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PHONOLOGICAL AWARENESS

AND

ALPHABET KNOWLEDGE

IN THE

ACQUISITION OF LITERACY SKILLS

A thesis
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of the requirements for the Degree
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ABSTRACT

The nature of the relationship between phonological awareness and the acquisition of literacy was investigated in a longitudinal study of 29 children during their first two years at school. At the beginning of the study, when all children were nonreaders, syllable awareness was the strongest predictor of later word reading and spelling. During the first year, correlations from rhyme or alliteration awareness to later literacy were significant over intervals of two or three months. Correlations in the other direction, that is, from literacy to later rhyme or alliteration awareness were also significant over these periods. These results support the notion that early awareness of syllables, rhyme, and alliteration has a small facilitative effect on the first months of learning to read and spell, after which time a reciprocal relationship develops. Children were unable to score on both measures of phoneme awareness until after they could read a number of words. From half way through the first year, significant correlations were often found from phoneme awareness to later literacy. Correlations in the other direction, that is, from literacy to later phoneme awareness, were also significant. These results are consistent with phoneme awareness initially being a consequence of learning to read and write, and then having a reciprocal relationship with literacy. Controlling for verbal ability or phonological memory made little difference to the size of the correlations between measures of phonological awareness and literacy. Controlling for letter knowledge, however, often resulted in substantial reductions in the size of the correlations. Letter knowledge was frequently a strong predictor of later literacy. It is argued that letter knowledge has a central role in the development of literacy skills and in the relationship between phonological awareness and literacy.

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PART ONE:

INTRODUCTION, LITERATURE REVIEW, AND METHOD

1

INTRODUCTION

In 1908 Edmund Huey wrote that:

> to analyse what we do when we read would almost be the acme of a psychologist's achievements, since it would be to describe very many of the most intricate workings of the human mind, as well as to unravel the tangled story of the most remarkable specific performance that civilisation has learned" (1908/1968, p. 6).

Since then, and especially in the last 30 years, considerable research has gone into analysing what occurs in the reading process. This research has revealed the tremendous complexity of a task that most of us take for granted. A number of models of reading have been proposed to explain how a reader combines knowledge of phonology (sound representations of letters and words), orthography (spelling patterns), word meanings, and context into a coherent understanding of the text (see Adams, 1990, for a review).

The findings of many research studies have emphasised the importance of word recognition as a basis for the process of reading. Although comprehension of text is the usual purpose of reading, comprehension will not occur if a reader cannot identify individual words. A reader with fast and accurate word recognition will be able to allocate more attention to comprehending a passage of text than a reader with inadequate word recognition skills (Adams, 1990).

Most children who have problems learning to read have difficulties at the level of word recognition (Rack, Hulme, & Snowling, 1993). The vocabulary and style of books that young readers encounter are such that most children would comprehend the text if the books were read aloud. Hence, general language comprehension skills are unlikely to be a limiting factor in the beginning years of reading. Instead it is likely to be word recognition skills that restrict what children can comprehend during the early stages of learning to read (Tunmer & Hoover, 1993).

Numerous research studies have been directed at finding what factors may be associated with the acquisition of word recognition skills. The findings of many of these studies have suggested that phonological awareness (an awareness of the sounds of spoken language) is the underlying cognitive factor that is most closely

linked to the development of word reading skills and word spelling skills. (For reviews, see Adams, 1990; Brady & Shankweiler, 1991; Goswami & Bryant, 1990, 1992; Sawyer & Fox, 1991; Stanovich, 1992.)

Despite the large number of studies that have shown an association between literacy and phonological awareness, there is still debate about the nature of the relationship. Different studies have produced contradictory evidence. Some researchers have concluded that phonological awareness enables or facilitates literacy, while other researchers have concluded that phonological awareness is a consequence of the development of literacy. Another possibility supported by some studies is that there is a reciprocal relationship between phonological awareness and literacy.

Some of the discrepancies in the findings of different studies may be due to differences in research design and the type of tasks that have been used to assess phonological awareness and literacy. Another source of discrepancy may be that some studies have given insufficient attention to the impact of other factors on phonological awareness and literacy, and the relationship between these variables. Two factors - letter knowledge and phonological memory - have frequently been identified as meriting attention when considering phonological awareness and literacy (Adams, 1990; Badian, 1995; Rohl and Pratt, 1995). The possible influence of these factors is considered as part of the following Literature Review.

2

LITERATURE REVIEW

2.1 Outline

The Literature Review is divided into three parts:

1. Phonological Awareness. This part discusses definitions and measurement of phonological awareness, and examines possible connections between phonological awareness and the acquisition of literacy.

2. Letter Knowledge. This part discusses the association between letter knowledge and the acquisition of literacy, and examines the influence of phonological awareness on this association. Letter knowledge and phonological awareness are also discussed in relation to a theoretical model of reading, the Knowledge Sources account.

3. Phonological Memory. This part first outlines what phonological memory is and how it is measured. The relationship between phonological memory and reading is then discussed, followed by an examination of the influence of phonological awareness on the relationship.

2.2 Phonological Awareness

2.2.1 Phonological Awareness: What Is It and How Is It measured?

As children learn to talk, they become familiar with the sounds that make up the words in their language. They become skilful at hearing and producing the particular combinations of sounds that are associated with particular meanings. By 4 or 5 years of age, children are able to produce most of the speech sounds that are required for their language, and they can readily distinguish between words that have only slight differences in sound structure (Owens, 1988).

At this stage, however, children's ability to distinguish between words is based on an implicit awareness of sounds rather than an explicit awareness. The attention of young children is focused on the meaning of language rather than its phonology. Young children will recognise, for example, that the words "cat" and "hat" refer to different objects, but they will not be aware that the reason they can distinguish between these words is because of the difference in beginning sounds. Having an implicit awareness of the sound structure of words is all that is required for listening and speaking, but a more explicit level of awareness appears to be important in relation to learning to read and write (Tunmer & Rohl, 1991).

A useful hierarchical model of the internal sound structure of words is shown in Figure 2.1. The first level of the model depicts *morphemes* or meaning units. At the next level of the model, morphemes are seen to be composed of one or more *syllables*. Syllables can be further divided into *intrasyllabic* units which, in turn, can often be divided into *phonemes*.

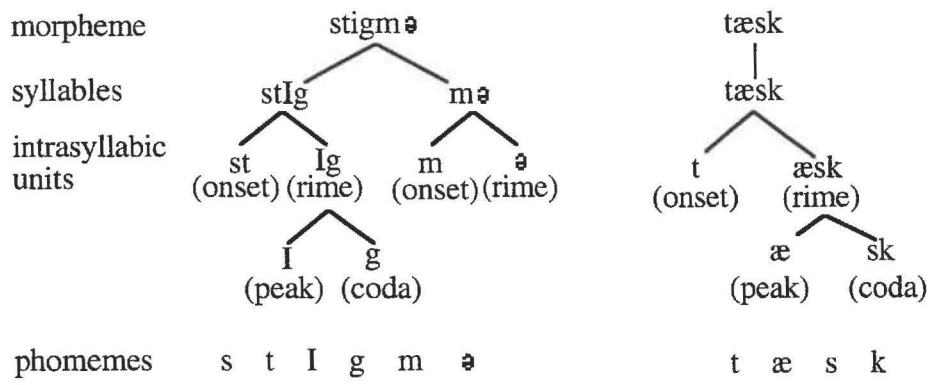


Figure 2.1. Hierachical model of the syllable (reproduced from Treiman, 1992).

Syllables are generally considered to be the smallest segments of speech that are independently articulable (Wagner & Torgesen, 1987). Although it is sometimes difficult to distinguish the exact beginning and end of a syllable, the boundaries generally correspond with the opening and closing of the vocal tract and show up as patterns in acoustic measures of the speech stream (Owens, 1988).

Research by Treiman (1985, 1992) provides evidence that syllables can be divided into two intrasyllabic units: the optional *onset* (beginning consonant or consonant cluster, e.g., cat, crack) and the *rime* (the vowel and any final consonants, e.g., cat, crack). Rimes can be further divided into the *peak* (vowel nucleus) and the *coda* (any final consonants).

The finest degree of subdivision occurs at the level of phonemes: the smallest perceivable units of speech sound that make a difference to meaning in a particular language. Although the human vocal apparatus can produce about 100 different speech sounds, each language uses only a subset of these. Speakers of a particular language learn to produce and hear the sounds of their language and may find it difficult to distinguish between sounds that are used in other languages but are not in their own. The number of phonemes said to exist in English varies according to dialect and system of classification, but is approximately 44 (Fromkin, Rodman, Collins, & Blair, 1990).

Although syllables exist as separate physical units within the speech stream, this is not the case for phonemes. Phonemes cannot usually be pronounced in isolation because they tend to run together within and across words. Hence the sound of any particular phoneme will be influenced by the phonemes occurring before or after it. This results in considerable overlap or "parallel transmission" of the phonemes making up words. Because phonemes do not exist in isolation, it is more difficult for children to become aware of phonemes than it is for them to become aware of syllables (Liberman, 1996; Liberman, Cooper, Shankweiler, & Studdert - Kennedy, 1967).

Tunmer and Rohl (1991) considered that the ability to be aware of, and to reflect on, the sound components of language is part of a broader category of abilities for reflecting on the structural features of language. These abilities are known as *metalinguistic awareness*. Metalinguistic awareness develops after children have mastered basic speaking and listening skills, and may be associated with the general development of metacognitive skills that occurs during middle childhood

(see Tunmer, Herriman, & Nesdale, 1988). Four main types of metalinguistic awareness are distinguished by Tunmer and Rohl: pragmatic, syntactic, word, and phonological. *Pragmatic awareness* involves an awareness of the relationships between a particular sentence and the total context in which it occurs. *Syntactic awareness* refers to the ability to reflect on and manipulate parts of the grammatical structure of sentences (see Tunmer, Nesdale, & Wright, 1987). *Word awareness* requires an ability to reflect on and manipulate language at the word level. Although young children may not initially be aware that the speech stream is made up of individual word units, the overtly separable nature of words means that it is relatively easy to encourage children to attend to language at this level (Adams, 1990). *Phonological awareness* is a more difficult skill than word awareness, requiring an ability to reflect on and manipulate the internal sound components of words. Tunmer and Rohl limit their definition of phonological awareness as being specific to the phoneme level.

Other researchers have included an awareness of syllables or intrasyllabic units (onsets and rimes) within their definitions of phonological awareness (e.g., Goswami & Bryant, 1990). Hence some definitions of phonological awareness include only awareness of phonemes whereas other definitions include an awareness of intrasyllabic units, or a combination of phonemes and intrasyllabic units. Often researchers have given insufficient attention to specifying what phonological awareness actually is, and instead have simply defined it as being what is measured by the particular tasks used in their studies.

Disagreement between researchers also exists as to whether phonological awareness requires conscious attention. Tunmer and Rohl (1991) stated that an explicit conscious level of attention is needed if phonological awareness is to be demonstrated (see also Shankweiler, & Crain, 1986). Other researchers, however, have noted difficulties in explaining what is meant by "conscious attention" in this area (see, e.g., Spencer, 1991; Stanovich, 1992). There is also some evidence to suggest that children may be assisted in learning to read and write by accessing a level of phonological representation that is not measured by activities requiring a conscious demonstration of metalinguistic knowledge (Rack, Hulme, Snowling, & Wightman, 1994).

Differences in definition may lead to confusion when comparing research findings in this area. Studies that use different measures will come up with different estimates of phonological awareness and may therefore find different relationships between phonological awareness and the acquisition of literacy skills. An

indication of the potential for confusion is seen when examining the large range of tasks that have been used in different studies. Lewkowicz (1980) has grouped these into 10 categories:

1. Sound-to-word-matching (e.g., "Does *cat* start with *cuh* ?").
2. Word-to-word-matching (e.g., "Does *dog* end with the same sound as *pig*?").
3. Recognition of rhyme (e.g., "Does *fish* rhyme with *dish* ?").
4. Isolation of a beginning, medial, or final sound (e.g., "What is the first sound of *cat* ?").
5. Phonemic segmentation (e.g., "What are the sounds in *cat* ?")
6. Phoneme counting (a type of segmentation task which involves counting or tapping the number of phonemes in a word, e.g., "Tap on the table for each sound you hear in *fish.*").
7. Phoneme blending (e.g., "What word is this - *cuh*, *ah*, *tuh* ?").
8. Phoneme deletion (e.g., "Say *dog*. Now say it without the first sound.").
9. Specifying which phoneme has been deleted (e.g., "Say *cat*. Now say *at*. What sound was left out of the second word?").
10. Phoneme substitution (e.g., Say *fish*. Now say it with *duh* instead of *fuh.*").

Tunmer and Rohl (1991) list three additional categories of tasks:

1. Rhyme and alliteration oddity (e.g., Which word is the odd one out: *hat*, *mat*, *fan*, *cat* ?" - see Bradley, 1984).
2. Phoneme reversal (e.g., "If I say *top*, you say *pot.* " - see Morais, Cary, Alegria, & Bertelson, 1979).
3. Invented spelling (Children's early spelling attempts are used to assess phonemic awareness - see Mann, Tobin, & Wilson, 1987).

Some research has been directed at finding the relative difficulty levels of different phonological tasks. For example, Stanovich, Cunningham and Cramer (1984) administered 10 tests of phonological awareness to a group of kindergarteners. Yopp (1988) carried out a similar study. Both studies found that rhyme tasks were the easiest and phoneme deletion tasks the most difficult. However, Gough, Larsen, and Yopp (1995) have pointed out that both studies neglected to correct for the guessing that would occur in tests requiring children to choose the correct word from three or four alternative words. When Gough et al. took guessing into account there were appreciable changes in the apparent difficulty levels of the tasks.

Another problem in trying to compare different categories of tasks is that differences in the difficulty level of tests within a particular category may be greater than differences between categories. The difficulty level of any individual test will depend on the specific items that it is composed of. Hence it is possible for one test from a particular category of tasks to be easier, while another test from the same category is more difficult, in comparison with a test from a different category.

