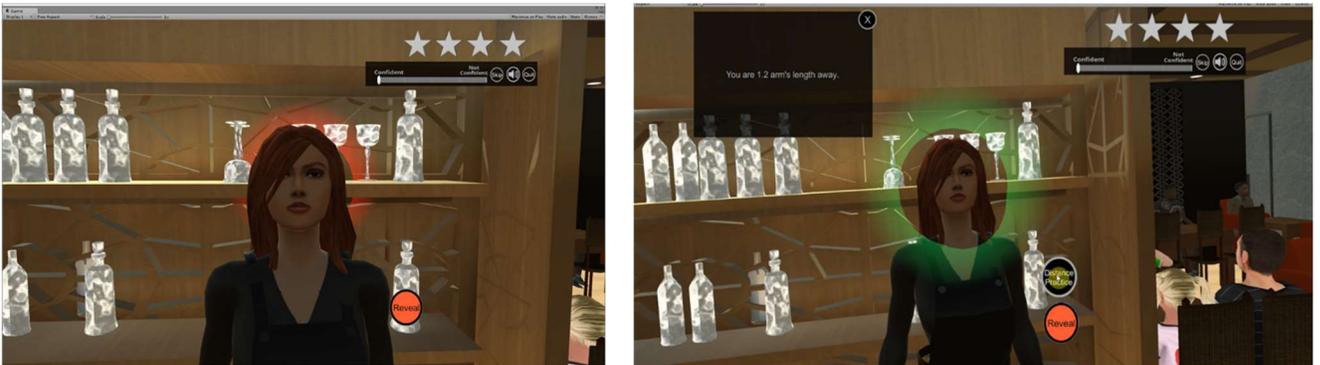
11. Get inside the restaurant and look to your sharp left.
12. You can see a red arrow on top of the destination chair. Stand at what you consider to be 3 arm's lengths from this chair.
13. Click on the reveal button to see the exact distance you are from that chair.
14. Move to what you consider to be 2 arm's lengths from that chair. Click the reveal button to check your distance from the chair.
15. Move to what you consider to be one arm's length from the chair. Click the reveal button to check your distance from the chair.
16. Use the down-arrow key to look down at what is on the table.



**Figure 6.6: virtual world task execution;(a) distance displayed: 1.4 arm's length from the chair, and (b) looking at the tabletop.**

17. Use the up-arrow key to look at the TV on the wall.
18. Use the left-arrow key to rotate towards your reflection on the wall.
19. Use the right- arrow key to turn around and locate the greeter.
20. Use the TAB key to swap between first-person and third-person views.
21. Get in the line of vision of the greeter by moving in the required direction. When you are in the line of vision of the greeter, the white vision halo will appear on the screen.
22. Once you are in the line of vision of the greeter, approach the greeter and stand at about two arm's lengths away from the greeter.

23. You will know that you made successful eye contact, and you are within the acceptable standing distance (between one and a half and one arm's length) from the greeter when the white vision halo turns green.
24. Get close to the greeter, and you will see the halo turn red to indicate you are too close to the greeter.
25. Click on Distance Practice; Find the Greeter in the restaurant?



**Figure 6.7: Halos; (a) red halo: standing too close, and (b) green halo: standing at an acceptable distance and made eye contact.**

26. Get in the line of vision of the greeter, remember the white halo indicates you are in the line of vision.
27. Stand at about one and a half arm's length and make eye contact. Remember that the green halo is an indication of successful eye contact.
28. Click on the reveal button to see how far/close you are to the greeter.
29. Now you are ready to start the social skill training. Press the Training Mode Button to start.
30. Please fill in the Questionnaire Session 1: real world and Virtual World.



Figure 6.8: Static environment: (a) standing at an arm's length, and (b) in-game survey completion reminder.

Familiarisation ended with the participant completing the real world and Virtual World questionnaire, as presented in Section 6.4.2. After familiarisation study, the participant could take a break or continue to the next session.

### 6.3.2 Training

In this session, the participant was requested to move on to the social skill training phase of the game. This session took place after the familiarisation study. The participant was invited to undertake the virtual social skill training for the skills of eye contact, initiating/starting conversation, maintaining conversation, and ending a conversation. The program was designed to require minimum help from the researcher. The social skill training phase was simulated in a manner that introduced and trained for one social skill at a time. The virtual training first addressed the social skill of eye contact and its sub-skills. Upon entering a restaurant, the training started with the first sub-skill required for eye contact that was 'getting in the line of vision,' and after addressing it through training, it moved onto the next relevant sub-skill. The training consisted of audio and text representation of introduction/instruction of the skill; followed by the display of a modelling video of that social skill; followed by the training opportunity in the game for the sub-skill. It was repeated for all the eye contact sub-skills in sequential order. After the training, the game generated a skill related scenario, and the participant was required to choose the best and worst response according to the taught skills. After the participant's selection, they were explained the merits/demerits of the provided options. Similarly, the program proceeded with the training for

the skill of starting a conversation with all its sub-skills, maintaining conversation with all its sub-skills, ending a conversation with all its sub-skills, and addressed them in order of occurrence.

The researcher observed the participant during virtual social skill training and assisted the participant where necessary. The participant was verbally informed that if they need assistance from the researcher, they could ask the researcher. The expectation was made that minimum assistance would be required from the researcher during gameplay.

### **6.3.3 Practice**

After the training session, the game study proceeded to the practice run, where the game restarts from the beginning of the virtual restaurant story, and the participant had to recall the training and apply the learned behaviour. During this stage, the game still provided feedback to assist the participant. It allowed the player to move from one virtual experience to another. However, the participant's progress in the game largely depended on the skills that they learned in the training session. It is the session where, when required, the game automatically paused and reminded the participant to complete the questionnaires before proceeding to the next step. It provided the participant with the opportunity to report back on their experience in very close to real-time, therefore allowing the retrieval of accurate quantitative data from the participant. The questionnaires in this session are about the training and practice of the social skills of eye contact, as detailed in Section 6.4.3. and the social skills of starting a conversation, maintaining conversation, and ending the conversation as described in Section 6.4.4.

### **6.3.4 Testing**

The test mode again restarted the game story, but this time withdrew assistive feedback to the participant during gameplay. The purpose was to check whether the participant carried over the taught and practiced social skills to the test environment. It was particularly useful for eye contact as coloured halos were identified to be very useful in making eye contact. Therefore, the test mode made it possible to check whether the participant had learned to engage in eye contact or had simply learned how to activate halos in the game. The program recorded the percentage of participant's eye contact and their response to the game built-in skill survey in both game modes (practice and testing) to determine whether the participant's performance varied significantly between practice and test mode. The session was followed by the test-mode questionnaire that

inquired about participant's experience with virtual training and their perceived anxiety level in a restaurant towards the addressed social skills after virtual training, as discussed in Section 6.4.5. It was the last questionnaire. The study concluded with the researcher debriefing the participant about their overall experience with the study, as detailed in Section 6.4.6. The study session, from start to end, approximately took 2 hours with each participant.

Figure 6.9 shows the overview of the user study with each participant, highlighting when each questionnaire was handed out, and when 15 minutes breaks were offered.

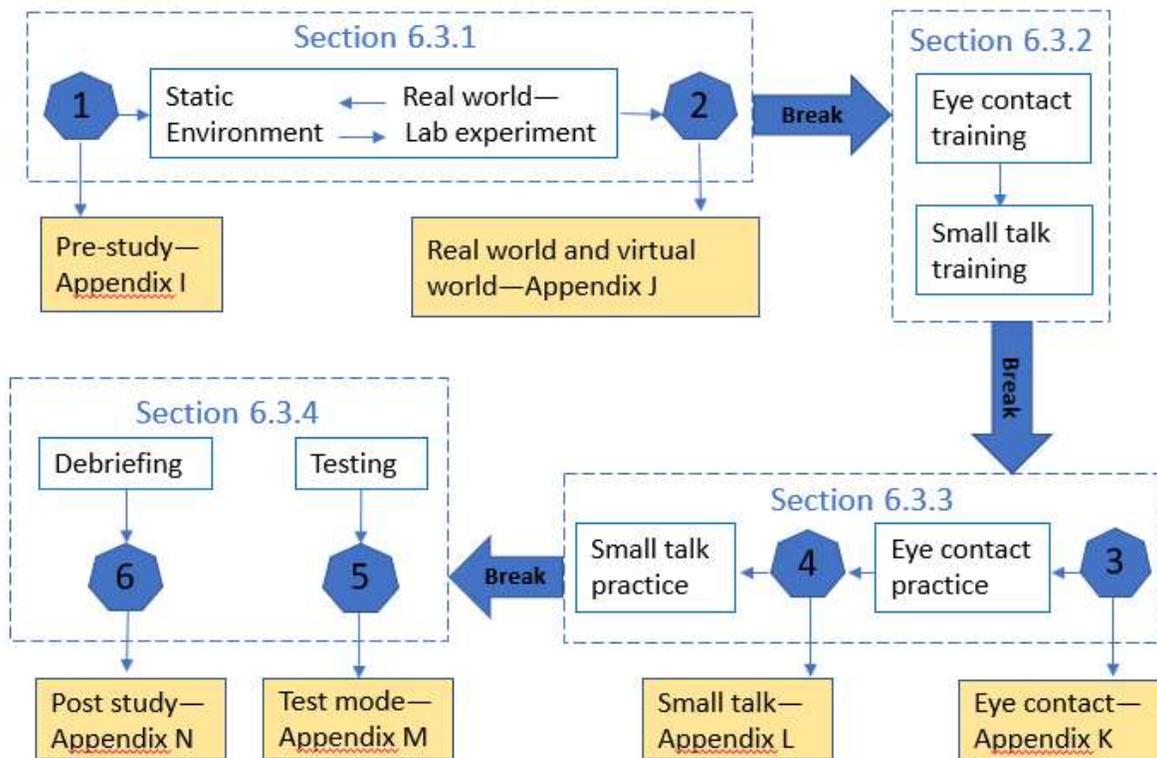


Figure 6.9: User study overview, showing the timing of each questionnaire.

## 6.4 Data Gathering

This section details the methods employed to retrieve qualitative and quantitative data from the user study to assist in the evaluation of the effectiveness of the game components and the usefulness of virtual social skill training. These methods consisted of a set of questionnaires carefully timed to allow the participant to report back during the user study; observation of the participant's behaviour during the study; the post-study debriefing with the participant to allow the researcher to interpret the qualitative data accurately; and the built-in game features to accumulate quantitative data during the participant's play. Due to the anticipated between-participant variability, each participant's data were individually analysed based on their performance and questionnaire responses. This data was then analysed against other participants' data to find participant variability and draw the overall conclusions for this study. Each questionnaire is introduced below and further detailed in corresponding sub-sections. Appendices I – N present the evaluation questionnaires.

The pre-study questionnaire (Appendix I) gathered demographic information and explored the participants' original comfort/anxiety levels of the social experiences being investigated in this study, with emphasis on the skills being addressed through the serious game. It enabled the identification of participants' awareness of social skills before the survey and their impact on their overall performance. This questionnaire formed the baseline of the study and provided data for comparison against the individual participants and the group findings. The data gathering is further detailed in Section 6.4.1.

The focus of the real world and virtual world study and questionnaire (Appendix J) was to check each participant's perception of distance in the real world and the virtual world and to find out if he or she made and held eye contact in the real world. An understanding of each participant's distance perception is important because the participant's ability to understand proximity to people is a vital part of social skills training and experiencing a realistic sense of distance from objects in the virtual restaurant space is a key aspect of realism for that environment.

Information about eye contact behaviour in the real world is valuable because it can later be compared to behaviour with eye contact simulated by directing the avatar in the game environment. If there is a match, then it would suggest that the serious game provided a plausible alternative to real life. If the eye contact in real life was significantly better or worse than in the virtual world

there would be a need to question the level of realism achieved in the virtual world. Section 6.4.2 provides a detailed explanation of the first experiment. The eye contact questionnaire (Appendix K) about the social skill training for the skill of eye contact as presented in Section 6.4.3 and small talk questionnaire (Appendix L) about the social skill training for the small talk as shown in Section 6.4.4, inquired about the participant's overall experience with the game. The questions queried the participant's social anxiety level towards the social skill while engaging with the gameplay, the usefulness of the game elements and game proxies, and the game environment. These questions were essential to understanding whether the game successfully replicated a real world training experience; removed social stressors; raised awareness of the expected steps for successful eye contact and engaging in small talk/conversation; allowed enough opportunity for practice of these steps thus provide evidence that the serious game was a feasible alternative to real life training for the addressed social skills. The participant was observed for attention to the game while engaged in eye contact tasks during game play. This was to find out if their in-game behaviour was reflective of their real eye contact or not i.e., when the participant managed to activate the green halo on screen indicating successful eye contact, did they then focus their attention on the screen or look away from the screen?

The test mode was designed to restart the game without assistive feedback to the participant during gameplay. The test mode questionnaire (Appendix M) was designed to enable participants further to report back on their social and learning experience and anxiety levels for social task execution in the game and report their anticipated future social anxiety towards each task as described in Section 6.4.5.

At the end of the test-mode study, the participants could revisit their answers for a set of questionnaires and change it, if they wished to do so. Although this was not initially anticipated, during the user study, some participants asked the researcher if they could revisit their answers to an earlier survey and change them. The study concluded with post-study debriefing (Appendix N) with the participant, as discussed in Section 6.4.6.

The built-in game features record data from the participant during the practice and test modes. The data recorded is the responses from the in-game on-screen skill evaluation survey, the extent of eye contact between the avatar and the person of interest, levels of 'fiddling' with mouse and keyboard, and the number of times the participant interrupted while 'listening'. The data was

recorded to enable cross-checking as to whether the participant recalled and carried over the taught and practiced social skills from practice to test mode. This is detailed in Section 6.4.7.

### **6.4.1 Pre-study questionnaire**

The first questionnaire was completed before starting the user study (Appendix I). It gathered demographic information such as the participant's age, gender, height, and diagnosis status. It was followed by an inquiry into the participant's experience of social skills training program, familiarity with first-person controller game, and then an exploration of the participants' existing anxiety levels for each social skill and sub-skill that was addressed through the game. The information about age, gender, and diagnosis status was used as factors that might influence the results. Height was included because it might be significant for measuring distance (proximity) and perception of distance in both the real and virtual worlds. The question of prior exposure to the social skills training program was necessary for exploring the participant's response to the social skill training game. The question of familiarity with first-person controller games was relevant to understanding barriers to the operation of the computer game prototype.

A self-report scaling model was used for designing the anxiety related questions as it is one of the two most common evaluation instruments in social anxiety psychometric studies for young adults and adults (Wong et al., 2016). The inquiry into the existing social anxiety of the participant opened with a yes/no question of whether the participant currently felt socially anxious in a restaurant situation. It was followed by a 5-point scale anxiety survey ranging from 'Not Anxious' to 'Extremely Anxious' where the participant reported on their existing anxiety for each of the nine specific social skills/experiences. The nine social skills/experiences were:

- 'Finding your way to the restaurant staff,'
- 'Getting in the line of vision of restaurant staff,'
- 'Making eye contact with restaurant staff,'
- 'Knowing the appropriate distance to stand from another person,'
- 'Starting a conversation with someone,'
- 'Maintaining a listening position while someone is speaking to you,'
- 'Showing interest while another person is speaking,'
- 'Turn-taking during a conversation.'

- 'Ending the conversation with someone.'

Each of these nine skills was addressed in the social skill training game prototype. These questions were repeated at the end of the user study, with the participant reporting their anticipated social anxiety towards each social skill/experience in future real world encounters (Section 6.4.5). This data was used to address the research question as to whether the social skill training game prototype might reduce anxiety towards the future encounter of the addressed social skills.

#### **6.4.2 Real world and virtual world perception study**

The second questionnaire (Appendix J) was designed to retrieve relevant data from the participants after the familiarisation study. It was divided into two parts: the first part was completed after 'Real world distance and movement,' and the second was completed after 'Virtual world distance and movement.' The sequence in which these two parts were run was swapped for half of the participants to identify or rule out any learning effect that may occur.

The study focused on the participants' perception of distance and ability to make eye contact in the real world and the virtual world, to find patterns of behaviour in both environments. The objects of interest for distance measurement were a chair, door, and greeter. These objects were selected as these are objects that a person is required to interact with during a restaurant experience. The focus for social interaction was the distance against the restaurant greeter (proximity) as successful eye contact necessitates awareness of the distance from someone we interact with. The study explored the distance perception against chair and door for two reasons; firstly, these are objects of contact in a restaurant experience, and secondly, they vary in size from each other and a person, therefore, allowing the researcher to draw accurate conclusions for the participant's perception of distance. Furthermore, for eye contact behaviour in real world, the actor observed the participant during the user study and reported straight after on the observation sheet whether: the participant got in the line of vision, made eye contact, and maintained the eye contact.

The participant was requested to complete the steps in 'Real world distance measurement' as detailed in Section 6.3.1-Real world, and in 'Virtual world distance measurement' as described in Section 6.3.1-Virtual world. The measurements in each study were recorded on the observation sheet (Appendix O). Initially, all distance measurements, including the participant's height, were taken in centimetre units. The social skills training literature teaches about appropriate distance in

arm's length units. The average human arm's length is approximately half their height. For this study, participants' arm's length was assigned on the average arm's length calculation. These recorded centimetre units were converted to participant's arm's length based on their height. Similarly, in the virtual world, an arm's length was set to half the height of the first-person controller character. It was to maintain consistency in measurements in both worlds.

For the study of eye contact, the actor observed the participant execute the tasks of getting in the line of vision, making eye contact, and maintaining eye contact in the real world. The actor was informed of the intent of this study. He was given instruction to not actively seek eye contact but to wait for the participant to establish it, by to fixating his vision on a spot on the wall directly opposite himself. The actor was intentionally placed at a 45-degree angle from the opposite wall to make sure that the participant was standing in the actor's line of view, not directly in front of the actor. The actor was asked to report whether the participant got in his line of vision, successfully made eye contact, and maintained that eye contact. The actor reported his findings on the observation sheet provided (Appendix O), and this enabled comparison with the participants' perceptions of these tasks as they reported it in real world and virtual world questionnaire (Appendix J).

Alongside distance measurement, participants were asked to perform movement and rotation tasks in both the real and virtual worlds, and the follow-up survey enabled the participants to compare their real world and virtual world experiences. This survey examined the overall comfort level of participants with game controls and identified whether using a game controller is a barrier to the operation of the game prototype. The participants reported on their experience of each social skill on a 5-point scale ranging from 'Very Difficult' to 'Very Easy.' Also, they reported on their satisfaction level for successful completion of each task on a 5-point scale ranging from 'Completely Dissatisfied' to 'Completely Satisfied.' It was done for their experience with each social skill in both the real world and the virtual world. After this experiment, the participant completed the virtual world vs. real world comparison questionnaire, where they identified their virtual experience of each task to be either 'easier,' 'same,' or 'harder' than in the real world.

### **6.4.3 Eye contact questionnaire (data gathering)**

The eye contact questionnaire attempted to retrieve essential data from the participants about their experience with the serious game (Appendix K). The first set of questions inquired about the participant's level of anxiety during gameplay with the eye contact related tasks. It was hypothesized that the game would remove anxiety related to real world eye contact, thus enabling the participant to focus on and practice eye contact in a stress-free environment using the provided proxies. This questionnaire allowed an immediate response to their virtual experience. The next set of questions was about the usefulness of the game elements and game proxies intended to assist in learning the skill of eye contact from the participant's perception. The game element and proxies were designed to provide dynamic assistive feedback and enable a smooth experience; therefore, these questions were to query how the participant found these elements. The last set of questions focused on retrieving information as to how the participant perceived the atmosphere of the game environment and report on their overall experience with the skill of eye contact by agreeing or disagreeing with the given propositions. It was to compliment the two earlier questionnaires and provided a comments section to enable the participant to add anything they deemed relevant to their experience of virtual eye contact.

### **6.4.4 Small talk/conversation questionnaire (data gathering)**

The small talk/conversation questionnaire (Appendix L) was intended to retrieve data from the participants about their experience with the small talk/conversation aspects of the game. The first set of questions inquired about the participants' level of anxiety during gameplay for the small talk/conversation related social skills. It was hypothesized that the game would remove anxiety due to time constraints when engaging in conversation. The game also provided conversational assistive options to remove the stress of having to find topics when engaging in conversation. The hypothesis was that this would allow the participant to focus on the process of conversation and the selection of the kinds of statements that are appropriate at different stages. The next set of questions was about the usefulness of the game elements and game proxies that assisted the skill of engaging in a small talk from the participant's viewpoint. The game element and proxies were designed to provide dynamic assistive feedback and enable a smooth experience; therefore, these questions were to query how the participant found these elements. The last set of questions focused on retrieving information about the participant's overall experience with the skill of engaging in

small talk/conversation by agreeing or disagreeing with the given propositions. The comments section enabled the participant to add anything they might deem relevant to their experience of engaging in small talk/conversation in the game environment.

#### **6.4.5 Test mode questionnaire (data gathering)**

The test mode questionnaire was designed to retrieve information about the social and virtual experience of the participant. The first set of questions was used to find out how often the game proxies assisted the participant and successfully replicated social experience. The next set of questions were focused on whether the participant found the game to help increase their confidence in engaging in the addressed tasks in the future. The last set of questions focused on the social anxiety that the participant felt while engaging with the addressed social skill during gameplay and their anticipated real world social anxiety towards the addressed social tasks in the future. This information could be compared to the participant's pre-study social anxiety questionnaire and their software use/gameplay to draw conclusions about the usefulness of the social skill training program.

#### **6.4.6 Post-study debriefing (data gathering)**

After the study, the researcher did a quick de-briefing with the participant where the researcher asked the participant the following questions:

- A. Ease of use: what were the barriers (if any) to the operation of the game prototype?
- B. Could you identify the features that were the focus of this study in the game prototype, e.g., a mechanism for eye contact identification, etc.?
- C. Did the game prototype successfully represent real world like environment/experiences?
- D. Were the proxies/feedback used in-game useful as learning alternatives to real life equivalents?
- E. Were there realistic distractions in the environment? TV, background noise, other patrons
- F. Were you aware of social skills being addressed before the study?
- G. Did you maintain an awareness of the social skill while you were undertaking the training, was it immersive enough?
- H. Did you exhibit the social skill that the program was trying to show you during the test session? Were you doing what the program wanted you to do in the test session? Did you

carry forward the skills addressed in the training session to the test session when feedback was withdrawn?

- I. Did the training provide a feasible practice opportunity for introduced and modelled social skills?
- J. Did you identify the main learning objective and maintain it? (test mode, absence of halo)
- K. Did the program reduce anxiety towards future encounters of addressed social skills?
- L. Did the program raise awareness of the expected neurotypical behaviour in the social scenario?
- M. Did the program increase awareness of each addressed skill for the participant?

These questions are the main research questions for the usability study, as presented in Section 6.1. Although the user study observation and questionnaire provided evidence to allow conclusions to be drawn for these questions, the researcher felt it was beneficial for the overall outcome to find out how the participants perceived their performance.

#### **6.4.7 Built-in game features (data gathering)**

The game incorporates features to record objective data from the participants' practice and test-mode sessions. The on-screen multi-choice survey measures the recall of the taught social skills in both the practice and the test modes and shows whether the participant's performance varies significantly between modes. The participant was required to select the following for each given social skill as discussed and practiced in the training phase: the three correct strategies from the presented five strategies, the best option they used for completing the presented social task from the listed four options and the worst option for completing the presented social task from the presented four options. Figure 6.10 shows the questions included in the survey, covering the correct strategies, the best/used option, and the worst option for each social skill. As the social skill training aims at raising awareness of the addressed skills, these measurements complement the participant's reported awareness of the skills.

The game further measured during each social skill task the amount of successful eye contact, the extent of interruptions during conversation, and the occasions when the participant fiddled when required to maintain a listening position (quiet hands). Eye contact was required while the person of interest spoke, therefore successful eye contact was measured by recording the amount of time the participant avatar maintained eye contact with the speaker during conversation. This

measurement was converted to a percentage by calculating the participant's values against the required time frame. The in-game training raised awareness of the importance of refraining from interrupting others while they are speaking as per the social skills training, therefore, the game recorded the occasions the participant pressed the *Speak-now* button as the other person was speaking. The game also recorded the occasions the participant fiddled while listening as maintaining conversation required the teaching and practice of listening position where the participant maintained quiet hands and feet. This was measured by recording the occasions the participant used/played with the keyboard or mouse when the other person was speaking.

|  |   |
|--|---|
| <p><b>Eye contact</b></p> <p><b><u>Correct strategies:</u></b></p> <ol style="list-style-type: none"> <li>1. Getting in the line of vision</li> <li>2. Wave at the other person</li> <li>3. Maintain eye contact when they look</li> </ol> <p><b><u>Best / used option:</u></b><br/>Get in the line of vision</p> <p><b><u>Worst option:</u></b><br/>Call the greeter</p>  | <p><b>Initiating/starting conversation</b></p> <p><b><u>Correct strategies:</u></b></p> <ol style="list-style-type: none"> <li>1. Making eye contact before speaking</li> <li>2. Asking how the other person is</li> <li>3. Asking the other person relevant questions about them or the environment you are in</li> </ol> <p><b><u>Best / used option:</u></b><br/>Make eye contact and then asked the friend how they were</p> <p><b><u>Worst option:</u></b><br/>Told friend how my day has been</p> |
| <p><b>Maintaining conversation</b></p> <p><b><u>Correct strategies:</u></b></p> <ol style="list-style-type: none"> <li>1. Adopting quiet hands and feet</li> <li>2. Maintaining eye contact with the other person</li> <li>3. Waiting for a pause then asking a relevant question</li> </ol> <p><b><u>Best / used option:</u></b><br/>Looked at friend, maintained quiet hands and once there was pause followed their statement with relevant questions</p> <p><b><u>Worst option:</u></b><br/>Looked at friend, maintained quiet hands and feet and once there was a pause followed their statement with relevant questions.</p> | <p><b>Ending conversation</b></p> <p><b><u>Correct strategies:</u></b></p> <ol style="list-style-type: none"> <li>1. Allowing the other person to finish speaking</li> <li>2. Explain why you have to leave</li> <li>3. Ensure you have engaged in at least one conversation with the other person</li> </ol> <p><b><u>Best/ used option:</u></b><br/>Explained to the other person why you must leave</p> <p><b><u>Worst option:</u></b><br/>Left without saying anything</p>                          |

Figure 6.10: In-game survey required responses.

## **6.5 Summary**

The goal of the evaluation study was to analyse the potential of a serious game built on the research recommendations presented in Section 2.4 in simulating real world social skills training and identify its impact (or lack thereof) on the user. This chapter elaborated on the qualitative and quantitative measures used to retrieve relevant information from the participants. The evaluation study identified the research questions (Section 6.1), reported on the participant recruitment process (Section 6.2), and presented the rationale behind the study format (6.3). It further presented the data gathering methodology and explained the significance of each questionnaire in addressing the overall research questions (Section 6.4). The systematic assessment of the game, as discussed in this chapter, was vital to understand participants' gameplay behaviour and experience. It provides a measure of the effectiveness of the game components and the usefulness of virtual social skill training. The next chapter discusses the data analysis process and presents the results.

## 7 Data analysis

Chapter 6 presented the design for the evaluation of the game through a user study using qualitative and quantitative measures. This chapter details the data analysis and reports on the findings from the user study. The data analysis to evaluate the usefulness and effectiveness of the game is divided into six sections. Section 7.1 analyses the real world and virtual world perception study, as was presented in Section 6.3.1, including an analysis of barriers to operating the game. Section 7.2 presents the analysis of the game elements and proxy data, and Section 7.3 presents the analysis of experience study data as was discussed in Section 6.4.3 and Section 6.4.4. Section 7.4 presents analysis of post-study reflection data on the functional and social aspects of the game, and Section 7.5 analyses the real world and virtual world social anxiety study as described in Section 6.4.5. Section 7.6 presents the analysis of the post-study debriefing as was discussed in Section 6.4.6.

### 7.1 Real world and virtual world study

The real world and virtual world study aimed to analyse the perception of distance and eye contact related behaviour in both worlds to determine if the serious game provided satisfactory environment for practicing the social skill. It further enabled analysis of the overall experience of the participants with set tasks in both worlds, to identify barriers to operation of the game (Section 6.3.1).

It had two sections and each section concluded with a questionnaire as presented in Section 6.4.1. This section explains the data analyses process and presents results obtained through this study with each participant.

The participants were randomly allocated to one of two sequences: real world study first, or virtual world study first. For details, please refer to Section 6.3.1.

As explained in Section 6.4.2, the real world measurements for distance were taken in centimetre units and then converted to arm's length unit according to the participant's height. For each participant, multiple distance measurements were recorded against each object (Chair, Door, and Actor). In real world, 3 measurements (1 arm's length, 2 arm's lengths and 3 arm's lengths) were taken against each object making a total of 9 measurements (Figure 5.1). In virtual world, 3 measurements were taken against the Chair (Figure 5.3) and 2 measurements were taken against

the Door (Figure 5.2) and the Greeter (Figure 5.4; Figure 5.5). The data of interest from these measurements were the scale and inconsistency of the distance estimates against the 3 objects in real and virtual world. To find the scale, the slope and y-intercept of measurements against each object was calculated and these values were used to find the linearity of each measure using the formula:

$$y = mx + c$$

m is the slope; x is the ratio of measurement; and c is the y-intercept.

The y value was used alongside the participant's actual value for each measure to calculate the absolute deviation measure. The absolute sum of deviations was calculated for each object. The average deviation and average scale for real world measures was calculated for each participant.

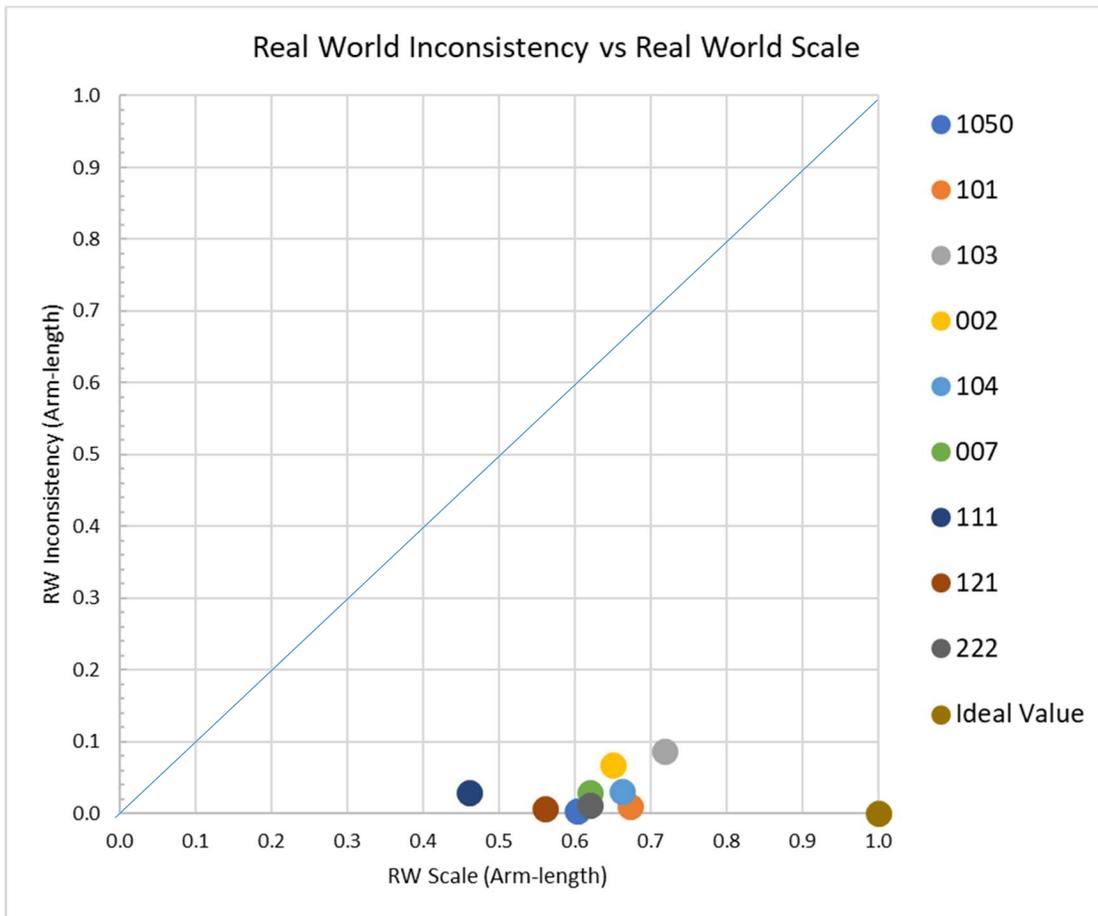
$$\frac{\sum | (y_i - x_i * m + 0) |}{3}$$

For virtual world measures, the above formula was used only for calculating the scale and inconsistency of distance estimate against the Chair. Only two measurements were taken against the Door and Greeter therefore nullifying the need for further calculations as presented in Figure 7.1. The ideal scale of measurements is 1 and the ideal standard deviation/inconsistency is 0.

| Participant | RW Scale | RW Inconsistency | VW Scale | VW Inconsistency |
|-------------|----------|------------------|----------|------------------|
| 1050        | 0.603    | 0.003            | 0.350    | 0.200            |
| 101         | 0.674    | 0.010            | 0.650    | 0.200            |
| 103         | 0.719    | 0.087            | 0.100    | 0.800            |
| 002         | 0.650    | 0.067            | 0.250    | 0.067            |
| 104         | 0.663    | 0.031            | 0.100    | 0.267            |
| 007         | 0.620    | 0.030            | 0.700    | 0.133            |
| 111         | 0.461    | 0.030            | 0.500    | 0.000            |
| 121         | 0.561    | 0.007            | 0.850    | 0.600            |
| 222         | 0.621    | 0.011            | 0.500    | 0.533            |

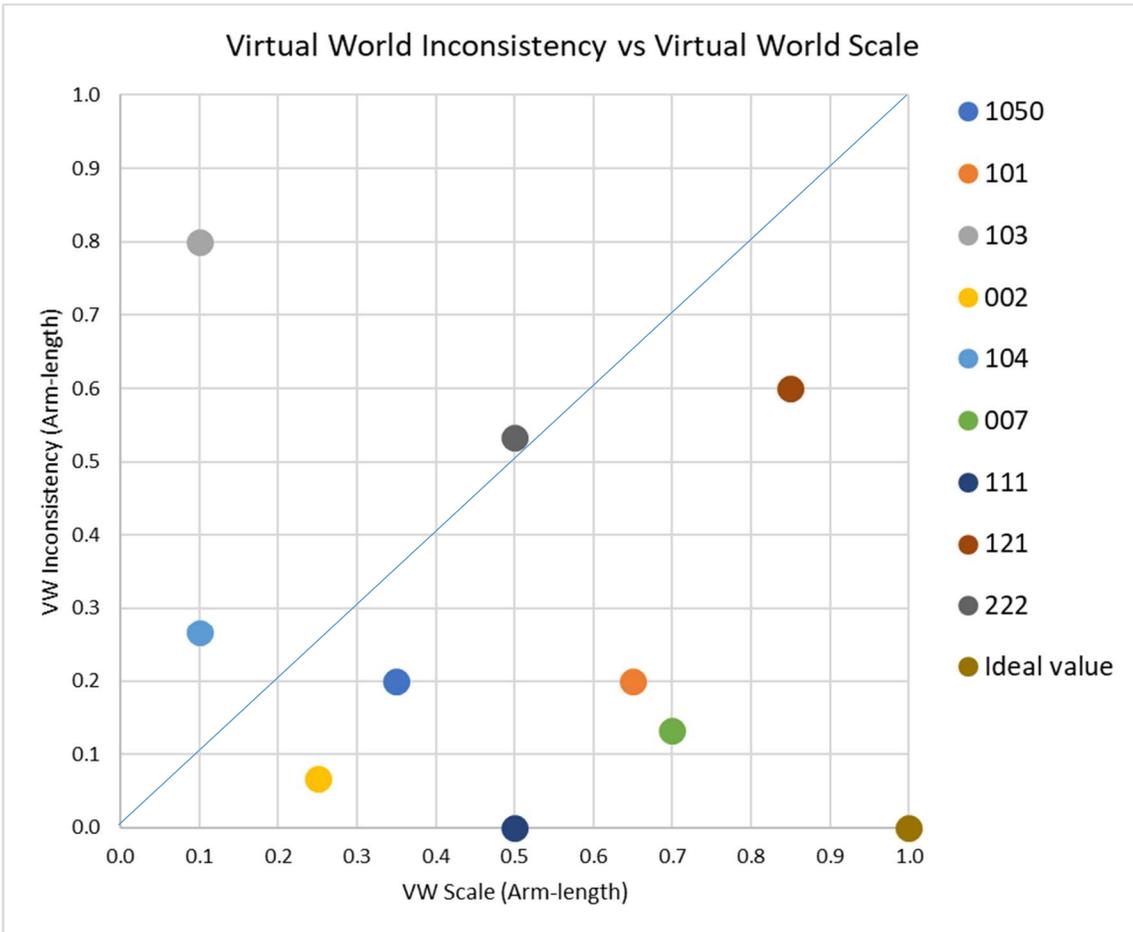
Figure 7.1: Non- averaged deviation calculated

The core of the real world and virtual world study was to find the correlation between a participant's perception of distance (Scale) and the accuracy/inconsistency of perceived measure (Inconsistency) against object in a given environment. Comparisons of the participants' data were made between the real world scale and inconsistency (Figure 7.2), the virtual world scale and inconsistency (Figure 7.3), the real world scale and virtual world scale (Figure 7.4), and real world inconsistency and virtual world inconsistency (Figure 7.5).



**Figure 7.2: real world distance perception inconsistency vs. virtual world scale represented in units of arm's length, with an error of (0) and scale of (1) being ideal.**

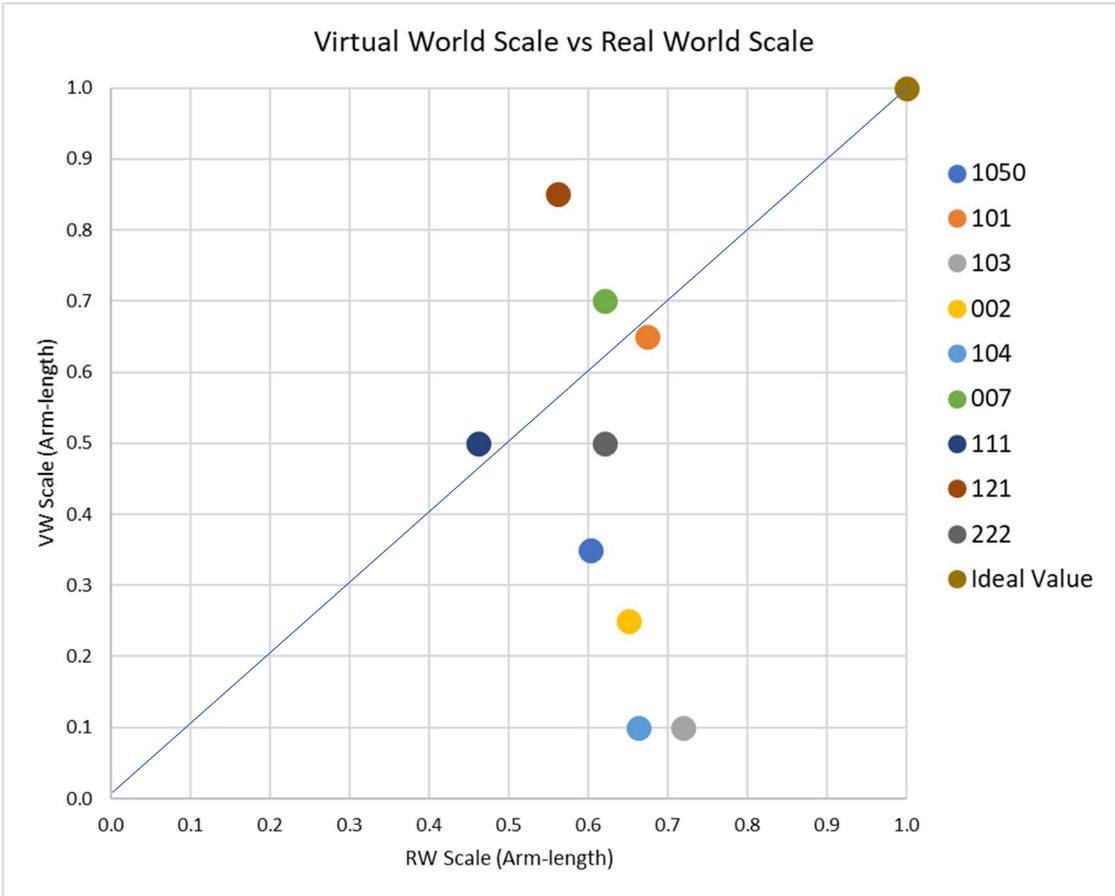
Figure 7.2 shows that the none of the participants estimated the correct measurement for one arm’s length, however eight out of nine participants estimated over 0.55 arm’s length to be an arm (variations between 0.55 and 0.72) and the distance inconsistency observed for all participants was very low (variation between 0 and 0.1) thus reporting that this scale was well maintained by the participants.



**Figure 7.3: virtual world distance perception inconsistency vs. virtual world scale represented in units of arm’s length, with an error of (0) and scale of (1) being ideal.**

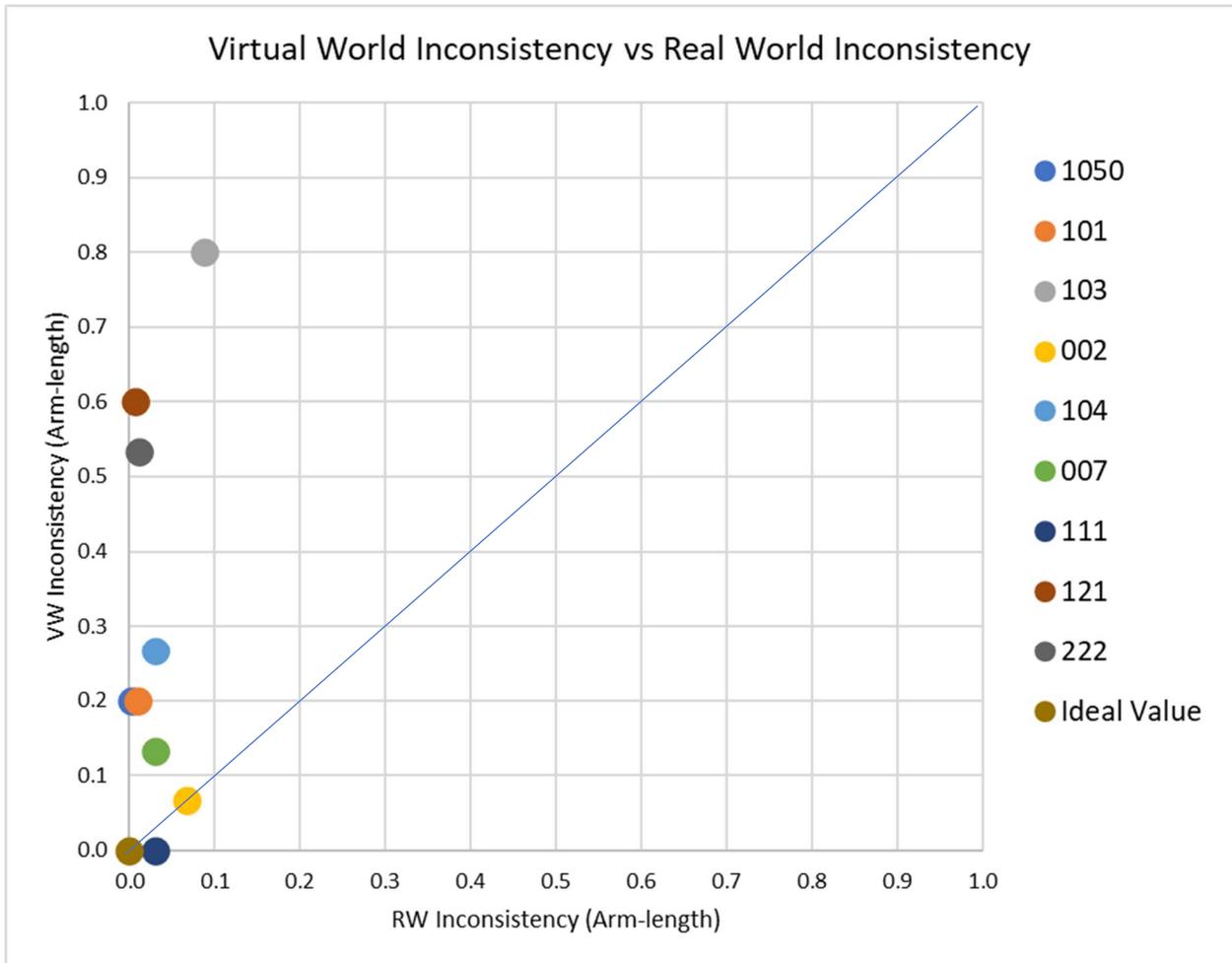
Figure 7.3 shows that participant’s distance estimate (scale) and the distance inconsistency was spread across the axes (variations between 0 – 0.85) in the virtual world. Although none of the participants perceived the accurate distance for one arm’s length, all participants underestimated this distance with four participants estimating an arm’s length to be less than half of an arm’s

length, and five participants estimating it to be half or more of an arm’s length. The distance inconsistency was under 0.3 for six out of the nine participants thus reporting that most participants maintained the distance estimate across the different measurements.



**Figure 7.4: virtual world vs. real world distance estimate/scale. The scale is represented in units of arm’s length, with a scale of (1) being ideal.**

Figure 7.4 shows that participant’s distance estimate was better in the real world (variations between 0.46 and 0.72) than in the virtual world (variations between 0.1 and 0.85). However, five out of nine participants estimated 0.5 or above for an arm’s length unit in virtual world, and two of these participants estimated distance better in virtual world than in real world.



**Figure 7.5: virtual world vs. real world distance perception inconsistency. The distance inconsistency is represented in units of arm's length, with an error of (0) being ideal**

Figure 7.5 shows that participant's distance perception inconsistency was much lower in the real world (variations between 0 and 0.1) than in the virtual world (variations between 0 and 0.8). However, it can also be seen that six out of the nine participants performed quite well in the virtual world, as shown by the cluster of points near the origin, the ideal point (0, 0).

The results showed that all participants underestimated distances in both the real and virtual world. On average, participants were better at detecting distance and maintaining that accuracy in real world as opposed to virtual world. In virtual world the participants' scale and scale inconsistency was spread out as some participants got close to expected values while others estimated far shorter distances for the measures. The results suggest a compatibility between the two worlds as the

participants did not accurately estimate distance in both worlds, although overall the estimation variation in the real world was much lower than in the virtual world.

For the tasks of eye contact, the actor observed and reported the participants' behaviour. The results from the observation sheet (Appendix O) were as follows:

| Participant | Got in line of vision             | Made eye contact  | Maintained eye contact |
|-------------|-----------------------------------|---|------------------------|
| 101         | Yes, but not 100% direct          | Yes   | Yes                    |
| 222         | Slightly right of direct vision   | Yes   | Yes                    |
| 104         | Not at first, then moved again    | Made eye contact, after moving a second time                      | Yes                    |
| 002         | Yes                               | No eye contact  | No                     |
| 007         | Yes, although he was slightly off | No eye contact  | No                     |
| 111         | Yes                               | Yes, clear contact  | Yes                    |
| 103         | Yes, direct vision                | Yes   | Yes                    |
| 121         | Yes                               | Yes   | No                     |
| 1050        | Yes                               | Yes, direct eye contact but eyes swapped from eye contact to away | No                     |

**Figure 7.5b: Participant eye contact behaviour in real world**

Figure 7.5b shows that seven of the nine participants managed to get into the line of vision on the first attempt, one got into the line of vision by moving a second time, and one participant stood slightly to the right of direct vision. Of the seven who got into the line of vision and made eye contact, only five maintained that contact. The actor reported that those who failed to maintain eye contact looked away almost immediately after making eye contact. Two participants did not make

or maintain eye contact. This shows variation in the participants' eye contact behaviour, with five participants successfully executing all tasks, two participants getting in line of vision and making eye contact but failing to maintain that eye contact, and the remaining two participants successfully getting in the line of vision but failing to make or maintain eye contact.

The virtual world eye contact behaviour contrasts with the results from the real world observations. In the game, all participants managed to execute all assigned tasks successfully (getting in the line of vision, standing at the right proximity, making eye contact with the greeter). Participants were not required to maintain eye contact. In fact, it encouraged them to break it immediately by popping up the Button that takes them to the next step in the study. The evidence shows that the participants were mostly able to make eye contact in the real world. It shows that they were able to operate the proxy for eye contact in the virtual world successfully, whether they could maintain contact in the virtual world is addressed later in the later stages of the study. Whilst it is possible that the virtual world reduced the stressors and enabled a proper eye contact behaviour, we cannot directly conclude that, and it is equally possible that the virtual world was not sufficiently realistic to determine whether they were properly making eye contact.

### **7.1.1 Task experience and response results**

The post task survey quizzed the participants on their experience with tasks and their opinion of successful completion of these tasks in real world and virtual world. The findings were visualized (Figure 7.6 – 7.15) for further analyses, to identify interpersonal and intrapersonal variation of performance towards each assigned task. Figures 7.6 to 7.13 explored the participants task experience and completion, and Figure 7.14 and Figure 7.15 compared the participants experience of tasks in both worlds.

As can be seen from Figures 7.6 to 7.13, there is a general trend that the tasks that participants identified as being relatively easy ('Undecided', 'Easy' or 'Very Easy') corresponded to those for which the completion satisfaction level was relatively good ('Satisfied' or 'Completely Satisfied'). Similarly, the tasks that the participants identified to be harder ('Difficult' or 'Very Difficult') corresponded to those for which the completion satisfaction level was 'Dissatisfied' or 'Completely Dissatisfied'. This trend was maintained for tasks in both real and virtual world.

The intrapersonal variation analysis revealed that the participants' experience and completion satisfaction level varied for the 8 tasks in real and virtual world tasks.

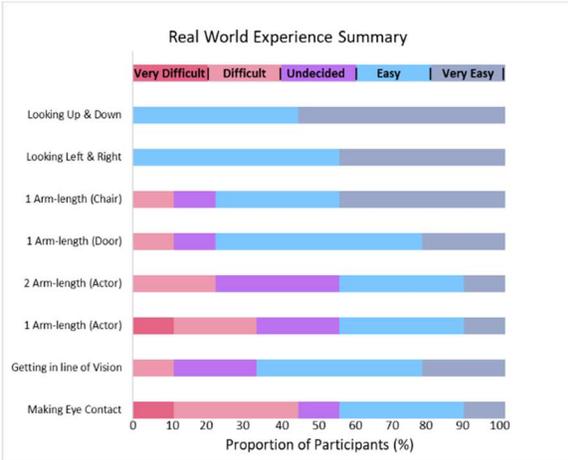


Figure 7.6: real world task experience summary

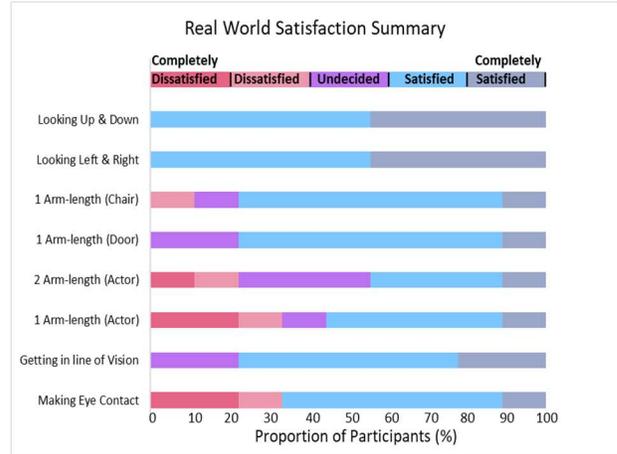


Figure 7.7: real world task completion satisfaction summary

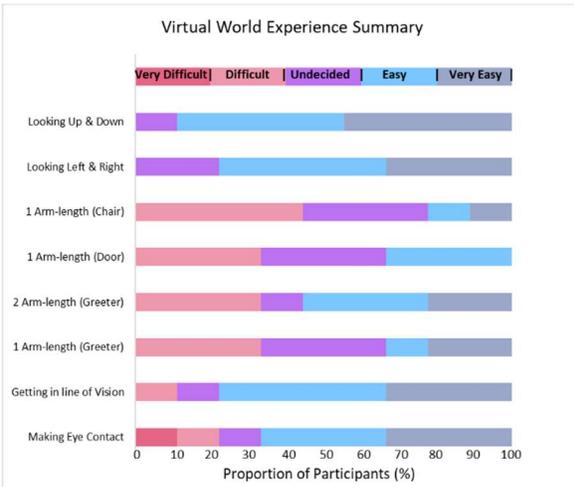


Figure 7.8: virtual world task experience summary

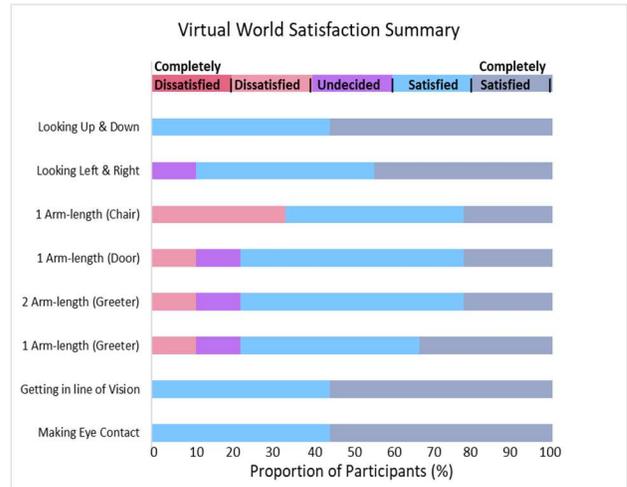


Figure 7.9: virtual world task completion satisfaction summary

Figure 7.6 -7.9 summarizes the findings according to task completion in real world. Figure 7.6 shows that for the tasks 'Looking Up & Down' and 'Looking Left & Right' all participants found the task to be either 'Easy' or 'Very Easy'. This corresponds to the satisfaction level shown in Figure 7.7, where all participants were satisfied or completely satisfied with successful completion of these tasks. The tasks involving the actor were reported to be on the range of 'Very Difficult'

or 'Difficult' by at least one participant. Similarly, the measurement tasks were reported to be difficult by at least one participant although most reported them to be on the 'Undecided' or 'Easy' range of the scale. Figure 7.7 shows that on average the completion satisfaction level corresponds to its task experience scale in Figure 7.6.

Figure 7.8 shows that on average the participants found the tasks in the virtual world to be more challenging than in real world, especially the tasks of distance measurements against the objects and movement are rated higher. However, the task of 'Getting in line of vision' and 'Making eye-contact' were rated higher in difficulty in real world as opposed to virtual world. The satisfaction level for completion of the task in virtual world as shown in Figure 7.9 is higher than that in real world. The evidence for eye contact in Section 7.1 supports this, as all participants got in the line of vision and made eye contact in the virtual world, yet their real world experience varied as was reported in the actor observations. This is expected result as the virtual world removed real life stressors and, provided visual feedback to assist the user during gameplay.

Figures 7.10– 7.13 examined the individual participant performance and their completion satisfaction level for each task in real and virtual world. For real world experience fewer participants identified tasks to be 'Very Difficult' and 'Difficult' whereas most tasks were reported to be in the category range of 'Undecided', 'Easy' and 'Very Easy'. The completion satisfaction level survey corresponded well to the assigned difficulty level for each participant, hence most tasks were categorized to be 'Undecided', 'Satisfied' and 'Completely Satisfied'. The pattern for virtual world differs marginally from real world as more participants categorized more tasks to be 'Difficult' and 'Undecided', however, the completion satisfaction level survey corresponded to the task category for each participant. The participant responses are further explored.

The analysis for intrapersonal variation revealed that in the pre-study questionnaire, four participants identified themselves to be anxious in restaurant environment, three participants reported being anxious sometimes, and two participants reported they were currently not anxious in restaurant environment. The real world and virtual world (6.4.2) enabled identification of any patterns (or lack thereof) of behaviour within the participants group.



Figure 7.10: real world participant experience summary

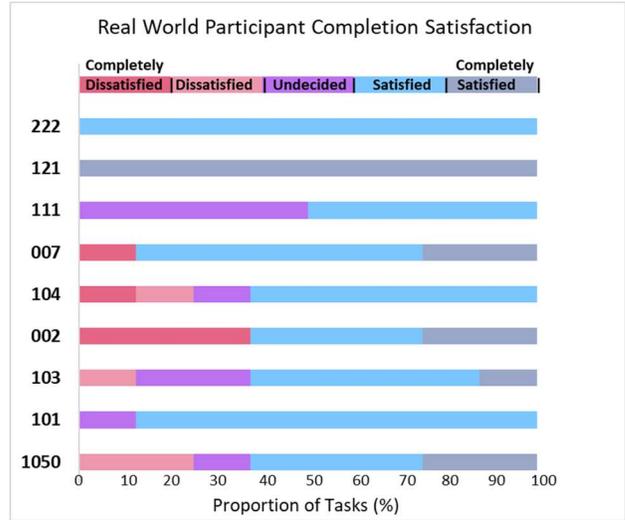


Figure 7.11: real world participant completion summary

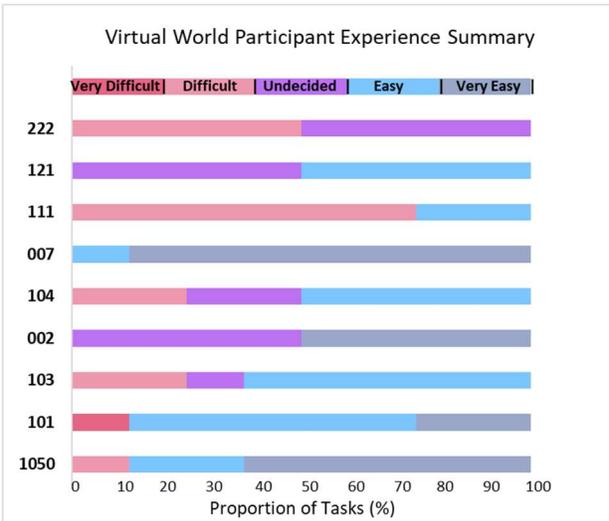


Figure 7.12: virtual world participant experience summary

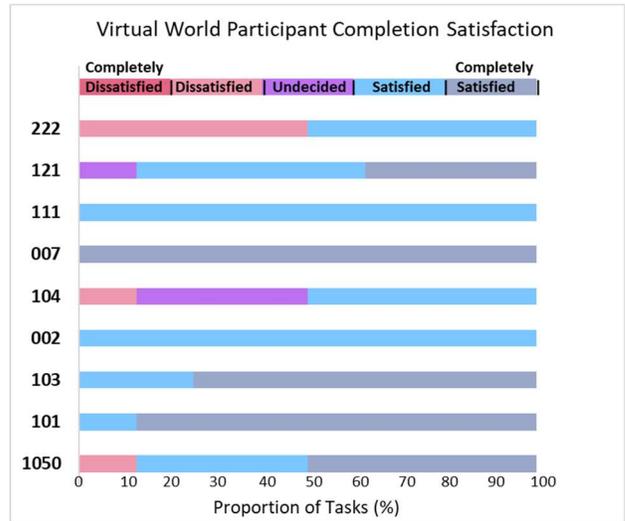


Figure 7.13: virtual world participant completion summary

The data gathered from real world study was analysed and the findings are as follows. Three out of the four participant that identified themselves to be anxious in a restaurant environment reported for real world tasks an average anxiety level of ‘Moderately Anxious’ across the social skills addressed in the pre-study questionnaire. Two out of these three participants reported the real world tasks involving the actor to be ‘Very Difficult’, ‘Difficult’ or ‘Undecided’ with varying

completion satisfaction level of ‘Completely Dissatisfied’, ‘Dissatisfied’, ‘Undecided’ and ‘Satisfied’.

For virtual world study, one participant from the two reported all the distance measurement tasks to be ‘Undecided’ and the rest of the tasks to be ‘Very Easy’ with corresponding completion satisfaction level of ‘Satisfied’ for all tasks. The other participant reported for the virtual world study, the distance measurement tasks against the greeter to be ‘Difficult’ with corresponding completion satisfaction level of ‘Undecided’ and the distance measurement tasks against the objects to be ‘Undecided’ with corresponding completion satisfaction level of ‘Undecided’ or ‘Dissatisfied’ whereas the remaining tasks were reported to be ‘Easy’ with corresponding completion satisfaction level of ‘Satisfied’.

The third participant from this group reported all the real world tasks to be ‘Easy’ with corresponding completion satisfaction level of ‘Satisfied’. This participant reported for virtual world tasks, the distance measurements tasks to be ‘Difficult’ with corresponding completion satisfaction level of ‘Dissatisfied,’ and the other tasks were reported to be ‘Undecided’ with corresponding completion satisfaction level of ‘Satisfied’.

Regarding the other participant from this category, in pre-study questionnaire an average anxiety level of ‘Not Anxious’ was reported towards the real world social tasks and all the tasks were identified to be ‘Very Easy’ with corresponding completion satisfaction level of ‘Completely Satisfied’. For the virtual world study, the participant reported the 1 arm’s length distance measurement tasks to be ‘Undecided’ with corresponding completion satisfaction level of ‘Satisfied’ for distance measurement tasks; the task of ‘Looking left & Right’ to be ‘Undecided’ with completion satisfaction level of ‘Undecided’ and all the other tasks to be ‘Easy’ with completion satisfaction level of ‘Completely Satisfied’.

The three participants that identified themselves to be sometimes anxious in a restaurant environment in the pre-study questionnaire, all reported an average anxiety level of ‘Slightly Anxious’ towards real world tasks. One participant reported the eye contact tasks involving the actor to be ‘Difficult’ and ‘Easy’ with corresponding completion satisfaction level of ‘Completely Dissatisfied’ and ‘Satisfied’. All distance measurement tasks with actor and with objects were reported to be ‘Undecided’ with corresponding completion satisfaction level of ‘Satisfied’ and the rotation tasks were reported to be ‘Very Easy’ with corresponding completion satisfaction level of

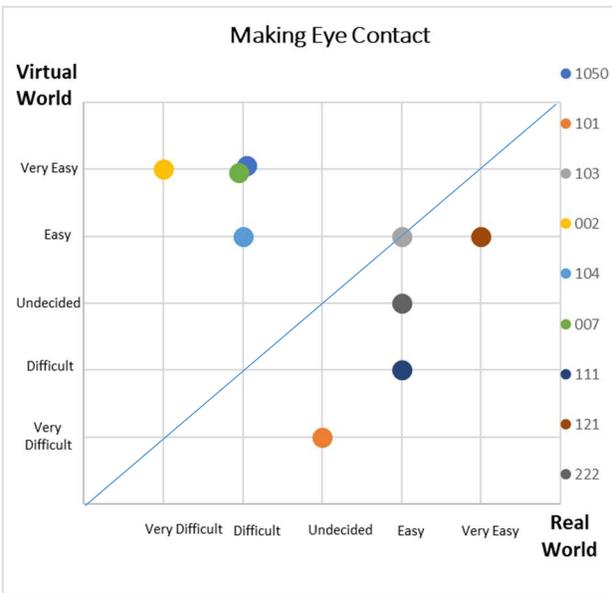
‘Completely Satisfied’. For the virtual world study, this participant reported an average anxiety level of ‘Not Anxious’ with all the tasks being ‘Very Easy’ except ‘1 arm’s length (Door)’ that was reported to be ‘Easy’; the corresponding completion satisfaction level for all tasks was ‘Completely Satisfied’.

The second participant from this group reported for the real world study, the tasks involving the actor to be ‘Undecided’ or ‘Easy’ and all other tasks to be ‘Easy’ with completion satisfaction level of ‘Satisfied’ for all tasks except the task of ‘2 arm’s lengths from actor’ that was reported to be ‘Undecided’. For the virtual world study, the participant reported the task of ‘Making Eye contact’ to be ‘Very Difficult’ and all the other tasks to be ‘Easy’ or ‘Very Easy’. The corresponding completion satisfaction level for the tasks was ‘Completely Satisfied’ except the task of ‘2 arm’s lengths (Greeter)’ that was reported to have a completion satisfaction level of ‘Satisfied’. The last participant from this group reported all the tasks in real world to be ‘Easy’ or ‘Very Easy’. Most tasks were reported completion satisfaction level of ‘Satisfied’ or ‘Completely Satisfied’ except 3. These 3 tasks were ‘2 arm’s lengths (Actor)’, ‘1 arm’s length (Door)’ with corresponding completion satisfaction level of ‘Undecided’ and the task ‘1 arm’s length (Chair)’ the completion satisfaction level was ‘Dissatisfied’. For the virtual world study, most tasks were reported to be ‘Easy’ with corresponding completion satisfaction level of ‘Completely Satisfied’. The exceptions were ‘1 arm’s length (Greeter)’ that was reported ‘Undecided’ with corresponding completion satisfaction level of ‘Completely Satisfied’ and the tasks of ‘1 arm’s length (Door)’ and ‘1 arm’s length (Chair)’ were reported to be ‘Difficult’ with the corresponding completion satisfaction level of ‘Satisfied’.

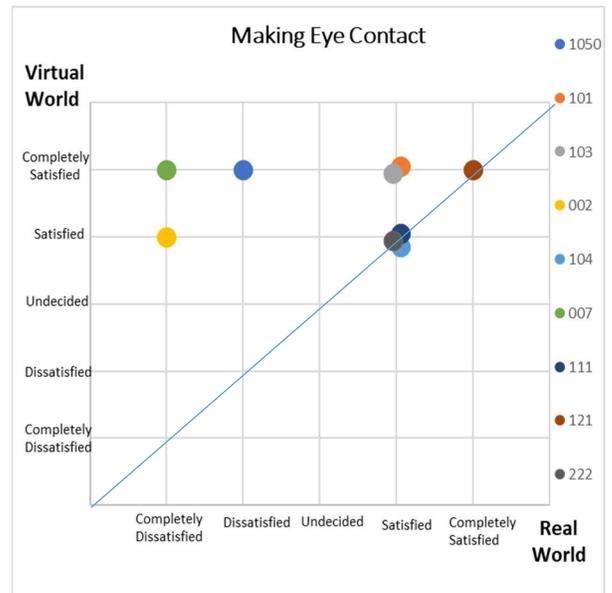
The two participants who reported that they were not anxious in restaurant environment reported varied responses for real world. One participant reported an average anxiety level of ‘Moderately Anxious’ towards the social skills. The tasks involving actor were reported to be ‘Difficult’ with corresponding completion satisfaction level of ‘Dissatisfied’, and ‘Undecided’; the distance measurement tasks were reported to be ‘Easy’ and rotation tasks to be ‘Very Easy’ with corresponding completion satisfaction level of ‘Satisfied’ and ‘Completely Satisfied’. For the virtual world, the participant reported an average anxiety level of ‘Not Anxious’ with all the tasks being ‘Easy’ or ‘Very Easy’ with corresponding completion satisfaction level of ‘Satisfied’ or ‘Completely Satisfied’ except for the task of ‘1 arm’s length (Chair)’ that was reported to be

‘Difficult’ with corresponding completion satisfaction level of ‘Dissatisfied’. The other participant reported in pre-study questionnaire an average anxiety level of ‘Not Anxious’. The participant reported all the real world tasks except distance measurements to be ‘Easy’ with corresponding completion satisfaction level of ‘Satisfied’. The distance measurement tasks were reported to be ‘Difficult’ with corresponding completion satisfaction level of ‘Undecided’. This participant reported for the virtual world study an average anxiety level of ‘Not Anxious’ with all the tasks involving greeter and distance measurement to be ‘Difficult’ and the tasks of rotation to be ‘Easy’. For all the tasks the participant reported completion satisfaction level of ‘Satisfied’ even though some tasks were reported to be difficult; this is because game provided feedback to assist successful execution.

Figures 7.14 to 7.32 represent the participants’ response to each assigned task in real and virtual world alongside their completion satisfaction level for the task in both worlds. The participants that fall on the diagonal represent same responses for the given task in real and virtual world. The participants that cluster above the diagonal, represent better experience of virtual world compared to real world. The participants that cluster below the diagonal, represent better experience of real world than virtual world. Three participants (111, 121 and 222) did not play first-person controller games prior to this study, whereas the other had played first-person controller games previously.



**Figure 7.14: VW vs. RW social task ‘Making eye contact’ participant experience summary**



**Figure 7.15: VW vs. RW social task ‘Making eye contact’ participant completion satisfaction level**

Figure 7.14 shows the participant’s response to the task of making eye contact in real world and virtual world. The graph shows that Participants fall into one of the 3 categories: those who found making eye contact in real world easier than in the virtual world, those who found the task easier in virtual world than in real world, and one participant found the task easy in both worlds. Figure 7.15 shows that the participants’ responses fell into 2 categories: those who found were equally satisfied with the task completion in real and virtual world, and those who were more satisfied with their task completion in virtual world than in real world.

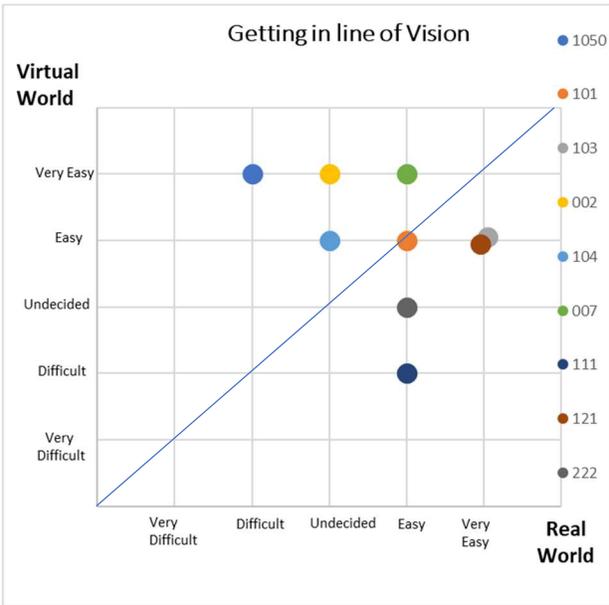


Figure 7.16: VW vs. RW social task ‘Getting in line of vision’ participant experience summary

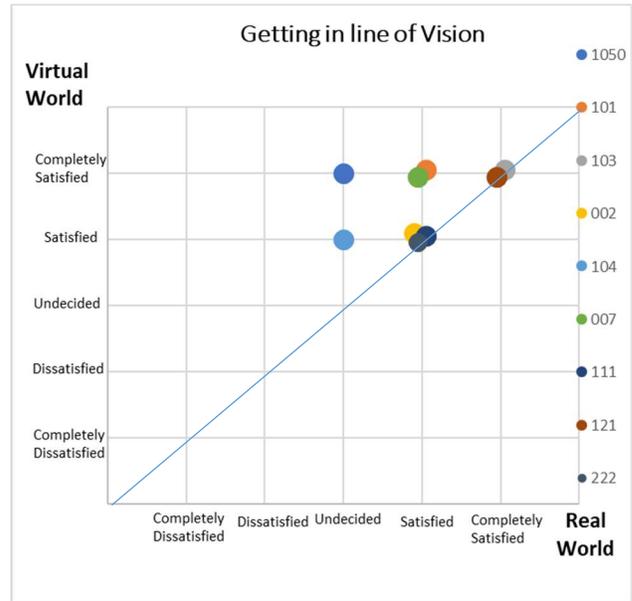
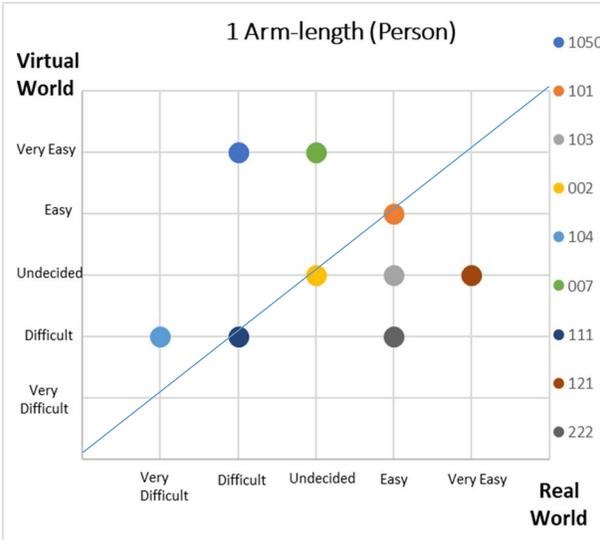
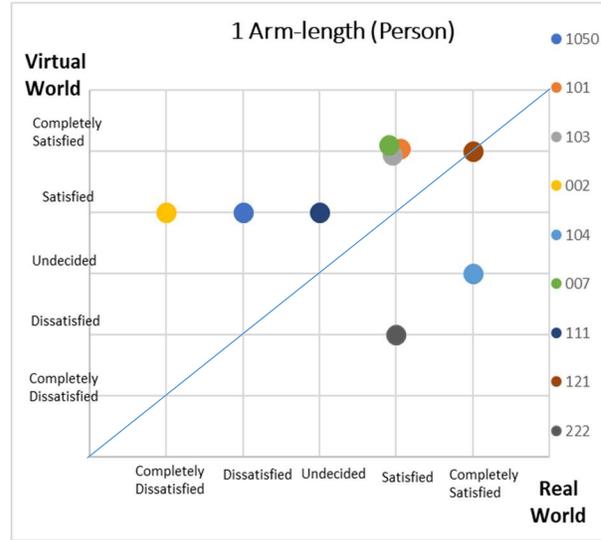


Figure 7.17: VW vs. RW social task ‘Getting in line of vision’ participant completion satisfaction level

Figure 7.16 shows that one participant found the task of getting in line of vision to be easy in both worlds, four participants reported the task to be easier in real world than in virtual world, and four participants found the task to be easier in virtual world than in real world. Figure 7.17 shows that five participants felt equally satisfied with the task completion in real and virtual world, whereas the rest of the participants felt more satisfied with their virtual world performance than their real world performance. Participant 111 and 222 maintained their level of difficulty and performance satisfaction for the above 2 tasks in both worlds. Overall, the participants reported same or higher completion satisfaction level towards these two tasks.

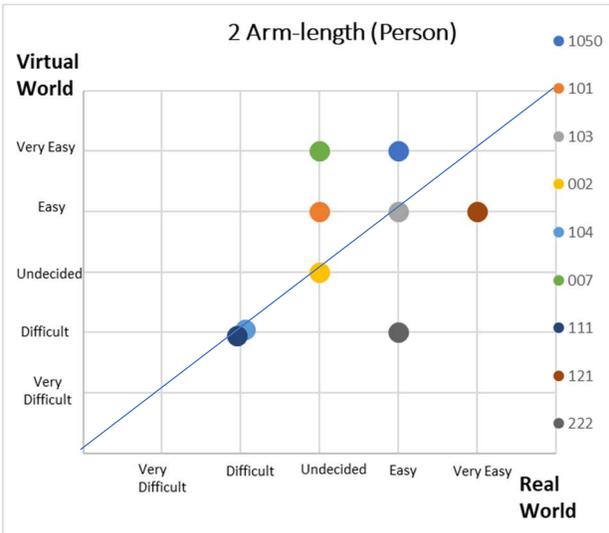


**Figure 7.18: VW vs. RW distance measurement '1 arm's length from person' participant experience summary**

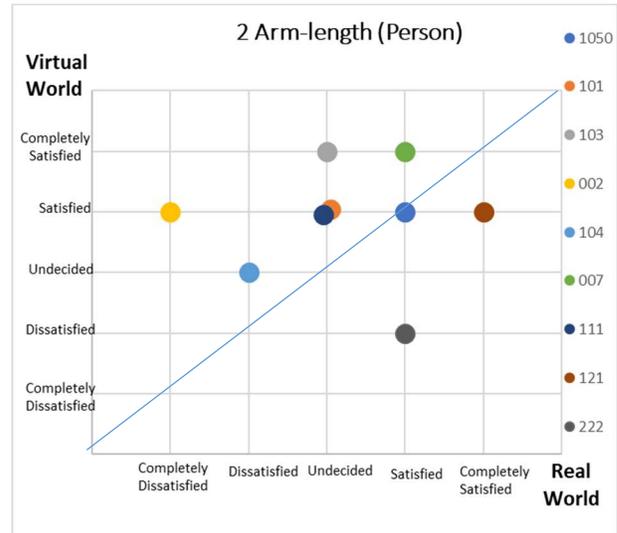


**Figure 7.19: VW vs. RW distance measurement '1 arm's length from person' participant completion satisfaction level**

Figure 7.18 shows that three participants reported the same level of difficulty/ease for the task of standing at 1 arm's length from the person in real and virtual world, three participants reported the task to be easier in real world than virtual world, and three participants reported the task to be easier in virtual world than in real world. Figure 7.19 shows that higher ratio of participants was more satisfied with their virtual world performance over their real world performance, whereas only two participants were more satisfied with their real world performance than their virtual world.

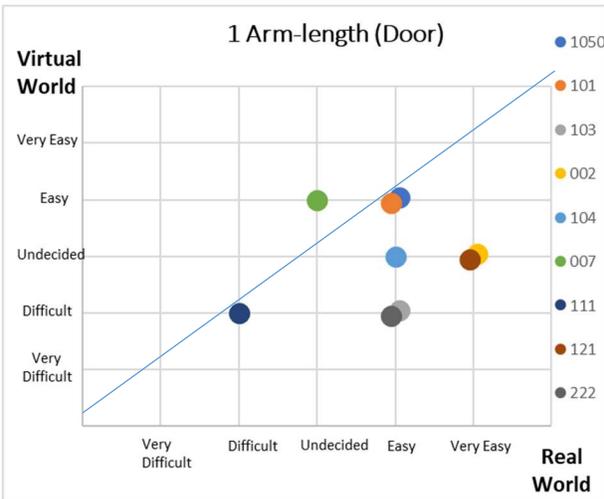


**Figure 7.20: VW vs. RW distance measurement '2 arm's lengths from person' participant experience summary**

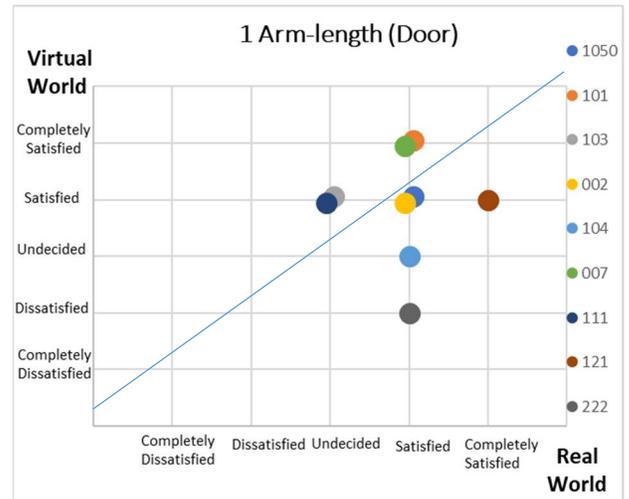


**Figure 7.21: VW vs. RW distance measurement '2 arm's lengths from person' participant completion satisfaction level**

Figure 7.20 shows that majority of the participants reported same difficulty or ease level for the task of standing at 2 arm's lengths from the person in real and virtual world, whereas three participants found the task easier in virtual world than in real world and two participants found the task easier in real world than in virtual world. Figure 7.21 shows that most participants were more satisfied with their performance of the task completion in the virtual world, one participant felt the same level of satisfaction for both worlds, and the two participants who reported they found the task easier in real world than in virtual world were better satisfied with their performance in real world than in virtual world.

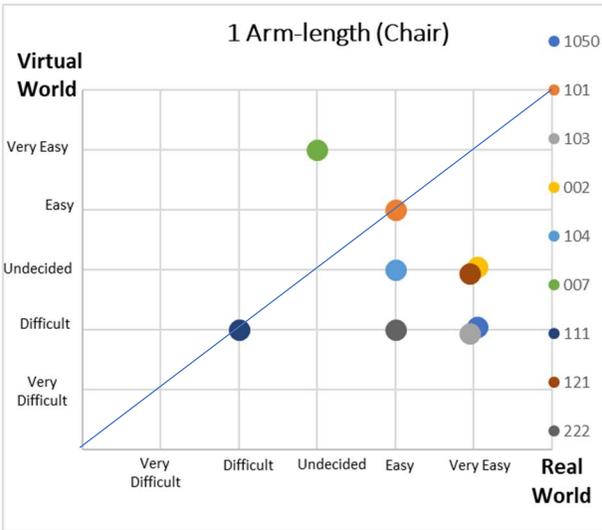


**Figure 7.22: VW vs. RW distance measurement '1 arm's length from the door' participant experience summary**

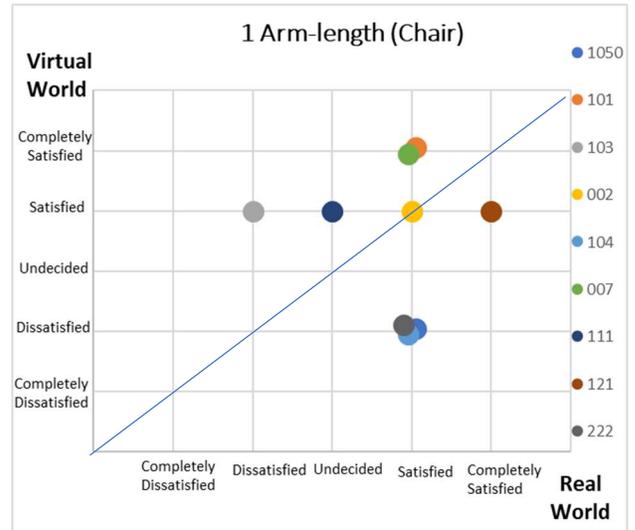


**Figure 7.23: VW vs. RW distance measurement '1 arm's length from the door' participant completion satisfaction level**

Figure 7.22 shows that most participants found the task of standing at 1 arm's length from the door to either be easier in the real world than in the virtual world or they found them to be the same. Only one participant reported that the virtual world experience was easier than real world. Figure 7.23 shows that most participants were more satisfied with their virtual world task completion compared to their real world task completion. Two participants were equally satisfied with their real and virtual world performance, whereas three participants were more satisfied with their performance in real world than in virtual world.