The individual characteristics of particular tests will affect any analysis of the factorial structure that underlies performance on a range of tests. This may be why different studies have come up with different underlying constructs for phonological awareness. Stanovich, Cunningham, and Cramer (1984) found that all nonrhyming tasks loaded highly on one factor for a group of kindergarten children. Yopp's (1988) sample of kindergarten children showed evidence for two major factors: a simple phonemic awareness factor (found in segmentation, blending, isolation, and phoneme counting tests) and a compound phonemic awareness factor (found in tests of deletion and word matching). Wagner, Torgesen, Laughon, Simmons, and Rashotte (1993) provided evidence of two major factors for their samples of kindergarten and second grade children: (a) analysis (represented by the common variance across phoneme segmentation, phoneme deletion, sound isolation, and oddity tasks), and (b) synthesis (represented by the common variance across blending tasks involving onsets and rimes, or phonemes of words and pseudowords). A study of children in Norway revealed three clear factors for a group of preschoolers and for a group of first graders. When the children's performance on a range of tests was analysed it was found that each test loaded most heavily on either a rhyme factor, a syllable factor, or a phoneme factor (Hoien, Lundberg, Stanovich, & Bjaalid, 1995).

The above factor analyses are useful for exploring patterns of common variance among phonological awareness tests, but provide little information about the underlying cognitive abilities that performance on these tests depends on. McBride-Chang (1995) suggested that three main abilities are involved in performing phonological awareness tests: general cognitive ability, short-term memory, and speech perception. General cognitive ability is involved because subjects must think about and operate on particular stimuli. Short-term memory is required when subjects need to hold stimuli in memory. Speech perception is involved because subjects need to first perceive speech segments in order to then operate on them McBride-Chang assessed these abilities in a group of third and fourth graders and found that each ability explained unique variance in performance on phonological awareness tests. Together, the three abilities accounted for 60 %

of the variance in performance on the phonological awareness tests among their sample of children.

McBride-Chang further explored the role of speech perception in phonological awareness tasks by examining the effect of manipulating the speech perception-related characteristics of particular items of phoneme awareness tests. McBride-Chang found that the difficulty of items was influenced by their linguistic characteristics. This included the number of phonemes within a word, type of phonemes (related to how they were articulated), number of phonemes within a consonant cluster, and position of phonemes. The effects of these factors varied depending on whether the task required phoneme segmentation, phoneme deletion, or identification of the position of a phoneme.

Other studies have also found that the difficulty level of phonological awareness tests is influenced by the linguistic characteristics of particular items. For example, Treiman and Weatherston (1992) found that children were more successful at isolating the initial consonants of short words and words that did not begin with consonant clusters. Snowling, Hulme, Smith, and Thomas (1994) found that children could more readily identify the "odd word out" in an oddity task if the target word was more phonetically dissimilar to the other items (i.e., where it differed in both place of articulation and phonetic voicing rather than differing on only one of these characteristics).

Stahl and Murray (1994) investigated the effects of using tasks that varied according to four levels of linguistic analysis (as set out in Treiman's (1992) model - see Figure 2.1). The four levels were: analysing onsets and rimes, analysing vowels and codas within rimes, analysing phonemes composing cluster onsets, and analysing phonemes composing cluster codas. For each of these linguistic levels, Stahl and Murray constructed tests of phoneme blending, isolation, segmentation and deletion. The tests were administered to a group of kindergarten children and a group of first grade children. Stahl and Murray found that phoneme isolation was the easiest type of operation for their sample of children, followed by blending, deletion and segmentation. In terms of linguistic level, the easiest tasks involved analysis into onset and rime units. (Although Stahl and Murray considered this to be a measure of phoneme awareness, it would be more precise to see it as simply a measure of onset-rime awareness. The onset happened to be a single phoneme in these tasks, [e.g., food], but children only required an awareness of onset and rime, not an awareness of phonemes, in order to correctly perform the tasks.) More difficult tasks required analysis of the phonemes

represented by the vowel and terminal consonants of a rime unit. Tasks requiring an awareness of phonemes within final consonant blends were the next hardest, while the most difficult tasks required an awareness of the phonemes within initial consonant blends.

Although this pattern of task difficulty was found in the sample of children tested by Stahl and Murray (1994), it may not necessarily generalise to other children. Other studies have shown that patterns of task difficulty are likely to vary according to the age and reading level of children and the type of instructional programme (see, e.g., Carillo, 1994). Stahl and Murray's study was not designed to examine the effect of these variables.

Most of the above studies concerned with speech perception investigated how manipulating the linguistic characteristics of test items affected the difficulty levels of particular phonological awareness tests. The findings of these investigations suggest that speech perception plays an important role in phonological awareness. The findings, however, do not show that individual differences in speech perception are associated with individual differences in phonological awareness. Only McBride-Chang's (1995) study actually measured children's performance on several tests of speech perception. The tests used in this study measured two key aspects of speech perception: sensitivity to manner of articulation, and sensitivity to voice onset time (the time between opening the lips and vibration of the vocal cords). Using structural equation modelling, McBride-Chang found that a latent construct based on the speech perception tests was able to explain unique variance in the phonological awareness construct. However, an examination of the intercorrelations between the individual tests shows that no test of speech perception correlated more than $r = .26$ with any test of phonological awareness (all operating at the phoneme level). This suggests that although speech perception-related manipulations can affect the difficulty of test items, individual differences in speech perception do not account for much variance in phonological awareness.

A lack of connection between individual children's speech perception abilities and their phonological awareness skills was also reported in a study by Gibbs (1996). In a cross-sectional sample of children in the first three years of primary school, Gibbs found no significant association between performance on a test of sensitivity to voice onset time and performance on rhyme and alliteration oddity tasks. A longitudinal study, also reported by Gibbs, found evidence of a significant association between children's speech perception at the age of 5 years, and oddity task performance at the age of 6 years, but Gibbs made no attempt to partial out

possible confounding variables such as IQ to see if this connection still held. A further finding of interest in Gibbs' study is that a group of hearing impaired children, who scored significantly lower on a measure of speech perception, showed similar levels of oddity task performance in comparison with a group of children with normal hearing. Gibbs therefore concluded that good speech perception is not essential for phonological awareness as measured in his study.

The complexity of the measurement issues associated with phonological awareness makes it difficult to interpret and compare the findings of studies in this area. Some past research reviews have given insufficient attention to the different ways in which phonological awareness has been assessed in different studies. Reviewers have sometimes used a broad definition of phonological awareness that includes tasks ranging from syllable awareness through to phoneme awareness (e.g., Rayner & Pollatsek, 1989). Other reviewers have used a more specific term, such as phoneme awareness or phonemic awareness, when they have actually been referring to all phonological awareness skills and not just a specific awareness of phonemes (e.g., Ball, 1993; Snider, 1995).

In the current study, phonological awareness is broadly defined as an awareness of speech sounds. This includes an awareness of syllables or rhyme or alliteration or phonemes. More specific definitions relate to the size of the phonological segment of interest (see Figure 2.1). That is, syllable awareness is an awareness of syllables, rhyme awareness is an awareness of rhyme (or rime units), alliteration awareness is an awareness of alliteration (or onset units) and phoneme awareness is an awareness of phonemes. The following review of studies will also identify measurement tasks in terms of the operation that is required to be carried out to show awareness of the particular segment (e.g., detection, isolation, blending, deletion, or substitution).

Ideally, an examination of a particular study would also consider the linguistic characteristics of the items making up the tests used in that study. As has been noted, the linguistic characteristics (e.g., type of phoneme, presence of phoneme clusters) can affect the difficulty level of test items. Although there has been some research examining the effects of linguistic characteristics for specific types of tests used for particular groups of children, the generalisability of the findings is not known. A further difficulty with examining the linguistic characteristics of test items is that many published studies do not provide details about the precise items that were used in their tests.

2.2.2 Phonological Awareness and the Acquisition of Literacy Skills

Many studies have found a strong association between various measures of phonological awareness and the acquisition of literacy. Stanovich (1991) has argued that the "specification of the role of phonological processing in the earliest stages of reading acquisition . . . is one of the more notable scientific success stories of the last decade" (p. 78). But while the *existence* of a relationship between phonological awareness and literacy is well established, there is still considerable debate about the *nature* of the relationship. Making a comparative analysis of research in this area is difficult because not only is there the problem that studies have used different measures of phonological awareness, but there is also the problem that studies have used different measures of literacy. Most investigations have looked only at connections between phonological awareness and reading progress and have largely ignored possible links with the development of spelling skills. Another complication when comparing different studies is that outcomes may be affected by specific subject characteristics. It is therefore also important to take account of factors such as the age of participants, their cognitive abilities and reading levels, and the type of instructional programme they have been exposed to.

Investigations in this area can be broadly grouped according to whether they are concerned with one of the three following alternative hypotheses about the relationship between phonological awareness and literacy (see Ehri, 1979; Tunmer & Rohl, 1991; Wagner & Torgesen, 1987; Wagner et al., 1994):

1. Phonological awareness has a causal role in the acquisition of literacy.
2. Phonological awareness is a consequence of the acquisition of literacy.
3. Phonological awareness and the acquisition of literacy show a reciprocal relationship.

Research relating to each of these three hypotheses is examined in the following three main sections of this review. Within each section, studies are grouped into three categories according to their research design:

1. Concurrent correlational studies (henceforth referred to as correlational studies).
2. Longitudinal correlational studies (henceforth referred to as longitudinal studies).
3. Experimental studies.

Grouping studies according to research design is an approach that has been used by previous reviewers of research on phonological awareness (see, e.g., Ball, 1993; Wagner & Torgesen, 1987). Correlational, longitudinal, and experimental studies can all provide different types of information about possible connections between measures of phonological awareness and literacy. A systematic examination of these studies can help to identify the commonalities and differences in the findings of the myriad of investigations in this area. A large number of studies, often with complex designs, are discussed in the following parts of the Literature Review. To highlight key findings, a summary is provided at the end of each subsection.

2.2.3 Phonological Awareness has a Causal Role in the Acquisition of literacy

2.2.3.1 Correlational studies.

Correlational studies measure phonological awareness and literacy at the same time for a particular group of children. A correlational study may include a sample of children of a specific age group, or may include a number of samples in order to provide a cross-section of different ages. Correlational studies are useful for establishing whether there is an association between phonological awareness and literacy. If an association is found, it is important to be able to rule out the possibility that the association is simply a reflection of the common connection of the variables to a third variable. For this reason, a measure of other variables that may have a causal influence, such as general or verbal ability, should also be included. The possible influence of these variables can then be taken into account when analysing the results. A carefully designed correlational study can show whether there are specific relationships between particular variables. It cannot, however, indicate the causal direction of these relationships.

The following review of correlational studies is divided into two sections according to the size of the phonological segment under investigation: (i) rhyme awareness and alliteration awareness (i.e., an awareness of rimes and an awareness of onsets); and (ii) phoneme awareness.

2.2.3.1.1 Correlational studies of rhyme awareness and alliteration awareness, and literacy

An association between rhyme awareness or alliteration awareness[1], and literacy, has been found in a number of studies that have measured these variables in groups of children. Further analysis of this association is limited when studies have not measured possible confounding variables such as verbal ability (e.g., Hoien et al., 1995; Stahl & Murray, 1994). Fortunately, some studies have included an assessment of verbal ability. For example, Kirtley, Bryant, MacLean and Bradley (1989) examined the connection between performance on rhyme oddity tasks and alliteration oddity tasks, and reading for a group of 6- and 7-year-olds. After partialling out age and verbal ability as measured by receptive vocabulary scores, performance on any of the oddity tasks was found to explain significant additional variance (ranging from 9% to 19%) in word reading.

This finding suggests that rhyme awareness and alliteration awareness make contributions to word reading that are independent of general language ability. The validity of this conclusion, however, depends to some extent on the adequacy of the test that Kirtley et al. used to measure general language ability. The suitability of the test, (the British version of the Peabody Picture Vocabulary Test), was questioned by Bowey and Patel (1988). They considered that this test, along with a number of other single measures of language skills, does not provide a sensitive enough control for general language ability.

For this reason, Bowey and Patel (1988) used a sentence imitation test, in addition to the Peabody Picture Vocabulary Test - Revised, (Dunn and Dunn, 1981), in order to control for general language ability in their own correlational study. They found that general language ability - as measured by these two tests - explained 41% of the variance in the word identification skills of a sample of first graders. After taking account of general language skills, the variance explained by the children's performance on rhyme oddity tasks and alliteration oddity tasks was not significant. Bowey and Patel concluded that their findings do not imply that rhyme awareness and alliteration awareness do not contribute to reading development but

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[1]. Rhyme awareness, and alliteration awareness will be labelled separately when separate tasks have been used to measure each of them. This is to avoid the confusion that can arise when the phrase "rhyme and alliteration awareness" may refer to either performance on two tasks that separately assess rhyme awareness and alliteration awareness, or performance on one task that contains items to assess both rhyme and alliteration awareness.

do imply that rhyme awareness and alliteration awareness are not statistically independent of general language development.

A different conclusion about the independent contribution of phonological awareness skills was made from a similar study carried out by Hansen and Bowey (1994). The researchers combined rhyme and alliteration oddity tasks to provide a measure of subsyllabic oddity. They also used a phonemic oddity task that required children to detect differences at the phoneme level (e.g., pit, pin, pack). The connection between these phonological awareness skills, and word and pseudoword reading, was examined for a group of second grade children. As in Bowey and Patel's (1988) study, the variance accounted for by the children's scores on the PPVT-R and the sentence imitation test was partialled out using regression analysis. In addition, the influence of scores on a test of IQ and a test of working memory were also partialled out. Controlling for working memory helped to reduce the possibility that the memory demands of the phonological awareness tasks were responsible for any connection that was found with reading.

In contrast to Bowey and Patel's study, Hansen and Bowey (1994) found that the phonological awareness measures explained additional variance in reading after taking account of the language, IQ, and memory measures. The subsyllabic measure and the phoneme measure each explained significant additional variance, and together accounted for about 19% of the variance in pseudoword reading and about 10% of the variance in word reading. Considerable variance was shared between the subsyllabic measure and the phoneme measure. After controlling for the language and cognitive measures and the subsyllabic oddity scores, the phoneme measure explained no significant additional variance in word or pseudoword reading. When the language and cognitive measures were controlled, followed by the phoneme measure, the subsyllabic measure explained no significant additional variance in word reading, but did explain significant additional variance in pseudoword reading.

The greater contribution of the phonological awareness scores to pseudoword reading than to word reading probably reflects the different demands of these reading measures. Pseudoword reading usually requires phonological recoding (i.e., an indirect strategy requiring grapheme-phoneme knowledge) whereas word reading can also be accomplished through a direct visual route (i.e., "sight" reading) (see Ehri 1992; Thompson, Cottrell, & Fletcher-Flinn, 1996). Hansen and Bowey (1994) suggested that because phonological awareness is particularly

important for the development of phonological recoding skills, it is likely to show a closer connection with pseudoword reading than with word reading.

Hansen and Bowey (1994) noted that their findings are inconsistent with those of Bowey and Patel (1988) who, as discussed above, found no significant association between phonological awareness scores and reading after controlling for performance on the PPVT-R and sentence imitation tests. A possible explanation for the difference in findings is that the first grade children in Bowey and Patel's study were younger and less advanced in reading than the second grade children in Hansen and Bowey's study. Hansen and Bowey suggested that the younger children may have been reliant on visual cues and partial phonological recoding as strategies for word reading whereas the older children would have made fuller use of phonological recoding. Because the contribution of phonological awareness to reading may be particularly salient for the development of phonological recoding skills, then the connection between phonological awareness and reading may become more apparent during second grade, as this is when children start to make more use of phonological recoding.

Evidence that phonological awareness may continue to be important during the third grade was provided in a study by McDougall, Hulme, Ellis, and Monk (1994). After taking account of age, IQ, and working memory, McDougall et al. found that rhyme oddity performance and phoneme deletion each accounted for significant additional variance in word reading (9.4% and 12.8% respectively). Further analysis showed that phoneme deletion scores explained significant additional variance (5%) even after controlling for rhyme oddity scores, but that rhyme oddity scores did not make a unique contribution to variance over and above that explained by phoneme deletion.

The finding by McDougall et al. (1994) that rhyme oddity performance did not make a unique contribution to word reading is in agreement with the results of Hansen and Bowey (1994). Hansen and Bowey, however, had also measured pseudoword reading and did find a unique contribution of rhyme awareness to this. McDougal et al.'s finding of a unique contribution of phoneme awareness to word reading differs from Hansen and Bowey's results where there was no unique contribution of phoneme awareness after controlling for subsyllabic awareness (i.e, a combined measure of rhyme and alliteration awareness. It is possible that phoneme awareness was more important for the reading skills of the children in McDougall et al.'s sample as they were a year older, and further on in reading development, than the children in Hansen and Bowey's study.

It is also possible that the different pattern of results in each study was due to differences in the phonological awareness tests they had each used. McDougall et al. (1994) used an oddity task to assess rhyme awareness and a deletion task to assess phoneme awareness whereas Hansen and Bowey (1994) used all oddity tasks to assess rhyme, alliteration, and phoneme awareness. Hence McDougall et al.'s tasks differed not only in the level of the target segment (i.e., at the onset-rime or phoneme level) but also in the type of operation required to show awareness (i.e., oddity detection or deletion). Generally tests of different levels of phonological awareness are more comparable if they require the same type of operation. Because Hansen and Bowey's tests all used oddity operations it is likely that they shared more variance than was the case for McDougall et al.'s rhyme oddity and phoneme deletion tasks. The possibility that Hansen and Bowey's tasks had greater shared variance than McDougall et al.'s tasks may explain why Hansen and Bowey did not find separate contributions of subsyllabic awareness and phoneme awareness to reading whereas McDougall et al. did find evidence of this.

Hansen and Bowey (1994) found that the second grade children in their study showed slightly higher average scores on the subsyllabic (rhyme and alliteration) oddity task than the phoneme oddity tasks. Other studies that have compared rhyme and phoneme awareness in children have usually found large advantages for the rhyme awareness tasks (Hoien et al., 1995; McDougall et al., 1994; Stahl & Murray; 1994; Stanovich, Cunningham, & Cramer, 1984; Yopp, 1988). However, while Hansen and Bowey used the same type of task (oddity detection) to measure subsyllabic and phoneme awareness, other studies have used tasks that differ in the types of operations that children are required to carry out. Rhyme awareness has most commonly been assessed with oddity tasks whereas phoneme awareness has usually been assessed by types of segmentation (including phoneme counting) and deletion tasks. This may have given an advantage to the rhyme awareness tasks because generally a less explicit level of awareness of phonological units is required for oddity tasks in comparison to segmentation and deletion tasks (Cardoso-Martins, 1994; Morais, 1991a, 1991b).

Two recent correlational studies of phonological awareness are of particular interest because they have used segmentation measures to assess both rhyme awareness and phoneme awareness (Nation & Hulme, 1997; Seymour & Evans, 1994). Children in these studies were required to segment nonwords into onset and rime or into phonemes. Seymour and Evans found that both segmentation tasks were

too difficult for nonreading preschool children, but Grade 1 and 2 children were able to perform at higher levels on phoneme segmentation than onset-rime segmentation. Phoneme segmentation was correlated with reading but onset-rime segmentation was not. Similar findings for school-age children were made by Nation and Hulme. These researchers also administered a rhyme oddity task but found this did not correlate with the onset-rime segmentation task. The rhyme oddity task, however, did correlate significantly with concurrent reading and spelling measures. Digit span was controlled for but no measure of verbal ability was made.

Seymour and Evans (1994) have pointed out that one reason for the advantage of phoneme segmentation over onset-rime segmentation may have been the influence of school instructional programmes. They did not rule out the possibility that children could have a disposition to separate words into onset and rime (as suggested by Treiman, 1985). Seymour and Evans believed, however, that the influence of reading instruction involving letter-sound relationships will override any such disposition so that school children may favour breaking words into smaller phoneme units based on their orthographic knowledge.

A shortcoming in all of the above discussed correlational studies is that none of them have taken account of the possible influence of letter knowledge on the relationship between rhyme awareness and alliteration awareness, and literacy. Although studies have often controlled for possible confounding variables such as verbal ability or memory, the same attention has not been given to letter knowledge. Letter-name or letter-sound knowledge may assist children with rhyme oddity and alliteration oddity tasks by helping them to gain insights into the phonological structure of words (see Burgess & Lonigan, 1998; Johnston, Anderson, & Holligan, 1996). As letter knowledge is known to be associated with literacy acquisition (Adams, 1990), particularly in the early stages, researchers would be advised to measure and control for its effects when examining connections between phonological awareness and literacy.

Summary

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Correlational studies of rhyme awareness and alliteration awareness, and literacy have frequently found a positive association between these variables. Although there have been some mixed findings, this association has usually remained

significant after partialling out the influence of general or verbal ability (e.g., Kirtley, Bryant, MacLean, & Bradley, 1989).

Some correlational studies have included measures of both rhyme awareness and phoneme awareness. However, there are difficulties in comparing the contributions of these variables to reading when the tasks used to assess these variables differ not only in the size of phonological unit, but also in the type of operation that is required. If a study uses a detection task to assess rhyme awareness, and a segmentation or deletion task to assess phoneme awareness, the finding of higher performance levels for rhyme awareness may simply reflect that it is easier to detect sound units than to segment or manipulate them (e.g., McDougall et al., 1994).

Two recent correlational studies that used segmentation tasks to assess both rhyme and phoneme awareness found that school children did less well when segmenting nonwords into onsets and rimes than when segmenting words into phonemes (Nation & Hulme, 1997; Seymour & Evans, 1994). It is possible that school instructional factors may have encouraged the children to break words into the smaller phonological units. Phoneme segmentation, but not onset-rime segmentation, was correlated with reading in these studies.

A shortcoming in correlational studies of rhyme awareness and alliteration awareness, and literacy is that none of them have controlled for the possible confounding effects that letter knowledge may have on the connection between the variables. Letter knowledge is known to be related to the acquisition of literacy (Adams, 1990), and may assist children in gaining insights into the phonological structure of words (Johnston et al., 1996). It is an important variable to take into account when examining the relationship between particular types of phonological awareness and the development of literacy skills.

2.2.3.1.2 Correlational studies of phoneme awareness and literacy

Correlational studies of phoneme awareness and literacy are able to provide information about the relative difficulty level of specific phoneme awareness tasks, and the association of these tasks with literacy, for particular groups of subjects of particular ages. Such studies can also provide information about whether the apparent connection between phoneme awareness and literacy varies not only

according to the measure of phoneme awareness, but also according to the measure of literacy.

One of the most comprehensive correlational studies in this area was conducted by Vandervelden and Siegel (1995). Children from three age groups - kindergarten, Grade 1, and Grade 2 - were given a range of phoneme awareness and literacy tests. Vandervelden and Siegel found that while the order of difficulty of the phoneme awareness tests was the same for all three age groups, the size of the performance differences between the tests varied with age, largely because of ceiling effects. Children found the phoneme recognition tests to be the easiest tasks and it was here that ceiling effects were most apparent, especially at Grade 2. Segmentation tasks were more difficult and less affected by ceiling effects. The deletion and substitution test was the hardest task, with even Grade 2 children scoring an average of less than half the items correct.

Vandervelden and Siegel (1995) used several methods to assess literacy development. These included a simple word matching test (where children were told a word, and had to choose which one it was from a set of three printed words), and a pseudoword reading test. When the measures of phoneme awareness were correlated with the measures of reading, a complex and changing pattern of associations was found. The simplest measure of phoneme awareness (i.e., phoneme recognition) was found to relate most strongly to the early levels of reading (i.e., word matching). The more difficult measures of phoneme awareness (i.e., deletion and substitution) related more strongly to the higher levels of reading skill (measured by pseudoword reading) that were found mainly in the sample of older children. As Vandervelden and Siegel did not assess general verbal ability, they were unable to assess the possible effects of this on the relationships between phoneme awareness and reading.

The finding that some measures of phoneme awareness were too difficult for children who had not yet started school, and for many children in their first year at school, suggests that performance on these tasks may be influenced by skills, such as literacy, that develop at school. Alternatively it could be that greater success in these tasks is linked to age-related changes in children's cognitive development.

Other correlational studies of phoneme awareness and reading have not included as broad a range of ages or measures as were used by Vandervelden and Siegel (1995). Each of these other studies has generally included only one age group of children in their sample and therefore could not provide information about how

performance on specific tasks may vary across ages. Each study used its own particular measures of phoneme awareness, making it difficult to make comparisons across studies. Nevertheless, some insights can be gained by examining the studies according to the category of phoneme awareness tasks that have most commonly been used, that is, phoneme counting and phoneme deletion.

Phoneme counting tasks (a type of segmentation task where children are asked to count or tap out the number of phonemes in a word) have shown significant correlations with reading in nearly all studies in which they have been used (an exception being Leather & Henry, 1994). Most studies of this type, however, have not controlled for possible confounding variables such as general or verbal ability (e.g., Calfee, Lindamood, & Lindamood, 1973; Hoien et al., 1995; Leather & Henry, 1994; Lenchner, Gerber, & Routh, 1990; Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977).

A study that did control for the possible effects of verbal ability was conducted by Tunmer and Nesdale (1985). Their study examined the connection between phoneme tapping and pseudoword reading for a group of first graders. The tapping task required the children to tap out the number of sounds in a list of real words and a list of pseudowords. Half of the words of each type contained digraphs (i.e., a single phoneme that is represented by two letters, e.g., -ee-, -oa-), and the other half did not. Performance on the non-digraph phoneme tapping items was strongly related to the children's ability to read pseudowords. After controlling for differences in the children's scores on a receptive vocabulary test (PPVT-R), the relationship remained significant. Scatterplots of the results for the non-digraph tapping task indicated that ability to perform this task was necessary, but not sufficient, for the development of word decoding skills.

Because Tunmer and Nesdale (1985) were able to partial out the effects of verbal ability, their findings for the non-digraph tapping task provide evidence that the connection between phoneme awareness and literacy is not due to the confounding influence of verbal skills. However, the simultaneous correlational design of the study means that it is not possible to determine the direction of the relationship. Indeed, evidence from the study can be used to support the proposition that phoneme awareness is both a cause and a consequence of reading. Although the scatterplots for the non-digraph tapping tasks indicated that an awareness of phonemes assists with reading skill, the results of the digraph tapping tasks suggested the relationship could be operating in the other direction. The children's performance on the digraph tapping task appeared to be affected by their experience

with print. They were found to make "overshoot" errors when tapping the number of phonemes in words containing digraphs. For example, children would tap three times for a three phoneme word that contained three letters, (e.g., "red"), but were likely to tap four times for a three phoneme word if one of the phonemes was represented by a digraph (e.g., "boot"). It therefore appeared that the children's performance on the tapping task was somewhat dependent on their knowledge of the word's spelling and thus may have been influenced by reading experience (see also Tunmer & Nesdale, 1982). In later work, Tunmer and colleagues recommend that pseudowords should be used for phoneme tapping tasks in order to avoid the possible influence of spelling knowledge (Tunmer et al., 1988).

Apart from counting tasks, the most commonly used measures of phoneme awareness in correlational studies have been deletion tasks. A number of studies have reported significant correlations between phoneme deletion skills and reading (e.g., Badian, 1993; Leather & Henry, 1994; Lenchner, et al., 1990; McDougall et al., 1994; Stahl & Murray, 1994). When measures of phoneme deletion and counting were both made, deletion scores showed higher correlations with reading than did counting scores (Leather & Henry, 1994; Lencher et al., 1990).