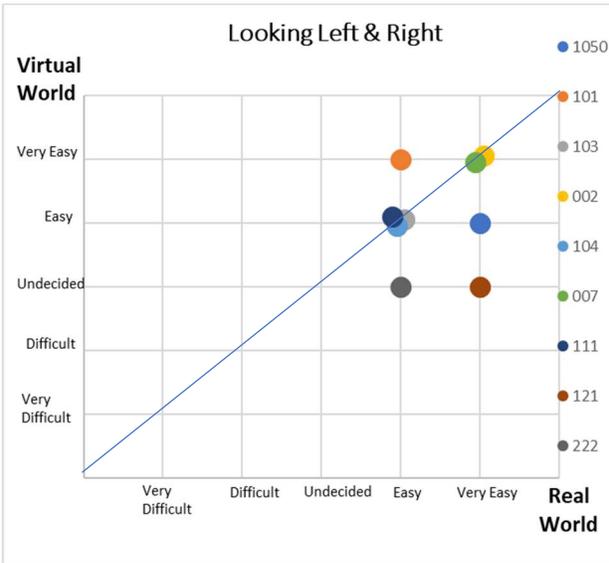


**Figure 7.24: VW vs. RW distance measurement '1 Arm's length from the chair' participant experience summary**

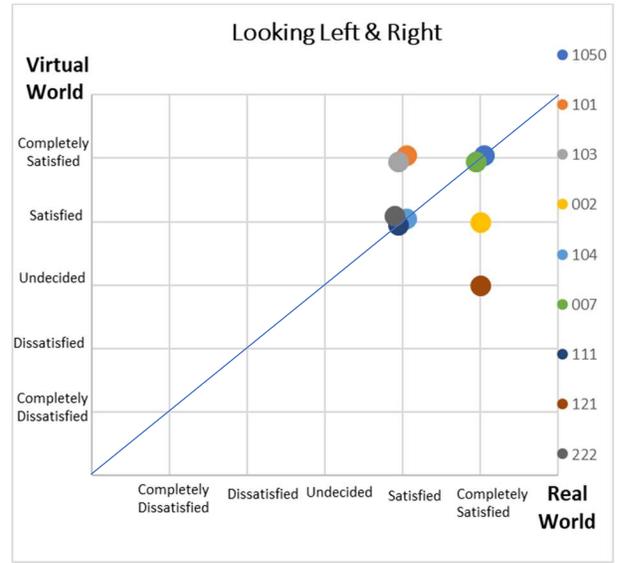


**Figure 7.25: VW vs. RW distance measurement '1 Arm's length from the chair' participant completion satisfaction level**

Figure 7.24 shows that majority of the participants found the task of standing at 1 arm's length from the chair to be easier in real world than in virtual world. Two participants found the task to be the same, whereas one participant found the task to be easier in virtual world than in real world. Figure 7.25 shows that one participant was equally satisfied with real and virtual world performance, half the participants were more satisfied with their virtual world performance, and half were more satisfied with their real world performance.

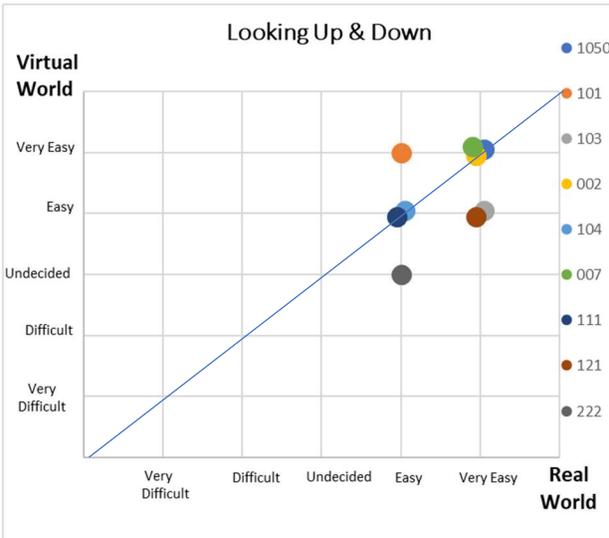


**Figure 7.26: VW vs. RW task ‘Looking left & right’ participant experience summary**

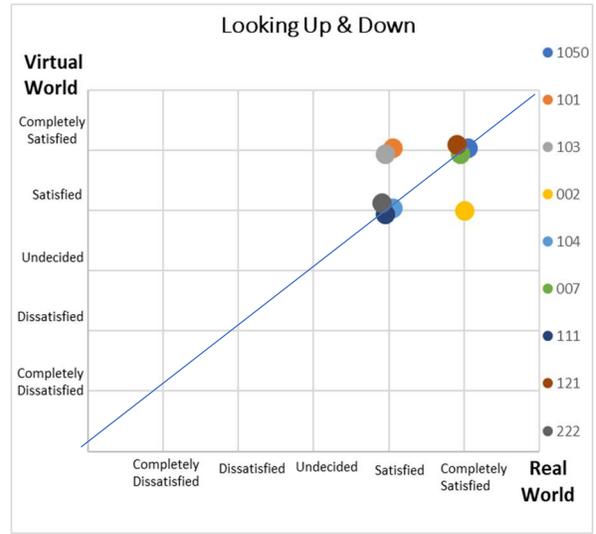


**Figure 7.27: VW vs. RW task ‘Looking left & right’ participant completion satisfaction level**

Figure 7.26 shows that majority of the participants found the task of looking left and right to be the same in real world as in virtual world. Three participants found the task to be easier in real world, and only one participant found the task easier in virtual world compared to real world. Figure 7.27 shows that only two participants were more satisfied with their real world performance, majority of participants were equally satisfied with their real and virtual world performance, and two participants were more satisfied with their virtual world performance compared to their real world performance.



**Figure 7.28: VW vs. RW task 'Looking up & down' participant experience summary**



**Figure 7.29: VW vs. RW task 'Looking up & down' participant completion satisfaction level**

Figure 7.8 shows that most participants found the task of looking up and down to be equally easy in real and virtual world; three participants found it easier in real world, and one participant found it easier in virtual world. Figure 7.29 shows that most participants were equally satisfied with their performance in real and virtual world, two participants were more satisfied with their virtual world performance, and one was more satisfied with the real world performance.

### 7.1.2 Task experience and response summary

Figure 7.30 shows that more participants found the execution of tasks in virtual world to be same as or harder than in real world. Very few participants identified the execution of tasks in virtual world to be easier than real world. The task of 'Making eye contact' was reported to be easier in virtual world than in real world by most, and to be same as real world by the remaining participants.

Figure 7.31 shows that most participants rated their execution of majority of the tasks in virtual world to be harder than or same as their real world experience. Only one participant identified most tasks to be easier in virtual world than in real world, some tasks to be same as real world and no task to be easier in real world.

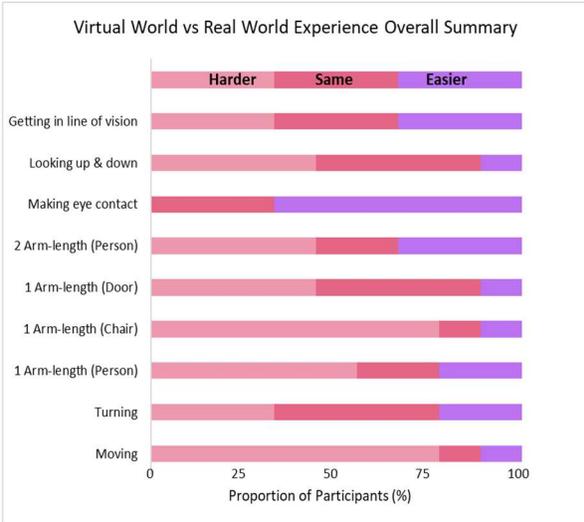


Figure 7.30: VW vs. RW task experience summary

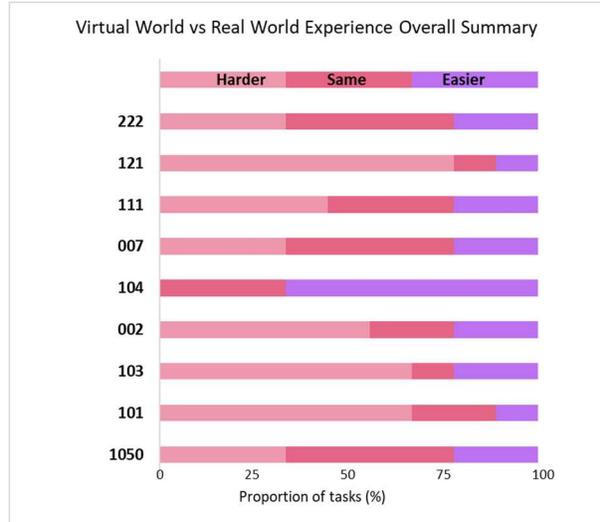


Figure 7.31: VW vs. RW participant experience summary

### 7.1.3 Impact of participant's prior experience

To sum up the participants findings, an overview of the findings for each participant was created as presented in Figure 7.32. The factors considered for the overview were derived from pre-study questionnaire as presented in Section 6.4.1 and the real world and virtual world task comparison as presented in Figure 7.31. These factors from pre-study were the participant's exposure to social skill training program and first-person controller FPC games and their reported anxiety status in a restaurant environment. For the real world and virtual world task experience comparison, the most frequent task response was considered, and it was compared with their actual task performance.

Only one (007) out of the nine participants had reported taking part in a social skills training program. This participant reported playing FPC games daily; sometimes being anxious in restaurant, and for the real world and virtual world task completion, reported most of the tasks in virtual world to be the same as in the real world. The distance measurement study for this participant supports this analysis as their virtual world and real world scale values are over half an arm's length with a difference of 0.08 arm's length unit between the two environments. Similarly, the inconsistency in both worlds is low as it is under 0.13 arm's length with an inconsistency difference of 0.1 arm's length unit between the two environments. This concludes that the participant estimated the distance better in the virtual world but maintained the difference better

in real world, therefore supporting the participant’s analysis. It is worth noting that overall, this participant performed the best in real world and virtual world study compared to others.

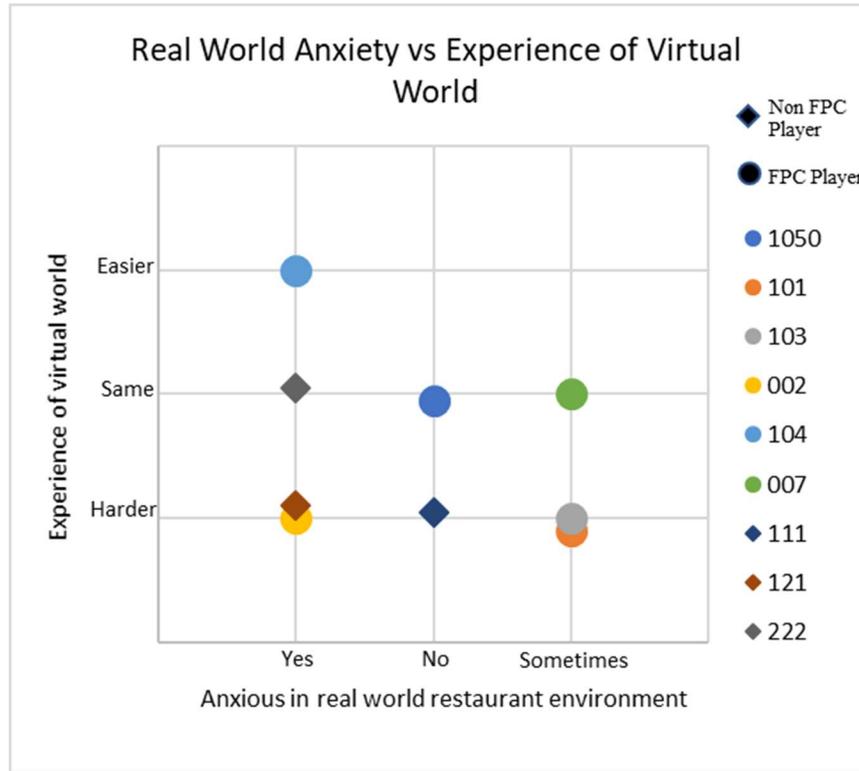


Figure 7.32: Overall level of anxiety in real world vs. harder/easier in virtual world

Out of the eight participants that reported no exposure to social skills training program, three participants reported that they also had no exposure to FPC games. One (111) of these participants reported not being anxious in restaurant, and for the real world and virtual world task completion reported most of the tasks in virtual world to be harder than in the real world. Ironically, the distance measurement did not support this analysis as the participant performed marginally better in the virtual world than in real world with the virtual world to real world scale difference is 0.04 arm’s length unit and inconsistency is -0.02 arm’s length unit. The participant estimated half and just under half arm’s length to be an arm’s length and maintained this distance well with an inconsistency of under 0.02 arm’s length unit. This concludes that the participant both estimated the distance and maintained the distance difference better in the virtual world than in real world,

thus the participant's report that tasks were harder in the virtual world is inconsistent with their performance.

The other two participants who reported no exposure to social skill training program and FPC games, reported they were anxious in restaurant. One (121) of these participants reported for the real world and virtual world task completion that most tasks were harder in the virtual world. The distance measurement study for this participant showed that the participant estimated the distance better in the virtual world (0.8 arm's length unit for an arm) than in real world (0.56 arm's length unit). However, the participant did not maintain the distance well in virtual world with a high inconsistency of 0.6 arm's length unit. This was contrasted by the real world inconsistency of 0 arm's length, thus reporting perfect carry over of the scale from one measure to another. This participant's report that virtual world tasks were harder than real world was supported by the distance measure as the participant failed to retain the distance difference.

The other participant (222) from this category reported most of the tasks in virtual world to be the same as in the real world. The distance measurement study for this participant showed that the participant reported over half arm's length unit for an arm's length with similar distance scale for both environments, and a minor distance difference of real world to virtual world of 0.11 arm's length unit. The participant maintained the distance a lot better in the real world with a real world and virtual world inconsistency difference of -0.51 arm's length unit. This concludes that the participant both estimated the distance and maintained that distance difference better in the real world than in real world, thus the findings did not support the participant's analysis that both worlds were the same.

The five remaining participants that reported no exposure to social skills training program, reported that they had used FPC games. One of the participants (1050) reported not being anxious in restaurant, and for the real world and virtual world task completion, reported most of the tasks in virtual world to be the same as in the real world. The distance measurement study for this participant showed that the participant estimated the real world distance at 0.6 unit for an arm with perfect carry over accuracy for the different measurements. For the virtual world, the estimated distance was less than half an arm's length at 0.35 arm's length unit and this was not accurately carried over the different measurements. The real world and virtual world scale difference was 0.25 arm's length unit, and inconsistency difference was -0.2 arm's length unit. This concludes

that the participant performed better in real world than in virtual world, thus their report that tasks in both environments were the same is not supported by their performance.

Two of the participants reported being anxious sometimes and for the real world and virtual world task completion, both reported that the tasks were harder in virtual world. Upon individual distance measurement analysis, it was evident that one (101) of these participants produced similar results for both worlds with a scale of almost 0.7 arm's length unit for one arm's length and a perfect carry over of this accuracy in real world however in virtual world it had a slight inconsistency of 0.2 arm's length unit. The real world and virtual world distance difference of scale was 0.03 arm's length unit and the difference of inconsistency was -0.2 arm's length unit. This concludes that this participant performed marginally better in real world and was better at accurately carrying over their distance estimate in real world thus their analysis that the virtual world was harder is supported by their performance. The distance measurement analysis for the other participant (103) showed a great inconsistency between the measures for the two environments with participant reporting real world scale to be 0.7 arm's length unit for one arm and this was accurately carried over with a low inconsistency of 0.1 arm's length. The real world and virtual world scale difference was 0.61 arm's length unit and inconsistency difference were -0.7 arm's length unit. This concludes that the participant performed well in real world however in the virtual world the distance measurement was poor (0.1 arm's length unit for one arm) with a high inconsistency in carrying over of the distance estimate. Therefore, the participant report that tasks in the virtual world were harder is supported by the distance measures.

The last two participants that did not have exposure to social skill training program and first-person controller games; they reported being anxious in restaurant environment. For the real world and virtual world task completion, one (002) of these participants reported the virtual world being harder than real world. The distance measurements analysis revealed that this participant reported the real world scale to be 0.65 arm's length unit and underestimated the virtual world scale at 0.25 arm's length unit; that is real world and virtual world difference of 0.45 arm's length unit thus significantly high difference. The scale for both environments was accurately carried over with a low inconsistency of 0.08 arm's length unit. This concludes that the participant carried over their projected scale accurately in both real and virtual world however the participant estimated distance

much better in real world compared to the virtual world. This is consistent with the participant's report that they found the task execution harder in the virtual world compared to the real world.

The other participant in this category is the only participant in this study that reported that the tasks were easier in virtual world than in real world. The analysis of distance measurement revealed that the participant estimated the real world one arm's length to be 0.68 arm's length unit with low inconsistency of 0.02 arm's length unit and underestimated the virtual world distance to be 0.1 arm's length unit with a higher inconsistency of 0.28 arm's length unit. This means the difference of real world and virtual world scale is 0.58 arm's length unit thus it is significantly high and the difference of inconsistency for real world and virtual world is -0.26 arm's length unit. This concludes that the participant was better at estimating distance and maintaining distance accurately in real world however, the participant performance in virtual world was very poor thus the distance measurement did not support the participant's analysis.

The findings for the impact of participant's prior experience with first-person controller games and their anxiety status towards real world restaurant, on the perceived difficulty of task execution in the real and virtual world varied. Five participants' performance and analysis matched, one of them had exposure to social skill training program and first-person controller game; three of them did not have exposure to social skill training program but had used first-person controller game and one did not have exposure to social skill training program or first-person controller game. The only common factor was that all these participants identified themselves to be anxious or sometimes anxious in restaurant however not all participants who identified themselves anxious or sometimes anxious fell in this category. The four remaining participants' performance and analysis did not match. All of them did not have exposure to social skill training program whereas two of them had exposure to first-person controller game and two of them did not have exposure to first-person controller games. Among the two participants that had exposure to first-person controller games, one declared to be anxious in a restaurant while the other declared not being anxious in a restaurant. Similarly, the two participants with exposure to first-person controller, one declared being anxious while the other reported not being anxious in restaurant. The pattern is that the participant who reported not being anxious in a restaurant and analysed their performance were overconfident as their actual performance did not support their analysis, whereas the participants who reported being sometimes anxious or anxious in a restaurant varied in their performance. Therefore, the

study findings concluded that there was no common factor that directed the results towards a particular outcome rather the results varied from person to person. This is expected outcome as people with Asperger's Syndrome/HFA vary vastly from one individual to another thus the lack of common factor(s) influencing the overall results.

#### **7.1.4 Summary**

The static virtual environment was created as part of the real world and virtual world study (Section 6.4.3), with particular focus on real world and virtual world distance perception, and eye contact behaviour to identifying barriers to operation of the serious game. Analyses were made based on participants responses to the questionnaire, their performance during the study, and the debriefing after the study.

Although some participants reported not doing well in the game, the results show that the participants' distance estimations in the real world and the virtual world were remarkably similar, although not particularly accurate. All participants underestimated the distance (scale) in both environments and the distance inconsistency varied. The distance measurement on average was carried out better in the real world; this could be because in the virtual world the peripheral vision is absent. The participants' performed the eye contact tasks better in virtual world than in real world.

A secondary objective of the real world and virtual world study was to familiarise the participants with controls and environment of the serious game and allow them to comment on its usability hence verify if the serious game was useable. The three participant who did not have exposure to the first-person controller games prior to this study, reported being comfortable with the experience post familiarisation. At no instance during the study did any participant ask for assistance in operating the serious game or reported it being difficult in the post-study debriefing. In summary, the participants in this study found the serious game to be useable and did not identify significant barriers to operation.

## **7.2 Game elements and proxies' study**

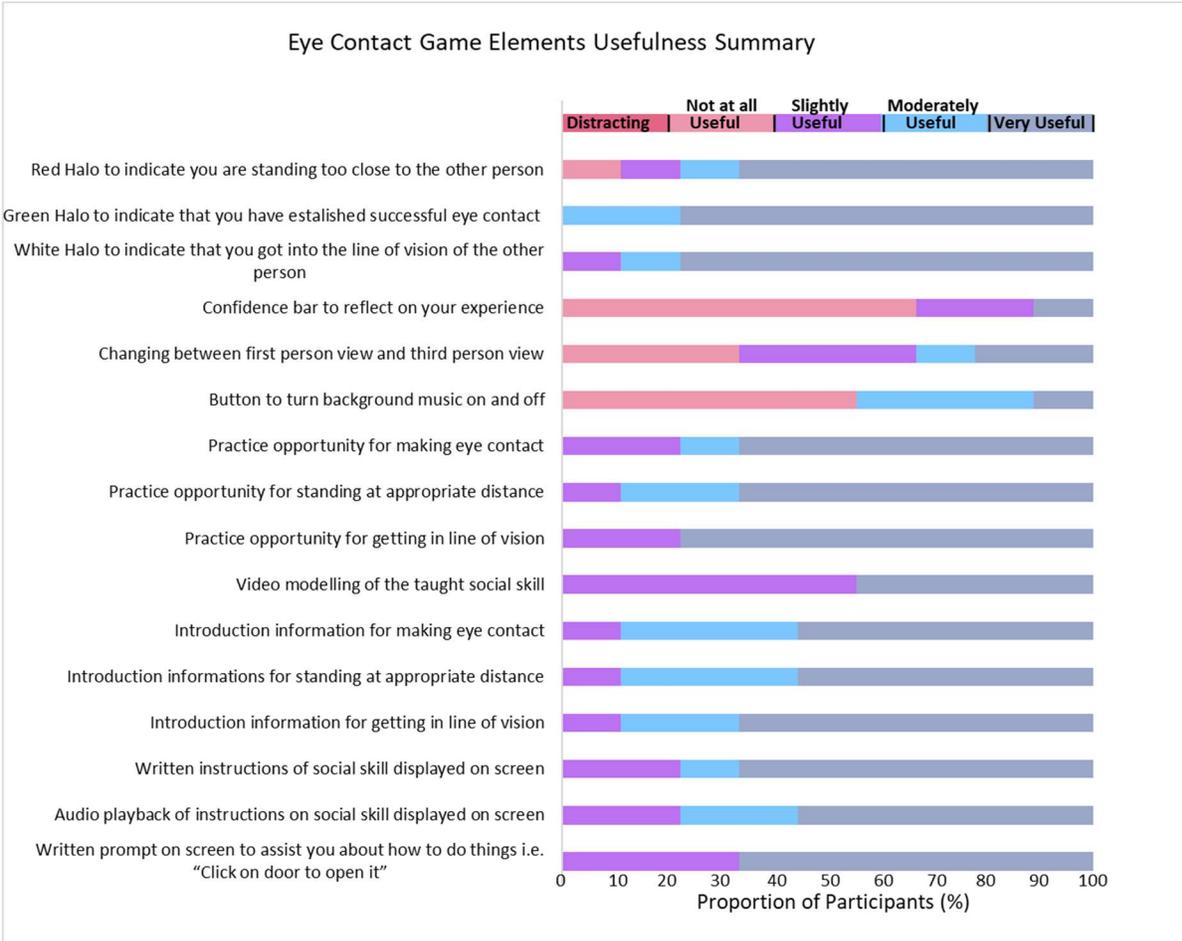
The program used feedback mechanism (game elements) and proxies to assist user with gameplay. The game elements were used throughout the gameplay whereas the proxies were chosen

according to the social task at hand. The standard game elements were the background noise control, confidence bar, change between first- and third-person view, keyboard input for movement, arrow key input for rotation, mouse clicks for interaction with active object and feedback stars for task completion. The proxies were the presentation of social skill instructions through text and audio playback, the social skill modelling videos for skill modelling, the coloured Halos for eye contact, the speak now button and conversational options for engaging in small talk/conversation, written prompts as assistive feedback, skill and sub-skill practice opportunity as presented in Section 4.4. The game elements and proxies were designed to provide maximum feedback eliminating the need for interference from the researcher. It was important to find out whether the participant perceived these to be useful and if their perceived performance was supported by the data gathered through built-in game features. The analysis of qualitative data gathered through the survey is presented next, followed by the analysis of the quantitative data gathered through the game as presented in Section 7.2.1.

The data collection of the game elements was conducted on immediate response basis therefore the participant was asked to report on the usefulness of the game elements and feedback for eye contact experience after the training phase of the game and during the practice run of the game; this was repeated for the small talk scenario in the small talk questionnaire to conclude if the participant found them helpful for both or only one social skill.

Figure 7.33 shows the participants response to the game elements and proxies designed for the skill of eye contact. The findings fall under two categories: those that participants found to range between 'Slightly Useful' to 'Very Useful' and those that participants found to range between 'Not at all Useful' to 'Very Useful'. Regarding the first category, it shows that for all elements and proxies (except one), a higher proportion of the participants found them to be very useful whereas a smaller proportion of the participants found them to be slightly or moderately useful. The exception is 'Video modelling of the taught social skill' that was rated as slightly useful by a higher proportion of participants. The audio that accompanied the social skill modelling videos was not loud enough, and some participants asked if the audio could be turned up. In the debriefing a participant commented for improvement to make the video louder. The researcher was aware that the audio was not amplified however wanted to see whether this significantly impacted the

findings. The interesting finding here is that despite the audio being not loud enough, 40% of participants found it to be very useful and 60% found it to be slightly useful.

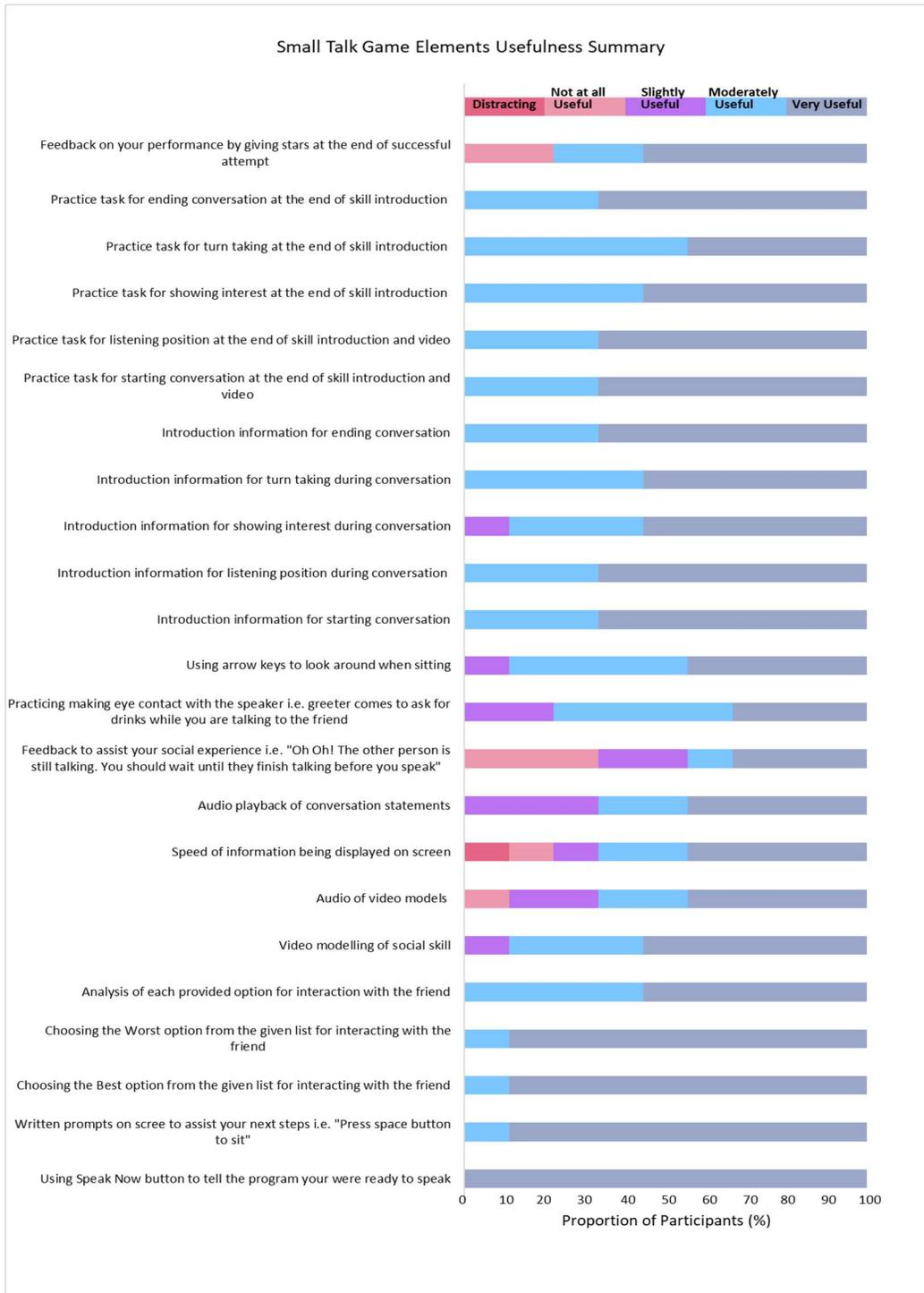


**Figure 7.33: Participants response to usefulness of the game elements and proxies designed for assistance of the skill of Eye contact**

One proxy and three elements fell in the second category. The proxy is the red halo for standing too close. One participant found it not at all useful, one found it slightly useful and one found it moderately useful, yet the highest proportion of participants reported it to be very useful. It was observed that none of the participants used the Red Halo during study except when they were assigned the task in the static environment study. Two elements out of the three elements were reported to be not at all useful by a higher proportion of participants and fewer participants found

it to range between slightly useful and very useful. These two elements were the confidence bar and the button to turn the music on and off. The researcher noted that none of the participants used the confidence bar and only one participant used the button for turning the music off therefore the outcome is expected. The researcher asked the participants at the debriefing post-study why they did not use the confidence bar, the common answer was that they forgot about using it. The last element that was reported to be not at all useful by three participants was changing between first-person view and third-person view however the rest of the participants rated it to range between slightly to very useful. It was observed that this feature was only used in the familiarisation study by all participants based on the provided instructions (Section 6.3.1) and not in the gameplay. Overall, the participants found most of the game elements and proxies implemented in the game to be useful in their interaction with and learning from the game/system.

Figure 7.34 shows the participants response to the game elements and proxies designed for the skills of engaging in small talk/conversation. For all the elements and proxies, the higher proportion of participants reported finding them to be in the range very useful and moderately useful. Five out of the 23 elements were reported by a smaller proportion of participants to be slightly useful extending the useful range to be between slightly useful to very useful. Three elements contained the rating of not at all useful in its range. One of them was the ‘Audio of social skill modelling videos’, as mentioned earlier the audio was low therefore 10% of the participants reported it to be not at all useful for the tasks of engaging in small talk whereas 90% reported it to range between slightly useful to very Useful. The other element was ‘Feedback to assist your social experience, e.g., *"Oh oh! The other person is still talking. You should wait until they finish talking before you speak"*’, this was reported by three participants to be not at all useful and the rest reported it to range between slightly useful to very useful. It was observed that none of the participants came across this statement as they pressed the ‘*Speak Now*’ button when the other person would finish talking following the training advice. For the participants who reported this feature was very useful, they mentioned it would be if it was needed although they did not use it. Two of the nine participants rated ‘Feedback on your performance by giving stars at the end of successful attempt’ to be not at all useful and they mentioned that they didn’t notice it whereas 8 participants rated this to range between moderately useful to very useful.



**Figure 7.34: Participants response to usefulness of the game elements and proxies designed for the skill of Small talk**

The one element that stood out was the ‘Speed of information being displayed on screen’, as it was rated to be distracting by one participant, not at all useful by one participant and slightly useful by one participant; whereas 2 participants reported it to be moderately useful and 4 reported it to be very useful. Overall, the participants found majority of the elements and the proxies to be useful in their interaction with and learning from the game/system.

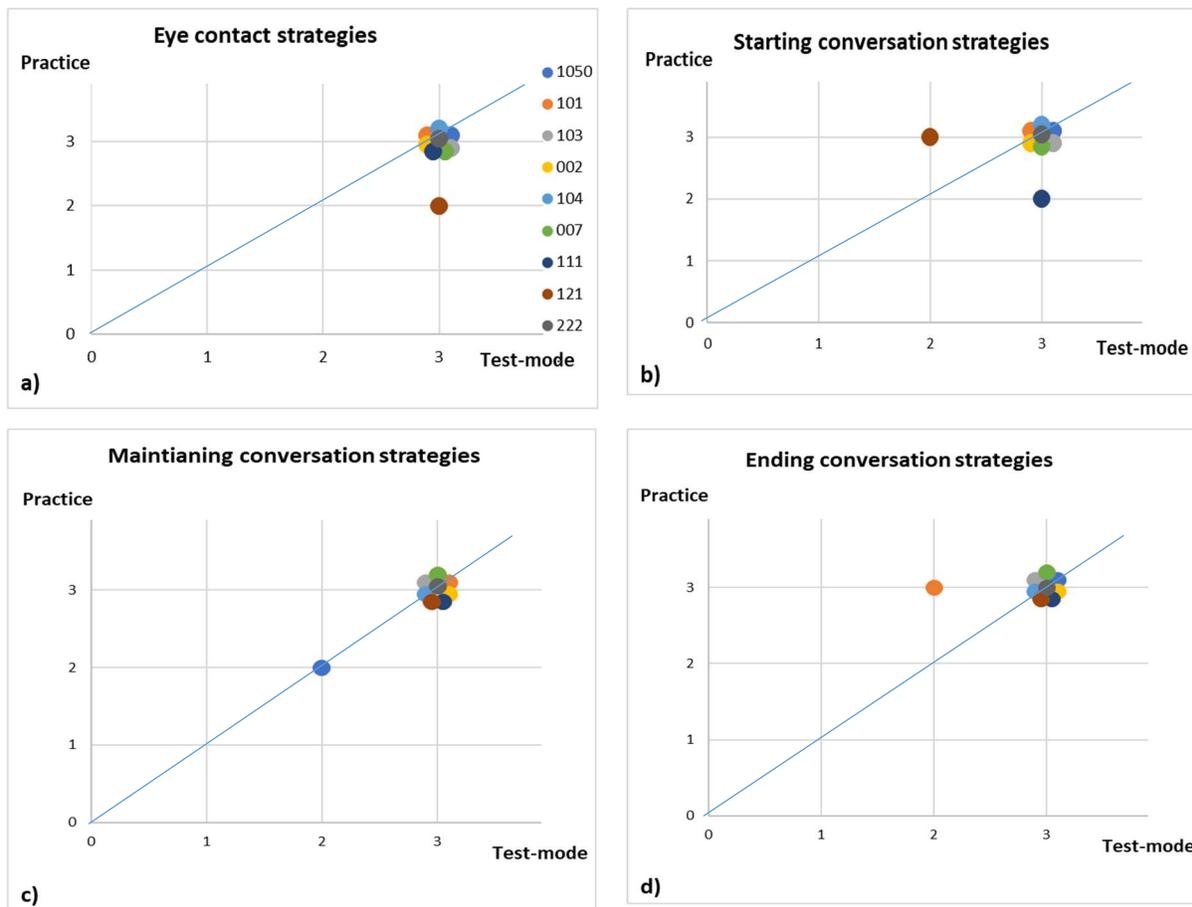
The qualitative data analysis of the game elements and proxies for the skill of eye contact and small talk shows that the participants found most of the elements and proxies to be useful. The few elements or proxies that were rated to be not at all useful by some participants were either the assistive feedback that was activated when the user struggles with the gameplay, e.g., the red halo, thus it was not used during the gameplay as the participants managed to play well; or it was extra elements that did not directly require the participant’s engagement, i.e., confidence bar, thus the participant did not use it yet successfully engaged with the gameplay.

### **7.2.1 In-game data analysis**

The game incorporates features to record objective data from the participants’ practice and test-mode sessions to measure whether they could recall and carry over the learnt behaviours. Participants were asked to identify the number of correct strategies for each addressed social skill, the best-used strategy, and the worst strategy for the given social skill task through a multi-choice on-screen skill evaluation survey. The game software recorded quantitative measures of the participants’ activities; the successful eye contact between the user avatar and the person of interest during the social task, the occasions the participant interrupted the speaker in game, and the occasions the participant fiddled with keyboard or mouse when required to maintain a listening position as described in Section 6.4.7.

Figure 7.35 presents the number of strategies (out of the three correct strategies for each given social skill) that the participant correctly recalled post-training, during practice mode and test mode. Figure 7.36 presents the participants’ responses to identification of the best-used strategy for each social skill in the practice and test-modes; Figure 7.37 presents the participants’ responses to identification of the worst strategy for each social skill in the practice and test-modes; and Figure 7.38 presents the percentage of successful eye contact for each social skill. Figure 7.39 presents the occasions the participant interrupted the speaker while executing the social skill tasks in the

practice and test-modes, and Figure 7.40 presents the ratio of participant fiddling with the keyboard or mouse while required to maintain a listening position in the practice and test-modes. This analysis is valuable as it identifies variation between the patterns of behaviour for each social skill and compares the participant's performance in the practice and test-mode, to identify if learning is carried over from training, and maintained in the test-mode. This is then compared to the participant's reported measures to validate whether the reported behaviour and the measured behaviour are similar.



**Figure 7.35: A comparison of the number of correctly identified strategies for social skills between practice and test mode; (a) Eye contact, (b) Initiating/starting conversation, (c) Maintianing conversation, (d) Ending conversation.**

Figure 7.35 shows that most participants recalled all three strategies correctly in both practice and test modes for all four tasks. The exceptions were that one participant recalled better in practice mode for the social skill of initiating/starting conversation and ending conversation, one participant recalled better in test mode for the social task of eye contact and initiating/starting conversation, and one participant recalled only 2 correct strategies out of the 3 in both practice and test modes. This shows that largely the participants could recall the taught behaviour and carry it over to the test mode.

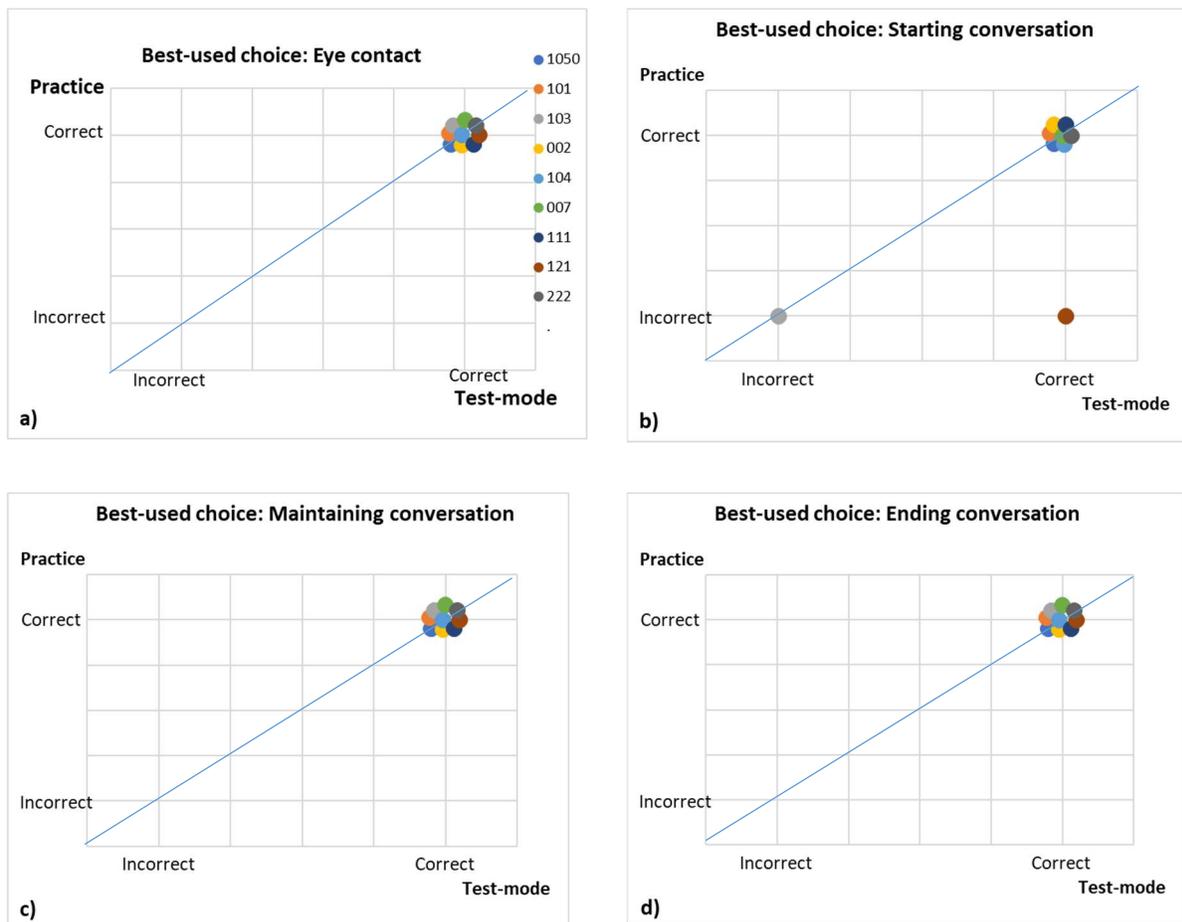
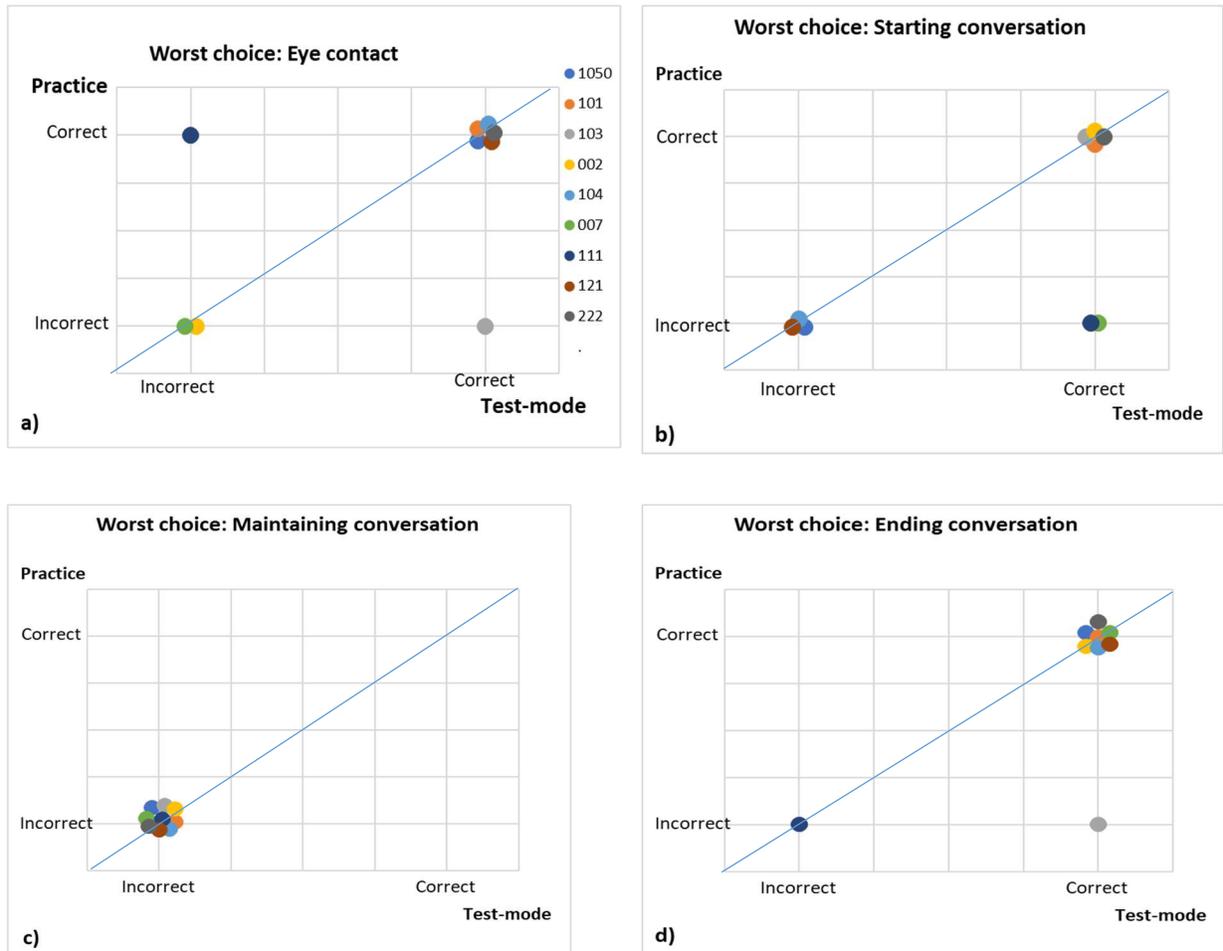


Figure 7.36: Recall of the best-used choice for social skill tasks in practice and test-mode; (a) Eye contact, (b) Initiating/starting conversation, (c) Maintaining conversation, (d) Ending conversation.