A number of studies that have used phoneme deletion measures have not controlled for the possible effect of general or verbal ability. There are two studies, however, that have taken account of ability factors (Badian, 1993; McDougall et al., 1994). McDougall et al. found that phoneme deletion scores accounted for nearly 13% of the variance in word reading, after taking account of age and IQ scores for a group of 8 year-old children. Badian found that phoneme deletion scores explained about 6% of the variance in word reading, and 18% of the variance in pseudoword reading, after first partialling out the effects of IQ and time at school for a group of children aged from 6 to 10 years. The finding of a higher correlation for pseudoword reading fits with the idea that phonological awareness is particularly important for the development of phonological recoding skills, and is therefore more likely to show a closer connection with pseudoword reading than with word reading.[2]

A deletion task was used in an investigation by Johnston et al. (1996) who also used a segmentation task to assess phoneme awareness. Johnston et al. were not interested in the correlation between phoneme awareness and reading skills because their sample was of nonreading preschoolers (mean age = 4 years 6 months). The

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[2] See the earlier discussion of this point in Section 2.2.3.1.1.

children were screened with two reading tests, including one of Clay's (1985) lists of high frequency words. Any child who could read a word was excluded from the sample. Johnston et al. found a significant correlation between phoneme awareness skills and ability to recognise environmental print (product names as they appeared on packaging). The relationship remained significant after controlling for vocabulary skills, but not after also controlling for alphabet knowledge. Johnston et al. concluded that children usually acquire alphabet knowledge before they develop phoneme awareness and that recognising letters in environmental print may help children become aware of the way sounds are represented in words.

These are interesting conclusions but the most significant of Johnston et al.'s (1996) findings is that nonreading children were able to score on two phoneme awareness tasks - one requiring deletion and the other segmentation. An examination of the results shows that children scored most highly for saying a word without the final phoneme in the deletion task (16% correct) and for saying the first phoneme of a word in the segmentation task (24% correct). Scores for the other phonemes in these tasks were much lower (e.g., only 2% of children could delete the initial phoneme of a word, and only 6% could segment the last phoneme of a word). The pattern of scoring indicated that some children were able to say the first part of a word and then stop before saying the rest of the word. Other researchers, however, have questioned whether this type of performance is really a sign of phoneme awareness or whether it is an indication that children can learn "to monitor one's articulation of a utterance and stop just before the last articulatory gesture" (Content, Kolinsky, Morais, & Bertelson, 1986, p. 67).

Summary

Correlational studies have shown that phoneme awareness tasks vary considerably in difficulty level, but are often unable to be performed by preschoolers (Vandervelden & Siegel, 1995). One study found that some nonreading children were able to succeed on a task that required them to say the first part of a word (Johnston et al., 1996). There is debate, however, about whether such a task involves phoneme awareness or is the result of articulatory control (Content et al., 1986).

Counting and deletion tasks have been the most commonly used measures of phoneme awareness in correlational studies. Each of these studies has nearly

always found a significant correlation between phoneme awareness and reading, and this connection has remained significant in the studies that have partialled out the influence of general or verbal ability (Badian, 1993; Hoien et al., 1995; Leather & Henry, 1994; Lenchner et al., 1990; Liberman et al., 1977; McDougall et al., 1994; Stahl & Murray, 1994; Tunmer & Nesdale, 1985; Vandervelden & Siegel, 1995).

No correlational studies of phoneme awareness and reading have taken the possible confounding effects of the important variable of letter knowledge into account. Correlational studies of rhyme awareness and alliteration awareness, and literacy, also have this shortcoming.

2.2.3.2 Longitudinal Studies

Longitudinal studies provide additional information to that which is available from correlational studies where children are assessed at only one time point. Because a longitudinal study assesses the same group of individuals at different points in time, it is possible to observe the rate of development for members of the group, and to examine whether scores for a particular variable at one time are predictive of scores for that variable, or for other variables, at a later time. The information that longitudinal studies provide about the sequence of development of particular variables is useful for examining possible causal relationships. A causal relationship from Variable A to Variable B cannot exist if Variable A does not occur until after Variable B (Keeves, 1997).

The likelihood of correctly identifying a causal connection can be improved by giving attention to the variables that may influence the relationship between phonological awareness and literacy. As with correlational studies, it is necessary to assess possible confounding variables, such as general or verbal ability. The effects of these variables can then be partialled out when analysing the results of a study.

Because longitudinal studies examine connections between variables over time, it is important that phonological awareness and reading are both assessed at each time point. If a study only measures phonological awareness at one time, and reading at a later time, then little can be said about the direction of the relationship between the variables. It may be that early phonological awareness skills are influencing later reading, or it could be that early phonological awareness skills have already been

influenced by the reading skills of the children at that time. The latter situation would mean that an apparent connection between early phonological awareness and later reading may simply reflect that children with strong initial reading levels (which are positively influencing their phonological awareness skills) are more likely to be reading at high levels at a later time. Measuring both phonological awareness and reading at each time point can help to avoid problems of ambiguity in interpreting the findings of longitudinal studies. Ideally, a study should begin with non-readers because this allows the researcher to rule out any possible influence of reading on phonological awareness at the time of first assessment.

2.2.3.2.1 Longitudinal studies of rhyme awareness and alliteration awareness, and literacy

Numerous studies have found a significant correlation between the rhyme and alliteration awareness of young children and their later reading skills. A number of these studies, however, have not controlled for possible confounding variables, such as general or verbal ability, phonological memory, letter knowledge or initial reading levels (e.g., Cataldo & Ellis, 1988; Lundberg, Oloffson, & Wall, 1980; Stuart & Coltheart, 1988). Such studies are only able to provide limited information about possible causal relationships between the variables of interest.

Some other longitudinal studies have taken account of the effects of general or verbal ability, but have either not assessed initial reading with a sensitive test, or have inadequately controlled for it (Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Ellis & Large, 1987, 1988; Lazo, Pumfrey, & Peers, 1997; Vellutino & Scanlon, 1987; Walton, 1995; Wimmer, Landerl, & Schneider, 1994).

Bradley and Bryant's (1983) study is an example. They measured the performance of a large group of 4- and 5-year-olds on rhyme oddity and alliteration oddity tasks. Significant correlations were found between the children's scores on these tasks and their reading and spelling skills three to four years later. Regression analyses showed that the relationships remained significant after partialling out differences in age, IQ, receptive vocabulary and memory. For the sample of 4-year-old children, a combined rhyme and alliteration score explained 9.8% additional variance for word reading and 8.1% additional variance for word spelling. The equivalent figures for the sample of 5-year-old children were 4.1% and 5.6%.

Bradley and Bryant (1983) screened their initial sample for reading skills but the test they used - the Schonell Reading test (Schonell & Goodacre, 1971) - may not have been adequate for this purpose. None of the children could read any of the words in the Schonell test. However, the test is not intended to be a sensitive measure of early reading skill. It begins with relatively simple words such as *tree*, *milk*, *egg*, and *book*, but there are many higher frequency words that children may first learn to read (see Carroll, Davies & Richman, 1971). The norms for the Schonell test confirm that it was not designed for the first year of reading (when children in English schools are usually 5 years old) as it assigns a reading age of 6 years or higher to any child who can read more than one of the words that make up the test.

Hence it is possible that Bradley and Bryant's (1983) sample contained some children with early reading skills, thereby blurring the causal implications of the data. Bowey and Francis (1991) have noted that preschool children who are able to read even a few words are likely to score more highly on rhyme awareness and alliteration awareness tasks and to show higher reading progress than children who can read no words before starting school. If a study includes children who are already reading when rhyme awareness and alliteration awareness are first assessed, then it is not possible to infer whether their later reading progress is related to early rhyme awareness and alliteration awareness, or is simply an outcome of their initial headstart with reading. Bowey and Francis pointed out that even a small number of early reading children with rhyme awareness skills can have a large effect on the size of predictive correlations between awareness or rhyme and alliteration and later reading.

In addition to the possible problems with screening out early readers in Bradley and Bryant's study, there may also be problems with their efforts to partial out the effects of the memory demands of the oddity tasks. In an attempt to rule out the possibility that performance on the oddity tasks was largely a reflection of the working memory requirements of these tasks, Bradley and Bryant included a word-span memory test in their initial assessments. Wagner and Torgesen (1987), however, have argued that this test may not have adequately assessed the complex memory demands of the oddity tasks and would therefore have provided an insufficient control for the effects of children's working memory skills on oddity task performance.

A longitudinal study by Bryant, MacLean, Bradley, and Crossland (1990) is also complicated by methodological issues related to the need to control for confounding variables such as initial reading skill and verbal ability. The study examined relationships between rhyme awareness and alliteration awareness and reading and spelling by assessing a group of children at several time points, from when their average age was 4 years 7 months to when their average age was 6 years 7 months of age. (In an earlier study, the sample children had been assessed on receptive vocabulary, at the age of 3 years 4 months, and IQ, at the age of 4 years 3 months - see Bryant, MacLean, & Bradley, 1990). Oddity tasks were used to assess rhyme awareness and alliteration awareness at the first time point, and reading and spelling were assessed on the last occasion. In an effort to control for the memory demands of the oddity tasks, Bryant, MacLean, Bradley, and Crossland used pictures to illustrate each of the words. Children were then able to refer to the pictures as cues to the words while they decided which was the 'odd one out'. Regression analyses showed that the children's early awareness of rhyme or alliteration was able to account for significant variance in reading and spelling achievement, even after removing the effects of age, mother's educational level, receptive vocabulary, and IQ.

Path analyses of the results were interpreted as suggesting that rhyme awareness and alliteration awareness acted both indirectly and directly to influence reading. The indirect influence operated through increasing the awareness of phonemes, which in turn affected reading. Reading was also influenced directly through the distinct contribution that rhyme awareness and alliteration awareness made. Bryant, MacLean, Bradley, and Crossland (1990) concluded that experience with rhyme makes children aware of categories of words that share a common sound. The researchers claimed that making the connection between rhyme categories and the spelling categories that share common letters enhances early reading progress by helping children to become aware of the common patterns that occur in English orthography. (Evidence to support this claim is provided by Goswami, 1986, 1988, 1990.)

The validity and reliability of the verbal ability tests used by Bryant, MacLean and Bradley (1990) has been criticised by Bowey (1990). Bowey also expressed concern that the length of time between language testing and reading testing was usually a year longer than the time between sound awareness testing and reading testing. Bowey suggested that these difficulties resulted in an inadequate assessment of the influence of the children's language skills on the relationship between rhyme awareness and alliteration awareness, and reading.

Bryant, MacLean, Bradley and Crossland's (1990) investigation is of particular interest for the suggestions it makes as to the mechanisms through which rhyme and alliteration awareness may affect reading. However, confidence in the study's findings is somewhat lessened by methodological concerns related to the efforts to partial out verbal ability, and by the inclusion of children who may have already been reading at the beginning of the study. As previously discussed, such problems result in ambiguity when trying to determine the direction of the relationship between measures of phonological awareness and reading. Bryant, MacLean, Bradley, and Crossland did not report any measures of the reading skills of their sample at the time of first assessing rhyme awareness and alliteration awareness, but the results of another study of the same group of children (MacLean, Bryant, & Bradley, 1987) shows that some of them were already reading at that time.

A similar problem of including some children who were already reading may have occurred in a study by Walton (1995). At the beginning of the study children were screened with 8 words selected from Baron's (1977) reading test (*bed, pit, bet, sin, hug, man, bag, rag*). Children who could read two or more words were excluded from the sample. This procedure is unlikely to have screened out children who were in fact able to read a large number of higher frequency words (e.g., to, is, up, for, big: see Carroll et al, 1971).

Walton used a rhyme oddity task (with pictures to reduce memory load), to assess the rhyme awareness skills of the sample children when they were in kindergarten (mean age = 5 years 8 months). The children's word reading skills were then assessed near the end of Grade 1 (mean age = 6 years 10 months). After partialling out the effects of age and measures of vocabulary, phoneme awareness, and letter-sound knowledge made at the start of the study, Walton found that early rhyme awareness was able to explain an additional 7% of the variance in Grade 1 word reading. The possibility that children with early reading skills were included in the initial sample introduces an element of doubt as to the specific contribution of rhyme awareness to later reading. However, Walton's control for the letter-sound knowledge that children had at the beginning of the study is likely to have also helped to control for any differences between early word reading skills that were in existence at this stage. (Letter-sound knowledge and early word reading are strongly linked - see Adams, 1990.)

Another longitudinal study in this area that controlled for IQ, but did not take direct account of initial reading skills, was carried out by Wimmer et al. (1994). The researchers were interested in examining whether the relationships between rhyme awareness and alliteration awareness, and reading that had been found for children learning to read English would also be found for children in Austria who were learning to read German. Wimmer et al. used rhyme oddity and alliteration oddity tasks to assess their sample of children (mean age = 6 years 0 months) four months before they began school. Because the children had not begun reading instruction at this time they were not given a reading test. It is possible, however, that some of the children could have developed early reading skills by this stage, especially as some of them were nearly six and a half years old.

After a year at school the children were given a timed word reading test. Spelling achievement was also assessed at this time and again several years later at the end of Grade 4. Children were found to score considerably lower on the alliteration oddity test than the rhyme oddity test. Wimmer et al. (1994) noted that this pattern of task difficulty was also found by Bradley and Bryant (1983) and suggested that a possible explanation is that the alliteration oddity tasks in these studies require an awareness of smaller phonological segments (i.e., the onset, usually of one consonant only) than is required for the rhyme detection tasks (where the difference is in a vowel plus final consonant[s]). It is therefore possible, according to Wimmer et al., that the alliteration oddity and rhyme oddity tasks were measuring different aspects of phonological awareness. This suggestion, however, is not supported by the results of a number of other studies where children have been found to score at similar levels on both alliteration oddity and rhyme oddity tasks (e.g., Bryant, MacLean, Bradley, & Crossland 1990).

Wimmer et al. (1994) found that preschool rhyme awareness showed small but significant correlations with word reading speed (r = .21) and spelling (r = .23) after a year at school (IQ was partialled out for all correlations). A correlation of similar value (r = .25) was found between preschool alliteration awareness and Grade 1 spelling, while a somewhat higher correlation existed between preschool alliteration awareness and Grade 1 word reading speed. The correlation between early rhyme awareness and spelling increased significantly for the Grade 4 measure (to r = .37) while there was actually a small decline in the correlation between early alliteration awareness and Grade 4 spelling (to .21). No measure of reading was given at Grade 4, but the results of a smaller study also reported by Wimmer et al. suggest that reading achievement would have correlated highly with the spelling

measure at this point. It would therefore be expected that early rhyme awareness could also have shown a significant correlation with reading progress at Grade 4.