Figure 7.36 shows that all the participants identified the correct best-used methods for the social skills of eye contact, maintaining conversation, and ending conversation in both practice and test-modes. Although most participants identified the correct best-used choice for the social skill of

initiating/starting conversation, one participant consistently guessed the wrong option in both practice and test-mode, and one participant got it wrong in the practice but identified the correct one in test-mode. This shows that largely the learning was carried over in the participant group.



**Figure 7.37: Recall of the worst choice for social skill tasks in practice and test-mode; (a) Eye contact, (b) Initiating/starting conversation, (c) Maintaining conversation, (d) Ending conversation.**

Unlike the previous examples, Figure 7.37 shows variance for identifying the worst choice for the different social skills. For the skill of eye contact, five participants identified the correct choice in both practice and test-mode; one identified the wrong choice in practice mode but identified the correct option in test-mode; two participants consistently identified the wrong option in both the

practice and the test-mode; and one participant identified the correct option in practice yet when it came to test-mode, they failed to identify the correct choice.

For the task of initiating/starting conversation four participants recalled the correct worst choice in both practice and test-modes, whereas three participants chose the wrong options in both practice and in test-modes. The last two participants chose the wrong option in practice but then identified the correct option in test-mode.

For the task of maintaining conversation all the participants consistently chose from the wrong options in practice and in test-mode.

For the task of ending conversation, most participants identified the correct option except two. One participant got it wrong in practice but then identified the correct one in test-mode, whereas, one participant failed to identify the correct option in both practice and test-mode. This latter participant has consistently fallen on the incorrect axis, either in practice or in test-mode, or in both for the given social skill tasks.

Figure 7.38 presents the results for maintaining successful eye contact during the given social skill tasks. It shows that for the tasks associated with the social skill of making eye contact, most participants reported better performance in the test-mode after the practice phase, however two participants struggled to maintain the higher percentage of eye contact once the feedback was withdrawn.

For the tasks associated with the social skill of initiating/starting conversation, all participants maintained successful eye contact 80% or more of the time during practice, with five participants maintaining this ratio in test mode, however two participants engaged in successful eye contact for only 25% of the required time when feedback was withdrawn.

For the tasks associated with the skill of maintaining conversation, the participants' successful eye contact values are clustered between 66% and 80% for practice, and for majority this ratio is the same in test mode, except for those two participants who managed to maintain successful eye contact only 50% of the time once feedback was withdrawn.

For the tasks associated with the skill of ending conversation, a similar pattern to the above is shown, except the values are more varied. For practice, the values range is between 50% -80%, and for test-mode it is between 45% - 70%.

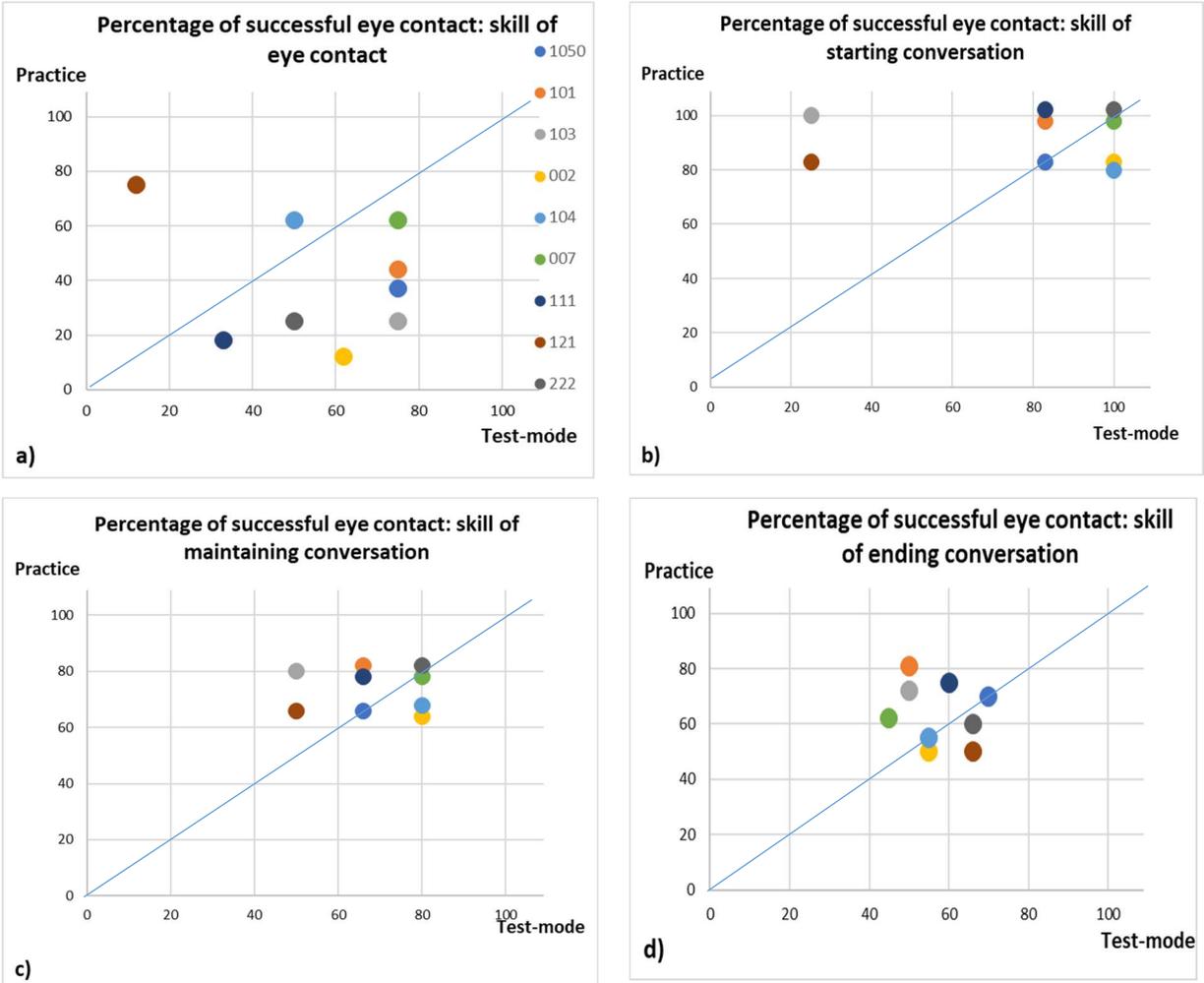
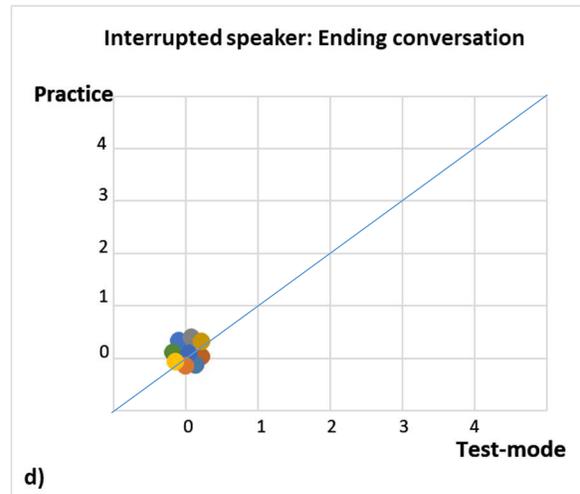
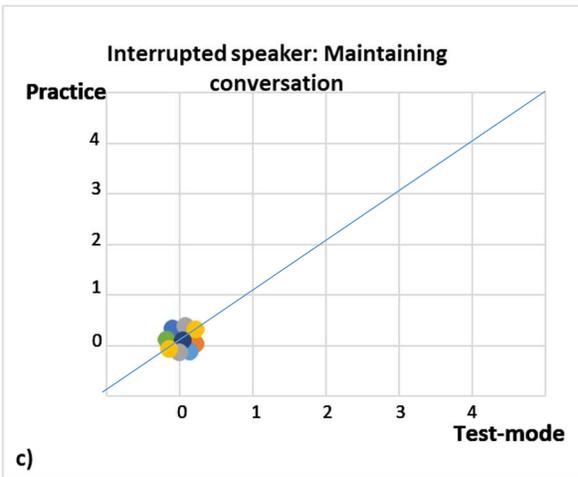
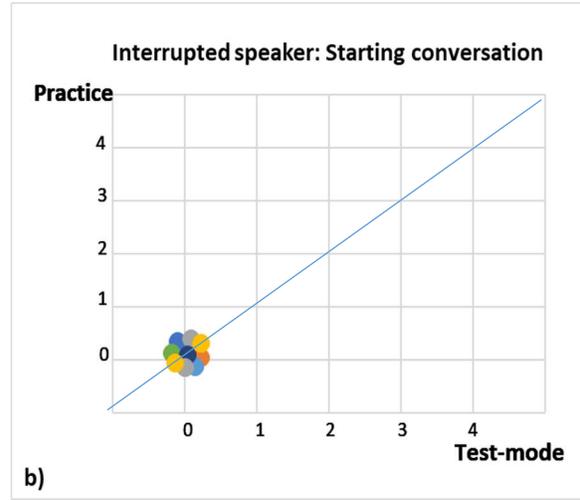
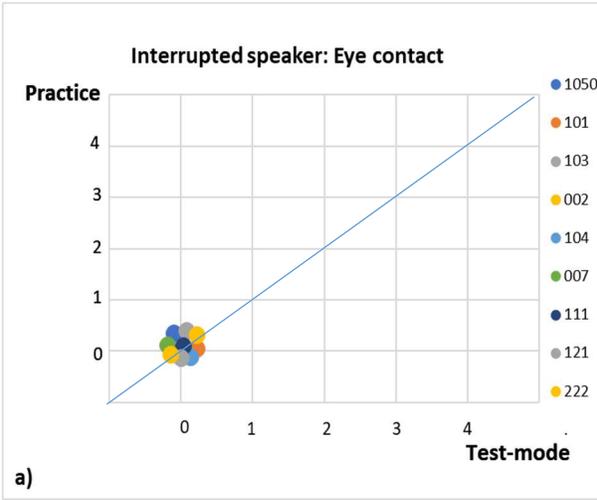
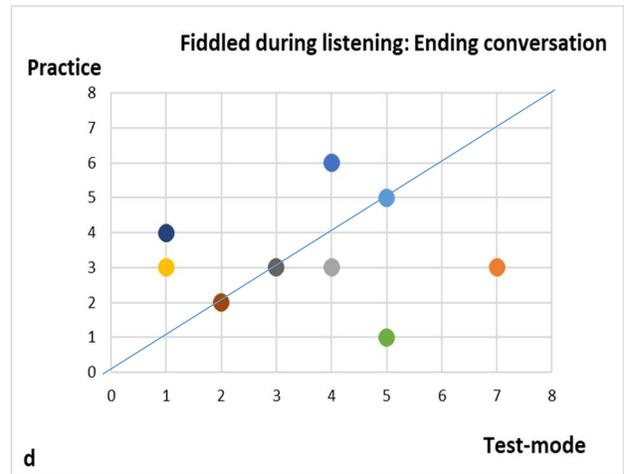
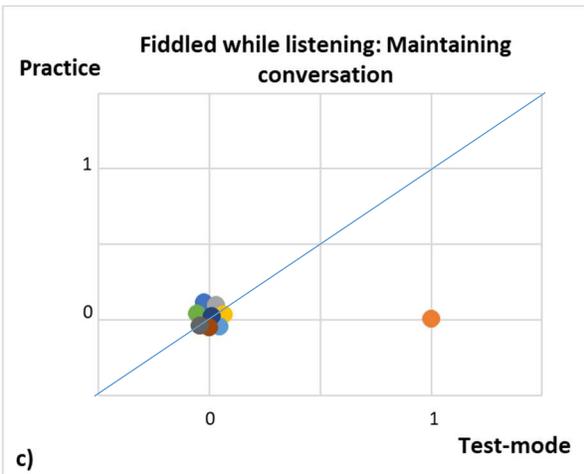
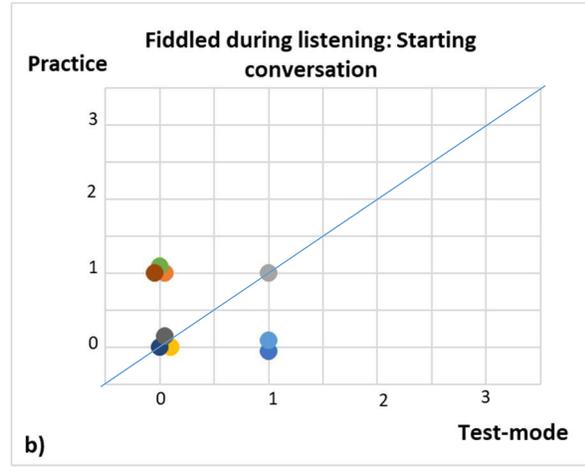
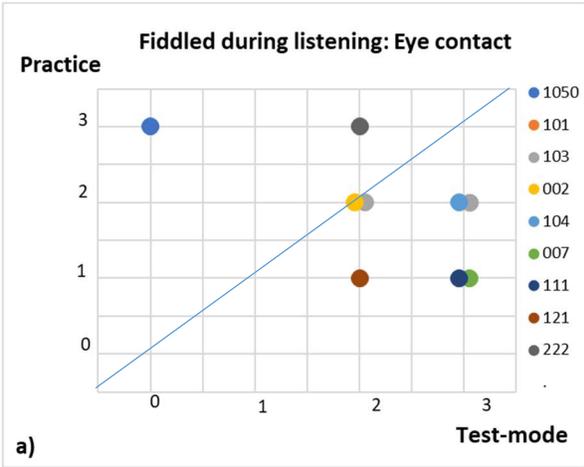


Figure 7.38: A comparison between practice and test mode, of the percentage of time for which eye contact was maintained during skill exercises; (a) Eye contact, (b) Initiating/starting conversation, (c) Maintaining conversation, and (d) Ending conversation.



**Figure 7.39: Number of times the participant interrupted the speaker while listening during practice and test-mode; (a)Eye contact, (b)Initiating/starting conversation, (c) Maintaining conversation, (d) Ending conversation.**



**Figure 7.40: Number of times the participant fiddled with keyboard or mouse while listening during practice and test-mode; (a)Eye contact, (b)Initiating/starting conversation, (c) Maintaining conversation, (d) Ending conversation.**

Figure 7.39 shows that none of the participants interrupted the speaker during conversation tasks in all the social skill practice and test-mode sessions. This shows that post-training, the participants were aware that listening required that they allow the speaker to finish speaking before continuing with the conversation.

Figure 7.40 shows that all participants fiddled with keyboard or mouse at least once and at most three times when completing the social skill tasks associated with eye contact. This number dropped drastically for the next two social tasks, with the fiddling ranging between 0-1. However, for the social skill of ending conversation fiddling, increased with all participant to some extent.

For the task of initiating/starting conversation, three participants did not fiddle at all in both practice and test-mode, three participants fiddled in practice but not in test-mode, two participants fiddled in test-mode but not in practice, and lastly, just one participant fiddled once in both modes.

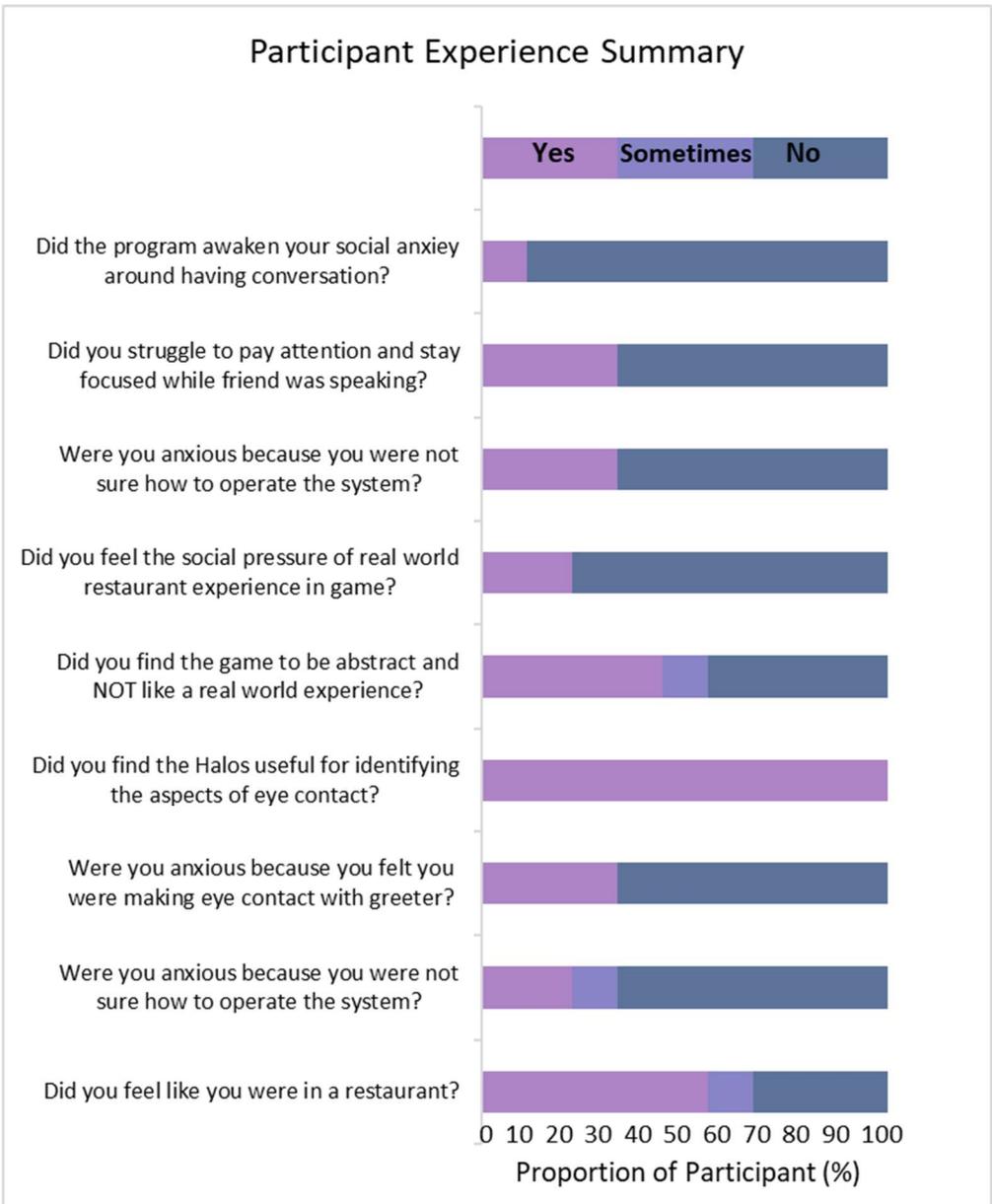
For the task of maintaining conversation, all except one participant did not fiddle in both practice and test-modes, whereas the one participant did not fiddle in practice but did once in test-mode.

The results for the social skill task of ending conversation shows considerably greater variation. All participants fiddled at least once in both practice and test-mode with maximum fiddling of 6 times in practice mode and 7 in test-mode.

It is seen that most participants learned the mechanisms of the game and remembered to do the various tasks in the game, hence they carried the targeted skills over from training to practice and from practice to test-mode. Although individual results varied, some level of learning occurred for all participants. Furthermore, the program successfully recorded the participant's behaviour and reported the variance.

### **7.3 Experience study**

The focus of this research was to find out if the game can be successful in replicating real life social skill training as the game presents advantages to real world training. Several questions were designed and carefully timed during the user study to enable the participant to report on their experience with the virtual training. The participants' responses were further analysed and are presented below.



**Figure 7.41: Participant social experience with the game**

Figure 7.41 summarizes the participant’s response to their social experience of the game. These questions were asked in the last part of the ‘Eye contact Questionnaire’ (Section 6.4.3) and ‘Small Talk Questionnaire’ (Section 6.4.4) however as they are interrelated, they are combined for analysis. The top three questions were asked in the small talk questionnaire and the bottom six questions were asked in the eye contact questionnaire. The questions were divided into 2 sections: functional and social experience.

There were four functional experience questions, relating to the usefulness of the halos, the abstraction of the virtual world experience, and the small talk and eye contact operations. The question about the usefulness of the halos investigated whether they served the purpose of a functional proxy and all the participants agreed that it served its purpose. The question of whether the game was abstract and unlike real life was to discover if the game failed to replicate real life environment. Four participants reported it was abstract and unlike real life, whereas four participants disagreed with the statement and stated it did successfully replicate real life environment and only one participant reported that it sometimes replicated real life and failed to do so at other times. The last two questions enquired about the source of anxiety, whether it was due to game operation for eye contact and small talk scenarios. For eye contact, two participants and for small talk three participants reported the anxiety was due to game operation whereas majority of the participants (7 for eye contact, and 6 for small talk) reported the source of anxiety was not due to game operation.

There were five questions related to the social experience, immersed into restaurant, experiencing social pressure, experiencing social anxiety related to eye contact and small talk and struggling to pay attention to the speaker. The first question queried whether the game successfully replicated the restaurant aura; five out of the nine participants agreed that it did; one participant stated it sometimes did whereas three participants felt it did not feel like they were in a restaurant. The second question examined whether the game activated the social pressure of restaurant experience; only two participants agreed that it did whereas all the other participants did not feel that it did. The next question was to find if the cause of nerves/anxiety was due to the realism of engaging in the social skill of eye contact; two participants agreed that it was, one participant mentioned that sometimes it was however the other six participants disagreed that the anxiety was caused by the realism of the social aspect. The question of whether the program awakened social anxiety around having conversation was to inquire the source of nerves/anxiety; one participant agreed that it did awaken it however all the other participants disagreed. The last question in this category was whether the participant struggled to pay attention while the other person spoke; three out of nine participants agreed that they did struggle whereas all the other participants disagreed hence did not struggle to pay attention. As stated in Section 4.4, it was not actually possible in this context to measure real eye contact between the user of the game and the person of interest. Hence, eye contact was measured through the proxy of the user's avatar. This raises the question of whether

the user's in-game engagement with eye contact was reflective of their real eye contact behaviour. To provide some additional evidence, alongside the survey questions and the in-game eye contact calculations, the participant was observed during the study to see if they were engaged with the gameplay (always looking at the screen) once they managed to get the avatar to make eye contact in the game, or whether they looked away from the screen and appeared distracted. It was observed that all the participants maintained engagement with the game and did not appear distracted.

The above analysis concludes regarding the functional experience that all participants agreed that the halos were helpful in identifying eye contact; almost half the participants found the program to be abstract whereas the other half found the experience to be realistic; a small proportion of the participants associated the anxiety of social experience of eye contact and small talk to operating the system whereas the majority felt otherwise. For the social experience, majority of the participants felt like they were at a restaurant where a small percentage of participants reported feeling the social pressure of real life experience; one third of the participants reported feeling anxious when making eye contact in virtual world, whereas only one participant reported this to be true for having conversation and one third of participants reported struggling to pay attention during the virtual conversation.

As mentioned earlier each questionnaire provided a comments section. Although not all participants added comments, but some did. One participant who felt the restaurant experience was not like real life stated "Obvious it was a computer game, ..." and "Trying to green Halo is hard/distracting"; another participant stated "Conversation felt like everyday conversation but the whole experience was not realistic and felt like a game and not real life". One participant who reported not feeling stressed stated "With no effort required in constructing sentences while maintaining eye contact. There was no stress in making eye contact." and "The gameplay make me feel good because it felt real and simulated success."; another participant who expressed similar views mentioned "The halos made me more incentivized to make eye contact in the game" and "Didn't feel anxious at all, instead felt more confident about talking about the program.". One participant stated "Applicable and transferable experience. Extremely informative - great learning tool."

The above questions retrieved information from the participants during the training and practice stage about their gameplay experience. The focus was whether the proxies met its purpose; the

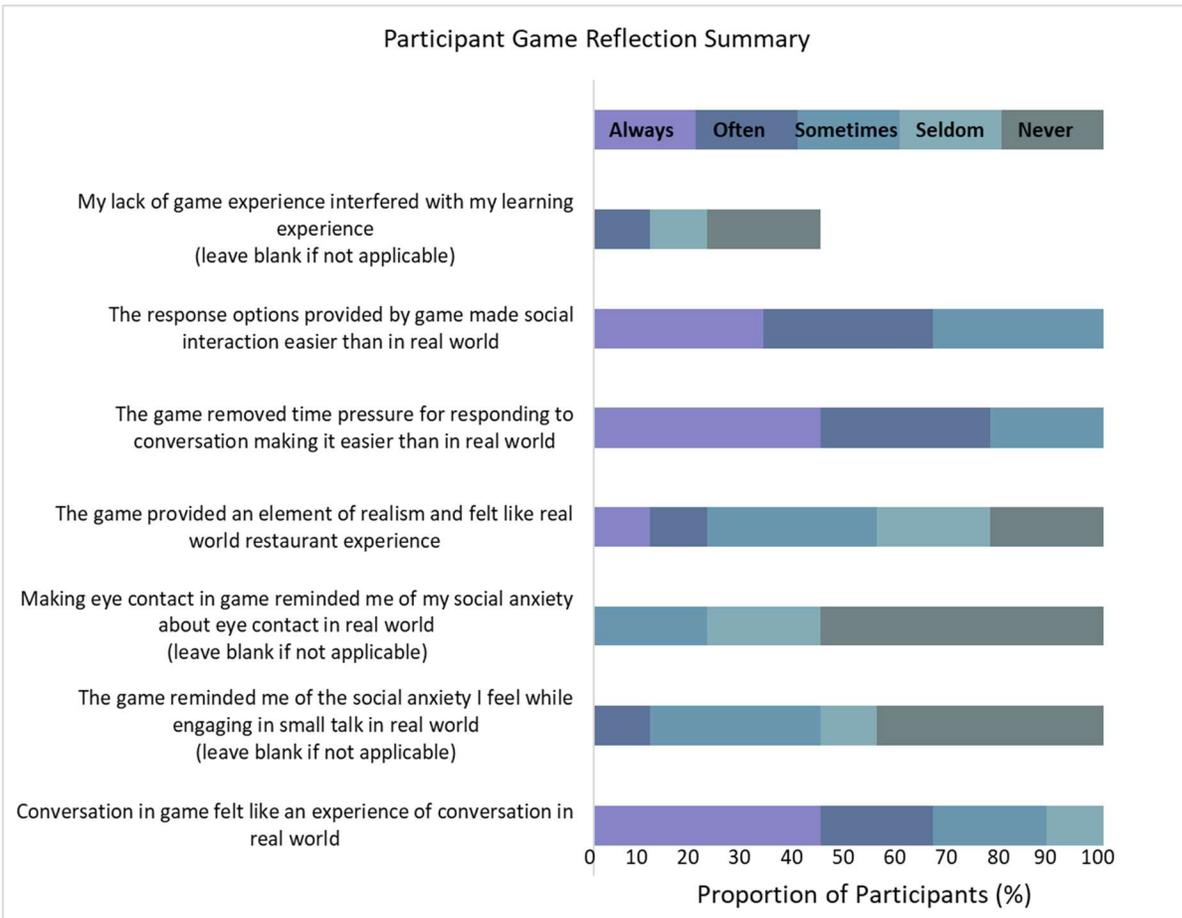
game provided real life like restaurant environment and experience; it awakened social stress towards the social tasks and engaged them in the social experience. The analysis of these questions shows that all participants felt the proxies met their purpose; the majority reported the game provided a life-like restaurant environment and experience; the majority felt engaged in the social experience, and the majority did not feel the social stress towards the social tasks. This was a desirable outcome, showing that the game provided real life-like experiences, while minimizing social stress to the participants.

#### **7.4 Post-study reflection**

This questionnaire was completed at the conclusion of the test mode. The aim was to allow the participant to reflect on their experience with the system after they had completed all the stages of the learning and gameplay. Two types of questions were asked, the ones related to the functional and social aspects of the game, and the questions related to the social anxiety study. The anxiety study is covered in Section 7.5.

This section discusses the functional and social aspects of the game. Figure 7.42 summarizes the participant's reflection of the game experience.

There were three functional experience questions, whether learning was affected by lack of game experience, whether response options assisted interaction and removed time pressure making it easier than real world. About 50% of participants responded to the question about lack of experience interfering with learning, as the option of leave it blank if not applicable was provided and out of these participants 1 felt it often interfered, 1 felt it seldom interfered and 3 felt it never interfered with the learning experience.

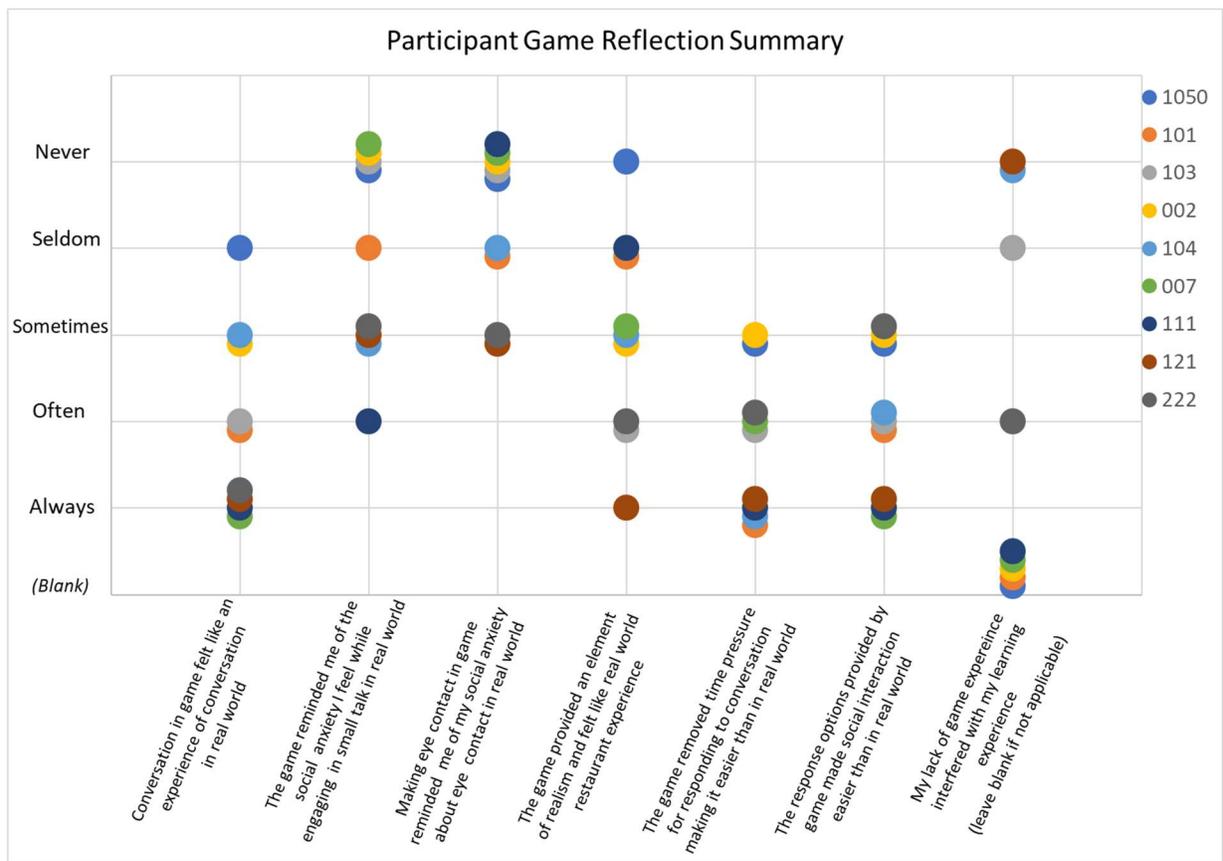


**Figure 7.42: Participant game reflection summary**

Figure 7.42 shows that for the response options provided by game made social interaction easier than in real world, one third stated it always did so, one third stated it often did and one third stated it sometimes did. Four participants stated that the game always removed time pressure for responding to conversation making it easier than in real world whereas three participants stated this was often true and the last two participants stated this was sometimes true.

There were four social experience questions, relating to realism of environment and experience, experience reminded of the social anxiety related to eye contact and small talk, and conversation felt real life like. Seven participants agreed within the range of always and seldom that the game provided an element of realism and felt like real world restaurant experience whereas as only two participants reported that was never true. Five participants stated that the game never reminded them of the social anxiety about eye contact in real world whereas from the other four participants,

2 stated it sometimes did and 2 reported it seldom did. Five participants stated that to some extent (often to seldom) the game reminded them of the social anxiety felt in engaging in real world small talk whereas four participants stated never feeling so. All participants stated the conversation in game felt like an experience of conversation in real world to some extent (ranging from always to seldom) with majority stating this to always be the case.

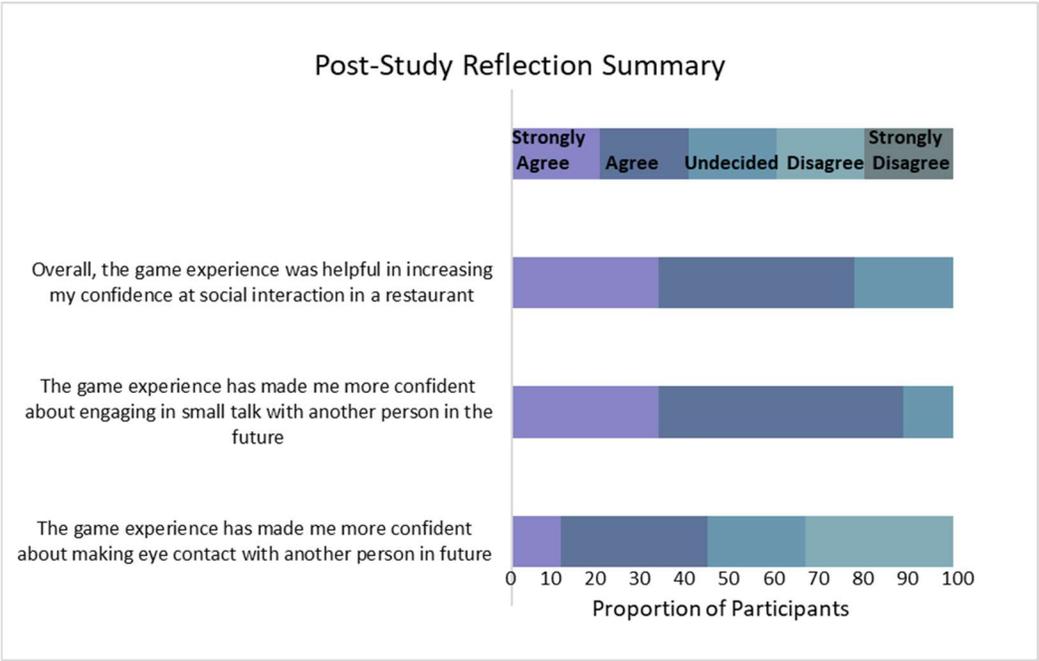


**Figure 7.43: Participant response to game reflection question**

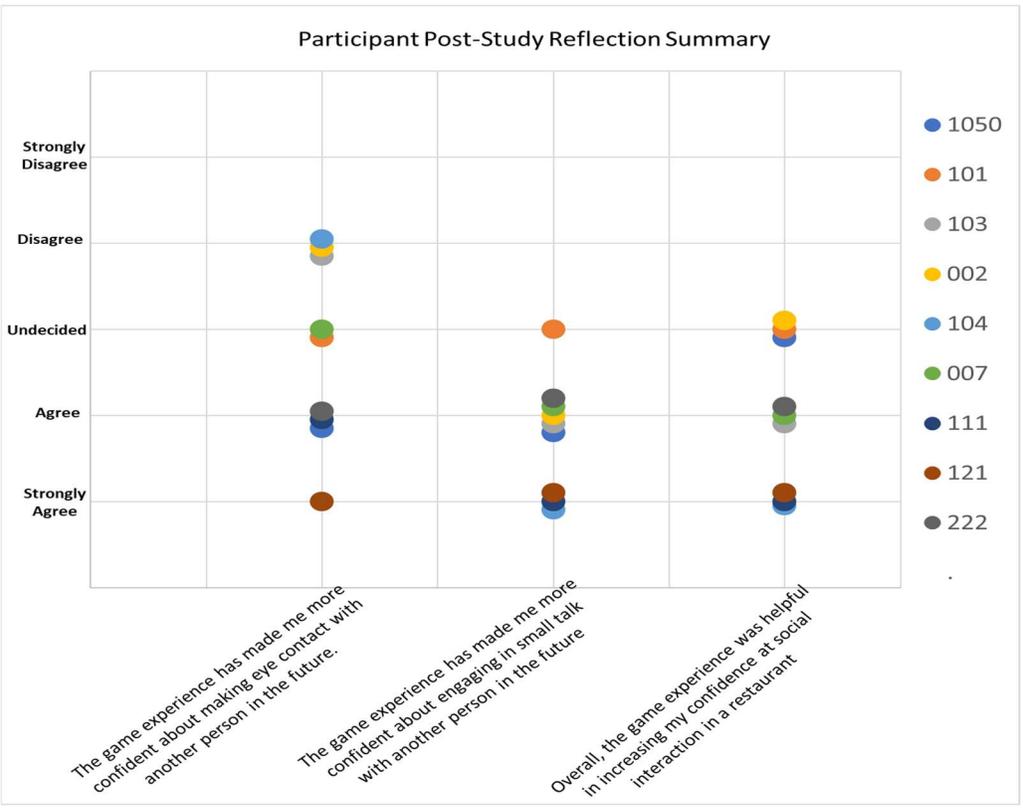
Figure 7.43 show the participants response to individual questions. The participant response to each questions varies and isn't necessarily same for all questions for example: participant 007 reported that conversation in game always felt like real world conversation yet the game never reminded him/her of the social anxiety associated with real world eye contact or small talk; the game sometimes provided an element of realism and felt like real world restaurant experience, it

often made engaging in conversation easier by removing time pressure for responding to conversation and the response options provided by game always made the interaction easier than real world however the participant left blank the question about lack of game experience interfering with learning.

The next questionnaire inquired about the effect of the game experience on participant's confidence towards engagement in the addressed social skills in the future with focus on three aspects: social interaction at the restaurant, engaging in eye contact and engaging in small talk. Figure 7.44 shows that three participants strongly agreed and 4 agreed that the game experience was helpful in increasing their confidence at social interaction in a restaurant, yet the last two participants were undecided about the accuracy of this statement. Three participants strongly agreed and 5 agreed that the game experience made them more confident about engaging in small talk with another person in the future and one participant was undecided. One participant strongly agreed and 3 agreed that the game experience made them more confident about making eye contact with another person in future however 2 were undecided and 3 disagreed that this was true for them. With the varied results it was interesting to see how the individual participants responded to these questions. Figure 7.45 shows that although participant responses varied, some participants reported the game experience affected their confidence towards the social interaction, small talk and eye contact same, whereas for others it varied and they reported confidence towards one or two skill being more affected than the other.



**Figure 7.44: Confidence reflection**



**Figure 7.45: Individual participant Confidence reflection**

### **7.4.1 Post-study reflection summary**

To sum up, the aim of first set of questions was to retrieve information from the participants about whether the game provided real life like experience while removing social stressors, time pressure and provided dynamic feedback. The questions were further categorized under functional and social aspects.

The questions that were categorized under the functional aspect were: whether the lack of game experience negatively affected learning experience; the response options provided for social interaction made it easier than real world interaction and game removed time pressure for responding to conversation thus making virtual experience easier than real world. For the participants in this study, seven participants reported the lack of game experience did not interfere with their learning experience; all participants agreed that to some extent the response options provided by the game made social interaction easier than in real world; all participants agreed that to some extent the game removed time pressure for responding to conversation, thus making it easier than in real world.

The questions that were categorized under the social aspect were: whether the game provided realistic restaurant like environment and experience; whether the game experience awakened the social anxiety that the participant associated with real world eye contact and small talk experience during gameplay; and whether the conversation in the game provided real life like experience of conversation. Most participants stated that the game environment and restaurant experience was realistic to some extent; majority of participants reported never feeling the social anxiety associated with real world eye contact in their game experience; majority reported never feeling the social anxiety associated with real world small talk during the game experience; and majority of participants reported the conversation in game always felt like a real world conversation.

The second set of questions were aimed at finding out whether the game experience increased participants' confidence in engaging in the addressed social skills in the future. Almost all the participants agreed that the game experience has made them more confident in engaging in small talk with another person in the future; whereas majority of participants agreed that the game experience made them more confident at social interaction in a restaurant; for the effect of game

experience on increasing confidence in making eye contact with another person, although majority did not fall in the agree, but they also did not fall in the disagree as some participants were undecided therefore the ratio of strongly/agree to disagree shows that from this group (excluding the undecided) majority agreed that the game experience made them more confident in engaging in eye contact with another person in the future.

## **7.5 Real world and virtual world anxiety study**

One of the research goals of this study was to analyse whether virtual training has the potential to reduce anxiety towards future encounters of the addressed skills. As detailed in Section 6.4.1, the pre-study questionnaire included questions that inquired about the anxiety level of the participant towards each of the social skills that the game addresses. Similarly, the eye contact questionnaire and the small talk/conversation questionnaire (Sections 6.4.3 and 6.4.4) included questions to retrieve information from the participant about the level of anxiety towards the social tasks during gameplay; and test mode questionnaire (Section 6.4.5) included inquiry into the participant's anticipated anxiety level towards each addressed skill in future real world restaurant visits. The participants' expressed pre-study anxiety level about the social skills was compared to their reported social anxiety level during gameplay and to their anticipated social anxiety towards future encounters.

### **Eye contact social skills**

Figures 7.50 to 7.53 show the comparison of participants' pre-study real world anxiety with anxiety during gameplay and with anticipated anxiety towards future encounters of the social skills related to the task of eye contact.

Figure 7.50 shows the shifts in participant anxiety for the task of 'Finding the way to the restaurant staff' from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.50(a) shows that most participants fell on the diagonal indicating that their stated real world anxiety matched their reported anxiety during the gameplay. One participant fell above the diagonal on the graph showing they were more anxious during gameplay in comparison with their pre-study real world experience of the skill. Two participants were below the diagonal of the graph showing they were less anxious during gameplay compared to their pre-study real world experience. Figure 7.50 (b)

shows that most participants fell on the diagonal, thus reported no change in their anticipated social anxiety following the game experience, and two participants were below the diagonal, reporting lower anticipated anxiety levels post-study.

In summary, most participants reported experiencing the same level of anxiety during gameplay thus supporting the research argument that the serious game provides a realistic experience. Where there was change, it was generally an improvement (reduced anxiety) and in just one case, slightly higher anxiety. The reported future anxiety was the same as in the pre-study for most participants and was reduced for two indicating improved anxiety levels towards this task.

Shifts in anxiety levels: Finding the way to the restaurant staff

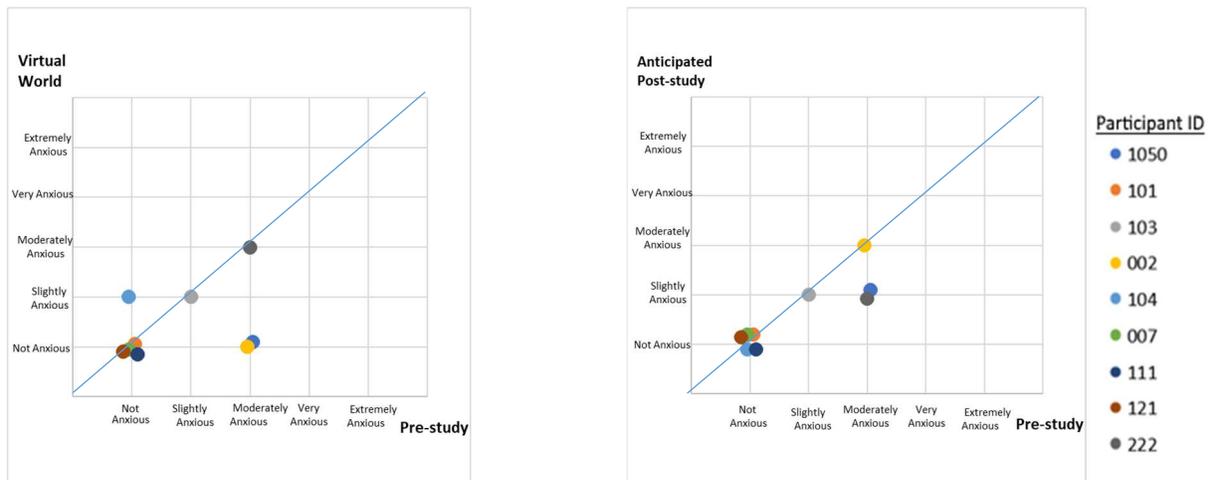


Figure 7.50: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study

Shifts in anxiety levels: Getting in the line of vision of the restaurant staff

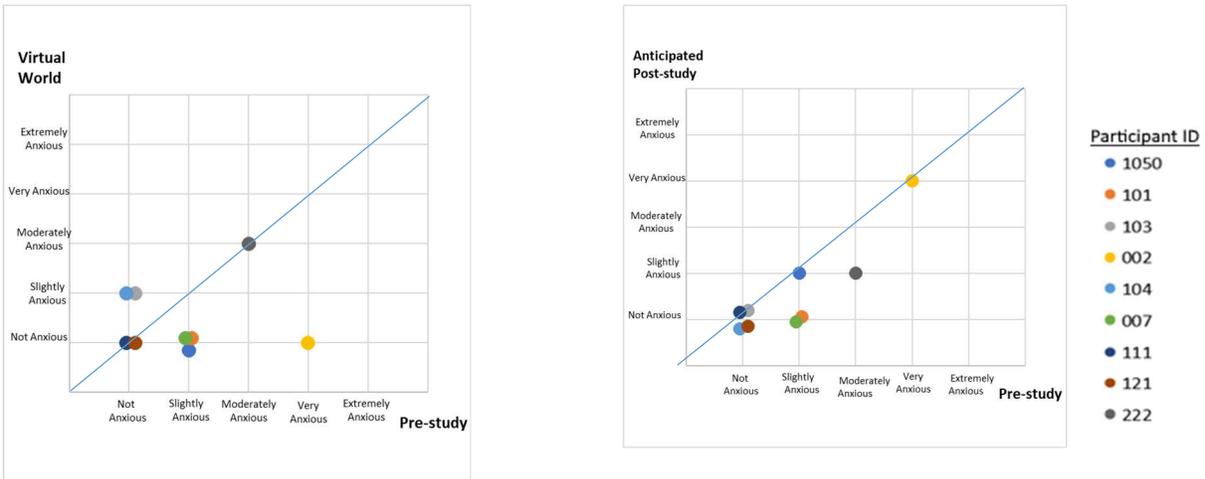
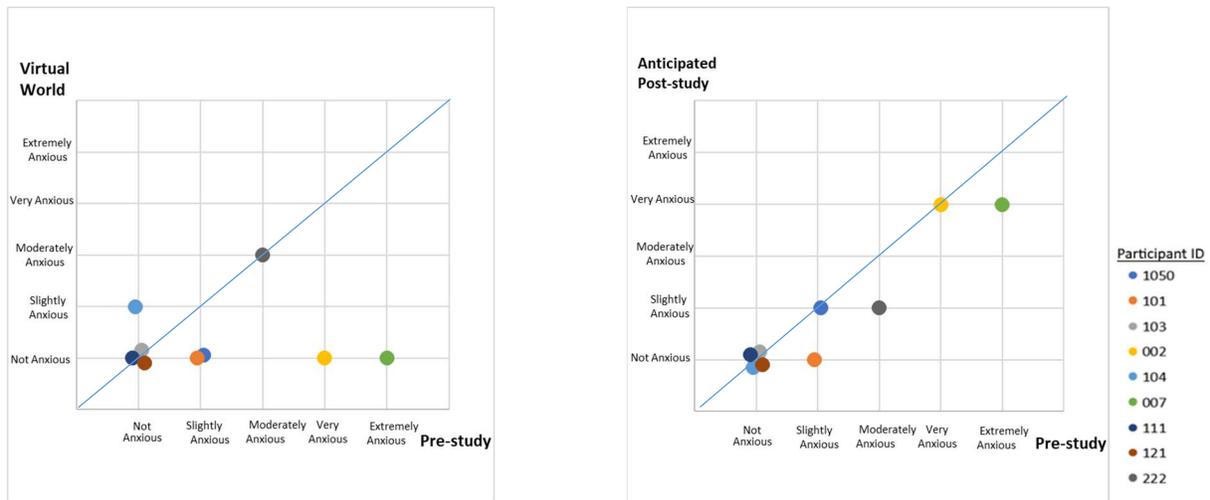


Figure 7.51: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study

Figure 7.51 shows the shifts in participant anxiety for the task of ‘Getting in the line of vision of the restaurant staff’, from pre-study real world anxiety to (a) anxiety during gameplay, and (b) anticipated anxiety for real world encounters of the skill following the study.

Figure 7.51 (a) shows that the largest group of participants were below the diagonal indicating they were less anxious during gameplay in comparison to their pre-study real world experience. three participants fell on the line showing that their stated real world anxiety matched their anxiety during the gameplay, and two participants were above the diagonal indicating they were more anxious in the virtual world (during gameplay) as opposed to their pre-study real world experience of the skill. Figure 7.51 (b) shows that most participants reported the same stated real world social anxiety and anticipated social anxiety post game experience. Those participants who showed a change all reported lower anticipated anxiety levels post-study. Overall, the participants reported varied anxiety levels. Those that indicated being more anxious in the pre-study showed either equal or lower anxiety. The participants that reported higher anxiety in gameplay had reported no anxiety in the pre-study.

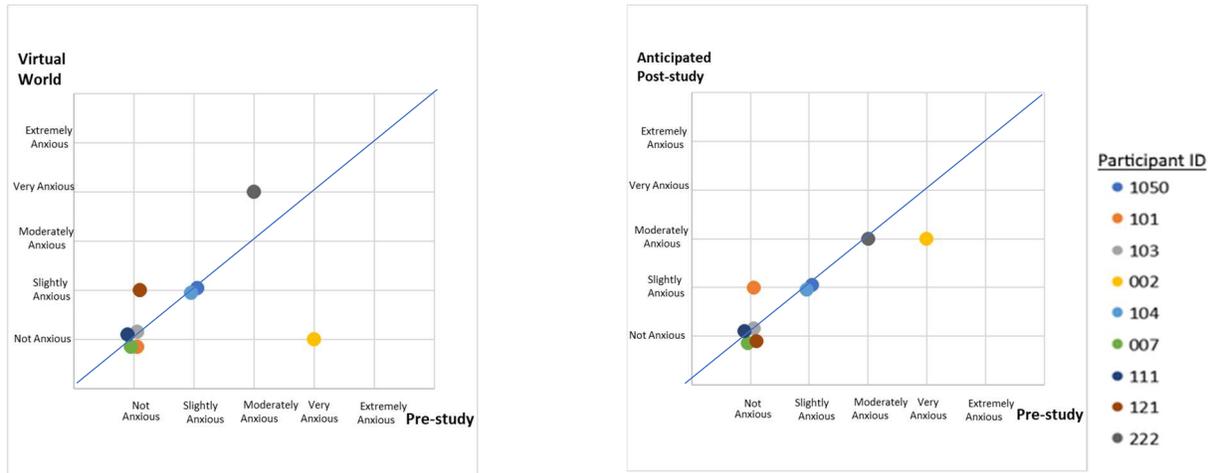
Shifts in anxiety levels: Making eye contact with the restaurant staff



**Figure 7.52: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study**

Figure 7.52 shows the shifts in participant anxiety for the task of ‘Making eye contact with the restaurant staff’ from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.52(a) shows similar pattern of response by participants as for the above task except for one participant who had reported increased anxiety for the task in Figure 7.51(a) yet has reported maintaining their pre-study anxiety levels during gameplay for this task. Similarly, Figure 7.52(b) shows that all participants reported similar response pattern as in Figure 7.51(b). In summary, it is seen that although the participants did not exhibit identical anxiety level towards the tasks of ‘Getting in line of vision of the restaurant staff’ and ‘Making eye contact with the restaurant staff’, they did however maintain their location with respect to the diagonal hence those who fell on the line for one task, roughly fell on the line for the other task too.

Shifts in anxiety levels: Knowing the appropriate distance to stand from another person.



**Figure 7.53: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study**

Figure 7.53 shows the shifts in participant anxiety for the task of ‘Knowing the appropriate distance to stand from another person’ from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.53(a) shows that majority of participants fell on the line therefore indicating that their stated real world anxiety matched their anxiety during the gameplay, one participant was below the diagonal reporting less anxiety during gameplay and two participants fell above the diagonal indicating higher anxiety during gameplay compared to their pre-study real world experience of the skill. Figure 7.53(b) shows that most participants fell on the line showing that their stated real world anxiety matched their anticipated social anxiety post game experience, one participant fell below the diagonal reporting lower anticipated anxiety levels post-study and one fell above the diagonal reporting increased anticipated anxiety. In summary, the participants reported varied results for both comparisons however most participants reported maintaining their anxiety levels for both the virtual world and for anticipated real world.

The above comparisons are further analysed to find the participants' patterns of behaviour for the task of eye contact. The comparison of participants' pre-study real world anxiety with their anxiety during game shows that most participants fell on the diagonal indicating that their stated pre-study anxiety levels were the same as their anxiety level during gameplay thus the gameplay provided reasonable realism of the social experience. Few (average of 2.7, thus 3) participants were below the diagonal across the tasks, indicating lowered anxiety towards the given tasks during gameplay. This supports the research argument that the game provides socially less stressful environment without compromising the realism. On average one participant fell above the diagonal suggesting increased level of anxiety during gameplay. Analysis of the Figures 7.50(a) – 7.53(a) shows that the participants that were below the diagonal were participant ID: 1050, 101, 002 and 007. The demographic analysis showed the participants were both male and female from different age group however, the common factor of these participants was that they all played virtual games regularly/daily. The participants that appeared above the diagonal for one or more tasks were participant ID: 103, 121, 222 and 104. While the first three participants fell above the diagonal for one task, participant 104 is seen to appear above the diagonal for three out of four tasks. This group also had gender and age variation but interestingly, they had varied virtual gaming experience as well. While 121 and 222 did not have any virtual gaming experience, 103 and 104 reported having exposure to virtual gaming previously. The differentiating factor between these two participants was that in the demographic survey, participant 103 stated not being anxious in a restaurant whereas participant 104 stated being currently anxious in a restaurant.

The comparison of participants' pre-study real world anxiety with their anticipated real world anxiety after the study shows that most participants fell on the diagonal indicating that their stated pre-study anxiety levels were the same as their anticipated anxiety for future encounters whereas all the other participants were below the diagonal with an average of two participants per task thus reporting reduced anxiety for future encounters. The only data above the diagonal was by participant 101 in Figure 7.53(b) indicating a slight increase in anxiety level. This is ideal outcome as it indicates that serious game was effective in reducing anxiety for at least two participants for the social tasks related eye contact.

Figure 7.54 to Figure 7.58 shows the comparison of participants' pre-study real world anxiety with anxiety during gameplay and with anticipated anxiety towards future encounter of the social skills related to the task of eye contact.

Figure 7.54 shows shifts in participant anxiety for the task of 'Initiating/starting conversation with someone' from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters. Figure 7.54(a) shows that most participants were below the diagonal line were below the diagonal of the graph showing they were less anxious during gameplay compared to their pre-study real world experience whereas one participant fell on diagonal indicating that the stated real world anxiety matched the reported anxiety during the gameplay. Figure 7.54(b) shows a similar pattern, where two participants fell on diagonal reporting same level of anxiety in pre-study and for anticipated encounters and all other participants reported lower anticipated anxiety post-study than their pre-study real world experience. In summary, most participants reported reduced anxiety levels for the virtual world (gameplay) and reduced anticipated anxiety for future encounters whereas a couple of participants reported same anxiety level before, during and after the study. The favourable shift in the anxiety levels for most participants translates into a good social experience.

### **Small Talk social tasks**

Figure 7.55 shows the shifts in participant anxiety levels for the task of 'Maintaining a listening position when someone is speaking to you' from pre-study real world anxiety to (a) against their anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.55(a) shows that almost half the participants fell on the diagonal indicating same levels of anxiety whereas the other half were below the line indicating lower anxiety levels during gameplay and only one participant fell above the line indicating higher anxiety levels during gameplay compared to their pre-study real world experience. Figure 7.55(b) shows that two third of the participants fell on the diagonal reporting anticipating same anxiety levels for future encounters of the skill as stated in the pre-study real world whereas one third of the participants were below the diagonal stating lower anticipated anxiety levels for future encounters post the study. In summary, most participants reported exhibiting same anxiety levels for this task before, during and after the study. At least one third of participants reported lower

anxiety levels than their stated pre-study anxiety during gameplay and anticipated for future encounters and one participant reported exhibited higher anxiety during gameplay.

Shifts in anxiety levels: Starting a conversation with someone

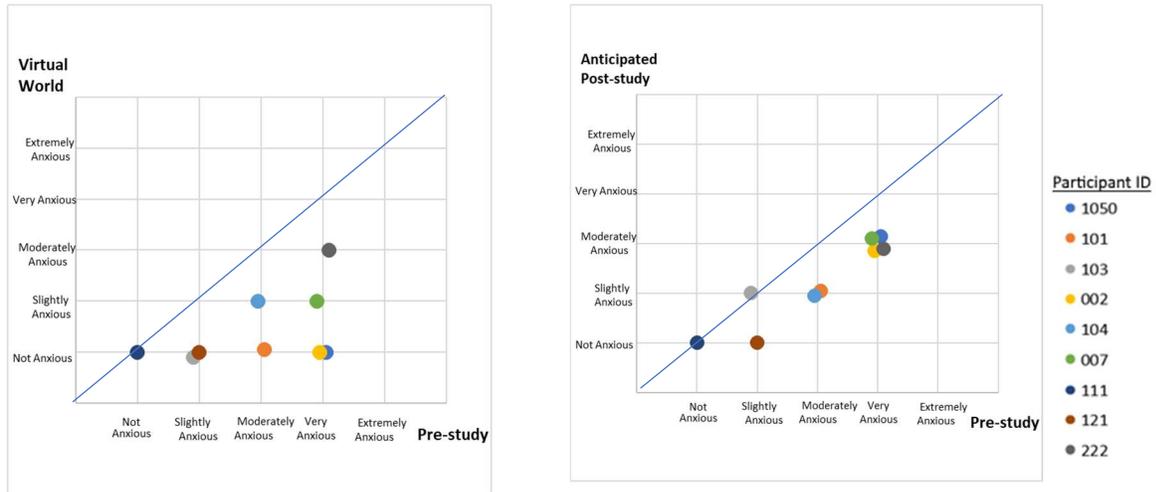


Figure 7.54: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study

Shifts in anxiety levels: Maintaining a listening position when someone is speaking to you

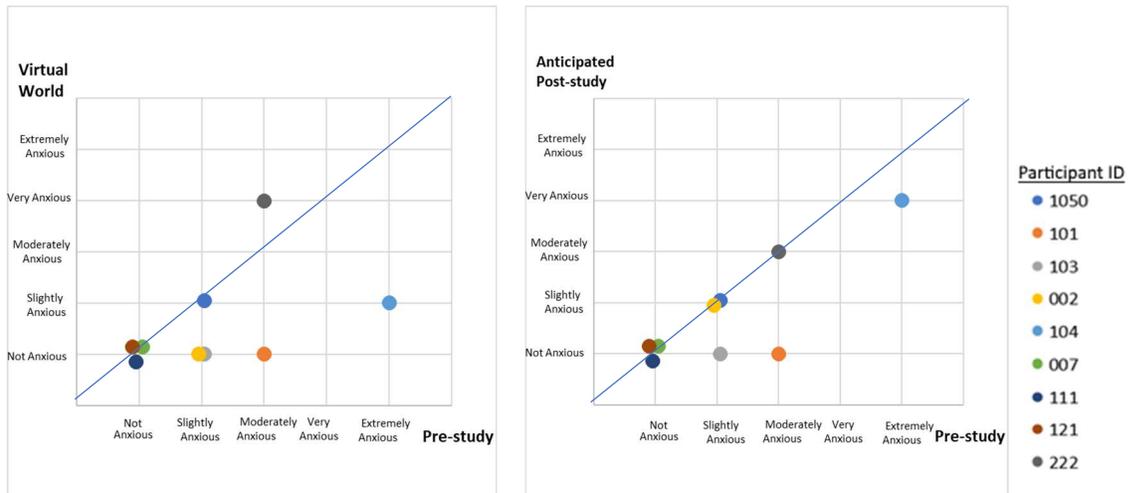
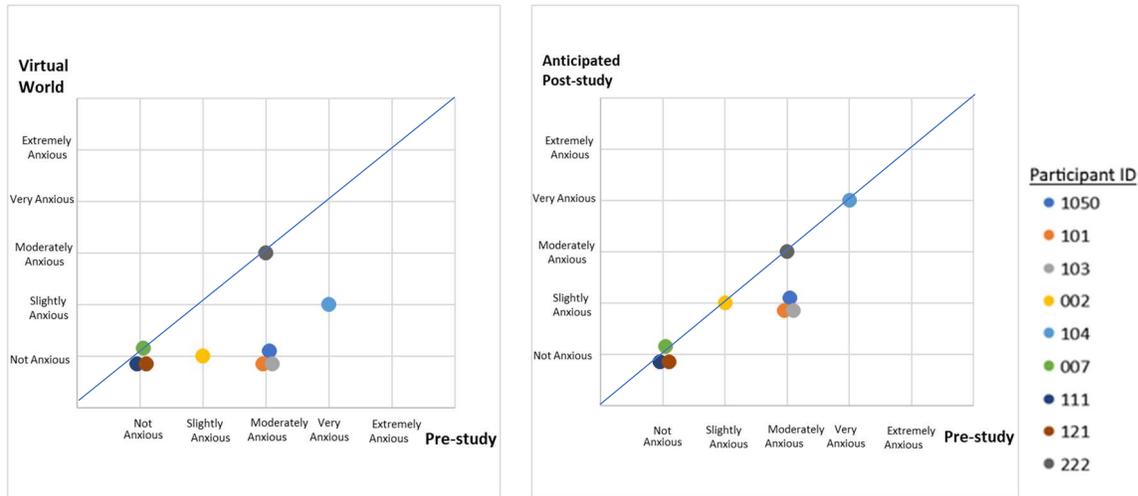


Figure 7.55: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study

Shifts in anxiety levels: Showing interest while another person is speaking



**Figure 7.56: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study**

Figure 7.56 shows the shifts in participant anxiety for the task of ‘Showing interest while another person is speaking’ from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.56(a) shows that most participants were below the diagonal line showing they were less anxious during gameplay compared to their pre-study real world experience whereas the rest of the participants fell on diagonal indicating that the stated real world anxiety matched the reported anxiety during the gameplay. Figure 7.56(b) shows that two third of the participants fell on the diagonal reporting anticipating same anxiety levels for future encounters of the skill as stated in the pre-study real world whereas one third of the participants were below the diagonal stating lower anticipated anxiety levels for future encounters post the study. In summary, participants reported exhibiting lower or same anxiety levels as their stated pre-study anxiety level for this task during gameplay. Similarly, participants reported exhibiting same or lower anxiety towards future encounters of the social skill. This shows that the serious game received favourable response from the participants regarding this task as a good balance of realism of social task and reduction in social anxiety was achieved.

Shifts in anxiety levels: Turn taking during conversation

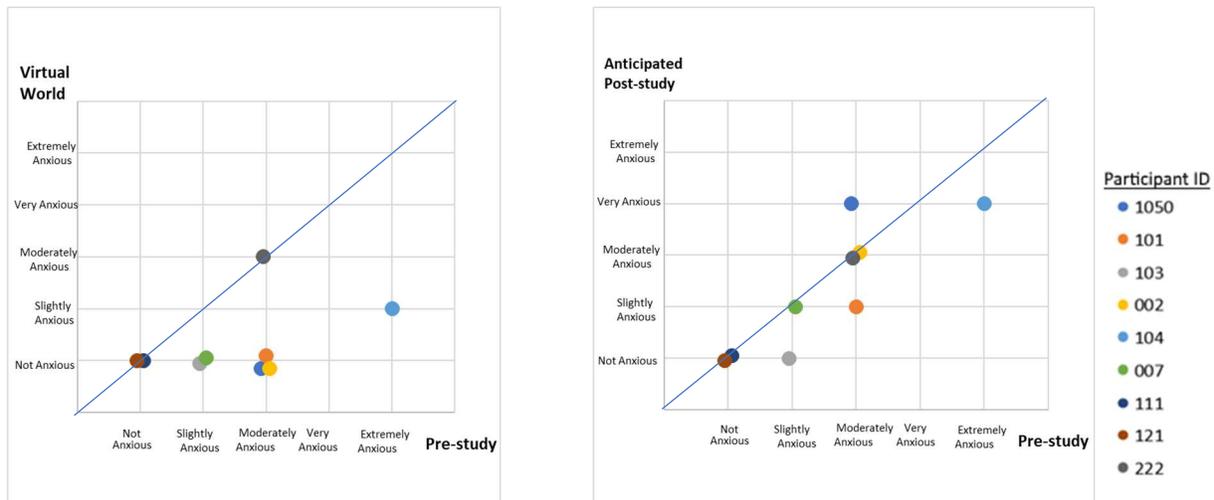


Figure 7.57: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study

Figure 7.57 shows the shifts in participant anxiety for the task of ‘Turn taking during conversation’ from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.57(a) shows that most participants were below the diagonal line demonstrating they were less anxious during gameplay compared to their pre-study real world experience whereas one third of the participants fell on diagonal indicating that the stated real world anxiety matched their reported anxiety during the gameplay. Figure 7.57(b) shows that most participants fell on the diagonal reporting anticipating same anxiety levels for future encounters whereas one third of the participants were below the diagonal stating lower anticipated anxiety levels and one participant fell above the diagonal indicating increased anticipated anxiety level of the skill compared to the stated pre-study real world anxiety. In summary, participants reported exhibiting lower or same anxiety levels as their stated pre-study anxiety level for this task during gameplay. Similarly, most participants reported exhibiting same or lower anxiety towards future encounters of the social skill except one.

Shifts in anxiety levels: Ending conversation with someone

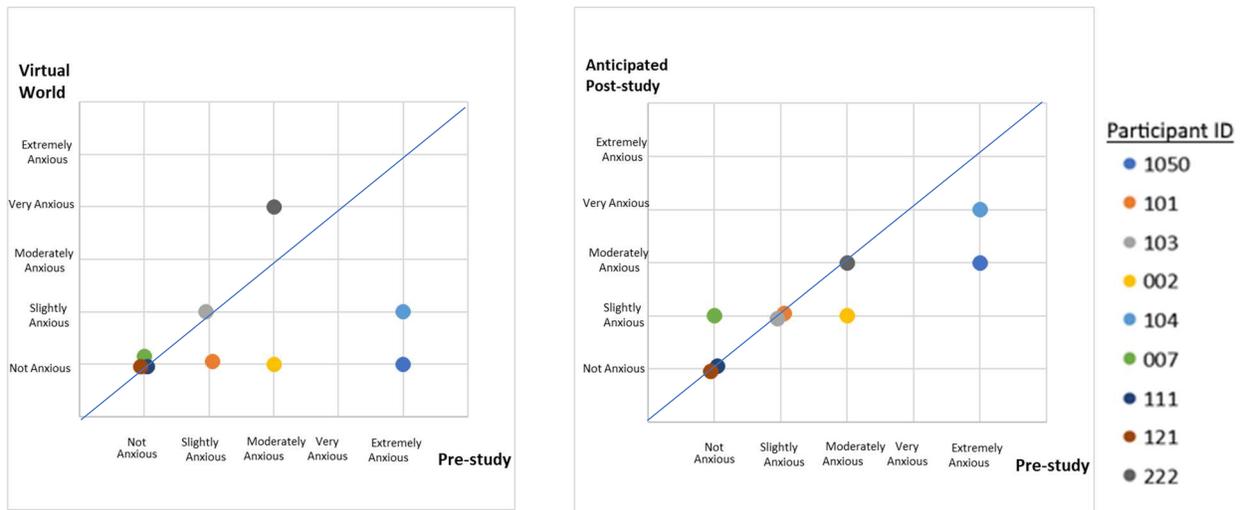


Figure 7.58: Participant pre-study anxiety levels comparison against (a) anxiety during the gameplay, and (b) anticipated anxiety following the study

Figure 7.58 shows the shifts in participant anxiety for the task of ‘Ending conversation with someone’ from pre-study real world anxiety to (a) anxiety during gameplay and (b) anticipated anxiety for real world encounters of the skill following the study. Figure 7.58(a) shows similar pattern to Figure 7.55(a), and Figure 7.58(b) shows similar pattern to Figure 7.57(b).

The above comparisons are further analysed to find the participants’ patterns of behaviour for the tasks associated with the skill of engaging in small talk. The comparison of participants’ pre-study real world anxiety with their anxiety during game shows that most participants were below the diagonal across the tasks, indicating lowered anxiety towards the tasks during gameplay compared to their stated pre-study anxiety levels and the rest mostly fell on the diagonal stating same anxiety level during gameplay. On average, five participants were below the diagonal and four participants fell on the diagonal per task in this category. This supports the research argument that the game provides socially less stressful environment without compromising the realism. Analysis of the Figures 7.53(a) – 7.58(a) shows that participant ID 222 fell above the diagonal for 2 tasks. The demographic analysis showed this participant did not have exposure to virtual gaming prior to this study.

The comparison of participants' pre-study real world anxiety with their anticipated real world anxiety after the study shows that on average, four participants fell on the diagonal indicating that their stated pre-study anxiety levels were the same as their anticipated anxiety for future encounters across the small talk tasks. Most participants (on average 4) were below the diagonal thus reporting reduced anxiety for future encounters across the small talk tasks. The only exception above the diagonal was 1050 in Figure 7.57(b) and participant 007 in Figure 7.58(b) indicating a slight increase in anxiety level. This is excellent outcome as it indicates that serious game was effective in reducing anxiety for at least four participants for the social tasks related to small talk.

### **7.5.1 Anxiety study summary**

This study compared the participants stated pre-study anxiety levels towards each task associated in the eye contact group or small talk group, with their reported anxiety levels in virtual world (during gameplay) and their anticipated anxiety towards future real world encounter of the social skill. The above analysis shows that for the given tasks the participants fell under one of three categories: those on the diagonal line, those below the diagonal line and those above the diagonal. The participants that fell on the diagonal line reported exhibiting same anxiety level in their pre-study questionnaire and during gameplay indicating that the gameplay provided reasonable realism. Those who were below the diagonal reported exhibiting lower anxiety levels during gameplay indicating the game successfully reduced anxiety towards the social skill during gameplay by removing social stressors. Those who fell above the diagonal reported exhibiting higher anxiety levels during gameplay indicating that the participant found the virtual task more challenging than their pre-study experience. Similarly, the participants who fell on the diagonal line for the pre-study and anticipated post-study graphs reported anticipating same level of anxiety for the given social task in future encounters as in their pre-study questionnaire. Those who were below the diagonal reported exhibiting lower levels of anxiety towards future encounters of the task compared to their pre-study anxiety levels and those that fell above the diagonal reported anticipating higher anxiety levels for the future encounter of the social task compared to their reported pre-study anxiety.

The analysis of Figures 7.50(a) to 7.53(a) shows that for the tasks of eye contact pre-study real world anxiety compared to virtual world (during gameplay) an average of five participants fell on the diagonal indicating feeling same level of anxiety during gameplay as their stated pre-study real

world anxiety suggesting that the gameplay provided reasonable realism in this context. On average three participants were below the diagonal thus reporting lower anxiety levels during gameplay compared to their stated pre-study real world anxiety. This provides some support for the argument that the virtual world potentially reduces social stressors, providing an environment that was no more stressful than the real world for a third of the participants who took part in the study. However, one participant even fell above the diagonal indicating higher anxiety than the stated pre-study real world anxiety although the difference was from not anxious to slightly anxious.

Demographic analysis revealed that the participants who were regular/daily gamers reported lower anxiety during gameplay, whereas the participant who reported higher anxiety had somewhat exposure to virtual gaming however was anxious in restaurant environment. The analysis of Figures 7.50(b) to 7.53(b) shows that for all the tasks of eye contact pre-study real world anxiety compared to anticipated anxiety towards future encounters of the social task, most participants with an average of six participants per task fell on the diagonal indicating same level for both. On average, three participants were below the diagonal across eye contact tasks indicating reduced anticipated anxiety towards the social task. These results demonstrate that for participants in this study, the virtual world (gameplay) provided a realistic experience, and in some cases reduced the social anxiety associated with real life eye contact.

The analysis of Figures 7.54(a) to 7.58(a) shows that for the tasks of small talk pre-study real world anxiety compared to virtual world (during gameplay), an average of three participants fell on the diagonal per task indicating feeling same level of anxiety during gameplay as their stated pre-study real world anxiety; suggesting that the gameplay provided reasonable realism to these few individuals. On average five participants were below the diagonal per task indicating lower anxiety levels during gameplay compared to their stated pre-study real world anxiety and supporting the argument that the serious game potentially reduced social stressors therefore provided less stressful environment than real world for this small group.

The analysis of Figures 7.54(b) to 7.58(b) shows that for all the tasks of small talk pre-study real world anxiety compared to anticipated anxiety towards future encounters of the social task, majority of participants with an average of five participants per task fell on the diagonal indicating same anxiety level for both. On average, four participants were below the diagonal across small

talk tasks thus reporting lower anticipated anxiety towards future encounters of the skill compared to their stated pre-study real world anxiety. This suggests that for a small number of participants, the serious game was effective in reducing anxiety and therefore positively impacted their experience of tasks associated with engaging in small talk.

Overall, the results obtained for the anxiety study for the tasks of eye contact and small talk, shows that majority of participants either fell on the diagonal or were below the diagonal. This indicates that the gameplay provided somewhat realistic social experience. In a few cases, it reduced social anxiety associated with real world experiences as the participants reported anticipating same or less anxiety for future encounters of the social skill. At least one or more participants reported lowered anxiety levels thus the serious game has positively impacted the social experience of these participants.

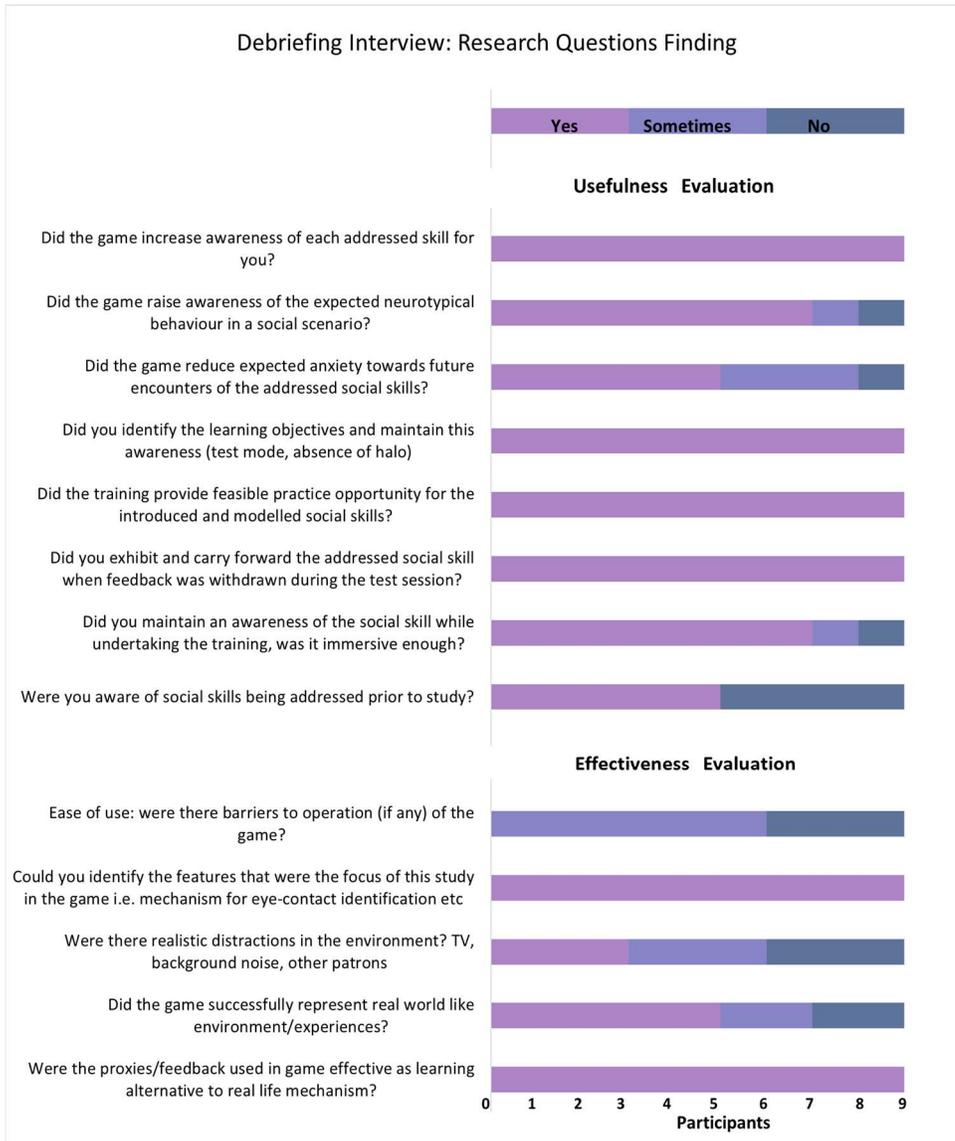
## **7.6 Post-study debriefing interview**

The purpose of the user study was to investigate the effectiveness of the game components and usefulness of virtual social skill training thus the experiments and questionnaires provided the researcher with information to explore the participants' experience with the game and their learning from the virtual training as presented in Section 6.1. At the conclusion of the user study, the researcher asked the participants direct questions and recorded their responses.

To determine the effectiveness of the computer program/game the participants were asked if the proxies/feedback were effective as learning mechanism; if it successfully represented real world like environment/experiences; if there were realistic distractions; if they could identify the features that was the focus of the study and if there were barriers to operating the program. Figure 7.61 shows the findings for these questions under the 'Effectiveness Evaluation'. All participants responded that they found the proxies/feedback used in the game effective as learning alternative to real life mechanism. Five out of the nine participants agreed that the game successfully represented real world like environment/experiences; two participants agreed that it sometimes did represent real world like environment/experiences and two participants disagreed with this statement. One third of the participants stated that the computer environment provided realistic distractions; one third stated it did so sometimes whereas one third said it did not provide realistic distractions. The evaluation revealed that all participants reported that they could identify features

in the game that were the focus of this study such as the eye contact mechanism. Evaluation of ease of use revealed that two third of the participants stated there were no barriers to operating the game whereas one third of participants stated that sometimes there were barriers to operation of the game.

To determine the usefulness of the computer program/game the participants were asked if they were aware of the social skills addressed prior to the study; if the participants felt immersed in the social experience by maintaining awareness of the social skill during gameplay; if they exhibited and carried forward the social skills when feedback was withdrawn; if the game provided feasible training and practice opportunity for the addressed social skill; if they identified the learning objective and maintained this awareness; if the game reduced expected anxiety towards future encounters of the addressed social skills and if the game increased awareness of each addressed skill. Figure 7.61 shows that five participants stated that they were aware of the social skill that were addressed prior to the study while four stated they were somewhat aware of these skills. Seven out of nine participants stated that they maintained an awareness of the addressed social skill during gameplay thus found it immersive, one stated sometimes maintaining this awareness whereas one participant mentioned not maintaining this awareness during gameplay. All participants stated that they exhibited and carried forward the social skills when feedback was withdrawn during the test mode. All participants agreed that the game provided feasible practice opportunity for the introduced and modelled social skills. All participants agreed that they could identify the learning objectives and maintain this awareness during gameplay. Five participants agreed that the game reduced expected anxiety towards future encounters of the addressed social skills, one participant stated this was somewhat true whereas three participants disagreed that the program reduced expected anxiety towards future encounters of the addressed social skill. Seven participants agreed that the game raised awareness of the expected neurotypical behaviour, with one agreeing it sometimes did whereas one disagreeing to it. All participants agreed that the game increased awareness of each addressed skill.



**Figure 7.61: Participants response to debriefing questions**

### 7.6.1 Debriefing summary

The study evaluated the effectiveness and usefulness of the serious game by exploring the user study research questions with nine participants. The questions that were used to evaluate the effectiveness of the serious game show that all participants agreed that the proxies/feedback were effective for learning; majority (7 out of 9) of participants agreed that the prototype successfully represented real world like environment/experiences; most (6 out of 9) participants agreed that

there were somewhat realistic distractions in the environment; all participants agreed that they could identify the features that was the focus of this study and most participants stated that there were no barriers to operating the game. These results support the argument that the serious game effectively represented real world like experiences and provided proxies that were effective alternatives to real world behaviour for the participants.

The questions that addressed the usefulness of the serious game shows that most (5 out of 9) participants were aware of the social skill addressed prior to study; all participants exhibited and carried forward the skills to test mode; all participants agreed that the game provided feasible practice opportunity for the taught skill; all participants identified the main learning objectives and maintained it during gameplay; majority (8 out of 9) of participants reported reduced anxiety towards future encounter of the social skills; majority (8 out of 9) of participants reported the game raised awareness of the expected neurotypical behaviour in social scenario; all participants agreed that the game raised awareness of the each addressed skill.

As was explained in literature review Section 2.4, an important benefit of using games for learning purposes is that they immerse and engage the users. A majority (8 out of 9) of participant reported that they maintained social skill awareness during training and found it to be immersive; this is supported by additional evidence as at least six participants reported that the serious game successfully represented real world like environment/experiences and presented somewhat realistic distractions in the environment. These results show that the serious game was useful as it was immersive, raised awareness of the social skills, and provided practice opportunity for the social skills.