Wimmer et al. (1994) put forward some interesting ideas to explain the pattern of correlations shown in their research. They noted that German orthography is more regular than English orthography and that children who are taught to read German with a phonics approach become skilful at using key letter-sound knowledge and blending skills by the end of Grade 1. They suggested that an awareness of how words are made up of component phonemes is useful for this initial indirect (or phonological recoding) word recognition and regular spelling stage, but that an awareness of larger phonological units (such as the rimes involved in rhyme detection) is not involved at this time They went on to speculate that the reason why rhyme awareness increases in predictive value after several years of schooling is because of the role it plays in helping children build up the memory representations required for direct (or visual) word recognition and orthographic spelling of irregular words. They argued that children who show high rhyme awareness before school may have an advantage in using patterns of sound and letter groupings for direct word recognition.

In support of their suggestion, Wimmer et al. (1994) noted that researchers such as Ehri (1992) and Perfetti (1992) provided evidence for the use of phonological information in establishing and using direct word recognition strategies. Wimmer et al. pointed out that in the studies done by Bryant and colleagues of children learning to read English, rhyme awareness had been found to be strongly related to reading from the first year of schooling, rather than later on as happened for the children learning to read German. They suggested that this is because English orthography is much less consistent than German orthography, and thus requires English reading children to make early use of direct word recognition strategies where children with rhyme awareness have an advantage.

The most informative longitudinal studies of rhyme awareness and alliteration awareness, and literacy have controlled for ability factors and also taken account of the possible influence of initial reading skill, either by assessing this and statistically partialling out its influence (as in a study by Stuart, 1995), or by carefully screening to ensure only nonreaders are included at the beginning of a study (Bowey, 1995; Muter, Hulme, Snowling, & Taylor, 1997; Rohl and Pratt, 1995).

Stuart (1995) assessed children's reading skills at the beginning of her study by using two tests: the first was one of Clay's (1985) lists of high frequency words, and the second was a list made up of the most frequent words in the books that children were using at the start of the school term. These tests, and tests of rhyme detection and alliteration detection, were given to a group of children during their first term at school when their average age was 4 years and 9 months. After partialling out the effects of initial reading, Stuart found no significant correlation between the rhyme detection and alliteration detection skills of the children and their word reading at the end of the first year at school.

Muter et al. (1997) excluded any child from their sample who could read a single word from a list that included high frequency words (the British Ability Scales Word Reading Test; Elliot, Murray, & Pearson, 1983). The sample children were then assessed with a rhyme detection test and a rhyme production test shortly before they started school (mean age = 4 years 3 months). Factor analysis showed that both rhyme tests loaded heavily on a 'rhyming factor'. After taking IQ into account, the pre-school rhyming factor was not significantly correlated with word reading or spelling at the end of the first or second years at school.[3]

Hence two of the studies that have taken account of the possible influence of early reading, either by partialling it out (Stuart, 1995) or by careful screening (Muter et al., 1997) did not find a significant connection between early rhyme awareness and later reading. However, a significant connection was found in two other studies that used careful screening procedures to rule out the possible influence of early reading (Bowey, 1995; Rohl & Pratt, 1995).

Both of these studies made use of Clay's (1985) lists of high frequency words to screen for early word reading skills. Rohl and Pratt (1995) used one list of 15 words and excluded children who could read more than one word (81 of the 83 children who were included in the study could read no words). Bowey (1995) used all three of Clay's lists (i.e., 45 words altogether) to screen for early reading. Both studies used the PPVT-R to control for verbal ability.

Rohl and Pratt (1995) assessed rhyme and alliteration awareness with a combined oddity task that was administered near the start of Grade 1. After controlling for verbal ability, age, and memory, scores on the oddity task explained significant additional variance in a composite reading and spelling measure at the end of Grade

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[3] This study is also discussed in Section 2.2.3.2.2.

1 (increase in variance of 23%) and towards the end of Grade 2 (increase in variance of 8%). Rohl and Pratt's careful screening of reading skills, along with their control of verbal ability, age and memory, means that their study provides stronger evidence than many others of the specific contribution of early rhyme and alliteration awareness to later skills. A difficulty with their study, however, is that they did not control for the effects of initial letter-knowledge. Many studies have found a strong correlation between early letter knowledge and later progress in reading and spelling (Adams, 1990 - see also Section 2.3.1 of this Literature Review). Rohl and Pratt did not assess letter knowledge but it is possible that performance on their rhyme and alliteration oddity task was influenced by knowledge of letter names and sounds. This is especially likely when it is noted that of the 15 items that made up the combined rhyme and alliteration oddity task, 10 were measures of alliteration. Knowledge of letter names and sounds may give children an advantage with rhyme awareness items by helping them to recognise end sounds, but it is likely to give a greater advantage with alliteration items because the sounds at the beginning of a word are generally easier to link with letter knowledge than the sounds at the end of a word.[4]

Some support for the idea of a connection between letter knowledge and awareness of rhyme and alliteration is found in a study by Bowey (1995). Bowey found a significant correlation ($r = .47$) between letter name knowledge and a combined measure of rhyme and alliteration awareness for a group of preschool children. (The rhyme and alliteration awareness measure used sound identity tasks that required children to identify which of two words either shared an onset or a rime with another word.) Letter-name knowledge was also found to correlate significantly with word reading ($r = .60$) at the end of first grade. This correlation was larger than the correlation between rhyme and alliteration awareness and later word reading ($r = .32$). After partialling out the effects of a number of variables, including age and verbal ability, Bowey found that rhyme and alliteration awareness explained a small but significant amount of additional variance in later word reading (4.7%). However, it is possible that this contribution was a reflection of the common link that rhyme and alliteration awareness and letter knowledge have with reading. Because Bowey did not partial out the effects of letter knowledge, no conclusions can be made about whether rhyme and alliteration awareness contributed additional variance to word reading than would have been explained by letter knowledge.

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[4] Rohl and Pratt's (1995) study is also discussed in Section 2.2.3.2.2.

Summary

Longitudinal studies have shown that children who have not yet started school are able to perform successfully on a range of rhyme awareness and alliteration awareness tasks. Numerous longitudinal studies have found a significant correlation between early rhyme awareness and alliteration awareness and later reading skills (Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Cataldo & Ellis, 1988; Ellis & Large, 1987, 1988; Lundberg et al., 1980; Stuart & Coltheart, 1988; Vellutino & Scanlon, 1987; Walton, 1995; Wimmer et al., 1994) . However, methodological problems, especially the lack of control for ability factors and preexisting reading skills, threatens the validity of the findings from many of these studies. Of the studies that have controlled for ability factors, only a small number have also taken account of the possible influence of the reading skills that children may have had at the beginning of a study (Bowey, 1995; Rohl & Pratt, 1995; Muter et al., 1997; Stuart, 1995). These more carefully designed studies have reported mixed findings about whether there is a significant predictive correlation between rhyme awareness and alliteration awareness and reading, but none of them partialled out the effects of initial letter knowledge.

2.2.3.2.2 Longitudinal studies of phoneme awareness and literacy

Longitudinal studies that assessed both phoneme awareness and awareness of rhyme or alliteration have consistently found that phoneme awareness tasks are more difficult (e.g., Cataldo & Ellis, 1988; Stuart & Coltheart, 1988). Difficulties exist in making this comparison, however, as the tasks used to assess rhyme awareness or alliteration awareness (e.g., oddity detection) usually involve operations that require a less explicit awareness of target phonological segments than is required for the phoneme awareness tasks (which commonly use segmentation or deletion tasks). The same point was noted earlier in this review when discussing correlational studies of phoneme awareness.

The earlier discussion of correlational studies also pointed out that many studies did not consider the influence of general or verbal ability when examining the relationship between phoneme awareness and reading. This omission also occurs with many of the longitudinal studies in this area (e.g., Cataldo & Ellis, 1988; Lundberg et al., 1980; Mann, 1984; Mann, 1993; Mann & Dittuno, 1990; Mann, Tobin, & Wilson, 1987; Snider, 1997; Stanovich, Cunningham, & Cramer, 1984; Stuart, 1995; Stuart & Coltheart, 1988).

Although it is usually advisable to assess and partial out general or verbal ability (see Bowey and Patel, 1988), omitting to do this does not necessarily affect the outcomes of a study. Wagner and Torgesen (1987) reanalysed data from several longitudinal studies in order to take account of the possible effects of IQ. For Mann's (1984) study they found that the correlation between kindergarten phoneme reversal and first grade word reading was unchanged after controlling for IQ (r = .75). Controlling for IQ also had little effect on the results of Lundberg et al.'s (1980) study. (e.g., the correlation of kindergarten phoneme reversal with first grade reading changed from r = .55 to r = .53).

Tunmer et al. (1988) found that verbal ability had nonsignificant correlations with phoneme awareness and reading scores. Partialling out verbal ability would therefore have had little effect on the pattern of results in this study. Tunmer et al.'s sample consisted of 118 first graders, some of whom had beginning reading skills (i.e., they could read a number of words from one of Clay's (1985) basic word lists). The children's phoneme tapping skills were assessed at the beginning of first grade. Their scores on this task were found to be significantly related to pseudoword reading at the end of first and second grade.

In some other longitudinal studies, general or verbal ability has been found to influence the correlation between phoneme awareness and later reading (e.g., Ellis & Large, 1988; Rohl & Pratt, 1995). Given the possibility that ability factors may be influential it is advisable to make an assessment of these at the same time that phoneme awareness is first measured. This has been common practice for many of the longitudinal studies in this area.

It is also important to assess and control for initial reading levels. Ideally a longitudinal study should begin with non-readers, as this provides a clearer indication of the direction of any causal connections between phoneme awareness and reading. Although many studies have taken account of ability factors, most have not controlled for initial reading levels. Studies that have controlled for general or verbal ability, but not for initial reading, include: Bryant, MacLean Bradley, and Crossland, 1990; Ellis and Large, 1987, 1988; Juel, Griffith, and Gough, 1986; Hurford et al., 1993; Hurford, Schauf, Bunce, Blaich, and Moore, 1994; and MacDonald and Cornwall, 1995.

Studies that have taken account of ability factors, but not initial reading levels, are unable to show the possible influence of early reading skills on phoneme

awareness. Such studies are still valuable, however, for revealing developmental changes in performance on particular phoneme awareness tasks, and for examining connections between phoneme awareness and later reading. The results of these studies show that children's performance on phoneme awareness tasks improves with time at school. A number of these studies have also shown that children's phoneme awareness skills are significantly correlated with later reading.

For example, Bryant, MacLean, Bradley, and Crossland (1990) found that both phoneme deletion and phoneme tapping skills for a group of children (with a mean age of 5 years 11 months) were able to explain small, but significant amounts of variance (ranging from 3% to 8%) in their later word reading and spelling (when their mean age was 6 years 7 months) after first partialling out age, mother's educational level, vocabulary, and IQ. Bryant et al. also assessed rhyme and alliteration awareness in this study, and concluded that rhyme awareness or alliteration awareness appeared to make a contribution to reading and spelling that was independent of the contribution made by phoneme awareness.

Ellis and Large (1987, 1988) also found a connection between phoneme tapping skills and later reading. Phoneme tapping at ages 5 and 6 years was found to correlate significantly with reading at ages 6 and 7 years respectively. However, after partialling out IQ, only the correlation between age 6 phoneme tapping and age 7 reading remained significant.

Partialling out IQ or verbal ability did not change the existence of significant associations in several other longitudinal studies of phoneme awareness. Hurford and colleagues (1993, 1994) found significant partial correlations (r = .36 and .27) between two phoneme deletion tasks given at the beginning of Grade 1 and word reading at the end of Grade 2. McDonald and Cornwall (1995) partialled out vocabulary skills and socioeconomic status and found significant correlations (r = .49) between deletion skills at the age of 6 years and reading and spelling skills at the age of 17 years (r = .49 and r = .53 respectively). This study is of particular interest because of the substantial length of time over which the predictive correlation extended.

Juel et al. (1986) assessed phoneme awareness with a range of tests that required either segmentation, blending, deletion, or substitution of phonemes. Scores on these tests were combined to form an aggregate measure of phonemic awareness. After partialling out IQ and listening comprehension, Juel et al. found that the aggregate phonemic awareness measure accounted for significant additional

variance in Grade 1 reading (36%) and spelling (49%), and Grade 2 reading (22%) and spelling (30%).

The interpretative value of Juel et al.'s (1986) findings is reduced by the combining of scores from tests involving different types of operations (segmentation, blending etc). However, a strength of this study is that all of the tests were focused on the phoneme level of phonological awareness. A problem with some other studies is that they have used measures that combine awareness of different levels of phonological awareness, that is, the onset-rime level and the phoneme level (e.g., Share, Jorm, Maclean, & Mathews, 1984; Stuart & Coltheart, 1988; Stuart & Masterton, 1992). This use of "scrambled data" limits the interpretation of the findings from these studies (Goswami & Bryant, 1990).

None of the longitudinal studies of phoneme awareness that have been discussed up to this point have taken account of the possible effects of initial reading skill. Neglecting initial reading skill makes it impossible to determine the direction of any relationships between early phoneme awareness and early reading. Fortunately, there are some studies that have assessed initial reading skill and either partialled out its influence (Badian, 1995; Mann & Dittuno, 1990; Stuart, 1995) or excluded any children who may have been reading at the beginning of the study (Muter et al., 1997; Rohl & Pratt, 1995). Key aspects of each of these studies are outlined below.

Mann and Dittuno (1990) partialled out kindergarten word reading skill when examining the connection between their measure of kindergarten phoneme awareness and Grade 1 reading. To assess phoneme awareness, they used an invented spelling task that required children to attempt to spell a list of words that was read to them. This task is said to indicate whether children can access the phonemic structure of words (Mann et al., 1987). After controlling for initial reading, Mann and Dittuno found a significant correlation between invented spelling scores and later reading. Some caution is needed, however, when interpreting these results. The invented spelling test may have provided a sensitive measure of reading related skills apart from phonemic awareness. In particular, performance on the invented spelling task was likely to have been influenced by letter knowledge. Hence it could have been letter knowledge, rather than phonemic awareness, that was responsible for the correlation with later reading. Although Mann and Dittuno partialled out the effects of scores on a word reading measure, this may not have fully accounted for the differences in letter knowledge that may

have existed amongst the kindergarteners. Another limitation on this study is that it did not control for general or verbal ability.

A study carried out by Stuart (1995) had a similar design to that of Mann and Dittuno (1990) in that it partialled out reading, but not general or verbal ability. At the beginning of Stuart's study, when children were in their first term at school, reading was assessed with a test containing high frequency words (including one of Clay's (1985) lists). After partialling out scores on this test, significant correlations (r = .37 and r =.45) were found between two segmentation tasks and word reading at the end of the first year at school. Interestingly, a much higher partial correlation (r = .75) was found between letter-sound knowledge and later reading. The study also assessed rhyme awareness but failed to find a significant connection between rhyme and reading.[5]

Another longitudinal study that takes account of the effects of early reading was carried out by Badian (1995). This study assessed phoneme deletion skill in Grade 1, and word reading in Grades 1, 2, 5 and 6. After controlling for age and listening comprehension, phoneme deletion was predictive of Grade 2 reading (r = .42) but not Grade 5 or 6 reading. However, when Grade 1 reading was also taken into account, the correlation between phoneme deletion and Grade 2 reading was no longer significant

Two longitudinal studies of phoneme awareness have used careful screening procedures to exclude any children who may have been reading at the beginning of the studies (Muter et al., 1997; Rohl & Pratt, 1995). Both of these studies also controlled for the influence of general or verbal ability.

Rohl and Pratt (1995) used a list of high frequency words (Clay, 1985) to check that the children in their sample were non-readers at the start of the study when their mean age was 5 years and 8 months. Rohl and Pratt found that the children's performance on a phoneme tapping task was very poor at the beginning of the study, even though the children were able to perform a rhyme and alliteration awareness task at this time.[6] It appeared that very few nonreading children were able to segment syllables into their component phonemes. It is possible that those children who did score a little higher on this task may have simply done so through

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[5] See the earlier discussion of this study in Section 2.2.3.2.1.

[6] This study was also discussed in Section 2.2.3.2.1.

random responses. The very low average score on the tapping task meant that Rohl and Pratt did not use the results from this time in any further analysis.

At the end of Grade 1, by which time most children were reading, the tapping task was readministered along with a phoneme deletion task. Many children were then able to perform these tasks. After controlling for verbal ability, age, and memory skills, scores on the tapping and deletion tasks were able to explain significant additional variance in a composite reading and spelling measure given towards the end of Grade 2: the increase in variance was 4 % for tapping, and 15% for deletion. These results show that the phoneme awareness skills of children who have been at school for nearly a year are predictive of later reading. But because the children were already reading when the phoneme awareness tasks were given at the end of Grade 1, no conclusions can be made about the causal direction of the relationship between phoneme awareness and reading.

Muter et al. (1997) also conducted a longitudinal study of phoneme awareness, which like Rohl and Pratt's investigation, included careful screening for reading at first assessment.[7] Any child who could read even one of the high frequency words on the British Ability Scales Test (Elliot et al., 1983) was excluded from their sample. Muter et al. found that the nonreading preschool children in their initial sample (mean age = 4 years 3 months) were able to score on a phoneme identification and a phoneme deletion task, albeit at very low levels. The phoneme identification task (for which the mean score was 2 out of 8) required children to say the end part of a word and thus may have been influenced by their articulatory control rather than their phoneme awareness (see Morais, 1991a). The phoneme deletion task was even more difficult for the children (the mean score was 0.4 out of 10). Muter et al. noted that some children may have scored positively on this task by treating it as a rhyming game, rather than by consciously deleting phonemes. A rhyming strategy may have helped children to guess answers because the correct responses rhymed with the target words, although they did not contain the initial phonemes (e.g., "bus without the /b/ says .... us").

Using factor analysis, Muter et al. (1997) found that children's preschool performance on the phoneme tasks loaded onto what they called a "segmentation" factor. Rhyme detection also contributed to this factor. Segmentation was significantly correlated with spelling, but not with reading, near the end of the first and second years at school. Preschool segmentation was indirectly related to

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[7] Muter et al. (1997) was also discussed in Section 2.2.3.2.1.

reading near the end of the first year via its significant correlation with segmentation near the end of the first year, which was in turn significantly correlated with reading at that time.

Muter et al. (1997) also found that letter knowledge was significantly correlated with reading and spelling measures. Importantly, they were able to show that significant concurrent correlations remained between segmentation and reading or spelling near the end of the first year at school, even after controlling for letter knowledge at that time. Muter et al.'s study appears to have been the only investigation of correlations between phoneme awareness and literacy that has taken note of the possible confounding effects of letter knowledge. However, letter knowledge was only controlled for in the concurrent correlations and not for the longitudinal correlations.

Summary

Longitudinal studies have found that children's performance on phoneme awareness tasks improves with time at school. These studies have also shown that phoneme awareness skills are significantly correlated with later reading skills (Cataldo & Ellis, 1988; Lundberg et al., 1980; Mann, 1984; Mann, 1993; Mann & Dittuno, 1990; Mann, Tobin, & Wilson, 1987; Stanovich, Cunningham, & Cramer, 1984; Stuart, 1995; Stuart & Coltheart, 1988; Tunmer et al., 1988). This relationship usually remains when the effects of general or verbal ability are partialled out (Bryant, MacLean, Bradley, & Crossland, 1990; Ellis & Large, 1987, 1988; Juel et al., 1986; Hurford et al., 1993; Hurford et al., 1994; MacDonald & Cornwall, 1995).

Some longitudinal studies have taken account of the possible influence of preexisting reading skills, either by partialling out children's initial reading levels or by excluding children with reading skills from the beginning sample. Two studies that partialled out initial reading levels (Mann & Dittuno, 1990; Stuart, 1995) found that significant correlations remained between early phoneme awareness and later literacy, but another study (Badian, 1995) found that partialling out initial reading levels reduced correlations to nonsignificant levels. Studies that screened their initial samples in order to exclude any readers found that the sample children usually scored at very low levels on the phoneme awareness tasks at the start of the studies (Muter et al., 1997; Rohl and Pratt, 1995). When individual children attained positive scores on these tasks it is possible that their performance was the

result of other factors (e.g., random responses, using a rhyming strategy) apart from an awareness of phonemes.

Only one longitudinal study has included controls for the influence of letter knowledge (Muter et al., 1997). This study found that significant concurrent correlations between measures of phoneme awareness and literacy remained significant after controlling for letter knowledge. However, the study did not include controls for letter knowledge when making predictive correlations.

2.2.3.3 Experimental Studies

Experimental studies can provide careful control of confounding variables and can record the effects on literacy of manipulating levels of phonological awareness skills in children. For these reasons, experimental studies can provide stronger evidence of causality than can correlational or longitudinal studies. However, unforeseen confounding variables can still occur with experimental studies, especially when random assignment of participants to different treatment groups is not possible. For example, if class groups of children are used as the treatment units, there may be teacher effects that will impact on the progress of children during the training period. Other complicating factors that may affect the outcomes of training studies include the age of participants, the age at which they start school, and the type of literacy instruction they are exposed to.

Care needs to be taken when interpreting the results from any particular experimental study. A negative outcome may not mean that the targeted aspect of phonological awareness is unimportant for literacy; rather it may be that the phonological skill is very difficult to train or that training was of insufficient duration. It is also possible that training could succeed in raising phonological abilities but that children still require other skills (e.g., letter knowledge) in order for their increased awareness to be reflected in progress in reading and writing. A positive outcome can also be difficult to interpret. Any training given to a particular treatment group will usually include a number of components and it may be impossible to link a positive outcome with a specific part of the training.

The following review of experimental studies is not grouped according to the size of the phonological segment under focus. Grouping studies into those that focused on rhyme awareness, alliteration awareness, or phoneme awareness, is an effective way of organising concurrent and longitudinal correlational studies but is not

appropriate for examining experimental studies. This is because nearly all experimental studies have provided training that was intended to increase phonological skills at the phoneme level rather than at the level of rhyme awareness and alliteration awareness. Rhyme and alliteration exercises have sometimes been included in training programmes but they were usually part of a package of activities that were intended to develop phoneme awareness and literacy skills.

Although it is not necessary to organise a review of experimental studies by size of phonological segment, it is valuable to organise studies according to whether or not they provided children with additional exposure to letters. Letter knowledge is known to be positively related to reading achievement (Adams, 1990). Where studies provided training that included exposure to letters, it may be difficult to separate out the effects of phonological awareness training from the effects of becoming more familiar with letters. To help clarify this issue, the following review of experimental studies is divided into two main categories according to whether or not the treatment conditions included exposure to letters.

2.2.3.3.1 Experimental studies where phonological awareness training did not include exposure to letters

These programmes can be divided into two groups according to whether training was given before or after children had begun school literacy instruction.

2.2.3.3.1.1 Training given prior to participants receiving school literacy instruction

Studies that have provided phonological awareness training to preschool children have the advantage of avoiding possible interactions with school literacy programmes. A disadvantage of these programmes, however, is that the young age of the children may make it difficult to provide training in particular phonological awareness skills.

The treatment conditions in two studies by Fox and Routh (1976, 1984) used letter-like symbols to investigate the effects of teaching preschool children to manipulate phonemes. Instruction in letter-sound correspondences was not given. In their first study, 4-year-old children were trained to blend phonemes to form words, and were then taught to associate particular phonemes with letter-like

symbols. Following this, the children were assessed on a reading analogue task that tested how well they read "words" made up of the letter-like symbols. Fox and Routh (1976) stated that the outcomes of their study showed that children could benefit from training in blending, but only if they were already proficient at segmental analysis. On the basis of these findings, Fox and Routh (1976) suggested that children need to have segmenting and blending skills if they are to make progress in early reading. There is a question, however, as to whether the reading analogue task used by Fox and Routh is a valid indication of the skills a child needs for word identification. Another limit on interpreting the results of this study are the floor effects for some of the measures (Wagner and Torgesen, 1987).

In their second study, Fox and Routh (1984) extended their initial investigation by including training in segmenting as well as in blending. Kindergarten children with low segmentation skills were randomly assigned to one of three groups. The segmenting training group were taught how to isolate the initial sounds of words. The segmenting and blending training group received the segmenting instruction as well as practise at blending sounds to make words. The third group acted as a no-treatment control. Results of the study showed that the segmenting training group's performance on a reading analogue task was at the same level as the control group, indicating that improving children's segmenting skills had no effect. Higher performance was found for the segmenting and blending training group. As with the first study, however, it is difficult to determine what is really being measured by the reading analogue task. Wagner and Torgesen (1987) have pointed out that because no group in Fox and Routh's (1984) study received training in blending alone, it was not possible to conclude whether improved performance resulted from the combination of segmenting and blending training, or whether training in blending alone would have been sufficient.

Another training programme carried out with preschool children was conducted by Lundberg, Frost and Peterson (1988). They carried out an extensive training programme with 235 6-year-old preschoolers who were attending kindergarten classes in Denmark. (Children in Denmark do not begin school until the age of 7 years.) The children were involved in a carefully structured programme aimed at raising their phonological awareness skills over an eight month period. The programme consisted of daily class sessions of 15 to 20 minutes duration in which a wide variety of phonological games and exercises, including rhyming and segmentation skills, were taught. No references to letters or printed words were made in any of these sessions. Progress of the training group was compared to a control group of 155 children from other kindergartens. Children in the control

group followed the normal Danish kindergarten programme which had a social and creative emphasis and avoided any attempt at early reading instruction.

After the completion of the training programme, the trained children showed significantly higher phonological awareness, especially for segmentation, than the control children. Later, when the children had been at school for seven months, measures of reading and spelling were made. Only a small difference in reading (significant at $p < .10$) was apparent between the trained and control children at this stage. Greater differences favouring the trained children were found for spelling. Larger effects for reading were found when the children were reassessed at the beginning of Grade 2. The trained children also continued to show significantly higher spelling scores than the control children at this time.

Although the effects on reading and spelling were significant, they were small, especially considering the long duration of the training programme. This suggests that, while phonological awareness skills can be trained, gains may not come easily. The finding that phonological awareness skills may be difficult to train is compatible with research showing that there is high stability of children's phonological processing abilities over time (see Wagner et al., 1993; Wagner et al., 1994). Another interpretation of Lundberg et al.'s (1988) results is made by Tunmer and Rohl (1991) who noted that the increased difference in reading achievement between the trained and control groups, as they went from Grade 1 to Grade 2, is consistent with Stanovich's (1986) suggestion that small differences in phonemic segmentation skills at school entry can result in greater differences in reading achievement over time. Tunmer and Rohl also pointed out that the age, and therefore cognitive level, of the Danish children in Lundberg et al.'s preschool sample was higher than in countries where children begin school at a younger age. Hence the type of activities used to increase phonological awareness in the Danish children may not be suitable for younger preschoolers in other countries.

Summary

Several studies have shown that phonological awareness skills (including phoneme blending and segmenting) can be successfully taught in preschool training programmes that do not involve letters (Fox & Routh, 1976, 1984; Lundberg et al., 1988). The one study that examined the effect of this type of phonological awareness training on later literacy skills found a relatively small effect, despite the comparatively long training period (Lundberg et al. 1988).

2.2.3.3.1.2 Training given while participants were receiving school literacy instruction

If children are trained in phonological awareness after they have started school, it is possible that the training may interact with their school literacy instruction. This can make it difficult to determine the specific effects of the training programme.

Lie (1991) conducted a training study that compared the effectiveness of two different types of phoneme awareness training for a large group of first grade children in Norway. Children were given 10 to 15 minutes of daily phoneme awareness training during their first term at school. Three classes of children received training in "positional analysis". These children were taught to attend to the initial, medial or final phonemes of spoken words and to identify other words which contained these particular sounds. Three other classes of children received training in "sequential analysis". These children were taught to identify all the component phonemes of a word, to say them separately, and to blend them. Training sessions were conducted orally and did not require any exposure to letters. The remaining four classes of children acted as the control group and spent the training time studying and discussing illustrations.