## 8 Discussion and conclusion

The work presented in this thesis addressed the research question:

**To what extent could a serious game based on existing social skill training strategies address the identified limitations of existing research in providing a plausible alternative to real life training for young adults and adults with HFA?**

The research question was developed from a consideration of the characteristics of HFA (Section 2.1), the evidence-based social skills training strategies (Section 2.2), the advantages of a computer-mediated social skills training system and the evidential research into the successful use of serious games in training people with Autism (Section 2.4), and the reported limitations and recommendations from prior research (Section 2.5).

The fundamental question led to the creation of a serious game prototype by addressing the research objectives (Section 1.1). This question was investigated by building and evaluating a prototype serious game. The process followed was to sequentially address the research objectives (Section 1.1). First, the evidence-based social skills training strategies that were effective and implementable in this game were identified, as presented in Chapter 2. A human-centered design thinking approach was used with end-users and an Autism expert to prototype a single complete (integrates multiple social behaviours) design with the most necessary/significant social skills for people with HFA, described in Chapter 3. The serious game design approach, the design framework game components, the design considerations, the design decisions for implementing virtual training, and the design for evaluation were discussed in Chapter 4. The game design was used to implement a serious game, presented in Chapter 5. An evaluation of the serious game was developed using qualitative and quantitative measures, reported in Chapter 6. The data analysis process and findings were presented in Chapter 7.

Background research (Chapter 2) was conducted into social skills training strategies/methods to identify the approach that would be most effective for the virtual game. Social skill training methods include one or more of social stories (Attwood, 2000; Boujarwah et al., 2012; Tse et al., 2007), comic strips (Attwood, 2000; Tse et al., 2007); direct instruction (Banda & Hart, 2010); video modelling (Charlop et al., 2010; Hart, 2010); and social skills group training (Cappadocia &

Weiss, 2011; Laugeson et al., 2014; Tse et al., 2007; White et al., 2010). The game developed in this research uses the social skills group training format as the overall training model. The social skill group training session typically consists of direct instruction, modelling, role-playing, and feedback (Minihan et al., 2011; Wilkinson & Canter, 1982). The game uses direct instruction for providing information, social skill modelling videos to support skill modelling, an in-game practice opportunity for role modelling, and a combination of on-screen skill analysis survey and star's reward system to provide feedback (Section 5.2.2).

The setting chosen for virtual social skill training was a visit to a restaurant. Restaurant dining was chosen because this scenario includes opportunities for structured and non-structured interactions and because it is a common social experience in New Zealand for young adults and adults (Section 4.1.3). A prototype of a single complete design system with the most necessary/significant social skills for people with HFA was created using a human-centred design thinking approach, where potential end-users and an Autism expert were engaged in the skill identification (Chapter 3). The prototype of a single complete design system integrates significant skills from multiple social behaviours. It consists of four social skills and sub-skills from the non-verbal, verbal, and assertive behaviour: making and maintaining appropriate eye contact, starting a conversation, maintaining a conversation, and ending a conversation.

The game was built to provide virtual training for the social skills identified as part of the complete design system through a 3D simulation (Chapter 4; Chapter 5). The fundamental research focus of this study was to investigate whether the game provides a plausible alternative to, or extension of, real life training for young adults and adults with HFA by evaluating the game with the prospective users for usability, effectiveness, and usefulness of the social skill training. The evaluation findings of a serious game for usability are discussed in Section 8.1, the evaluation findings for usefulness are discussed in Section 8.2, and the evaluation findings for effectiveness are discussed in Section 8.3.

## **8.1 Evaluation of usability**

To produce a good user experience, a software prototype needs to go through a usability testing process. Usability testing requires the engagement of either an expert in the field of human-computer interaction, or prospective users of the software prototype, or both, to identify the

weaknesses and usability issues in the software. The software is then modified to address these problems and (if needed) re-tested to ensure the concerns are resolved. If further issues arise, the usability testing cycle is repeated. This thesis largely follows a human-centred design thinking approach. However, for this project, the participants and an autism expert were only involved in early design decision-making processes, but not the final detailed design and implementation of the game, as would be expected in a full application of the human-centred design thinking approach. This was mostly because recruitment of users was difficult, and it was felt that the limited number available would be better used in the final study without prior detailed knowledge of the game. Consequently, the initial usability testing of the prototype was carried out with an HCI expert instead of the end-users.

The expert review was conducted with the initial game prototype, and the game was modified accordingly. It was then re-tested with the expert, and further minor usability concerns were addressed (Section 5.4) resulting in a final prototype of the serious game. However, as a secondary objective of the real world study, the participants were given the opportunity to comment on the usability of the serious game (Section 6.3.1).

### **8.1.1 Expert review**

An expert review of the first scenario prototype was conducted at the early stages of the software development to determine the feasibility of the design. It was undertaken to attain feedback on an existing design and make necessary changes to the software before presenting it for user study to participants as detailed in Section 6.1. The usability issues identified, and changes made were:

- lacking instruction in navigation and confusing narrative; resolved with controls menu and rewriting the narrative.
- unusual colours, busy menu design, inconsistent typography; resolved with the use of neutral colour; displaying only relevant objects and using consistent typography.
- Multiple active objects with same function and no feedback; resolved through removing multiple instances of functions and providing dynamic feedback on active objects.
- Menu transparency of Nervous-Happy scale interfering with text readability, the scale set to negative mood by default; resolved by decreasing transparency, changing scale to Confident-Not confident and setting the default to positive value of confident.

- Restaurant sounds audible on the outside; resolved by restricting the audio to inside only.
- Structural distortion and graphical glitches identified; both resolved.
- On screen feedback to relate to action and not be random; resolved by timing it to appear at required time and disappear after task completion.
- The player in game sat at unnatural angle and could rotate 360 degrees in chair; resolved by aligning the player and restricted in chair rotation to 90 degrees.
- Reviewer recommended consistency in formatting and alignment of active objects; resolved.

It was then presented for a follow up expert review, and suggestion was made that the player would benefit from training with controls before gameplay. This was resolved through introduction a ‘static environment’ – an operating mode at the start of the game in which players can experiment with controls and gain familiarity with the environment. The static environment was also used as a context in which participants could perform ‘virtual world tasks’ in contrast to ‘real world tasks’ during the first part of the study (Section 6.3.1, 8.1.2).

The expert questioned the role of the confidence bar, and whether the participants would find it beneficial. The confidence bar was not changed and left in the program. It was further discussed with users and left in the program for end-user usability testing. The program was then determined to be ready for an evaluation/user study with participants.

### **8.1.2 Real world and virtual world**

This study aimed to identify the similarities and/or differences between the perception of distance and eye contact behaviour in the real and virtual world. An ability to perceive distance (proximity) from other people is important in social conduct. In a simulation, good perception of distance is an important aspect of immersion. Participants were requested to make distance estimates according to the given instructions in the real and virtual world, as detailed in Section 6.3.1. The data analysis (Section 7.1) revealed that although some participants anticipated not doing well in the game, their behaviour in the real and virtual world was similar. All participants underestimated distance in both the real and the virtual world. Generally, participants were better at detecting distance and maintaining that accuracy in the real world than in the virtual world. Within the virtual world, there was variation in the participants' performance as some detected distance well and

maintained the distance difference for the three measurements well. In contrast, some participants perceived distances as being far shorter than they were and did not maintain the distance difference well between the three measurements. The virtual distance may have been affected by the absence of peripheral vision. The real world participant distance estimate also varied as all participants underestimated distance in both worlds yet managed to complete the tasks involving distance measurement in the virtual world successfully.

The real world eye contact study showed variation. Five out of the nine participants successfully got in the actor's line of vision, made eye contact, and maintained eye contact. Two out of the remaining four participants successfully got in the line of vision, made eye contact, but did not maintain the eye contact. Whereas the remaining two participants got in the line of vision but did not make or maintain eye contact. The virtual world study showed that all participants managed to successfully execute the eye contact tasks of getting in the line of vision, standing at the right proximity, making eye contact with the greeter, and maintaining eye contact with the greeter successfully.

Participants did not identify any issues with the serious game and all participants managed to complete the tasks in the virtual world regardless of their previous gameplay experience; hence the game did not present any significant usability issues.

Another element of the evaluation of usability was the participant's real vs. virtual world task execution and perceived experience of the tasks (Section 6.4.2). The evaluation focused on ease of task completion and completion satisfaction level for the set tasks in both worlds. The participants were also requested to compare their real world and virtual world task experience. The aim of this was to evaluate the difference in the participant's perceived experience and to identify limitations that the game may pose. The data analysis (Section 7.1.2) shows that all tasks involving movement and distance estimates, were reported on average by five out of the nine participants to be easier in the real world than in the virtual world. In contrast, the social tasks relating to eye contact were reported to be more difficult in the real world than in the virtual world by all participants except one, who found the task execution easier in the virtual world (Figure 7.30).

The evaluation of participant's prior experience with first-person controller games, their anxiety status towards real world restaurant, and the perceived difficulty of task execution in the real and virtual world, did not direct the results towards a particular outcome, rather the results varied from

person to person. This meant that the participant's ability to do the tasks was not affected by their prior game experience or any prior anxiety about real world restaurant, as their perceived difficulty with the task varied.

In conclusion, the research followed the usability testing process by conducting an Expert review of the prototype and followed it up with the required changes. It was then re-tested with a follow up expert review to confirm that the usability issues were addressed, and there were no more major issues. The usability testing with participants in the real world and virtual world study did not identify further usability issues with the serious game.

The participants showed no evidence of having their attention diverted by usability issues, as indicated by the responses to the question asked relating to the absence of distraction. The prototype was in an appropriate state to be evaluated, as there were no usability issues.

The experimental results from the real and virtual world study shows that the participants underestimated distance in both worlds but in a consistent way. There was however more estimate variation in the virtual world. This consistency suggests that the serious game has information that the participants can use to learn and carry out tasks, however the consistent underestimation means that caution is needed as to how this might transfer to the real world. Another aspect to consider relating to usability was the fact that participants described varying levels of difficulty in performing the tasks. The prevailing pattern was that the participants found the tasks in the virtual world to be the same as or harder than their experience in the real world. It is unclear whether the tasks were intrinsically difficult or if the usability of the system contributed to that.

The eye contact evidence shows that the participants were mostly able to make eye contact in the real world and they were able to operate the proxy for eye contact in the virtual world successfully.

## **8.2 Evaluation of effectiveness**

The serious game attempted to provide the user with a plausible alternative to or extension of real life experience of social skills training. Virtual reality potentially presents many advantages that make it desirable for this goal, however it also presents the challenge of devising effective work arounds to real life components. The game in this thesis used a combination of common gaming elements and newly introduced proxies to achieve this. Therefore, the evaluation of the effectiveness of these game elements and proxies was conducted during the evaluation/user study.

The common gaming elements implemented in the serious game provided feedback in the forms of visual representation of text, and an audio playback of text. The serious game provides control over this feedback by background audio control, option to change between first-person and third-person view, mouse, and keyboard input for interaction. The evaluation set out to determine which game elements and proxies were effective in that participants successfully used them in achieving the task objective, and which game elements were not effective in that the participants did not use them. This data was gathered through survey questions, and indirect results recorded by the game during practice (with feedback) and test modes (feedback withdrawn).

The participants reported the most game elements were very useful, and that fewer elements were only slightly or moderately useful. A small number of participants identified a few game elements to be not at all useful. These were the elements that the participants did not actively use during the user study, i.e., the confidence bar, changing between the two views, the notification when speaking over another person, and manipulating the background sound. None of the participants used these during the training and the practice runs, suggesting that the default set up and gameplay encouraged the appropriate social conduct.

Several proxies were included into the serious game to implement its social skills training strategy. The training strategy that was used in this study was based on the established social skill training program of instruction/introduction of skill, modelling of the skill, and role-playing/practicing the skill (Section 4.1.2). The proxy used for instruction was text accompanied by audio playback of the text. Social skill modelling videos were used as the proxy for modelling the skill. Coloured halos were used as a proxy to give dynamic feedback on eye contact related skills and sub-skills, and as a proxy for the role-playing tasks were created in the training phase to allow the participant to practice the taught skill. Speak now button, and conversational options were provided for interaction. The data show that across the proxies, at least six participants reported the proxies were very useful and at least three participants rated them between slightly to moderately useful, as detailed in Section 7.2. The exception was red halo for standing too close, that was reported to be not at all useful by one participant. The participants reported that the game elements and proxies used in the serious game were useful when they were explicitly asked, with some exceptions. There is indirect evidence that they were useful because the participants used them successfully in the practice and test modes. The exceptions were not reported to be un-useful in a negative manner,

but there were several features that did not get used. It was unclear whether the game elements and proxies not used were not effective, or simply not required, because of the nature of the evaluation. The task could be performed without them, and users were not explicitly asked to use them and find out.

An element of interaction that was discussed in detail in Section 5.5.1 is the confidence bar. Although initially the participants anticipated using the confidence bar, this was not the case during gameplay. The confidence bar was designed to enable the participant to give feedback on their experience during gameplay. Successful interaction with the system was not dependent on this functionality; therefore, the participants reported they were immersed in the experience and forgot to use it, and so reported the confidence bar not to be useful.

The confidence bar did not offer them any real value, they did not see a point to it, as stating how confident or not confident they are, is not something one does in a restaurant experience. It can be seen now that adding the confidence bar is breaking the experience, and it simply is not something that fits in well with the game experience. In retrospect, the confidence information would be useful to researchers or social skill trainer, however, the game element itself is not useful as the confidence bar was too crude a mechanism.

The evaluation shows that overall, the game elements and proxies were effective as the participants learned the mechanisms of the game and remembered to do the various tasks in the game. However, this does not automatically transfer to their real world behaviour. The important contribution of the serious game to learning the social skills, was that it raised awareness of when a skill is important. This worked in the serious game, as it provided reminders, and we have evidence that they remembered with (practice mode) and without feedback (test mode) at least in the short term. It was not established however that this would translate into real world behaviour.

### **8.3 Evaluation of usefulness**

The serious game simulated social skills training in the context of a restaurant experience with the goal of providing plausible alternative to real life training. It was important to investigate how useful the serious game and virtual training were in achieving this goal. The supporting argument for using a game for social skill training was that it could potentially: provide effective realism while reducing social anxiety/stress; reduce self-consciousness and worry of failure; offer an

opportunity for experimentation with social situations; encourages strategic decisions making in stressful situations; direct focus to achieving goals by removing distractions; minimise external stimuli; put the user in charge of the case (i.e., noise level control); and provide immediate feedback (Hirumi, 2010). The study engaged the participants at different stages of the user study to investigate the validity of each of the above arguments.

The first argument, that of providing effective realism while reducing social anxiety, reducing self-consciousness and worry of failure, was investigated through the anxiety related questions in the questionnaires related to the skill of eye contact and the skill of small talk, at the three different stages of the user study: pre-study real world (Appendix I), during virtual training (eye contact—Appendix K, and small talk/conversation—Appendix L), and test mode (post study—Appendix M). The questions inquired about the participant's anxiety level on a 5 point scale varying from not-anxious to very anxious in all three stages (social anxiety pre-study real world or before virtual training, anxiety during game play, and anticipated anxiety towards the real world future encounter of the tasks:

- 'Finding your way to the restaurant staff,'
- 'Getting in the line of vision of restaurant staff,'
- 'Making eye contact with restaurant staff,'
- 'Knowing the appropriate distance to stand from another person,'
- 'Starting a conversation with someone,'
- 'Maintaining a listening position while someone is speaking to you,'
- 'Showing interest while another person is speaking,'
- 'Turn-taking during a conversation.'
- 'Ending the conversation with someone.'

For the tasks of eye contact, comparing the results from the pre-study real world with the virtual world (during gameplay) for the nine participants, revealed that on average some (5 out of 9) participants reported the same anxiety level for both environments, suggesting that the gameplay provided reasonable realism in this context. On average, few (3 out of 9) participants reported reduced anxiety level during gameplay weakly supporting the argument that the virtual world potentially reduces social stressors, providing an environment that was no more stressful than the

real world. One participant even fell above the diagonal indicating higher anxiety than the stated pre-study real world anxiety although the difference was from not anxious to slightly anxious.

Similarly, for the task of eye contact, comparing the pre-study real world anxiety with anticipated real world anxiety for future real world encounter shows that on average most (6 out of 9) participants indicated anticipating the same anxiety levels as their pre-study reported anxiety; and a few (3 out of 9) participants reported reduced anticipated anxiety as detailed in Section 7.5. The results show that the serious game was useful in providing reasonable realism and/or a realistic experience as most participants reported the same anxiety levels in the pre-study questionnaire, questionnaire during the gameplay, and anticipated anxiety for future encounters.

The next questionnaire inquired about the participants' anxiety levels for the tasks related to the social skill of small talk. The comparative study of pre-study anxiety with the anxiety in the virtual world (during gameplay) revealed reduced or same anxiety levels in both worlds. On average, five out of nine participants reported reduced anxiety levels, and four reported the same anxiety levels in pre-study and during gameplay. The comparative study of pre-study anxiety against the anticipated anxiety for the future real world encounter of the tasks related to engaging in small talk revealed, on average, about half the participants reported anticipating the same anxiety level in future real world encounters. The other half reported reduced anticipated anxiety for all tasks except two: 'Turn taking during a conversation', and 'Ending a conversation'. For the task of 'Turn taking during a conversation', one participant indicated higher anxiety than the stated pre-study real world anxiety with the difference being from moderately anxious to very anxious. For the task of 'Ending a conversation', one participant indicated higher anxiety than the stated pre-study real world anxiety from not anxious to slightly anxious as detailed in Section 7.5. It is worth noting that the participants that reported higher anticipated anxiety are all different hence there is variation across participants.

The reported anxiety levels for the social tasks of eye contact and small talk addressed in this study varied. Comparisons of participant's anxiety levels in pre-study real world vs virtual world (gameplay), and virtual world (gameplay) vs anticipated real world encounters, showed variance for the nine participants. On average four or more participants reported the same anxiety levels for the social tasks across the two comparisons, strengthening the argument that the serious game provided an environment that is socially realistic enough to trigger some of the anxiety. At least

three participants reported reduced anxiety levels indicating that the serious game was successful in diffusing excessive levels of anxiety in the real world hence reporting that for some it reduced social stressors.

To further explore how effectively the game provided realism of social experience, the participants were asked specific questions embed in questionnaires at different stages (practice and test mode) of the study. The set of questions directed towards identification of realism were whether or not: the serious game felt abstract and unlike a real world experience; the participant felt like they were at a restaurant; the serious game successfully represented a real world like environment and/or experience; conversation in the game felt like a real-conversation; the serious game provided an element of realism and felt like a real world restaurant experience (Section 7.3). The findings showed that four out of the nine participants reported the game was abstract, whereas four participants reported it felt like world experience and one reported it sometimes did. Five participants reported feeling that they were at the restaurant and one reported it sometimes felt so. Five participants reported that the serious game successfully represented the real world like environment and/or experience and two reported it sometimes did so. All participants agreed that conversation in the game felt like real world experience. Two participants agreed that the game provided an element of realism and felt like a real world restaurant experience and five participants reported it sometimes did. The results by some participants show that to some extent the serious game provided realism of social experience however some inconsistencies were observed. Therefore, it is difficult to draw strong conclusions. Overall, the results show that for some participants the serious game did provide a realistic social experience, at least for some aspects, although this was not universal.

Another factor in establishing the extent of realism was identification of the source of anxiety that the participant experienced during gameplay. The argument was that the serious game potentially reduces social anxiety by reducing self-consciousness and worry of failure. The questions posed to participants during user study for exploring social anxiety (Section 7.5) were whether: the anxiety felt by participants during eye contact tasks was caused by uncertainty of operating the program or by feeling of engaging in the social experience of eye contact with the greeter; the anxiety experienced by participants during small talk tasks was caused by uncertainty of how to interact with the program or by feeling of engaging in the social experience of small

talk/conversation with other person; the serious game awakened social anxiety around having conversation; the game reminded the participants of social anxiety experienced while engaging in eye contact and small talk in real world; the game experience made the participants more confident in making eye contact and engaging in small talk with another person in the future; the game was helpful in increasing confidence at social interaction in restaurant; and it reduced anxiety towards future encounters of eye contact and small talk.

The findings show that on average, three out of the nine participants associated the anxiety experienced with operating the program, three associated the anxiety with engaging in the social skills of eye contact with the greeter and one associated it with small talk; whereas the others reported it was not caused by either. Only one participant stated the game awakened social anxiety around having conversation. Five participants reported never being reminded of the real world social anxiety while engaging in eye contact during gameplay, while the rest reported it sometimes did. Five participants reported the game sometimes reminded them of the real world social anxiety around engaging in small talk, while the rest reported not experiencing so. Four participants agreed that the game experience made them more confident about making eye contact whereas two participants could not decide, and three participants disagreed it did so. Eight participants agreed that the game experience made them more confident about engaging in small talk with another person in the future and one participant was undecided. Seven participants agreed that the game experience was helpful in increasing their confidence at social interaction in a restaurant, with the other two participants reporting being undecided about the accuracy of this statement. Five participants agreed that the game reduced expected anxiety towards future encounters of the addressed social skills, three participants reported it might do so, and one participant disagreed. This shows that for approximately half (5 out of 9) participants, the serious game helped reduced social anxiety and increased confidence in future social interaction/experience. For at least some participants, the serious game provided a useful level of realism and positively influenced their social experience, by reducing social anxiety and increasing confidence towards social interaction at a restaurant.

Furthermore, a game potentially reduces social and time pressure associated with strategic decision making in stressful situations. This argument was investigated by asking the participant if they felt the social pressure of a real world restaurant experience and if the game removed the time pressure

for responding to conversation required by real life. Two out of the nine participants reported feeling the social pressure of real world restaurant experience. In contrast, seven participants indicated they didn't feel the social pressure, and all participants agreed, to different extents, that the game removed time pressure for responding in a conversation. The variations in the data show that there is a tension between the goal of realism and this idea of defusing the situation to make it more tenable. The serious game reduced the social pressure but did it reduce it too much? The choice of the conversation format was successful, in that the participants found it posed similar issues to those they face in real life, but also it is not clear whether the conversation format chosen really allows sufficient opportunity for strategic thinking and decision making. The challenge in further developing the software is to show the users where the social pressure has been unrealistically dialed back, and to set up an effective way to vary its level. This could enable the user to experiment, increasing the social pressure as they progress, whilst remaining in control.

The next supporting argument for using a serious game was that it provides an opportunity for experimentation with social situations as it allows the user to choose which section they want to experiment with. It was investigated in the study through asking the participants whether: the training provided feasible/sufficient practice opportunity; they maintained awareness of the social skills during training and found the game to be immersive; they identified the main learning objective and maintain this awareness (practice mode, test mode) during the session; and they exhibited the social skill during the test session and carried forward the skills to the test session. All participants agreed that the game provided a feasible practice opportunity for the introduced and modelled social skills. Seven of the nine participants stated that they maintained an awareness of the addressed social skill during gameplay and found it immersive. All participants agreed that they could identify the learning objectives and maintain this awareness during gameplay (practice mode, test mode). And all participants stated that they exhibited and carried forward the social skills when feedback was withdrawn during the test mode. All participants reported that: the serious game provided feasible practice opportunity, they identified the learning objectives and maintained this awareness during gameplay, they exhibited and carried forward the social skill from practice mode to test mode, and seven of the nine participants maintained awareness of social skills during training. Therefore, the serious game was useful as a training and practice environment for the addressed skills.

Built-in game features recorded the participants' knowledge in questionnaires and directly measured their behaviour. It recorded whether the participants recalled and selected from the on-screen multichoice survey the correct strategies for the social skills, the correct best-used method, and the correct worst method, for completing the social skill tasks. It tracked the participants' behaviours of interest and measured their performance, such as the amount of time they made eye contact and maintained it; the amount of time they interrupted the speaker, and the amount of time they fiddled with the keyboard or mouse, to analyse whether they carried over their behaviour from training to practice, and then to test mode where feedback was withdrawn. The analysis showed that all of the participants responded well to the in-game questionnaires: a survey about the newly taught skill and selected acceptable response options for conversation. They managed to make and maintain good eye contact during the training session, and they did not interrupt the speaker. Although they did fiddle with the keyboard and mouse, overall the fiddling was not of concern as the session took almost 2 hours to complete, and the maximum fiddling was 6 occasions by one participant for the social skill tasks of ending conversation, with most fiddling staying in the 0 to 1 range. Participants carried this over to the test mode as they all maintained their behaviour from the training session. The aim of recording objective data from the participants in the practice and test-modes was to compare this against each participant's reported measures in the survey questions and draw conclusions. The data gathered in the game validates the participants' reported behaviour that they recalled and carried over the learning from training to practice and test-modes.

It was argued that the game directs focus on achieving goals by removing distractions and minimizing external stimuli. The participants were asked whether they struggled to pay attention and stay focused while the virtual friend was speaking during gameplay and whether they felt there were realistic distractions in the game environment. The findings show that three out of the nine participants reported struggling to pay attention while the virtual friend was speaking. However, the observation study showed that the participants did not appear distracted in real life and were focused on the screen and the tasks at hand. The game consistently engaged participants' attention. In particular, the participants were looking at the same in-game content as their avatar, providing evidence supporting the avatar's view as a workable proxy for user eye gaze. The six participants stated that the computer environment provided realistic distractions. It suggests that the game minimised external stimuli and removed distractions, although leaving enough to offer a realistic restaurant environment.

An important characteristic of a game is that it provides immediate feedback. The validity and usefulness of the feedback was tested with participants through the questions about whether they found the halos useful in identifying aspects of eye contact; whether the response options provided made the social interaction easier than in real world; whether they recognized the features that were the focus of this study; and whether the feedback and proxies used in the game were effective learning alternative. The findings show that all participants found the halos to be useful in identifying the aspects of eye contact; all participants agreed that to some extent the response options provided made the social interaction easier than in real world; all participants agreed that they could identify features that were the focus of this study in the game prototype and all participants agreed that the proxies and feedback used in the game were effective as learning alternative to the real life mechanism. All the nine participants reported that the game provided useful feedback and used effective proxies for real world situations. It is concluded that the feedback mechanisms used in the serious game were useful.

The next supportive argument for virtual training is that the user is in control of the situation. This was investigated through inquiring from the participant whether their lack of game experience (if applicable) interfered with their learning experience. Four out of nine participants responded to the question of lack of experience interfering with learning, as the option to 'Leave it blank, if not applicable' was provided; out of these, one participant reported it sometimes did and one reported it seldom did whereas the other two reported it never did. Only two of the nine participants reported that the lack of game experience sometimes or seldom interfered with their learning experience, hence it is concluded that the participants were in control of the serious game and training.

The participants were asked whether the game raised awareness of neurotypical behaviour and whether the game increased awareness of each skill. Seven out of nine participants agreed that the game raised awareness of the expected neurotypical behaviour, and all participants agreed that the game increased awareness of each addressed skill. The results obtained suggests that the serious game was useful in raising awareness about neurotypical behaviour and the addressed social skills in these social scenarios.

In summary, both positive and negative aspects of the serious game were discovered from this evaluation.

## 8.4 Conclusion

This project set out to explore the extent to which a serious game based on existing social skill training strategies, addressing the identified limitations and recommendations of existing research, could provide a plausible alternative to, or extension of, real life training for young adults and adults with High-Functioning Autism. It demonstrates that existing social skill training strategies covering the important skills in a specific social scenario can be effectively integrated into a single serious game.

A serious game simulating a restaurant scenario was developed. Inputs from both potential users and an autism expert were incorporated into the design, and the initial prototype was evaluated and refined with the assistance of a human computer interaction expert. At this stage it was ready for trial with potential users. A study was conducted of the plausible usefulness of this game in social skills training, and this produced the following outcomes:

- Barriers to operation:
  - Participants did not find any usability barriers to playing the game.
  - Participants indirect and reported results showed that a lack of gaming experience was not problematic.
- Plausible social skills training
  - Participants reported the serious game provided feasible practice opportunity.
  - Participants identified the learning objectives and maintained this awareness during gameplay.
  - Participants exhibited and carried forward the social skills from practice mode to test mode.
  - The game consistently engaged participants' attention during gameplay.
  - Most participants reported that the game raised awareness of the taught skills in the virtual world. Indirect evidence shows that the participants successfully carried the skills addressed in training forward into the practice and test modes.
  - Participants reported the game was useful in raising awareness about neurotypical behaviour, and the addressed social skills in these social scenarios.

- Effectiveness of elements and proxies
  - Participants reported that the game provided useful game elements and feedback; and used effective proxies for real world situations.
  - Quantitative measurements recorded during the user study validate the participants' reports about the proxies.
- Effectiveness of game experience
  - Participants learned the mechanisms of the game and remembered to do the various tasks throughout the gameplay, however, there is no evidence that this would translate into real-world behaviour.
  - Participants reported not feeling the social pressure, and all participants agreed that, to some extent, the game removed time pressure for responding to conversation.
  - Realism
    - Participants reported that conversation in the game felt like a real-world experience.
    - Half of the participants reported that the game overall provided a realistic restaurant experience.
    - Most participants reported that the game removed external stimuli and distractions and provided appropriate virtual distractions to offer a realistic restaurant environment.
    - Participants' reports on the realism of the overall restaurant experience were varied, but just two said that it was not realistic.
  - Eye contact
    - The users were successful in maintaining the facial alignment of the axis of the user avatar.
    - Participants maintained eye contact with the image of the person of interest in the centre of the screen, providing indirect evidence that they were maintaining eye contact.
  - Anxiety
    - Most participants agreed that the game reduced expected anxiety towards future encounters of the addressed social skills.

- Most participants reported increased confidence in social interaction with others in a restaurant, after the game experience.
- Half the participants reported increased confidence in making eye contact after gameplay.
- Most participants reported increased confidence about engaging in small talk with another person in the future.
- Some participants reported a lower level of anticipated anxiety in future real world restaurant experiences following the gameplay.
- Half of the participants reported the same level of anxiety for social tasks in the real world prior to gameplay, and in the virtual world (during gameplay), supporting evidence that the serious game is socially realistic enough, as it can trigger social anxiety.
- Some participants reported lowered anxiety for social tasks in the virtual world than in real world, providing evidence that the serious game successfully reduced social stressors, positively impacting the learning experience.

There is a tension between the goal of realism and this idea of diffusing the situation to make it more tenable.

- Inconsistencies:

- Half the participants reported the game was abstract, yet most reported it provided realism of social experience.
- The reported anxiety level prior to game experience vs. anticipated anxiety level for future real life restaurant experience for the social tasks of eye contact and small talk varied. Some reported reduced anticipated anxiety, some reported the same anticipated anxiety, but one reported increased anticipated anxiety for three of the nine tasks. For each task, a different participant reported the increase.
- In real life, some participants did not maintain eye contact after the initial contact was made, whereas in the virtual world that did not happen. This suggests that avatar eye contact is not fully equivalent to real life eye contact.

A single integrated serious game incorporating the social skills training strategies of direct instruction, role modelling, practice opportunity and feedback, has been demonstrated in a simulation of a restaurant experience. It provided game features and proxies to support the skill

and sub skills of eye contact and small talk. A user study showed that the participants responded positively to the mechanism used for simulating conversation. There was variable response from the users concerning the level of realism achieved in the game and the effect that it had on their anxiety about social interaction. The proxy used for eye contact – aligning the avatar’s field of view – served to show users when eye contact was appropriate. It did not appear to have a high level of realism as demonstrated by the fact that users did not find it as difficult to maintain the simulated eye contact, as they did in real eye contact. The serious game appears from the evidence gained to be a plausible alternative to real life training for the purposes of helping HFA people with the addressed social skill. Further work is required to make it sufficiently realistic to provide a complete training experience and to find out if the training it offers can be transferred into real world interactions.

## **8.5 Limitations and Future work**

The study was conducted with nine participants from a New Zealand Autism support group. The sample-related limitations include the sample size, the participants’ profiles, and the research process. Although for a single-subject research study, nine is considered a satisfactory number of participants, extending the study to include more participants would enable the researcher to capture more variation and draw strong conclusions representative of the Autism population. The participants all belonged to a New Zealand Autism support group, and this group holds regular social gatherings, with some are held at restaurants. Thus, the participants’ profile and experiences may differ to those who are not members of an Autism support group and have less exposure to real life restaurant experience.

The experiment was conducted in a usability lab that was set up with minimum distractions outside the game, because a game used in a situation that lacks major external distractions, is sufficiently immersive to enable people to function. As the game was played in this environment, it is unclear if the skills would transfer to a busier environment.

The qualitative data obtained is self-reported, cannot be independently verified and may contain potential biases i.e., selective memory (not remembering experiences from the past). To address this, surveys were presented to the participants immediately after completing the relevant task, and they proceeded to the next task after completing the survey. These responses were further explored

through the follow-up debrief with each participant, which attempted to ensure the data gathered was not an artifact of misunderstood questions.

There is an inconsistency in the conclusion for game experience, that it provided useful realism and reduced the social pressure. As the participants' results varied, further investigation into identifying the reasonable reduction of social pressure and implementing this into the game would be valuable. This research showed that the game can dial back the social pressure. The challenge in setting up the training and practice is to show the users where the social pressure has been unrealistically dialed back, and to set up an effective way for them to manipulate this. Enabling the customisation of the game could allow experimentation with social pressure and give the user more control.

Engaging in eye contact was measured through the avatar establishing eye contact with the person of interest in the game and observing the participant's focus on screen while the in-game eye contact is maintained. Is there some way to devise an experiment to directly measure the equivalence of staring at a screen and making eye contact with a person in real life? It is an outstanding problem, and further investigations might be possible.

It was discovered that the game provided successful simulation elements, as the participants were able to apply them to complete the various tasks in game. However, this does not automatically apply to their real world behaviour. The most important thing that they are going to come away with having practiced eye contact and an increased awareness of when it is important. This worked in the game, as the game provided reminders, and we have evidence that they remembered both with and without feedback, at least in the short term.

The game addressed a limited social skill set; future work can be directed towards adding more skills to the single complete system prototype of most necessary/significant social skills and addressing them through the game.

The game elements that were reported to be not useful included the volume of the social skill modelling videos, the ability to swap between first-person and third-person view, the red halo when standing too close, and the feedback when speaking over the other person. Although these were identified to be not useful, they are trivial as the participants did not report them to impact their social skills training experience. The last three were assistive feedback, and these were rated not useful because participants did not come across it.

As mentioned in Section 8.2, the confidence bar was not used by any participants, and it may not fit well with the game experience. Future research may be directed towards explicitly promoting user engagement with the confidence bar and evaluating how the data from confidence bar supports or refutes the anxiety data. The researcher or trainer can use this information to customise the gameplay to the user's anxiety level to provide an efficient game experience.

The overall conclusion derived in this thesis is that the participants were satisfied with the digital experience, but to find out if it will apply in the real world, future work should focus on a longitudinal study of the participant's performance in real life restaurants post-study, perhaps within a short time frame, then perhaps 3 months later, and then 6 months later.

### **8.5.1 Access to software**

If other researchers wish to follow-up or replicate the work, to access the software, please contact the primary researcher through email:

[kb60@students.waikato.ac.nz](mailto:kb60@students.waikato.ac.nz)

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# **Appendices**

# Appendix A: Ethical application for the research: preliminary social obstacles study

Computing and Mathematical Sciences  
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THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

16 December 2013

Khadija Bahiss  
C/- Department of Computer Science  
**THE UNIVERSITY OF WAIKATO**

Dear Khadija

## **Request for approval to conduct a research evaluation involving human participants**

I have considered your request to carry out a research study *Social Skills Training for People with Asperger Syndrome / High-functioning Autism* to be conducted in a place of choice by the participant. The purpose is to investigate the validity of using serious game in providing social skills training for people with Asperger Syndrome / high-functioning Autism.

The procedures described in your request are acceptable.

I note that no participants will be named in the publications and every effort will be made to disguise their identity. During the course of the study only the researcher will have access to the data. On completion of the study collected information will be stored in the FCMS data archive and destroyed after five years.

The research participants' information sheet, consent forms and questionnaires meet the requirements of the University's human research ethics policies and procedures.

I therefore approve your application to perform study.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'Mike Mayo'.

**Mike Mayo**  
Human Research Ethics Committee  
School of Computing and Mathematical Sciences

# Appendix B: Survey for evaluating social obstacles

ID Number: \_\_\_\_\_

## Steps and Obstacles involved in dining at a Restaurant

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- ❖ *represents the possible Steps in restaurant dining experience*
  - *represent the possible Obstacles in restaurant dining experience*

Please highlight with a highlighter pen or underline with a pen the Obstacles that you consider relevant when dining at a restaurant. These could be something you have experienced previously, or you think you might experience. Please feel free to add any experiences not mentioned here that you think are relevant. Thank you very much for your participation. It is much appreciated.

Researcher:

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Computing and Mathematical Sciences

University of Waikato

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- ❖ Pull/Push the door to open
  - Door may be locked.
  - I could trip on the doorstep.
  - I could see someone on the other side of the door who was mean to me somewhere else - a bully.
  - There is someone trying to go through the same door at the same time.
  - It makes noise
  - I could drop my things, and everyone would stare at me
- ❖ Walk into the restaurant
  - The door to the restaurant is jammed
  - The restaurant is too crowded
  - Someone is leaving at the same time you are entering
  - the electricity goes out
  - The restaurant is closed
  - you slip and fall
  - The door I chose to use has a sign saying to use another entrance.
  - There is extremely loud music, many people talking interfering with concentration.
  - People on the other side of the door are standing against it not allowing the door to open.

- There might be someone you don't like there.
- ❖ look around to assess the atmosphere/Observe the seating locations and guests
  - I found an empty table for two but there are four in my party.
  - Just as I locate and approach an empty table someone jumps in front of me and sits down.
  - the table is not clean and there are dirty dishes
  - There is an empty table - but no chairs to sit on
  - There is an empty table but there is food and garbage on the floor
  - There is no place to sit - all the tables are taken
  - no quiet tables
- ❖ smile at hostess
- ❖ Speak to host or hostess/greet employee/follow hostess to table
  - You misread the employee's nametag and greeted him/her with a wrong name.
  - "You greeted ""Good Morning!"" when it's already afternoon."
  - you slip and fall
  - someone bumps into you
  - Someone stops you to ask you a question.
  - Just as you arrived at an empty table another customer says "" I'm sitting here""!"
  - there are no empty tables available
  - The table is dirty
- ❖ follow hostess to table
  - I could fall
  - there is someone sitting at the table you chose
  - the table is dirty
  - alarm in kitchen goes off
  - a child screams
  - you get a call and have to leave
  - You could assume no one else was using the space and discover that someone else was.
- ❖ Locate a nice table and settle down/Look for a place to sit
  - no place to sit
  - sit close to a stinky person
  - person to sit close to looks dangerous
  - someone might break in the line
  - A large group of people are all waiting to be served/seated so you have to wait
- ❖ select a pleasant seat/choose the comfortable area & Sit down/Take the seat
  - place might be reserved by someone else
  - too many visual/aural stimuli to track leading to a potentially negative reaction
  - The chair or booth has food spilled on it.
  - someone takes your chair/You want to sit by the window but one of your companions beats you to that chair.