To assess the possible effect of the training on literacy development the children were given measures of reading and spelling at the end of Grades 1 and 2. Children in the positional analysis group showed similar reading progress to the children in the sequential analysis group. The reading performance of both of these groups was significantly higher than the control group at the end of Grade 1, but there was no significant difference between groups at the end of Grade 2. Lie (1991) suggested that ceiling effects on the reading measure may have affected the Grade 2 result. A more serious problem is that Lie used reading comprehension tests rather than word recognition or decoding tests as his measure of reading. Reading comprehension tests assess other factors in addition to word recognition, and are therefore less likely to show the effects of a programme directed at enhancing children's awareness of phonemes within words.

In Lie's (1991) study, spelling results at the end of Grade 1 showed that the performance of the sequential analysis group was significantly higher than the positional analysis group which in turn was significantly higher than the control group. Lie suggested that these results provide evidence that the sequential method is a more effective way of teaching word analysis than the positional approach. There is, however, only a small difference between the training groups at Grade 1,

and no difference between the groups at Grade 2 where they both scored significantly higher than the control group.

Another first grade training programme that did not include exposure to written letters was carried out by Cunningham (1990). Cunningham investigated whether a metacognitive form of phonological awareness training was more effective than training that simply taught isolated skills. Forty-eight Grade 1 children were divided into three groups. The first group, "skill-and-drill instruction", were taught the procedures of segmentation and blending. The second group, "metacognitive instruction", also learnt these procedures and in addition received training in the value and application of these skills for reading. In the third group, the control, children listened to stories and answered comprehension questions about them. Training sessions lasted 15 to 20 minutes and occurred twice a week over a 10 week period. All training sessions avoided exposure to letter-sound correspondences - the children in the two experimental groups were taught blending and segmentation skills with the use of wooden tokens to represent sounds (see Elkonin, 1973).

Children in both experimental groups showed similar scores on the tests of phonological awareness that were given after completion of the training programme. Both experimental groups scored significantly higher on these tests than the control group. Both experimental groups also scored significantly higher than the control group on a measure of reading achievement given after the training programme. There was also a significant difference in reading achievement between the experimental treatments in favour of the metacognitive instruction group. Cunningham (1990) concluded that the findings indicated that training in phonological awareness skills should not be given in isolation but should be explicitly linked to the reading process.

These findings, however, were not supported by the results of another first grade training programme that included similar treatment conditions to those used by Cunningham (1990). Weiner (1994) found no difference in outcomes for a treatment group who had received training that made explicit links between phonological skills and reading compared to a group who had simply learnt the skills. In fact Weiner found no difference between any of the treatment groups and the control group, and therefore concluded that phonological awareness training may not be beneficial for all groups of children.

Summary

Phonological awareness training that does not involve the use of letters, but is given to children who are attending school, may interact with the school literacy programme. Two studies using this type of training have shown positive effects on phonological awareness and literacy skills (Cunningham, 1990; Lie, 1991). One of these studies (Lie, 1991) included follow-up measures in the year following the training and found that the advantage of the trained group in reading no longer existed. A third study (Weiner, 1994) found that phonological awareness training of this type had no effect on literacy skills (Weiner, 1994).

2.2.3.3.2 Experimental studies where phonological awareness training included exposure to letters

These programmes can be divided into two groups according to whether or not the design of the programme provided for control of the additional exposure to letters (and associated work on letter names or letter sounds, or both) that occurred as part of the training in phonological awareness.

2.2.3.3.2.1 Design of study did not allow for control of the additional exposure of the phonological awareness training group(s) to letters

In a number of recent training programmes it is not possible to control for the fact that all treatment children received not only phonological awareness training but also additional exposure to letters, and associated work with letter names or sounds. These programmes can be valuable from an educational perspective, where the emphasis is on finding effective treatments for low progress readers, but they do not permit the determination of causal relationships between phonological awareness and reading. Where an effect on reading was found, it is not possible to know whether to attribute this to phonological awareness training alone, additional exposure to letters, or a combination of these two factors. Indeed a combination of phonological awareness activities and training in letter knowledge may effectively mean that the training group received additional reading tuition rather than just instruction in phonological awareness.

Some of these methodological issues occurred in a training programme conducted by Byrne and Fielding-Barnsley (1991). The programme involved the teaching of

phoneme identity skills (for five consonants and one vowel) to a group of 64 preschoolers. Training was given in 12 weekly sessions, each of 25 to 30 minutes duration. As well as being taught to recognise the phonemes, the children's attention was directed to the particular letters that represented the phonemes. At the end of the training programme the performance of the trained children was compared to a control group of 62 children of the same age who had spent the training time in story listening and semantic categorization activities. The experimental group showed significantly higher gains on measures of phoneme identity. Interestingly, this occurred for both trained and untrained sounds, indicating that the experimental group children were able to generalise their phoneme identity skills. Byrne and Fielding-Barnsley reported pretest scores for alphabet knowledge that showed the experimental and control groups had similar letter-name and letter-sound knowledge before training. Full tests of letter knowledge were not repeated after the training programme but the experimental group was found to be much more likely than the control group to know the sounds of the six letters that had been the focus of the training. It is possible that the training programme may have increased the experimental group's awareness of letters in general, giving them an advantage over the control group for nontrained as well as trained letters. As letter knowledge was not fully assessed after the training programme, this possibility cannot be ruled out.

A year after the training programme was completed, a follow-up study was made to evaluate the effect of the training on literacy (Byrne & Fielding-Barnsley, 1993a). The children were then near the end of their first year at school. The experimental group scored significantly higher than the control group on pseudoword identification but not on measures of spelling or word reading. Byrne and Fielding-Barnsley suggested that, because the two groups showed identical levels on a letter sound test at this time, the differences in pseudoword scores could not have been due to differences in letter-sound knowledge. Hence, they concluded, that the differences in pseudoword reading may have been due to the influence of the phoneme identity training. However, as noted above, the experimental group did have an advantage in letter-sound knowledge for at least some letters when they were tested at the end of the training programme. Although both groups scored identically on the letter sound test at the follow-up time, most children were approaching ceiling level. It is possible that the experimental children actually had greater mastery of letter-sound knowledge but that the letter sound test did not detect this. The letter sound test used in this study (and in Byrne & Fielding-Barnsley, 1991) was actually a test of recognition; it required children to point to which letter on a series of cards, each containing five or six letters, represented a

particular sound. Byrne and Fielding-Barnsley suggested that this type of test is more sensitive than the standard recall method. Such a test may be useful for assessing children who are in the early stages of acquiring letter-sound knowledge but it is likely to underestimate differences between children in later stages. A recall test (i.e., "What sound does this letter make?") would more accurately reflect the knowledge needed to read pseudowords and may have been more likely to detect performance differences between the experimental and control groups at the follow-up evaluation.

The literacy skills of the children in Byrne and Fielding-Barnsley's (1991) study were again assessed two and three years after the training programme (Byrne and Fielding-Barnsley, 1995). As for the one year follow-up, the experimental group scored significantly higher than the control group for pseudoword identification, but not on measures of word reading or spelling. The question remains, however, as to whether it was the effect of training on phoneme identity skills, the possible effect on letter knowledge skills, or a combination of these factors, that led to a difference in the children's decoding skills.

Blachman, Ball, Black, and Tangel (1994) also conducted a training programme where the treatment group received more exposure to letters than the control group. The experimental group for this study consisted of 84 kindergarten children who, prior to training, showed no differences to a group of 75 control children in terms of age, gender, receptive vocabulary skills, phoneme segmentation skills, letter knowledge and reading abilities. All children were exposed to the regular kindergarten curriculum which included some class lessons on the alphabet. The experimental group children were given additional instruction in letter-name and letter-sound knowledge and in phoneme segmentation and categorization. Control group children received no extra treatment. Training was given in 15 to 20 minute lessons, four times a week, over an 11 week period. At the end of this time the experimental group scored significantly higher than the control group on measures of segmentation, invented spelling and phonetically regular word and nonword reading lists. Blachman et al. suggested that these results showed that "training kindergarten children in phoneme awareness has a positive influence on early reading skills and developmental spelling" (p. 12). However, the results of the study do not support giving the credit to phoneme awareness training alone. The letter knowledge instruction that was included in the training programme may explain why the experimental group scored significantly higher on tests of letter names and sounds. It is possible that it was the increase in letter knowledge, or a

combination of gains in letter knowledge and phoneme awareness, that led to greater progress in early literacy for the experimental group.

Other training programmes where instruction in phonological awareness included practise with letters were carried out by Castle, Riach, and Nicholson (1994). The researchers conducted two experiments; the first examined the effects of training on spelling acquisition, and the second, the effects of training on reading acquisition. Both studies were carried out with 5-year-old children who were in their first few months of a New Zealand whole language primary school programme. In the first study, a treatment group of 15 children received instruction in rhyme activities, letter-sound associations, and the segmentation, substitution and deletion of phonemes. Training occurred in 20 minute lessons, twice a week for a 10 week period. The progress of the experimental group was compared to a matched control group of 15 children who spent an equivalent amount of time working on their own stories and using invented spelling (i.e., "process writing"). At the end of training, the experimental group significantly outperformed the control group on a composite test of phoneme awareness and on two of four tests of spelling. Castle et al. suggested that ceiling effects and other measurement problems may have been responsible for the nonsignificant results on the other two spelling tests. Further analyses of some of the spelling results showed the experimental group had made greater gains than the control group in phonemic spelling skills. The experimental group also showed an advantage over the control group in the spelling of pseudowords.

Castle et al. (1994) concluded that the findings of their first experiment "suggest that phonemic awareness training contributes to spelling development by enabling children to use phoneme-grapheme correspondence rules" (p. 353). But, as with other studies examined in this section of the review, it is not possible to separate out the effects of "pure" phonemic awareness training from the effects of additional exposure to letters. The fact that the experimental and control groups showed virtually identical scores and gains on a letter knowledge test given before and after the training programme may appear to indicate that the positive effects of the training on spelling were not simply due to increased letter knowledge. However, because the letter knowledge test was a measure of letter names and not letter sounds, the possibility that the training resulted in greater letter-sound knowledge for the experimental group cannot be ruled out. Indeed it seems likely that the experimental group would have shown greater gains in letter-sound knowledge as some training activities were specifically aimed at this. The advantage that the experimental group had over the control group in phonemic spelling skills and

pseudoword spelling could have resulted from greater letter-sound knowledge rather than improved phonemic awareness. Another possibility is that the advantage of the experimental group was due to a combination of gains in letter-sound knowledge and phonemic awareness. Improved awareness of the phonemic components of words may allow children to better apply letter-sound knowledge in their spelling attempts.

The second experiment reported by Castle et al. (1994) focused on the effects that a training programme had on reading acquisition. The 17 children in the experimental group received training in rhyme and alliteration, letter-sound correspondences, and in the segmentation, deletion and blending of phonemes. The progress of these children was compared to that of two control groups, each of 17 children. One control group received alternative training of semantic categorization activities and some work with rhyme and letter names. The other control group received no extra treatment. Instruction for the two groups who received training was given in a 20 minute lesson, every week, for 15 weeks. Interpretation of posttest results was complicated by significant differences in operativity levels that existed between the groups before training began. Operativity was therefore used as a covariate when testing for significant differences. Covariance analyses and follow-up contrasts showed the experimental group outperformed the two control groups on a composite measure of phoneme awareness, a test of pseudoword reading and a spelling test. There were no significant differences between the two control groups on these tests. No significant differences between any of the groups were found for letter knowledge and two tests of word reading.

As with Castle et al.'s first experiment, it is not possible to separate out the effects of the training in phoneme awareness from the effects of additional instruction in letter-sound correspondences. The letter knowledge test which showed no differences in group scores assessed letter-name knowledge. All children were nearing ceiling level on this test. What is not known is whether there were differences between groups in letter-sound knowledge. Only one group of children, the experimental group, received training in letter-sound knowledge and it is possible that this provided them with an advantage, particularly as letter-sound instruction may not be a focus of instruction in New Zealand whole language classrooms (Thompson, 1993). If the experimental group had an advantage with letter-sound knowledge, then as with the first study, this may explain in part their superior performance on some of the posttests.

Another study where it is not possible to separate out the effects of phonological awareness training from the effects of instruction involving letter-sound correspondences was carried out by Uhry and Shepherd (1993). The 22 children in the study were in first grade classrooms that followed a whole language approach, apart from one weekly phonics lesson. For the training programme the children were evenly divided into two groups and given twice weekly supplementary lessons, each of about 20 minutes. Training continued for a six and a half month period. Children in the experimental group received instruction on segmenting words into phonemes, and representing these phonemes with letters. They were also involved in spelling activities and played a number of computer games that involved analysing spoken words and representing sounds with letters. Children in the control group practised reading the same words used by the experimental group but they did not segment the words into phonemes, or spell the words. The control group also played with computer games that used letters and words but did not involve sound analysis.

At the end of the training period the experimental group was significantly better than the control group on tests of real and pseudoword reading, segmenting, blending, and spelling. However, because the experimental group had more training in letter-sound correspondences, it is possible that it was this aspect of the training, or a combination of this and the segmentation activities, rather than the segmentation activities per se that was responsible for the programme's effectiveness. As Uhry and Shepherd (1993) did not assess letter-sound knowledge it was not possible to see whether the experimental group had greater letter-sound knowledge than the control group. If a test of letter-sound knowledge had been given it may have been of limited usefulness anyway. The children were aged 7 years old at the end of the programme and it is likely that ceiling effects would have been apparent for both groups at this time, particularly as all children were receiving some letter-sound instruction in their regular classroom programmes. A test of letter-sound knowledge may have only shown that most children knew basic letter-sound rules but it would not have distinguished between the groups on their ability to apply this knowledge effectively in reading and spelling.

Summary

When the design of a study does not provide for the control of the additional exposure to letters that may be included with phonological awareness training, it is

not possible to determine which component of the training programme is responsible for any observed improvements in reading or spelling. A number of studies of this type have shown that training programmes can provide significant gains for children's literacy skills, especially for word decoding skills (Byrne & Fielding-Barnsley, 1991, 1993a, 1995; Blachman et al., 1994; Castle et al., 1994; Uhry and Shepherd, 1993). These studies are valuable from an educational perspective, where the emphasis is on finding effective treatments for low progress readers. It is, however, unclear whether the gains in reading were a result of the effects of the training on phonological awareness skills, the effects on letter skills, or a combination of both of these factors. In order to gain the maximum information about the effects of training on letter knowledge, studies should measure both letter-name and letter-sound knowledge at each assessment point.