- Somebody will pull your chair and you will fall down.
  - a person is standing in the way of you moving your chair
  - chair might break
  - Everyone else wants to sit in a booth but you prefer to sit at a table.
  - Everyone else wants to sit at a table but you prefer to sit in a booth
  - social anxiety faced by the press of a busy restaurant
- ❖ push chair in
    - You bump the table with the chair and topple over the drink glass.
    - the chair breaks
    - The chair is stuck and cannot be easily moved
    - I get the chair too far in and I might hurt myself when my stomach strikes the table.
    - can't figure out what chair is catching on
    - The chair is pushed too hard making a very loud noise
    - someone bumps into you
    - chair might hit a person's leg stretched forward sitting on opposite side of the table
    - the dining table is not cleaned properly
- ❖ Observe the seating locations and guests
- ❖ check if everything is there
- ❖ Ask for a menu
    - don't have a menu
    - the menu you have is missing a page or two
    - the menu you have is old and it's almost unreadable
    - all the waiters are busy and couldn't attend to you
    - menu is dirty
- ❖ determine how much money to spend
    - I suddenly find I am running short of money
    - I lost all my money
    - you're not sure you brought enough money
    - Price is more than you have with you.
    - others mistook us as a miser
    - Price for something you'd like to have is not listed.
    - realize you can't have your favourite today you can't afford it
    - we are in restaurant and unexpectedly a friend may come there, and we have to pay the bill
- ❖ Look at the menu/read the menu
    - the menu does not display prices
    - the menu is in a different language
    - there are no vegetarian options and I am a vegetarian
    - the menu is hard to read/understand
    - I forgot my glasses so I can't see the menu

- the food has unusual names I don't understand
  - I don't see anything I like
  - no descriptions
  - I can't find what I am looking for on the menu/my choice is not available
  - the specials are not on the menu
  - you can't decide and your friends are waiting for you
  - portion sizes aren't listed
  - the menu is not sensory friendly
  - the electricity goes out
  - everything is too expensive
  - what I want has cheese and I don't like cheese
  - the waiter says the potato fryer is broken
  - you are not yet ready to order
  - The menu is very confusing with different "deals" or "meals"
  - not able to pronounce the name of the food correctly
- ❖ Decide what to order/choose a meal/Identify your selection from the menu
    - change my mind after ordering
    - I order too much
    - I can't decide
    - order incorrectly
    - I am misunderstood
    - everything is too expensive
    - I rush because waiter is waiting
    - too anxious to order
    - the waiter is rude
- ❖ wait for waiter/Listen to order taker
    - I am misunderstood
    - You can't get the waiter's attention.
    - the waiter seats you but takes a long time to take your order
    - The waiter says some specials real fast and you can't remember them.
    - My choice is not available
    - The waiter is having a bad day and is very rude and you feel like he doesn't like you.
    - I see my ex-boyfriend/girlfriend with another guy in the same restaurant
- ❖ Speak to host/hostess/order food/ask for meal/Give them your order
    - I forget to ask them to leave out/add an ingredient
    - forget to specify if I want combo/side items
    - I can't decide what I want
    - forget what you were planning to order
    - forget to specify portion size
    - I order incorrectly/I worry that they got my order wrong
    - my choice is sold out
    - the restaurant is really loud, so I have trouble ordering
    - the florescent lights are bothering me so much

- I get nervous from looking at people and mess up my order.
- ❖ order your drink
  - difficulty in choosing the drink
  - I don't like any of the available drinks
  - cannot find the types of drinks available on the menu
  - menu is difficult to read
  - I do not have enough money for any of the drinks
  - out of desired beverage
- ❖ Wait
  - you can get an emergency call
  - the food could take longer than expected
  - they forget to put straw/napkins in your bag
  - you faint from hunger
  - quarrel between waiter and person
  - lunch break might end
  - It could be hard to engage in small talk while waiting
  - You don't know why you have to wait as no one gives you a reason for waiting
  - people who came after me were served food before me
- ❖ watch other people/anxiously watch people
  - It could be hard not to make remarks about people out loud and be considered impolite or rude
  - you can get the urge to go to the bathroom
  - Someone gets offended I'm looking at them.
  - You get weird looks when people notice you are watching them
- ❖ smile at hostess
- ❖ talk to other restaurant patrons
  - They may not like the jokes I tell.
  - The other person isn't interested in what I'm saying.
  - the person you talked to isn't in the mood for chit-chat
  - Another person freaks out.
  - the person you talked to is on the phone and you didn't realize it at first
  - the person is deaf
- ❖ Fill my drink cup and drink water
  - the electricity goes out
  - the water tastes funny
  - you spill the water
  - the water is hot
- ❖ find the bathroom
  - There was no sign showing where the bathroom is/Could not find the bathroom

- Could not figure out which bathroom was for my gender.
  - Bathroom is locked and do not know what to do.
  - Went into an employee only area door.
  - no toilet papers
  - you saw there's a long line outside the bathroom and you really have to go
  - The bathroom is not very clean
- ❖ enjoy conversation
- The restaurant is so noisy you can't hear what other people are saying to you.
  - You don't know if it is appropriate to talk to other people in the restaurant or just to your companions.
  - the other person has food between their teeth
  - the other person gets up and leaves
  - people stare and make comments
  - you do not grasp that a remark is a joke
  - you do not understand your friend's body language
  - you feel like you are interrupting too much
  - You want to use the restroom but don't want to tell someone and be overheard by other diners.
  - Make comments unrelated to conversation.
  - Idioms are used that you do not grasp
- ❖ receive my order
- the order you are handed is not what you ordered /Take the wrong order /Not sure if the order is yours but don't want to ask
  - my order is taking a long time and other people are getting irritated
  - wrong sauces on the burger or sandwich
  - long wait for the order makes me unhappy
  - My phone rings and I will be busy for a long time.
  - food looks bad/is cold
  - No eating utensil
- ❖ thank the person handing you your food
- Suddenly he/she spills the food on you.
  - The server is distracted by another customer and doesn't hear or respond to your thanks.
  - You can't tell whether the server is a male or female and don't know whether to say 'Sir' or 'Ma'am'.
  - you see your girlfriend with some other guy entering the restaurant
  - He/she might not know the language
  - the food is not good
- ❖ eat your meal
- There is a hair or bug in the food
  - You turn over your drink into someone else's plate ruining their food.
  - you don't have a fork and knife
  - You don't know whether to eat your 'fries' with your fingers or with a fork.

- meet an old friend and he wants some conversation
  - a noisy crowd came into the restaurant
  - the food tastes bad
  - You pick up your fork and it is obviously dirty (metal) or plastic fork is broken.
  - the food is cold
  - food may fall on your clothes
  - you realize your friend's food hasn't arrived yet and you are not sure to eat or wait
  - The food seems different from what it said on the menu.
- ❖ Again, order if feel hungry/if required order for a second item
    - if you order again may take too long to deliver
    - You liked what you ate the first time but can't remember what it is called.
    - It could be hard to go through the process of ordering again
    - waiter tells you "Sorry Sir It's closing time now"
    - Order and then realize not as hungry
    - It could be hard to ask others if they want to order again too
- ❖ wipe hands and mouth with Napkin
    - Napkin got stuck in mouth
    - The smell of the napkin.
    - napkin slips from hand and falls to the floor
    - the napkin is already dirty
    - You and the person sitting next to you have placed your napkins in the same place and you are unsure which one is yours.
- ❖ wash hands
    - They could be out of soap
    - challenge of not understanding the soap dispenser and/or drying mechanism
    - The sink to wash hand could be broken (no water)
    - There are no paper towels
    - may spill water onto another patron due to awkwardness
    - You could have an allergic reaction to the soap.
    - I can't find the rest room where I can wash my hands.
    - Water was too hot I burnt my hands
    - hogging the wash basin by repetitive washing of hands
- ❖ Give a feedback about the food
    - it may lead to debate if we comment badly on food.
    - you liked the food very much, but people misunderstood you and accidentally offended that staff and the manager
    - you didn't like the food and you don't know what to say
    - I have no opinion about the food
- ❖ Ask for bill
    - we may have to wait for a while to get the bill.

- Waiter doesn't understand me
- and you accidentally hit someone passing through the aisle as you raise your arm to get the waiter's attention
- added extra amount for the item which we have not ordered
  
- ❖ Clear my table and get up
  - I may forget something on the table
  - I spill a beverage or food
  - I trip over my chair.
  
- ❖ Go to the counter to pay
  - I forgot to take the money to pay at counter.
  - no one is at the counter
  - there was a spill that is blocking the counter
  - As I am walking towards the order counter I stumble and fall on the floor
  - someone cuts in front of me in line
  - cashier has thick barely understandable accent
  - too many bright signs
  - uneasy to stand at counter for a long time
  - A friend or acquaintance could see you and stop you to chat.
  - the cashier is rude
  - the cash register breaks
  - you accidentally bumped someone and spilt his food
  
- ❖ Get in the back of the line/stand in the queue
  - may be a slow person in front
  - It could be hard to understand where the line ends/begins
  - it could be hard to be patient
  - it could be hard to understand the necessity of getting in the back of the line
  - You get in the wrong line.
  - you begin to want to get out of the line
  - The people in the line around you are noisy or smelly
  - The line doesn't seem to move at all.
  - I can't decide which line should I get in
  - You stand in the wrong place that's not really the back of the line
  - a person suddenly asks you if you are in line
  - someone runs into you
  - another line suddenly opens, and cashier looks at you as she says "NEXT"
  
- ❖ move forward in line
  - someone cuts in front of me in line
  - I see my old friend standing in front of me.
  
- ❖ observe others online
  - someone cuts in front of me in line
  - someone gets into an argument with the cashier

- It could be hard not to make remarks about people out loud and be considered impolite or rude
- people behind me shoving me/getting too close
- I get nervous from looking at people
- Someone gets offended I'm looking at them You get weird looks when people notice you are watching them
  
- ❖ Wait in line until you are in front
  - Someone in the wait line starts teasing and making fun of you while you wait.
  - Someone jumps in line ahead of you before you can pay
  
- ❖ greet employee/smile at hostess
  - Cashier is dirty/smells.
  - Cashier is ignoring me and is conversing with a non-customer.
  - Realize you forgot your money
  - You don't speak the same language/Cashier does not speak English well.
  - I don't have enough money
  - cashier wants change for your big note
  
- ❖ take my money out of my wallet/pay for my order
  - my credit/debit card is declined
  - I don't have enough money
  - the total is wrong
  - forgot my wallet in the car/at home
  - the note/bill I have is too large and won't be accepted
  - I'm distracted by the shiny floor and forget the amount the cashier said
  - the cash register breaks
  - I drop my money/change
  - my cash is damaged
  - the person behind me is standing too close
  - the cashier is rude/ignores me
  - I am feeling creepy and afraid the cashier thinks I am stupid because I have counted my money so many times
  - There is no money in wallet
  - You drop the wallet Coins or things in your wallet might fall out.
  - You might accidentally hit someone while reaching for your wallet.
  - Your wallet is missing.
  - others may observe the content of wallet
  
- ❖ Receive change
  - The change is dispensed automatically, and you don't notice
  - they have to ask for change and make me wait
  - the cash register breaks
  - The attendant coughs in front of me without covering her mouth.
  - they hand you the wrong change
  - I drop my money/change

- ❖ put my change away
- ❖ Walk to door
- ❖ Exit the restaurant/leave the restaurant
  - Meet someone you know and don't want to say hi.
  - Someone says 'hi' tries to start a conversation and you don't know how to reply.
  - Someone is entering or exiting at the same time.
  - A tray of mints is beside the door and you don't know if you can take one
  - A flood of people enters just as you are exiting separating you from your companions.
  - lost keys wallet or phone
  - people blocking the exit

# Appendix C: Scripts for social skill modelling videos

CROWDED RESTAURANT, NO QUIET TABLES: GRAB ATTENTION BY GESTURING WITH HAND

CHARACTERS

DINER (A Man or Women)

WAITER (A Man or Women)

TIME AND PLACE

A restaurant. The present.

*[When the play opens, the diner is looking around the restaurant to locate the waiter. When s/he spots the waiter, s/he follows the waiter with his/her eyes]*

*[The waiter is standing, scribbling in his order book. He then nods smiles and walks away. He casually looks at tables/diners. He looks and catches the diner looking at him]*

*[As the diner catches the waiter's attention, s/he waves their hand to show they are seeking waiter's attention]*

CROWDED RESTAURANT, NO QUIET TABLES: GRAB ATTENTION BY TRYING TO GET EYE CONTACT

CHARACTERS

DINER (A Man or Women)

WAITER (A Man or Women)

TIME AND PLACE

A restaurant. The present.

*[When the play opens, the diner is looking around the restaurant to locate the waiter. When s/he spots the waiter, s/he follows the waiter with his/her eyes]*

*[The waiter is standing, scribbling in his order book. He then nods smiles and walks away. He casually looks at tables/diners. He looks and catches the diner looking at him]*

*[As the diner catches the waiter's attention, s/he keeps eye contact with waiter in order to indicate s/he wants waiter's attention]*

CROWDED RESTAURANT, NO QUIET TABLES: GRAB ATTENTION BY GETTING IN LINE OF VISION

CHARACTERS

DINER (A Man or Women)

WAITER (A Man or Women)

TIME AND PLACE

A restaurant. The present.

*[When the play opens, the diner is looking around the restaurant to locate the waiter.]*

*[The waiter is standing a little further scribbling in his book]*

*[The diner locates the waiter but notices that it is his side. S/he moves a few steps towards the waiter so s/he can notice him.]*

*[The waiter finishes scribbling in the book and turns to walk in another direction but notices the diner (who has moved to get in the waiters line of vision) looking at him.]*

*[The diner keeps looking at the waiter]*

CROWDED RESTAURANT, NO QUIET TABLES: ASK THE WAITER IF S/HE CAN ACCOMMODATE YOU

CHARACTERS

DINER (A Man or Women)

WAITER (A Man or Women)

TIME AND PLACE

A restaurant. The present.

*[The waiter walks towards the Diner. When the waiter comes close to the Diner and is standing at about an arm's length away from the Diner, s/he stops. The Diner looks at the waiter to ensure that s/he is making eye contact and has quiet hands and feet (is not talking to someone else)]*

Diner: Hi.

Waiter: Evening Sir/Ma'am. How may I help you?

Diner: I am looking for a table for two.

Waiter: Sure Sir/Ma'am.

CROWDED RESTAURANT, NO QUIET TABLES: ORDER THE FOOD TO GO

CHARACTERS

DINER (A Man or Women)

WAITER (A Man or Women)

TIME AND PLACE

A restaurant. The present.

*[The waiter walks towards the Diner. When the waiter comes close to the Diner and is standing at about an arm's length away from the Diner, s/he stops. The Diner looks at the waiter to ensure that s/he is making eye contact and has quiet hands and feet (is not talking to someone else)]*

Diner: Hi.

Waiter: Evening Sir/Ma'am. How may I help you?

Diner: I wanted to know if you guys do take away orders?

Waiter: Sure Sir/Ma'am.

CROWDED RESTAURANT, NO QUIET TABLES: DECIDE TO GO TO A DIFFERENT RESTAURANT

CHARACTERS

DINER (A Man or Women)

WAITER (A Man or Women)

TIME AND PLACE

A restaurant. The present.

*[When the play opens, the diner is in a crowded restaurant and looking anxious.]*

*[The waiter sees the diner and starts walking towards him/her.]*

*[The diner sees the waiter walking towards him/her and quickly looks down to avoid eye contact. S/he is moving her/his hands in awkward pattern and thinking]*

*[As the waiter gets closer, the diner turns around and starts walking towards the door avoiding any contact from the waiter.]*

## SMALL TALK: ALLOW OTHERS TO INITIATE SMALL TALK

### CHARACTERS

DINER 1

DINER 2

### TIME AND PLACE

A restaurant. The present.

*[As the scene opens, DINER 1 and DINER 2 are sitting across the table in a restaurant and they are waiting for their order to arrive. They are both quiet.]*

*[Diner 1 decides to wait for Diner 2 to start a conversation.]*

*[Diner 1 knows the basics of successful interaction with others start with non-verbal communication. S/he attempts to show welcoming look by making sure they are facing Diner 2. S/he adopts the listening position by looking towards Diner 2's eyes, maintaining quiet hands and feet (staying still) and a quiet mouth.]*

## SMALL TALK: INITIATE A CONVERSATION WITH OTHER(S)

### CHARACTERS

DINER 1

DINER 2

### TIME AND PLACE

A restaurant. The present.

*[As the scene opens, DINER 1 and DINER 2 are sitting across the table in a restaurant and they are waiting for their order to arrive. They are both quiet. This is the first time Diner 1 and Diner 2 have met.]*

*[Diner 1 decides to start a conversation with Diner 2.]*

*[Diner 1 knows the basics of successful interaction with others start with non-verbal communication. Diner 1 looks for signs of welcoming look from Diner 2 by observing whether Diner 2 is facing him/her.]*

*[Diner 2 is looking at Diner 1. S/he is maintaining eye contact with Diner 1 and has quiet hands and feet and quiet mouth. Diner 1 knows that this represents the listening position and starts a conversation.]*

Diner 1: How are you?

Diner 2: I am well, thank you. How about yourself?

*[Diner 1 understands that in order to start a conversation with someone you don't know it is a good idea to start with something that s/he has in common with the other person. In this case they are both at a restaurant to eat.]*

Diner 1: I am good thank you. *[Pause]* So have you been to this restaurant before?

*[Diner 1 listens attentively by maintaining eye contact and waiting for a pause before talking further.]*

Diner 2: Actually, I have. I last came here 2 weeks ago with my mum.

*[Diner 1 thinks about follow up questions. Follow up questions can be Who, What, Where, When, Why or How questions that are relevant to the topic that is being discussed.]*

Diner 1: Oh, that sounds fun. What is your favourite

## SMALL TALK: INITIATE A CONVERSATION WITH OTHER(S)

### CHARACTERS

DINER 1

DINER 2

### TIME AND PLACE

A restaurant. The present.

*[As the scene opens, DINER 1 and DINER 2 are sitting across the table in a restaurant and they are waiting for their order to arrive. They are both quiet. Diner 1 and Diner 2 have met before.]*

*[Diner 1 decides to start a conversation with Diner 2.]*

*[Diner 1 knows the basics of successful interaction with others start with non-verbal communication. Diner 1 looks for signs of welcoming look from Diner 2 by observing whether Diner 2 is facing him/her.]*

*[Diner 2 is looking at Diner 1. S/he is maintaining eye contact with Diner 1 and has quiet hands and feet and quiet mouth. Diner 1 knows that this represents the listening position and starts a conversation.]*

Diner 1: How are you?

Diner 2: I am well, thank you. How about yourself?

*[Diner 1 understands that in order to engage in a conversation with someone you know, you can ask about the past, the present, the future and the person's interests.]*

Diner 1: I am good thank you. *[Pause]*How was your day?

*[Diner 1 listens attentively by maintaining eye contact and waiting for a pause before talking further.]*

Diner 2: It has been tiring but good. *[Pause]* How about yours?

*[Diner 1 thinks about follow up questions. Follow up questions can be Who, What, Where, When, Why or How questions that are relevant to the topic that is being discussed.]*

Diner 1: Mine was busy. What did you do?

SMALL TALK: INITIATE A CONVERSATION WITH OTHER(S)

CHARACTERS

DINER 1

DINER 2

TIME AND PLACE

A restaurant. The present.

*[As the scene opens, DINER 1 and DINER 2 are sitting across the table in a restaurant and they are waiting for their order to arrive. They are both quiet.]*

*[Diner 1 wants to avoid talking to Diner 2]*

*[Diner 2 looks at Diner 1]*

*[Diner 1 turns his/her side to Diner 2 and avoids looking at Diner 2.]*

*[Diner 2 wants to talk to Diner 1]*

Diner 2: How are you?

*[Diner 1 briefly looks at Diner 2 then turns away. And takes out his/her mobile phone/picks up the menu and ignores Diner 2]*

*[Diner 2 observes that Diner 1 is not interested in talking to him/her and looks confused and embarrassed.]*

## **Appendix D: Social scenario draft**

Three Scenarios were created as a result of the participant study and discussion. One scenario is centred mainly on Physical Environment obstacles and the other is centred mainly on Social Environment with Group, the third scenario is generic with obstacles from a number of different Environments.

### **Characters:**

Julie is a 24 years old beautiful and vibrant female with Asperger's Syndrome. She is a student at the Polytechnic studying language. She is very bright and is hypersensitive to sound, lights and has social phobia. For those who are unaware of her diagnosis, she appears to be shy, aloof and somewhat weird as she maintains little to no eye contact with new people. However, she wants to make friends and wants to be able to socialise with others. Although she has social phobia, she can maintain a verbal conversation and is witty.

Ryan is a 29 years old male who is diagnosed with Asperger's Syndrome. He is studying Maths at his local university. He has a very high IQ and is doing well at his studies. However, he has poor communication skills hence struggles with making friends. His classmates find him weird as he tends to stare and make comments unrelated to conversations. He wants to make friends and be able to maintain a good conversation.

Anna is 24 years old Neuro-Typical (NT) female and has known Julie since primary school. Anna knows about Julie's diagnosis and is trying to help Julie socialise.

Julie has met Ryan through a group for young adults with Asperger's Syndrome and their friends and supporters.

### **Scenario 1:**

Anna and Julie are meant to meet for dinner at a restaurant. They were meant to meet at 6pm. As an Aspie, Julie arrives on time at the restaurant. Anna on the other hand is stuck in traffic jam. When Julie arrives at the restaurant, she enters through the door and finds that the restaurant is really busy (a lot of people in the restaurant). She receives a text from Anna saying she is running late due to traffic. Julie is horrified by the situation and social anxiety creeps in. Just when she is thinking of leaving she receives another text from Anna (who is aware of the possibility of Julie leaving) saying that she will shout (pay for the meal) Julie and watch her favourite movie with her if Julie has found them a table by the time Anna arrives. Julie loves the “Seafood Delight platter” that the restaurant serves but usually cannot afford it. She also thinks about watching “the Notebook” with Anna afterwards as she loves the movie and can never watch it enough while Anna is sick of it and refuses to watch it again. She thinks about Anna’s text and has to make a decision. She is rather hungry as well, so she decides to take Anna’s offer.

While she is waiting and deciding, the host/waiter comes and asks her if she wishes to be seated. She looks around and notices there are no quiet tables so she asks him if she could be seated in a quiet table. He politely says “sure, this way ma’am” and guides her by leading her to a quiet table. She is seated and he hands her the menu on the table. She tells the waiter she is expecting her friend soon. He leaves.

Just as she opens the menu, she realises they have changed the menu. The food has unusual names that she doesn’t understand, and it does not display prices. This leads her to get nervous as she doesn’t know what the prices are. While she is thinking about the menu, she looks up and sees Anna walk through the door. Her face lightens up and she waves to show Anna where she is seated. Anna comes and joins her. She greets her with a hug. Anna starts off by apologising and then explaining why she is late, and she thanks Julie for her patience.

Julie then informs Anna about the Menu problem and Anna tells her not to worry as Anna got her pay today and she is paying for the food. Julie is reassured but tells Anna how this is a bad idea to

change the menu and especially not to display prices. Together they decide to inform the waiter about the menu and to sort out the price issue. While they are still discussing, the waiter comes to take the order. Anna ate in the restaurant last week and she loved their “Meat magic platter” so she quickly places her order.

Julie starts looking at the menu and cannot decide what to order (or what the new name for Seafood delight platter may be). She is looking at the menu and notices that both the waiter and Anna are looking at her. She feels pressured to place her order but is unsure about what to order. Anna reads her nervousness and asks if Julie would like the waiter to come back later. Julie likes the sound of that and says, “yes please, could you come later, I am still deciding”.

Julie goes over the menu and there is a “Seafood grille platter”. She asks Anna if that might be the new name for “Seafood delight platter” and Anna suggests asking the waiter. Julie raises her hand to get the waiters attention. The waiter comes and asks if she is ready to order. She says she wanted to know if the “seafood grille platter” is the new name for “seafood delight platter”, the waiter tells her that yes, it is the new name for it and she orders it. The waiter takes the order and leaves.

A really noisy group comes and sits close to their table. Anna is telling Julie about how her day went but Julie can barely hear her and concentrate on what she is saying. The loud music in the background isn't helping as well. This distresses Julie and she tells Anna that she is getting unhappy with all the noise. Anna then asks what Julie would like to do and together they decide to talk to the waiter. Again, Julie calls the waiter. The waiter is busy, so she has to wait. After a bit of waiting the waiter comes and asks what the matter is. Julie informs him that the music is loud and that the people on the other table are very loud and this is causing her distress. He apologises and goes over to the other table and requests them to speak slowly. He then turns the music down and it helps.

Now she can hear Anna and they talk about their day. Anna's food arrives first, and Anna isn't sure whether to wait or eat. Julie notices Anna's hesitance in eating and asks if everything is ok. Anna tells her that she will wait for Julie's food to arrive as well. Julie tells her not to wait as the

food will get cold and Anna starts eating. Julie drinks a glass of water while waiting. The waiter brings her food as well. She “thanks him” and starts eating her food.

Julie’s food tastes different but she likes it. She mentions to Anna that it is not the exact same dish, but it is nice. They both finish their meals. The waiter clears their table. He asks if they want anything else. Julie says no and tells Anna that she wants to go home. Anna requests the waiter to bring the Bill. The waiter brings the Bill and leaves. Anna tells Julie they will go and pay for the food. They get in the line and Julie watches others. The person standing behind them is getting really close and she is getting uncomfortable. She turns around and politely tells him “could you please keep your distance.” He apologizes and she thanks him. They get to the head of the line and Anna pays the Bill. They thank the host and walk out of the restaurant.

## Scenario 2:

Ryan comes home from university and finds that there is no food in the fridge. He has been eating Pizza for the past few days and is getting sick of it. There is a restaurant close to his flat and he decides to go there and eat. He just got his scholarship approved not long ago and he wants to treat himself. He walks to the restaurant and finds that the restaurant is very crowded. He thinks about leaving but realises he is hungry and the food smells good. He decides to stay.

The host/waiter comes and greets him and asks if he would like to sit. He asks for a table. The waiter takes him to a table and seats him. He hands him the menu and leaves.

There are 2 girls sitting on the adjacent table and they are talking. He wants to join their conversation and decides to listen to them. He remembers that the best way to start a conversation with someone new is to keep some eye contact (a couple of gazes do not stare) and then to listen to their conversation and see if there is a common topic of interest. While looking at the menu he looks at them and then looks back at the menu (using the menu as a prop). He can see that one of the girls have ordered rice dish which smells and looks good. He loves rice. He tries to find the rice dish on the menu and finds there are 2 Rice dishes. The girls have started to notice him and will casually look back at him. When he sees them looking at him, he smiles and waits for their reaction. The girl smiles back at him. Now he gets up and start walking closer to their table. When they see him coming, they stop talking and look at him. He is nervous so he politely asks, "Excuse me, your food looks good, it is my first time here and I was wondering which rice dish this is". The girl tells him it's the "Curried Rice Platter". He then asks "is it nice? I mean I really like rice, but I am new here". She says "yes, it is delicious, and you should try it". He then assesses if they are interested in him by asking himself "are they talking to me? Are they facing me or giving me the cold shoulder? And are the looking at me?" he uses these to assist him to decide if they might be interested in talking to him.

Just as he is doing an assessment, another person goes and sits at his table. He gets nervous and one of the girls tells him "you can sit with us if you want". He says, "thank you I appreciate your

kindness” and sits with them. He can see that they are interested in talking to him. So, he decides to continue the conversation by asking what food they like since they are at a restaurant. The conversation starts and they reply and then ask him about his favourite food. He then says, “sorry I should probably introduce myself, my name is Ryan and I am studying Maths at the University”. He then turns to one of the girls and asks, “what is your name?” She says, “my name is Paula, I am also at the University, and this is Jen, she is my friend from the university!” There is silence after that and Ryan gathers his thoughts to ask the next relevant question, he then asks, “what are you guys studying?” Paula says, “I am doing Psychology” and Jen adds “I am a linguistics student”. The waiter comes to get Ryan’s order and he order the rice dish that Paula had suggested.

Ryan wants to keep the conversation going and adds “My mum is a Psychologist too”, Paula says “Oh wow! That is so cool! Is she working?” Ryan adds “Yea she is! She is usually really busy too” and smiles. He then asks Jen “are you enjoying your study?” Jen replies with “No way! It’s a grilling machine!” Ryan doesn’t grasp that it was a joke but when he sees that both Jen and Paula are laughing, he realises it was a Joke and smiles nervously. He struggles with small talk, so he decides to wait for a bit and see if they want to ask any questions. Jen turns to Paula and says “it is so cool we just met a mathematician at the restaurant! Can you believe it!” Paula says, “Yep Ryan you are cool!”

Ryan starts to feel more comfortable and adds “I like maths! I have always loved numbers and I especially like the ‘Euclid's proof of the infinitude of primes’!” He looks at Paula and Jen and realises their faces have gone blank. He realises he is going off topic and making comments unrelated to the conversation. He gets nervous and decides to smile it off. They both laugh and say, “whatever that was!” The waiter comes and brings his food. He thanks the waiter. He starts eating his food. Jen and Paula start talking about their weekend party. Ryan smiles causally while eating his food. Ryan has never been to a party before and doesn’t know about them, so he decides to just listen politely and eat his meal. The girls finish talking about the party and there is a pause in the conversation. Ryan takes this opportunity to thank Paula for suggesting the rice meal. He says “This is really nice! Thank you for suggesting it”. Paula says no worries. The waiter clears Paula and Jens dishes and brings them their bill. They say, “Ok Ryan nice to meet you enjoy your meal we are going to go now”. Ryan says “Nice to meet you too. Thank you for letting me on your

table and for the friendly conversation”. They say “the pleasure was ours. Catch you later” and Ryan says bye to them as they leave and enjoy his meal.

At the end of the meal, the waiter comes to clear his dishes; he asks for the bill and waits. The waiter brings his Bill. He thanks the waiter for the delicious food and gets up to pay the Bill. He can't tell where the line begins and ends. He politely asks the person standing in line where the line for payment is. The other patron directs him to the payment counter, and he goes there to pay the Bill. He gets at the end of the line. There is no one at the counter. He sees a bell on the counter and a message saying, “Please ring bell for assistance”. He rings the bell and the cashier comes. The cashier is rude and talking to someone on his mobile phone and ignores Ryan. Ryan waits for him to finish talking and says, “Could I pay this please”. The cashier says, “Sorry about the delay, sure sir you can”. Ryan pays the Bill. He gets the Pin wrong and his card is declined. The Cashier says, “I am sorry sir but that didn't go through”. Ryan asks to try again, and it goes through the second time. Ryan thanks the cashier and walks out of the restaurant.

## Appendix E: Game prototype expert review

### - Start Up Menu User Interface:



Figure a: Screen shot of the Start Up Menu. 1

At the start of the study, no instructions were given to user about the controls for navigating and the reviewer relied on verbal instructions from the researcher. This was evident from the reviewer's comment "Am I navigating with Keyboard at this point?". Providing on-screen instructions at the start of the game was proposed to benefit the player and avoid any ambiguity.

The narrative was not very explicit at the beginning as it started with the statement 'So you have heard...' to which the reviewer commented "I read this text naturally other way around; 'So have you heard' but that seems like slightly more natural phrasing but I think either way it is a question and it needs a question mark at the end."

The buttons did not provide any graphical or written feedback to the user, therefore there was no differentiation between inactive and active objects, i.e., buttons or text display. The active objects, i.e., buttons, did not provide information about its functionality. The reviewer commented "I am not sure what  button means as this is the first screen. That  button feels like its Back as well...I am confused by both...The  kind of feels like it is a duplicate of . It is not

clear what each button does here. There is no feedback to tell me I am in the target area; standard web design changes mouse cursor to hand when over an active area...”.

The active objects were divided in two sets. The objects next to the text display were related to text display: refresh  and move to next text . The objects at the bottom were related to the entire scene where the  button allowed the player to skip the narrative and move into the environment and the  button took the player to the ‘Log In’ which was implemented then. None the less, due to lack of assistive information in the game this was not clear to the user hence there was confusion over its functionality. The reviewer commented on this design approach “...if they are completely different [then] it doesn’t make sense that they are in completely different place rather than next to other active things. If it is supposed to do something, [then] it should give some feedback”. The study reported that the active object design lacked consistency as the text display objects used modern design approach with icons and the scene objects used text representation. The reviewer concluded “these don’t really fit in the graphical sensibility of these two [referring to text display buttons]”.

The colour choice and the menu design did not appear to be relevant to the restaurant theme as shown in the reviewer’s comment “Blue colour is not a common colour for menus unless if it is a seafood restaurant...the design around the edge seems like it is complicated, busy edging thing...you have a similar style of edging on the buttons and this almost feels like it is a mistake... where the decoration overlaps, it looks odd”. Furthermore, reviewer suggested precise and refined edging to make it look neater.

The typography varied between the narrative and the button’s text. The buttons used a combination of Italics and Bold and the reviewer suggested that it is not an ideal combination for button text. The font selection was clear to read however it did not “convey restaurant-ness” as suggested by the reviewer.

In conclusion, there was little consistency and continuity in the design choice of the Menu Interface. It did not explicitly convey the restaurant theme nor did it provide feedback to the user. The study suggested implementation of restaurant themed, precise and refined interface that provides dynamic feedback to the user.

#### **- In Scene User Experience:**

Instruction on the navigation tools for maneuvering in the environment were not provided inside the environment instead they were verbally given by the researcher at the start of the study. Navigation tools used were WASD for moving forward, left, backward and right. For looking around the mouse rotation was used. However, the need for explicit instructions in the environment was identified.

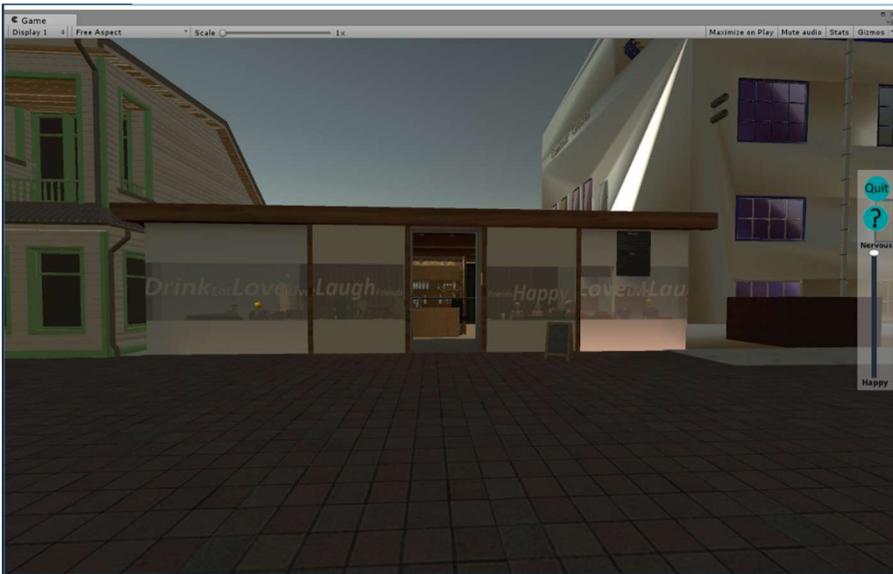


Figure b: Screenshot of screen upon entering.

The mouse was used for both rotation and interacting with active objects in the environment thus the reviewer struggled to interact smoothly with active objects as mouse movement towards the active object resulted in manipulation of the player's view and would rotate the player away from the desired position. This significantly impacted the player's interaction with the greeter/waiter as the player's attempt to respond to the greeter/waiter's questions through the buttons would turn the player away from the greeter/waiter.

The control bar on screen consisted of 3 options: Quit, Question mark and Nervous-Happy scale. The Quit button was activated via mouse press, however, the reviewer suggested that the user could benefit from alternative interaction option, i.e., "Q" key press for Quit.

The Question mark graphic was not very clear as the dot at the bottom and the line seem to merge into each other. It had different typography from the previous window. A clearer question mark

graphic would help those with challenged sight and consistent typography would contribute to sense of continuity in the environment. The reviewer recommended “the sense of continuity could be slightly reinforced by these texts and colours and type phases”.

The transparency of the control bar background made it difficult for the reviewer to read the text of the Nervous-Happy scale. There was no indication of the mode of interaction with the scale. By default, it sets the player into nervous mood and the scale places Nervous at the top of the scale but the reviewer suggested that happy is the positive thing therefore by default user should be placed on the positive scale not negative. The reviewer commented that “positive is better than negative and usually better things on scales are associated with the top of the scale” therefore suggesting that the scale should be inverted.

The sound icon did not provide feedback on its functionality or interactivity. The music and restaurant people chatter sound was audible from outside the restaurant that should not have been the case as the sound should stay within the restaurant. The reviewer commented on the ability for user to control audio via keyboard.

The restaurant architecture intersected with its neighbouring building and the reviewer pointed out that “a piece of bad architecture... it could irritate people”. There was no clear indication of the restaurant name which is unrealistic.

While moving in the environment, there was a glitch in the graphics. When the player reached the restaurant, hint popped up. The reviewer commented on importance of integrating the visual elements hence the use of consistent typography.

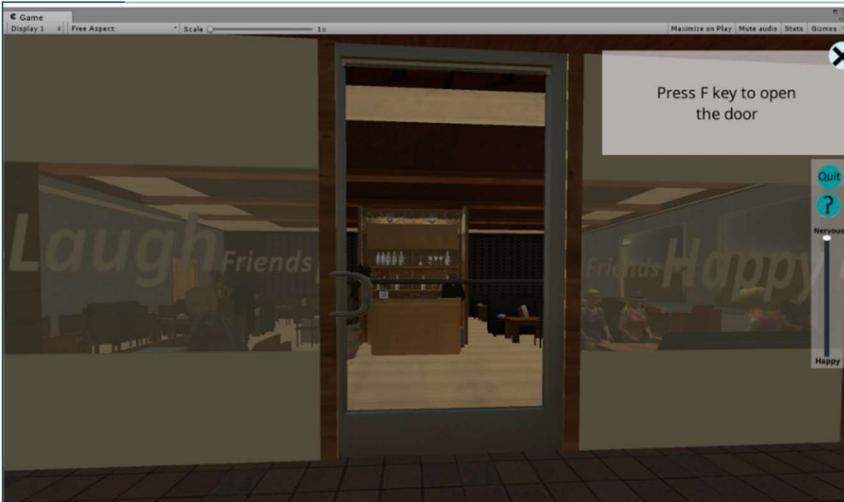


Figure c: Screenshot of user near the restaurant

The instructions advised user to press “F” key to open the door. The reviewer suggested the use of more relevant Key codes, i.e., “O” for Open door etc. The reviewer waited outside the restaurant and the help instructions for interacting with the greeter/waiter popped up. These hints were made to appear for 10 seconds and then disappear to avoid causing distraction.

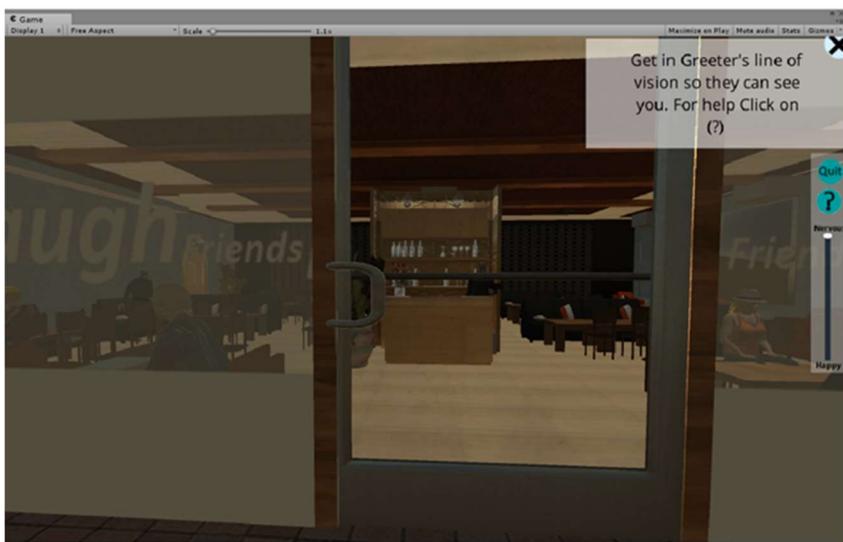


Figure d: Screenshot of instructions on interacting with the greeter/waiter.

The instruction of how to open the door only appeared once in the scene, further reminders would be valuable for user.



Figure e: Screenshot of user inside the restaurant.

Upon entering the restaurant, the reviewer was hoping to get the instructions again however they did not appear. The help button was used but it did not produce any results. The reviewer decided to use general knowledge and approach the greeter.

The interaction commenced between the greeter and the player, however, when the reviewer tried to respond from the available options, the mouse movement towards the buttons rotated the user away from the greeter's view which is unrealistic and rude in real life circumstances.

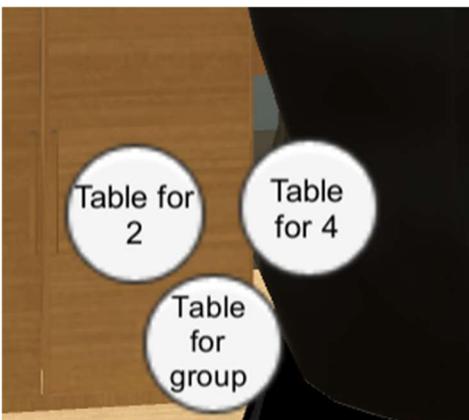


Figure f: Screenshot of buttons displayed

The reviewer suggested that the bottom button was not centred. For the table option, the formatting appeared inconsistent. The “Table for 2” ‘T’ and ‘r’ are pushed to the corners which the reviewer said “...looks odd”.

When the reviewer attempted to respond to button, he turned away from the waiter “In order to answer this question I have to rotate so I am no longer looking at this person which feels weird”. At this point it became apparent that the player’s rotation and responding to buttons both through the mouse control was not a good idea as it negatively affected the gameplay.

When the player moves forward, there is flickering graphics on screen which the reviewer said were irritating.

When the player reaches the seat, there are no instructions provided for the user on how to sit. The Help button also failed at this point and did not produce any instructions. The reviewer was provided with verbal instruction. The instruction for sitting down was using the ‘Space’ key. The reviewer commented that ‘C’ for chair or ‘S’ for sit would have been better options for sitting instead of ‘Space’. When the player sat down, he was not looking straight ahead “... I feel like I am at a skewed angle rather than kind of looking directly ahead.” The player was able to rotate unrealistically (360 degrees) within the chair when seated.

## Appendix F: Confidence bar survey

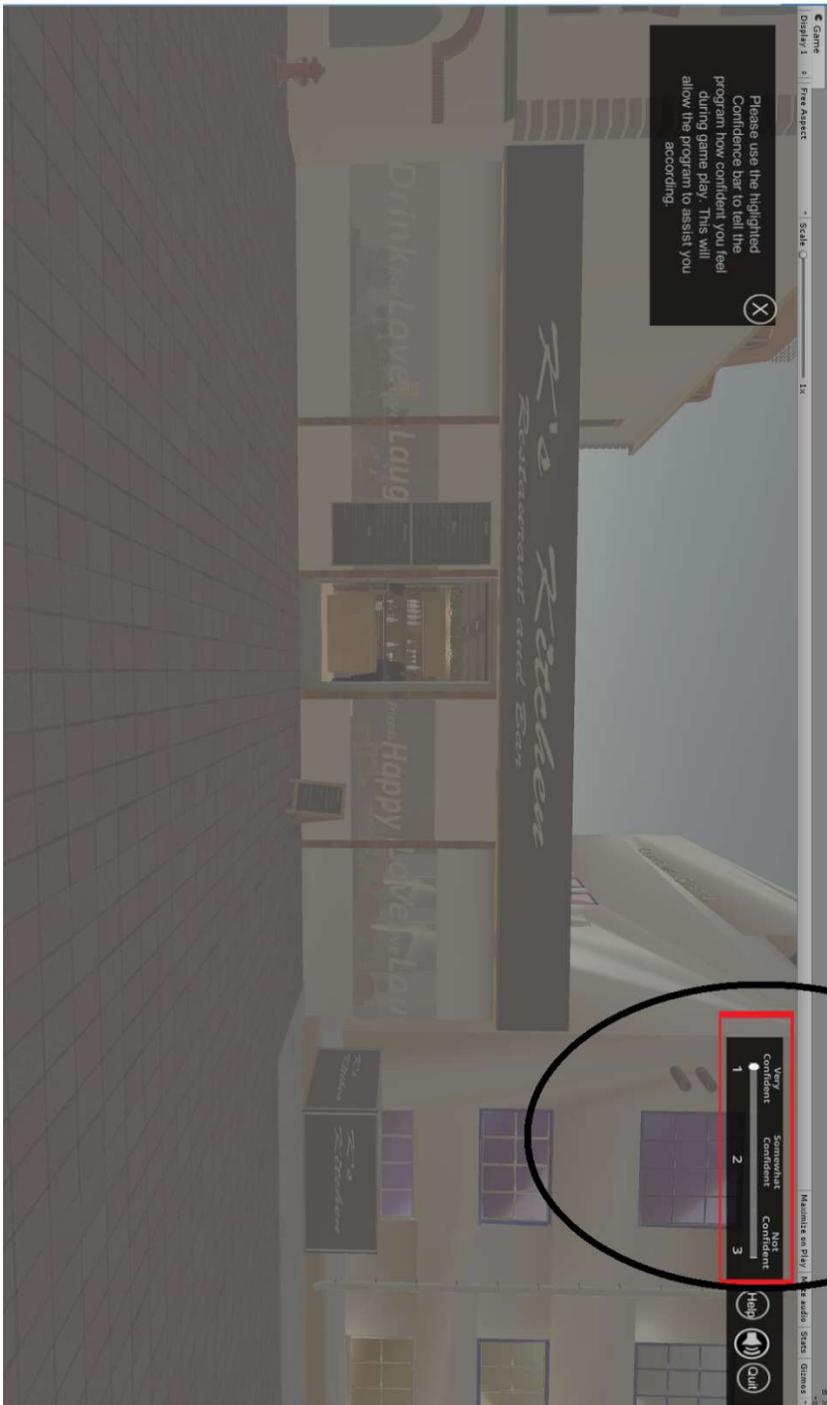
My name is Khadija Bahiss and I am a PhD student at the Computer Science department at the University of Waikato. I am working on social skill training simulator using restaurant experience. I am currently at the Interface design stage and am considering using a Confidence bar. This study will allow me to decide whether using a Confidence bar inside the social skill training game will benefit the game user. The Confidence bar allows the game user to communicate their level of confidence during gameplay. This information is vital for me to decide whether to use the Confidence bar in the simulation or not. I want to find out if you consider Confidence bar to be an effective tool of communication with the system. Please refer to the screen shot of the game attached on the next page for reference in completing the survey.

Please read all the question before answering. Please circle with a pen the response that is most relevant to you:

1. Do you know about the Likert scale? Yes  
No
2. If No, please go to Question 6.
3. If Yes, have you ever used it? Yes No
4. If you have used it, do you remember what it was for?  
Please give details here:
5. Did you find it useful and easy to use? Yes  
No
6. Do you think the highlighted confidence bar in the given picture will  
be useful in expressing your confidence level during Gameplay? Yes  
No
7. Will you be comfortable with using the given Confidence bar? Yes  
No

Thank you very much for taking time out to complete this survey. I appreciate your help ☺

Snap shot of program with the Confidence Bar introduction.



Confidence Bar during GamePlay

The 3 variations:

1: Very Confident

2: Somewhat Confident

3: Not Confident

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THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

19 June 2019

Khadija Bahiss  
c/- Department of Computer Science  
THE UNIVERSITY OF WAIKATO

Dear Khadija

**Request for approval to conduct a user study with human participants**

On the basis of the information you have provided on the SCMS Preliminary Ethics Application Form relating to your research "Serious game to provide social skills training for people with Asperger Syndrome/High-functioning Autism", the committee has given you approval to proceed with your proposed study.

We wish you well with your research.

A handwritten signature in black ink, appearing to read 'Nic Vanderschantz', followed by a horizontal line.

**Nic Vanderschantz**  
Human Research Ethics Committee  
School of Computing and Mathematical Sciences

# **Appendix G: Game instruction scripts**

## **Introduction Text**

The control Bar consists of a number of elements that are designed to provide assistance and feedback during gameplay. The 4 stars at the top show your progress. Each star is assigned to a social skill. At the start all 4 are white. On successful completion of a skill the white star will be replaced with golden star.

The confidence Bar is designed to allow you to reflect on how confident you feel during gameplay. It is your way of providing feedback to the system.

The Skip button allows you to advance to the next step.

The Audio button allows you to turn off or turn on the background noise.

The Quit button allows you to Exit the Game.

## **Introduce Vision**

"The hollow coloured circle is a representation of your visual focus (shows where you are looking) during gameplay."

"The visual focus changes colour to green when successful eye contact is established with the other person."

"The visual focus changes colour to Red when you get too close to the other person."

## **Crowded Restaurant Script**

Well done! You made it inside the restaurant. The next step is to interact with the greeter. Before you do that let us look at Interacting with another person. Interacting with anyone consists of 2 major steps: First: Getting the other person's attention. Second: Interacting or talking to them. The program will now proceed to the training, instructions followed by social skill modelling videosing for each behaviour.

Getting in the Line of vision of the other person so they can see you, you may need to move to a closer and clear view area of the other person.

Sometimes you may be required to use your body language to get the other person to notice you. For example: you may need to wave at them

Once you are in their view, make eye contact by focusing your attention on their eyes and maintain the eye contact. You do not have to stare at them for long periods after they have seen you and started walking towards you. At this point it is OK to look around a bit. However, continuing to maintain eye contact is the key.

Before you interact or talk with someone, you must make sure you are standing at a reasonable distance from the other person. Reasonable means you are not so close to them that you make them feel uncomfortable and at the same time you are not so far from them that you both cannot hear each other. The best distance from someone we interact with is at least one arm's length.

Once you are at an appropriate distance you can ask them a question. In this case you may ask the greeter to find you a seat. If they ask you a question first that is perfectly fine as well. You just answer their question. When you speak, your voice should neither be too loud to disturb other people around you nor should it be so quiet that the other person struggles to hear you.

If you look away, turn away fully or walk away it gives the other person the signal that you are no longer interested in talking to them. Therefore, make sure you maintain eye contact. Let us see what happens when someone breaks eye contact.

## **Crowded Restaurant Audios**

Welcome to K's Kitchen, do you have a reservation.

- Yes, I have a booking at 7
  - Yes, we are expecting you, please follow me.
- No I don't, I am sorry

- How many people are in your group?
  - 2, I am expecting a friend. (respond at Speak Now Button click)
  - Yes, we have a table for 2, please follow me.
- Pardon Me  
(Repeat audio)

Please follow me to your seat.

Here is your table. Please take a seat.

- Thank you

Dialogue box. "Press Space button to sit"

I am Anna, I will be serving you tonight, your menu is on the table. Our special for tonight is crusty cheese croutons, served with vegetable soup and salsa verde

Are you ready to order, or would you like me to come back

We are still deciding, could we have a few more minutes please

Certainly, I will be back soon.

## **Small Talk Script**

The important communication skills that will be covered are:

Eye contact,

Initiating/starting conversation,

Maintaining conversation,

Ending conversation.

You were introduced to using Eye contact with another person.

Successful eye contact involved the following steps:

-Getting in the line of vision of the other person

- Looking at the other person and waiting for them to see you
- If required waving at the other person to get their attention
- Maintaining eye contact to show interest.

Now let's practice making eye- contact with the person who is speaking. Use Arrow keys to look around as needed.

### **Dialogues:**

Friend: Hello there

Player: Oh hi, I was waiting for you, come sit down.

Friend: Cheers, how are you doing?

Greeter: Would you like something to drink?

Friend: I think I will go for an orange juice please

Greeter: Yes Ma'am, What about you sir? Would you like something to drink?

Player: Can I have some water Please

Greeter: Certainly.

Well done! you successfully practiced eye contact. Now we will learn about engaging in Small talk.

Engaging in small talk consists of:

- Starting/Initiating Conversation
- Maintaining conversation
- Ending Conversation

### **Start/initiate conversation:**

If the other person has not already started, then you can start a conversation by asking questions. Questions are important in communication. They are used for: finding out about the other person; showing interest; showing the speaker that you are listening therefore encouraging the speaker to continue talking to you.

The questions you can ask someone you know might be from any of the following categories:

Past: How was ...? e.g., your weekend, your drive, etc.

Present: What are you ...? e.g., eating, reading, drinking etc.

Future: What are you planning for...? e.g., this weekend, in holidays etc.

Interest: How is...? e.g., your family, your new video game, your job, etc.

Common Interest: What are your ...? e.g., hobbies, favourite movie, favourite food etc.

A good question is one that is directly relevant to you and the other person. In this case, you could ask questions about the restaurant, the food, the drinks, the order etc.

Now let's look at some video examples of starting or initiating conversation.

Let us practice Starting/initiating conversation. In this case, you are at the restaurant to dine with your friend Alicia. Alicia is a 22-year-old female and you first met her 2 years ago through your cousin. Alicia is neurotypical and shares several interests with you. You both like trains and have previously had a few conversations around the three engine types: electric, diesel and steam. Alicia is your friend now. Today you have met at the restaurant to have dinner together. Alicia has not started a conversation, so you want to start a conversation. Remember before you begin speaking, you need to make eye contact with the other person.

From the list below, please select the best topic for STARTING a conversation in the 'Best option' column and the worst topic for initiating/starting conversation in the 'Worst Option' column. Please read all the options before making a selection. The program doesn't allow you to change your choice once you have made it.

Best  
Option

Worst  
Option

Ask Alicia how she is

Ask Alicia if she has dined/eaten in this restaurant before

Ask Alicia if she saw the documentary last night about Electric trains on TV 3

Tell Alicia about the improvements in Electric trains as per the documentary

### **Dialogues:**

Player: How are you?

Friend: I am well, thank you. How about you?

Player: Have you eaten here before?

Player: Did you see the documentary last night about Electric trains on TV3?

Player: Did you know the electric trains have all kinds of gadgets now for passengers to use.

[Option 1 and Option 2 are the best responses, and Option 4 is the worst response for this example. If the player selects either Option 1 or Option 2 as best and Option 4 as worst, then they will be taken to the next step]

At the end of the quiz, an explanation of the appropriateness of each option will be given to the player.

Let us now review the options:

Option 1 is the best option as it is a safe conversation starter. It makes the listener feel that you are interested in them and want to hear more about them.

Option 2 is a good way to open conversation about the restaurant and food in the restaurant. As we are inside a restaurant, this is a good conversation starter. It gives the other person the impression that you are interested and value their opinion.

Option 3 revolves around your common interest with the other person, however, since we are in a restaurant, it is not relevant to our experience in a restaurant therefore it is not best option for initiating/starting conversation.

Option 4 is the worst option. Although it is one of the common interests between you and the other person. It is irrelevant, and it does not involve the other person as you are giving information that the other person may not be interested in at that moment. This gives the other person the impression that you are not interested in them or their opinion, as your conversation is about your own interest.

Best conversation starters are those that involve the other person and their views/experiences and are relevant to your surroundings.

Now let's practice making eye contact followed by starting a conversation.

-----

Now that you have started a conversation with the other person, and you have practiced it we will discuss how to maintain conversation. Maintaining a conversation consists of 3 major steps:

- Adopting the listening position
- Showing an interest in what other is saying
- Turn taking during conversation

### **Listening position:**

Listening position is important as it is the body's way of telling the other person that you are interested in talking to them. Listening position consists of:

- Sitting/Standing at an acceptable distance from the other person (an arm's length)
- Facing our vision towards them and making eye contact, good posture is very important
- Sitting still: Maintaining quiet hands and feet, so no fiddling around with other things or looking away (sometimes we don't know we are fiddling therefore we need to practice the listening position).

Let us look at a video showing the listening position:

[Plays video]

Let us practice listening position. At the start of this training, you will find yourself looking away from the friend. You are required to make and maintain eye contact with Alicia, practice good posture. When you have made eye contact with Alicia, you will notice a timer appear on screen. Practice maintaining quiet hands and feet, this means no fiddling with anything. You should maintain this position until the timer hits [0].

-----

While you are in the listening position, you have to show interest in what the other person is saying. You can show interest by:

-Verbal fillers, e.g., 'yes', 'mm', 'aha'

-Smiling

-Nodding

These indicate to the other person that you are interested in what they are saying, you like and respect them, and you want to know more.

Let us familiarise ourselves with showing interest. Let us assume that you started the conversation by asking Alicia if she has dined/eaten in this restaurant before. Alicia's response is:

"Yes, actually I came here last weekend with Mum. Their food is absolutely amazing."

What is the best thing and the worst thing for you to do while Alicia is speaking. Please choose the Best Option and Worst Option in the list.

Best  
Option

Worst  
Option

Stare at Alicia and fiddle with your phone

Look around for the greeter/waiter

Look at Alicia as she speaks and Nod

Look at Alicia, maintain quiet hands and feet and Nod. Smile at the end.

[Options 3 and 4 are the best responses, and Option 2 is the worst response for this example. If the player selects either Option 3 or Option 4 as best and Option 2 as worst, then they will be taken to the next step]

At the end of the quiz, an explanation of the appropriateness of each option will be given to the player.

Let us now review the options:

Option 1 is not the best option because staring is not good eye contact. It makes the other person feel uncomfortable. Quiet hands and feet are important for showing interest in the other speaker. Fiddling with anything while someone is speaking to you gives the other person the impression that you are not interested in their conversation.

Option 2 is the worst option from the given options as it cancels eye contact which is very important for showing interest in the speaker and conversation. Once a conversation has started it is important that you look at the speaker when the speaker speaks.

Option 3 is a good option as it uses both eye contact with the speaker and non-verbal filler 'nodding' which tells the other person that you are interested in them and their conversation.

Option 4 is the best option as it uses eye contact, listening position and non-verbal fillers ‘nodding’ and ‘smiling’. This tells the speaker that you are attentive to their conversation and interested in what they have to say.

---

## **Turn taking:**

Turn-taking is an important part of successful conversation. Normally, people take turns at speaking and listening. When the other person is talking, it is our turn to listen and show interest. When they finish talking, then it is our turn to talk. We know that it is our turn to talk when the other person finishes their sentence, pauses and looks at us/maintains Eye contact. It is important with turn taking that we do not talk too much or too little as that can bring conversation to a halt.

Let us look at a video of what turn taking looks like.

Now we will practice turn-taking. During this training you are required to decide when is appropriate for you to speak by selecting the “Speak Now” button. Let’s Proceed.

Friend: “Did you notice how busy the restaurant is today. It is as if everyone decided to come here!”

When speak now is pressed

Player: “Yes, there are not many tables left. ”

Well done! You have successfully completed the training phase for Maintaining conversation. Now that you know how to start and maintain a conversation, we will discuss how to end a conversation.

---

## Ending Conversation:

Ending a conversation in the correct manner is very important. If you do not end the conversation properly, the other person may consider it rude or may think you do not want to be their friend. Therefore, ending a conversation correctly is just as important as starting and maintaining conversation.

The best way to end a conversation is to wait until you have commented or asked at least one question about what the other person said to show that you were interested. After this, explain why you must go, e.g., You have finished eating and now want to go and sleep so you will tell Alicia “It was nice to spend time with you but I have to go because it is getting late”. Once Alicia has acknowledged your explanation then you say “Goodbye” or “Goodnight” before leaving.

From the options below please select the Best and the Worst Option for Ending the conversation.

Best

Option

Worst

Option

Say “I should go now, Goodbye Alicia” and leave

Get up and walk away while Alicia isn’t looking

Tell Alicia you are bored and leave

Tell Alicia “Thank you for today, It was very nice. I have to go because my mum is waiting”. When she responds then say “Goodbye”

[Options 1 and 4 are the best responses, and Option 3 is the worst response for this example. If the player selects either Option 1 or Option 4 as best and Option 3 as worst, then they will be taken to the next step]

At the end of the quiz, an explanation of the appropriateness of each option will be given to the player.

Let us now review the options:

Option 1 is an acceptable option; however the other person should be given a reason for leaving otherwise they might feel you didn't enjoy their company

Option 2 is not a good option as this will leave the other person confused and they will think you are rude. They may be discouraged from spending time with you again.

Option 3 is the worst option as the other person would feel that you are not interested in them and that you don't want to be their friend. It is likely that the other person would not want to socialise with you again.

Option 4 is the best option as it gives the other person explanation for you wanting to go, so they will understand your position. Allowing them to respond before saying goodbye shows that you value their understanding.

Your training for initiating, maintaining and ending conversation is complete. You will now enter Play mode which requires you to engage in small talk with Alicia. Remember you and Alicia have known each other for 2 years, you both like trains and are good friends.

-----

## **Unpressured Practice**

"Oh oh! You did not look at either the greeter or the friend when they were speaking... Remember when Listening we should turn towards the speaker to show them, we are listening. Let us try this again. Remember to use the Arrow keys to look around."

"Yay! You made eye contact with both greeter and friend when they were talking. Now that you are a pro in eye contact lets continue the training."

"Good! You made eye contact with the friend. Next time make sure you also look at the greeter when they speak to you."

"Good! You made eye contact with the greeter. Next time make sure you also look at the friend when they speak to you."

"Awesome! You made eye contact and practiced maintaining quiet hands and feet. "

"Well done! You chose the correct options. "

"Move closer to greeter and focus on the face area to make successful eye contact. When you have established eye contact, the Halo will turn green. If you are too close, the Halo will turn red"

"The hollow coloured circle (Halo) shows where you are looking during gameplay."

"The Halo changes colour to green when successful eye contact is established with the other person."

"The Halo changes colour to Red when you get too close to the other person."

"OH oh! the other person is still talking. You should wait until they finish talking before you speak."

-Survey

"Get in their line of Vision", "Look at them", "Get close to them", "Wave at them"

"Press Space button to sit", "Click on the door to open it", "Please enter the restaurant. Use the WASD Keys for movement.",

"You are too far away from the greeter. Wait until the greeter is at an acceptable distance (roughly an arm's length) from you before you speak."

"What method did you use to make Eye contact with the greeter. Select from the Used Option list the method that you used to establish eye contact. Select from the Worst Option list, the worst method of making eye contact with anyone"

"Get in the line of vision of the greeter and look at them", "Get close to the greeter", "Hide from the greeter ", "Wave at the greeter"

"Well done! You choose the correct options. "

"Move close to the door and click the door to open it. Remember, your first task is to get inside the restaurant."

"Congratulations " + player.playerName + "! You have completed the training." + " Here is a summary of your performance."

"Remember to get the greeter's attention by moving into their line of vision, looking at them and waving if needed."

"Please select 3 strategies involved in successful Eye contact"

"Get in the line of vision of the other person", "Wave at the other person", "Turn away when the other person looks at you.",  
"Look away as soon as the other person sees you", "Keep looking at the other person when they look at you"

Select from the Used Option list the method that you used to establish eye contact. Select from the Worst Option list, the worst method of making eye contact with anyone

"Wave at the greeter", "Get in the line of vision of the greeter", "Look at the greeter", "Call out to the greeter"

"Please select 3 strategies involved in starting conversation"

"Make eye contact before speaking", "Ask how the other person is", "Tell the other person about your day", "Ask the other person questions about themselves or the environment you are both in", "Ask the other person what movies they like"

"Select from the Used Option list, the method that YOU used to start a conversation with the other person. Select from the Worst Option list, the worst method for starting a conversation.";

"Tell the other person what I do in the evening", "Quickly ask the other person how they are", "Ask the other person how their weekend was", "Make eye contact then ask the friend how they are"

"Please select 3 strategies involved in maintaining conversation"

"Speak even if the other person is talking", "Adopt quiet hands and feet", "Maintain eye contact with the other person",  
"Wait for a pause and then ask a relevant question", "Share your thoughts about global warming with the other person"

Select from the Used Option list the method that YOU used for maintaining conversation with the other person. Select from the Worst Option list, the worst method for maintaining conversation with the other person

"Interrupt the other person and ask them a question", "Look at TV when the other person is speaking", "Look at friend, maintain quiet hands and feet and once there is a pause follow their statement with a relevant question", "Read the menu while the other person is speaking"

"Please select 3 strategies involved in ending conversation"

"Allow the other person to finish speaking", "Walk away while the other person is speaking", "Explain why you have to leave", "Don't leave until you and the other person have both spoken", "Get up and leave"

Select from the Used Option list the method that YOU used for ending conversation with the other person. Select from the Worst Option list, the worst method for ending a conversation

"Leave without saying anything", "Explain to the other person why you have to leave", "Leave when the other person is not looking", "Walk away while the other person is speaking"

"You are fiddling with keyboard or mouse. Let's try again."

"No, I don't I am sorry", "Yes, I have a booking at 7",

## **Narrative**

You friend Alicia has invited to you join her for dinner at a restaurant. You have not been to this particular restaurant before.

Through this restaurant experience, you will learn about the social skills that will assist you. The simulation is focused on the following 4 skills with reference to the restaurant context:

- Making and Maintaining Eye contact
- Starting conversation with another person
- Maintaining conversation
- Ending conversation

These social skills can be translated to other social situations.

## **Introduction**

This program simulates a restaurant visit in a game like environment. Its aim is to offer a self-paced experience where social and time pressures are lessened and there is opportunity to reflect. It is designed in 2 sessions. Session one provides training for the social scenario and session 2 allows for practice of the skills learned.

As you play, check the Confidence Bar regularly and set it to record the feeling of confidence you have in the social situation being presented at that time.

When ready, enter your name and press Start:

## **Controls**

Movement: WASD keys (W = Forward, A = Left, S = Backward, D = Right).

Looking around: Arrow keys (← = Left, ↑ = Up, → = Right, ↓ = Down).

Interacting with active object: left mouse clicks.

Tab button: swap between First-person view (through the avatar's eyes) and Third-person view (able to see your avatar in the scene).

Quit button: exit the game at any time.

Audio Button: allows you to turn off or turn on the background noise.

Skip: allows you to advance to the next step.

Confidence Bar: allows you to reflect on how confident you feel during gameplay. It is a way you can provide feedback to the system.

# Appendix H: Ethical application for evaluation- user study :

The University of Waikato  
Private Bag 3105  
Gate 1, Knighton Road  
Hamilton, New Zealand

Human Research Ethics Committee  
Julie Barbour  
Telephone: +64 7 837 9336  
Email: [humanethics@waikato.ac.nz](mailto:humanethics@waikato.ac.nz)



22 August 2019

Khadija Bahiss  
FCMS  
By email: [kb60@students.waikato.ac.nz](mailto:kb60@students.waikato.ac.nz)

Dear Khadija

HREC(Health)2019#54 : Serious game to provide social skills training for people with Asperger Syndrome/High-Functioning Autism

Thank you for submitting your amended application HREC(Health)#2019#54 for ethical approval.

We are now pleased to provide formal approval for your project where you will recruit 8 to 12 participants from the Monday Mates Group. These participants will be involved in the following activities:

1. A demographic questionnaire.
2. A perception (real vs. virtual) activity and questionnaire.
3. Use of social skill training software with proxies and feedback, with evaluation questionnaire, which will be video recorded.
4. Use of social skill training software without proxies and feedback, with evaluation questionnaire, which will be video recorded.

Please contact the committee by email ([humanethics@waikato.ac.nz](mailto:humanethics@waikato.ac.nz)) if you wish to make changes to your project as it unfolds, quoting your application number with your future correspondence. Any minor changes or additions to the approved research activities can be handled outside the monthly application cycle.

We wish you all the best with your research.

Regards,



---

Julie Barbour PhD  
Chairperson  
University of Waikato Human Research Ethics Committee

# Appendix I: Pre-study questionnaire:

## Software Evaluation



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

ID Number: \_\_\_\_\_

## Demographic Questionnaire:

Age: \_\_\_\_\_

Gender: Male  Female  Other  \_\_\_\_\_

Height: \_\_\_\_\_

Do you have a formal diagnosis of Asperger's Syndrome/High-Functioning Autism?  Yes  No

If No, are you self – diagnosed?  Yes  No

Add any comments about your diagnosis status: \_\_\_\_\_

Have you taken part in a social skills training program?  Yes  No

If yes, please specify: \_\_\_\_\_

Are you familiar with first-person controller games?  Yes  No

If Yes, how often do you use it?  Daily  Weekly  Monthly

Other (Please specify): \_\_\_\_\_

Are you currently socially anxious in restaurant situation?  Yes  No

Please select the option that best describes your current anxiety level for each social skill needed when going to a restaurant in real world

|                |                 |                   |                |                  |
|----------------|-----------------|-------------------|----------------|------------------|
| <i>Not</i>     | <i>Slightly</i> | <i>Moderately</i> | <i>Very</i>    | <i>Extremely</i> |
| <i>Anxious</i> | <i>Anxious</i>  | <i>Anxious</i>    | <i>Anxious</i> | <i>Anxious</i>   |

|   |                          |                          |                          |                          |                          |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Finding your way to the restaurant staff                          | <input type="checkbox"/> |
| Getting in the line of vision of restaurant staff                 | <input type="checkbox"/> |
| Making eye contact with restaurant staff                          | <input type="checkbox"/> |
| Knowing the appropriate distance to stand from another person     | <input type="checkbox"/> |
| Starting a conversation with someone                              | <input type="checkbox"/> |
| Maintaining a listening position while someone is speaking to you | <input type="checkbox"/> |
| Showing interest while another person is speaking                 | <input type="checkbox"/> |
| Turn taking during conversation                                   | <input type="checkbox"/> |
| Ending conversation with someone                                  | <input type="checkbox"/> |

# Appendix J: Evaluation - real world and virtual world questionnaire:

## Software Evaluation



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

ID Number: \_\_\_\_\_

### Session 1: real world

How would you rate your experience of doing the following tasks in REAL WORLD

|  | <i>Very<br/>Difficult</i> | <i>Difficult</i>         | <i>Undecided</i>         | <i>Easy</i>              | <i>Very<br/>Easy</i>     |
|--|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Making eye contact with the actor            | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Getting in exact line of vision of the actor | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at an arm's length from actor       | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at 2 arm's lengths from actor       | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at an arm's length of the Door      | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at an arm's length of the Chair     | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

|   |                          |                          |                          |                          |                          |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Looking to your sharp left and sharp right  | <input type="checkbox"/> |
| Looking up at ceiling and down at your feet | <input type="checkbox"/> |

How satisfied are you that you completed the following task successfully in REAL WORLD

|   | <i>Completely<br/>dissatisfied</i> | <i>Dissatisfied</i>      | <i>Undecided</i>         | <i>Satisfied</i>         | <i>Completely<br/>Satisfied</i> |
|---|------------------------------------|--------------------------|--------------------------|--------------------------|---------------------------------|
| Made eye contact with actor               | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Got in exact line of vision of the actor  | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at an arm's length from actor       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at 2 arm's lengths from actor       | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at an arm's length from the Door    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at an arm's length from the Chair   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Looked at your sharp left and sharp right | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |



ID Number: \_\_\_\_\_

Looked up at ceiling and down at your feet                             

### Session 1: Virtual World (Computer Game)

How would you rate your experience of doing the following tasks in the VIRTUAL WORLD

|  | <i>Very<br/>Difficult</i> | <i>Difficult</i>         | <i>Undecided</i>         | <i>Easy</i>              | <i>Very<br/>Easy</i>     |
|--|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Making eye contact with the greeter        | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Getting in line of vision of the greeter   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at an arm's length from greeter   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at 2 arm's lengths from greeter   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at an arm's length of the door    | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Standing at an arm's length of the chair   | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Looking to your sharp left and sharp right | <input type="checkbox"/>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Looking up at TV and down at your table

How satisfied are you that you completed the following task successfully in VIRTUAL WORLD

|   | <i>Completely<br/>dissatisfied</i> | <i>Dissatisfied</i>      | <i>Undecided</i>         | <i>Satisfied</i>         | <i>Completely<br/>Satisfied</i> |
|---|------------------------------------|--------------------------|--------------------------|--------------------------|---------------------------------|
| Made eye contact with greeter             | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Got in the line of vision of the greeter  | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at an arm's length from greeter     | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at 2 arm's lengths from greeter     | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at an arm's length from the door    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Stood at an arm's length from the chair   | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Looked at your sharp left and sharp right | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |
| Looked up at TV and down at your table    | <input type="checkbox"/>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>        |

For each of the groups of statements following, please Tick in the **best column**, the answer that **best represents you** and from the **worst column** the answer that **does not represent you**

---

*Best Option*

Moving forward and backward in virtual world was easier than in real world

Moving forward and backward in virtual world was same as in real world

Moving forward and backward in virtual world was harder than in real world

---

Turning to left and right in virtual world was easier than in real world

Turning to left and right in virtual world was same as in real world

Turning to left and right in virtual world was harder than in real world

---

Standing at an arm's length from a person in virtual world was easier than in real world

Standing at an arm's length from a person in virtual world was same as in real world

Standing at an arm's length from a person in virtual world was harder than in real world

---

Standing at an arm's length from chair in virtual world was easier than in real world

Standing at an arm's length from chair in virtual world was same as in real world

Standing at an arm's length from chair in virtual world was harder than in real world

---

---

Standing at an arm's length from door in virtual world was easier than in real world

Standing at an arm's length from door in virtual world was same as in real world

Standing at an arm's length from door in virtual world was harder than in real world

---

Standing at two arm's lengths from a person in virtual world was easier than in real world

Standing at two arm's lengths from a person in virtual world was same as in real world

Standing at two arm's lengths from a person in virtual world was harder than in real world

---

Making eye contact in virtual world was easier than real world

Making eye contact in virtual world was same as real world

Making eye contact in virtual world was harder than real world

---

Looking up and down in virtual world was easier than in real world

Looking up and down in virtual world was same as in real world

Looking up and down in virtual world was harder than in real world

---

Getting in exact line of vision of a person in virtual world was easier than in real world

Getting in exact line of vision of a person in virtual world was same as real world

Getting in exact line vision of a person in virtual world was harder than real world

---

# Appendix K: Evaluation - eye contact questionnaire

## Session 2A: Eye contact Questionnaire

With reference to your experience of the virtual world (gameplay), select the option that best describes **your anxiety level** with each social skill during gameplay

|   | <i>Not<br/>Anxious</i>   | <i>Slightly<br/>Anxious</i> | <i>Moderately<br/>Anxious</i> | <i>Very<br/>Anxious</i>  | <i>Extremely<br/>Anxious</i> |
|---|--------------------------|-----------------------------|-------------------------------|--------------------------|------------------------------|
| Finding your way to the greeter               | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Getting in line of vision of greeter          | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Making eye contact with greeter               | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Standing at appropriate distance from greeter | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |

With reference to your experience of the virtual world (gameplay), select the option that best describes how you found the game features

|   | <i>Not at all<br/>Distracting</i> | <i>Slightly<br/>Useful</i> | <i>Moderately<br/>Useful</i> | <i>Very<br/>Useful</i>   |
|---|-----------------------------------|----------------------------|------------------------------|--------------------------|
| Written prompt on screen to assist you about how to do things, i.e., “Click on door to open it” | <input type="checkbox"/>          | <input type="checkbox"/>   | <input type="checkbox"/>     | <input type="checkbox"/> |
| Audio playback of instructions on social skill displayed on screen                              | <input type="checkbox"/>          | <input type="checkbox"/>   | <input type="checkbox"/>     | <input type="checkbox"/> |
| Written instructions of social skill displayed on screen  | <input type="checkbox"/>          | <input type="checkbox"/>   | <input type="checkbox"/>     | <input type="checkbox"/> |

Introduction information for *getting in line of vision*

Introduction information for *standing at appropriate distance*

Introduction information for *making eye contact*

Video modelling of the taught social skill

Practice opportunity for *getting in line of vision*

Practice opportunity for *standing at appropriate distance*

*Distracting*      *Not at all Useful*      *Slightly Useful*      *Moderately Useful*      *Very Useful*

Practice opportunity for *making eye contact*

Button to turn background music on and off

Changing between first-person view and third person view

Confidence bar to reflect on your experience

White Halo to indicate that you got into the line of vision of the other person

Green Halo to indicate that you successfully made eye contact with the other person

Red Halo to indicate you are standing too close to the other person

**With reference to your experience of the virtual world (gameplay), please answer the following:**

Did you feel like you were in a restaurant?  Yes  No

Were you anxious because you were not sure how to operate the system?  Yes  No

Were you anxious because you felt you were making eye contact with greeter?  Yes  No

Did you find the Halos useful for identifying the aspects of eye contact?  Yes  No

Did you find the game to be abstract and NOT like a real world experience?  Yes  No



# Appendix L: Evaluation - small talk - conversation questionnaire

## Session 2B: Small Talk Questionnaire

With reference to your experience of the virtual world (gameplay), select the option that best describes **your anxiety level** with each social skill during gameplay.

|  | <i>Not<br/>Anxious</i>   | <i>Slightly<br/>Anxious</i> | <i>Moderately<br/>Anxious</i> | <i>Very<br/>Anxious</i>  | <i>Extremely<br/>Anxious</i> |
|--|--------------------------|-----------------------------|-------------------------------|--------------------------|------------------------------|
| Starting conversation with friend              | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Adopting listening position while friend spoke | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Showing interest while friend spoke            | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Taking turn while friend spoke                 | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Ending conversation to go to the bathroom      | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |

With reference to your experience of the virtual world (gameplay), select the option that best describes how you found each of the following

|  | <i>Distracting</i>       | <i>Not at all<br/>Useful</i> | <i>Slightly<br/>Useful</i> | <i>Moderately<br/>Useful</i> | <i>Very<br/>Useful</i>   |
|--|--------------------------|------------------------------|----------------------------|------------------------------|--------------------------|
| Using Speak Now button to tell the program you were ready to speak                     | <input type="checkbox"/> | <input type="checkbox"/>     | <input type="checkbox"/>   | <input type="checkbox"/>     | <input type="checkbox"/> |
| Written prompts on screen to assist your next steps, i.e., “Press space button to sit” | <input type="checkbox"/> | <input type="checkbox"/>     | <input type="checkbox"/>   | <input type="checkbox"/>     | <input type="checkbox"/> |

Choosing the Best option from the given list for interacting with the friend

Choosing the Worst option from the given list for interacting with the friend

Analysis of each provided option for interaction with the friend

Video modelling of social skill

Audio of video models

Speed of information being displayed on screen

Audio playback of conversation statements

Feedback to assist your social experience, i.e., "Oh Oh! The other person is still talking. You should wait until they finish talking before you speak"

*Distracting*      *Not at all Useful*      *Slightly Useful*      *Moderately Useful*      *Very Useful*

Practicing making eye contact with the speaker, i.e., *greeter comes to ask for drinks while you are talking to the friend*

Using arrow keys to look around when sitting

Introduction information for *starting conversation*

Introduction information for *listening position* during conversation

Introduction information for *showing interest* during conversation

Introduction information for *turn taking* during conversation

Introduction information for *ending conversation*

Practice task for *starting conversation* at the end of skill introduction and video

Practice task for *listening position* at the end of skill introduction and video

Practice task for *showing interest* at the end of skill introduction

Practice task for *turn taking* at the end of skill introduction

Practice task for *ending conversation* at the end of skill introduction

Feedback on your performance by giving stars at the end of successful attempt

**With reference to your gameplay experience, please answer the following:**

Were you anxious because you were not sure how to operate the system?  Yes  No

Did you struggle to pay attention and stay focused while friend was speaking?  Yes  No

Did the program awaken your social anxiety around having conversation?  Yes  No

Add any comments about your social experience of engaging in a conversation with others in the program (gameplay):

---

—

# Appendix M: Evaluation - test mode questionnaire

## Session 3: Test mode Post-study Questionnaire

### *Software Evaluation*



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

ID Number: \_\_\_\_\_

With reference to your virtual world experience (gameplay), please select the option that best represents your opinion of the following:

|   | <i>Always</i>            | <i>Often</i>             | <i>Sometimes</i>         | <i>Seldom</i>            | <i>Never</i>             |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Conversation in game felt like an experience of conversation in real world                        | <input type="checkbox"/> |
| The game reminded me of the social anxiety I feel while engaging in small talk in real world      | <input type="checkbox"/> |
| <i>(leave blank if not applicable)</i>  |                          |                          |                          |                          |                          |
| Making eye contact in game reminded me of my social anxiety about eye contact in real world       | <input type="checkbox"/> |
| <i>(leave blank if not applicable)</i>  |                          |                          |                          |                          |                          |
| The game provided an element of realism and felt like real world restaurant experience            | <input type="checkbox"/> |
| The game removed time pressure for responding to conversation making it easier than in real world | <input type="checkbox"/> |

The response options provided by game made social interaction easier than in real world

My lack of game experience interfered with my learning experience

*(leave blank if not applicable)*

Select the option that best describes your point of view from the given list below:

|   | <i>Strongly</i>          |                          |                          |                          | <i>Strongly</i>          |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|   | <i>Agree</i>             | <i>Agree</i>             | <i>Undecided</i>         | <i>Disagree</i>          | <i>Disagree</i>          |
| The game experience has made me more confident about making eye contact with another person in the future.    | <input type="checkbox"/> |
| The game experience has made me more confident about engaging in small talk with another person in the future | <input type="checkbox"/> |
| Overall, the game experience was helpful in increasing my confidence at social interaction in a restaurant    | <input type="checkbox"/> |

With reference to your experience of the **virtual world (gameplay)**, select the option that best describes **your anxiety level** with each social skill during gameplay:

|                |                 |                   |                |                  |
|----------------|-----------------|-------------------|----------------|------------------|
| <i>Not</i>     | <i>Slightly</i> | <i>Moderately</i> | <i>Very</i>    | <i>Extremely</i> |
| <i>Anxious</i> | <i>Anxious</i>  | <i>Anxious</i>    | <i>Anxious</i> | <i>Anxious</i>   |

|  |                          |                          |                          |                          |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Finding your way to the greeter                | <input type="checkbox"/> |
| Getting in line of vision of greeter           | <input type="checkbox"/> |
| Making eye contact with greeter                | <input type="checkbox"/> |
| Standing at appropriate distance from greeter  | <input type="checkbox"/> |
| Starting conversation with friend              | <input type="checkbox"/> |
| Adopting listening position while friend spoke | <input type="checkbox"/> |
| Showing interest while friend spoke            | <input type="checkbox"/> |
| Taking turn while friend spoke                 | <input type="checkbox"/> |
| Ending conversation to go to the bathroom      | <input type="checkbox"/> |

Now that you have experienced the social skill training program, please select the option that you feel might best describe the anxiety level you ANTICIPATE in future real world restaurant visits:

|   | <i>Not<br/>Anxious</i>   | <i>Slightly<br/>Anxious</i> | <i>Moderately<br/>Anxious</i> | <i>Very<br/>Anxious</i>  | <i>Extremely<br/>Anxious</i> |
|---|--------------------------|-----------------------------|-------------------------------|--------------------------|------------------------------|
| Finding your way to the restaurant staff      | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |
| Getting in line of vision of restaurant staff | <input type="checkbox"/> | <input type="checkbox"/>    | <input type="checkbox"/>      | <input type="checkbox"/> | <input type="checkbox"/>     |

Making eye contact with restaurant staff

Knowing the appropriate distance to stand from another person

Starting a conversation with someone

Practicing listening position when someone speaks to you

Showing interest in what another person is saying

Turn taking during conversation

Ending conversation with someone

# Appendix N: Evaluation- post-study debriefing

## Post-study Debriefing



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

ID Number: \_\_\_\_\_

- Were the proxies/feedback used in-game effective as a learning alternative to real life equivalents?
- Did the game successfully represent real world like environment/experiences?
- Were there realistic distractions in the environment, e.g., TV, background noise, other patrons?
- Could the participant identify the features that were the focus of this study in the game prototype, e.g., the mechanism for eye contact identification, etc.?
- Ease of use: what were the barriers (if any) to the operation of the game prototype?
- Was the user aware of social skills being addressed before the study?
- Did the training provide a feasible practice opportunity for the introduced and modelled social skills?
- Did the user maintain an awareness of the social skill while they were undertaking the training; was it immersive?
- Did the user identify the learning objectives and maintain this awareness (practice mode, test mode)?

- Did the user exhibit and carried forward the addressed social skill when feedback was withdrawn during the test session?
- Did the program reduce expected anxiety towards future encounters of the addressed social skills?
- Did the program raise awareness of the expected neurotypical behaviour in a social scenario?
- Did the program increase awareness of each addressed skill for the participant?

# Appendix O: Real world study observation sheet

## Participant Experiment Observation



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

ID Number: \_\_\_\_\_

---

*Real world*

---

3 arm's from chair \_\_\_\_\_

2 arm's from chair \_\_\_\_\_

An Arm from chair \_\_\_\_\_

3 arm's from door \_\_\_\_\_

2 arm's from door \_\_\_\_\_

An arm from door \_\_\_\_\_

Sharp Left \_\_\_\_\_

Sharp Right \_\_\_\_\_

At Ceiling \_\_\_\_\_

At your Feet \_\_\_\_\_

Got in line of vision? \_\_\_\_\_ (refer Actor Observation)

Actor observation: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

3 arm's from door \_\_\_\_\_

2 arm's from door \_\_\_\_\_

An Arm from door \_\_\_\_\_

---

*Static Environment:*

---

menu located? \_\_\_\_\_

Sharp left \_\_\_\_\_

Sharp right \_\_\_\_\_

Get to door \_\_\_\_\_

2 arm's length from door \_\_\_\_\_ Reveal: \_\_\_\_\_

Move to 2 arms if not there \_\_\_\_\_

Feel at 2 arm's lengths? \_\_\_\_\_

An arm's length from door \_\_\_\_\_

Open door \_\_\_\_\_

Get inside, locate chair \_\_\_\_\_

3 arms from chair \_\_\_\_\_

Reveal \_\_\_\_\_

2 arms from chair & reveal \_\_\_\_\_

An arm from chair & reveal \_\_\_\_\_

Look down at table \_\_\_\_\_

Look up at TV \_\_\_\_\_

Left to see reflection \_\_\_\_\_

Right to locate greeter \_\_\_\_\_

Get in line of vision, halo appears \_\_\_\_\_

2 arms from greeter \_\_\_\_\_

White Halo? \_\_\_\_\_

Red Halo? \_\_\_\_\_

Distance Practice : Find greeter: \_\_\_\_\_

Get in line of vision. \_\_\_\_\_

Green Halo? \_\_\_\_\_

Reveal : \_\_\_\_\_

Training Mode Click- Questionnaire \_\_\_\_\_

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