2.2.3.3.2.2 Design of study attempted to control for the additional exposure of the phonological awareness training group(s) to letters

In order to determine the specific contribution of phonological awareness training to literacy acquisition, it is necessary for studies to take account of the effects of the additional exposure to letters that often accompanies the training. In the first two of the studies reviewed below (Bradley & Bryant, 1983; Defior & Tudela, 1994) one of the treatment groups received "pure" phonological awareness training (i.e., without the use of letters) while another treatment group received phonological awareness training that included exposure to letters. The third study reviewed below (Ball & Blachman, 1991) controlled for the effects of letter exposure by giving the same letter instruction to the two training groups while providing only one of them with phoneme awareness training. The final study in this section (Hatcher, Hulme & Ellis, 1994) used three training groups in order to take account of the effects of exposure to letters. One group received phonological training alone, one group received reading training alone, including work with letters, and a third group received a combination of reading and phonological training.

The training study carried out by Bradley and Bryant (1983) has sometimes been cited as providing evidence that teaching phonological awareness skills to children can improve their reading progress (see, e.g., Cunningham, 1990; Yopp, 1992). A closer examination of the results of this study, however, shows that letter-sound instruction was an important part of the successful training. The participants in the study were 65 children who had scored poorly on a sound categorization task. The children, whose average age was 6 years 1 month, were divided into four matched

groups. Each group received a particular type of training during 40 individual sessions spread over a 2 year period. Children in the "sound categorization alone" group were taught to categorize words according to the sounds they had in common. They made no use of printed words or letters during their training sessions. Children in the "sound categorization and letter training" group received the same sound categorization training as the previous group but were also shown, with the aid of plastic letters, how common sounds are often represented by the same letter or letter group. Children in the "conceptual categorization control" group were taught how to categorize words on the basis of meaning, rather than sound. The fourth group was the "no-treatment" control.

At the end of the training programme the children were given standardised tests of reading and spelling. The sound categorization and letter training group showed the highest scores on both these measures. The next highest scores were for the sound categorization group, followed by the conceptual categorization group. The no-treatment control showed the lowest performance.

Comparison of the performance of the two sound categorization groups with the performance of the conceptual categorization control group provides information about the effectiveness of the phonological awareness training. (The no-treatment control group is not such a good comparison as the children in this group received no extra attention, unlike the children in the other three groups.) The sound categorization and letter training group scored significantly higher on the outcome tests than the conceptual categorization group by a margin of 9 months in reading and 17 months in spelling. The sound categorization alone group also scored higher than the conceptual categorization group, by 4 months for reading and spelling, but the differences were not statistically significant. The overall findings therefore suggested that training in sound categorization on its own is not sufficient for significantly improving reading and spelling progress. When such training is combined with practise in making letter-sound links it appears that significant achievement gains are possible. Combining letter-sound training and sound categorization means that children are not only receiving training in phonological awareness skills. Rather it could be said that the combined training is a form of reading instruction. Indeed, when Iversen and Tunmer (1993) used this type of training in their study of a modified form of Reading Recovery, they were careful to label it as training in "phonological recoding" rather than as training in phonological awareness.

Baddeley (1986) was critical of aspects of Bradley and Bryant's (1983) study. He noted that the size of each training group was fairly small and that of the different treatment conditions, "that involving practise on rhymes together with familiarisation of letters and their sounds could be regarded as so close to reading as to represent additional reading lessons, rather than simply practise in phonological categorisation" (p. 220).

Wagner and Torgesen (1987) have pointed out that the unanswered question in Bradley and Bryant's (1983) study is whether a group that had training in spelling using plastic letters, but no sound instruction, would have made comparable gains to that of the sound categorization and letter group. A later study by Bradley (1988) did include such a group. Interestingly, no significant differences in word reading and spelling were found between a group of 6-year-old school children who worked only with plastic letters, a group that received only sound categorization training, and a group that received a combination of letter training and sound categorization training. A possible explanation for the lack of differences between the groups is that the training may have been too short in duration to have had an effect (a total of 4 & 1/2 hours training in less than 4 months).

A similar result to that found by Bradley and Bryant (1983) was seen in a training programme conducted by Defior and Tudela (1994). The participants in this study were 96 first grade children in Spain who were randomly assigned to one of five groups. All of the groups except the control were taught to classify words (represented by pictures) according to certain criteria. Two of the groups were trained to categorize the words on the basis of common phonemes. Plastic letters were used as an aid by one of these groups but not the other. Two other groups were taught to categorize words according to conceptual criteria (e.g., colour). One of the groups could make use of written words (presented as labels underneath each picture) and the other group had no written aids. The fifth group served as the control and spent the training time engaged in manipulative activities such as cutting and colouring. Training occurred in weekly sessions, of about 90 minutes duration, over a period of 20 weeks.

Tests given at the end of the training programme showed that the group who had used plastic letters as an aid to categorizing words on the basis of phonemes, scored significantly higher than all the other groups on measures of letter-sound knowledge, reading and writing. No significant differences were found between the other groups on these measures. The results indicate that, as in Bradley and

Bryant's (1983) study, the phonological training was effective only when it made use of plastic letters. The unanswered question is, as with Bradley and Bryant's study, whether a group that had training using plastic letters, but not phoneme categorization, would have shown similar progress to the group where these elements were combined. Interestingly, Defior and Tudela (1994) explained that they deliberately decided not to include a "letters alone" group in their design as pilot studies had shown them that it was not possible to make use of plastic letters without providing at least some implicit training in phoneme categorization.

However, a training programme conducted by Ball and Blachman (1991) did include a group who apparently received instruction in letters but not in phonological awareness. The researchers included this group in an attempt to overcome the problem of being unable to determine what was the crucial component in training that involves instruction in both letters and phonological awareness. Their programme design included two treatment groups and one control group. Participants in the study were 90 kindergarten children (mean age = 5 years 7 months) who were assigned to one of the three groups. The first group ("phoneme awareness and letters" group) received training in segmentation and in letter names and sounds. The second group ("language activities and letters" group) were given no training in phonological awareness but participated in language activities such as story listening and vocabulary development, and received letter training that was identical to that received by the first group. The control group received no additional treatment. By providing both training groups with letter instruction, Ball and Blachman hoped to be able to more clearly isolate the effect of the phonological segmentation training. The two groups who received training were given 20 minute lessons, four times a week, for a total of 7 weeks.

Posttesting at the end of the programme showed that there were no significant differences in letter-name knowledge between the three groups. The phoneme awareness and letters group and the language activities and letters group scored at similar levels for letter-sound knowledge, with both these groups being significantly higher than the control group. On a measure of word reading the phoneme awareness and letters group scored significantly higher than the language activities and letters group which was in turn significantly higher than the control group. For a second measure of word reading, a spelling test, and a phoneme segmentation test, the phoneme awareness and letters group scored significantly higher than the other two groups whose scores did not differ significantly from each other.

Ball and Blachman (1991) claimed that because both the phoneme awareness and letters group and the language activities and letters group had an identical letter instruction component as part of their training, the advantage of the former group on measures of reading, spelling, and segmentation could not be due to differences in letter instruction, and therefore could be attributed to the phonological component of the training. Support for the claim that both groups received equivalent letter instruction came from the group's similar posttest scores on tests of letter-name and letter-sound knowledge. Although the training for both groups included an identical letter instruction component within their training, the phoneme awareness and letters group had a greater exposure to letters, as letters were also included as part of the phoneme awareness component of the training. It is therefore plausible that the phoneme awareness and letters group may have become more familiar with particular letters and faster at recognising them than the language activities and letters group. Although no significant differences were found between the two groups posttest letter knowledge scores, it is possible that differences in training may have contributed to differences in the speed of children's responses.

Ball and Blachman (1991) suggested that the near equal performance of the language activities and letters group and the control group on one of the two reading tests, and on the spelling and segmentation measures, indicates that letter instruction without phoneme awareness training is of limited value. However, the value of letter instruction may have been masked somewhat by the fact that children in all groups were receiving letter-sound instruction as part of the regular kindergarten programme. The effectiveness of this instruction can be seen in letter name posttest results where the control group scored at the same level as the two training groups. The letter-sound knowledge of the control group also increased over the period of training and while the posttest letter sound scores of this group were significantly less than the other two groups, the difference was not large (13.1 compared to 16.5). The similar letter knowledge levels of the control group and the other groups means that comparisons with the control group cannot be considered as valid comparisons to a group who had not had instruction about letters.

There is one other training study that has attempted to take account of the additional exposure to letters that may be associated with phonological awareness training. Hatcher et al. (1994) divided their sample of 128 seven-year-old poor readers into four groups. The "phonology alone" group received training in identifying, segmenting, deleting and synthesising sounds, but without reference to letters.

The "reading with phonology" group received explicit reading instruction that included work with letters, and activities to link reading activities with phonological awareness activities. The "reading alone" group were given reading instruction that did not involve any phonological awareness activities or examination of letter-sound relationships. A control group carried on with their regular classroom programmes.

Trained children were given two 30 minute lessons each week for a 20 week period. At the end of the training only the reading with phonology group scored significantly higher than the control group on measures of text reading accuracy and nonword reading. When text reading was reassessed 9 months later, the reading with phonology group had maintained this advantage. The higher reading skills of the reading with phonology group could not be attributed to an improvement in phonological skills because this group did not differ significantly from the control group in these skills. Only the phonology alone group scored significantly higher than the control group on phonological skills, but this gain was not accompanied by similar improvements in reading skill. It appeared that it was the combination of the phonology and reading training that was crucial for boosting reading skills. Hatcher et al. (1994) suggested that this finding is support for what they term the "phonological linkage hypothesis": combining reading and phonological instruction is effective because it "forms explicit links between children's underlying phonological skills and their experiences in learning to read" (p.42). (See also Fielding-Barnsley, 1997.)

Summary

Clearer indications of the relationships between phonological awareness and literacy can be found from studies that have controlled for the additional exposure to letters which accompany training in phonological awareness. Studies of this type have shown that phonological awareness training without the involvement of letters does not produce significant benefits for literacy, even though it may result in gains in phonological awareness (Bradley & Bryant, 1983; Bradley, 1988; Defior & Tudela, 1994; Hatcher et al., 1994). Studies that included a treatment condition of letter training without phonological awareness did not find this was effective, but methodological difficulties mean that the value of letter-sound training may have been underestimated (Ball & Blachman, 1991; Bradley, 1988). In general, the current experimental research evidence shows that the greatest gains for literacy occur when training combines phonological awareness skills with reading instruction that includes letter-sound activities.

2.2.3.3.3 Reviewing the Methodology of Experimental Studies of Phonological Awareness and Literacy

Troia (1999) conducted a review of the methodology of phonological awareness intervention research that provides valuable information on common problems in these studies. A total of 39 studies were evaluated in relation to checklists of criteria concerned with (1) internal validity (e.g., random assignment, alternative intervention for control group, sufficiently large sample size) and (2) external validity (e.g., procedures for participant selection, details of participant characteristics, assessment of transfer of learning). Troia assigned a weighting of from 1 - 3 to each criterion according to how important it is for interpreting the causality and generalisability of a study. The use of weightings for each criterion allowed Troia to rank each study according to its overall methodological quality.

Troia (1999) found that only 7 of the 39 studies that he reviewed met at least two thirds of the evaluative criteria. His review highlights the need for greater methodological rigour in experimental studies of phonological awareness training. However, the nature of Troia's review has resulted in an oversimplification of comparisons between studies. The use of criterion checklists and numerical ranking are convenient techniques for evaluating disparate studies but inevitably result in the loss of important detail about aspects of each study.

Some difficulties with a "checklist and ranking" approach to reviewing can be seen by examining the conclusion that Troia (1999) made on the basis of the seven studies that gained the highest rankings (Byrne & Fielding-Barnsley, 1991, 1993a, 1995; Castle et al., 1994, experiment 2; Foster, Erickson, Foster, Brinkman, & Torgesen, 1994, experiment 1; Hatcher et al., 1994; Slocum, O' Connor, & Jenkins, 1993; Torgesen, Morgan, & Davis, 1992; and Uhry & Shepherd, 1993). Troia stated that:

> Assuming these studies represent the best evidence available, we can conclude that metaphonological training can improve both analytic and synthetic awareness skills and literacy acquisition (at least basic reading skills, cf. Uhry & Shepherd, 1993) in as little as 2 months of small-group or individual instruction" (p. 49).

Although this conclusion would appear to be justified by the high rankings of the studies on Troia's (1999) criterion checklists, a closer look at the seven studies shows that each of them has design features that prevent a causal link being made between the training and progress in literacy. Two of the studies did not assess the

effects of phonological training on word reading (Slocum et al., 1993; Torgesen et al., 1992). Two other studies did not provide their control groups with alternate treatments to control for Hawthorne effects (Foster et al., 1994, experiment 1; Hatcher et al; 1994). The three remaining studies (Byrne & Fielding-Barnsley, 1991, 1993a, 1995; Castle et al, 1994, experiment 2; and Uhry & Shepherd, 1993) are all listed by Troia as achieving the criterion that the alternate treatment control group "were exposed to the same materials used for the experimental intervention to control for the novelty of treatment materials" (p. 33). However, as discussed in the current Literature Review (Section 2.2.3.3.2.1), each of these studies provided treatment groups with exposure to letter names or sounds that was greater than was provided to the control groups. It is therefore not possible to separate out the effects of phonological awareness training in these studies from the effects of additional exposure to letters.

Troia's (1999) use of checklists allows him to present valuable summary information about a wide range of studies. However, the above comments on Troia's highest ranking studies show that there are problems in placing confidence in a study's causal interpretations on the basis of its overall total on a checklist of criteria.

2.2.4 Phonological Awareness is a Consequence of the Acquisition of Literacy Skills

Previous sections of this review have noted that prereading children are able to perform a variety of tasks that assess rhyme awareness or alliteration awareness, but score at very low levels on tasks of phoneme awareness. The fact that prereaders exhibit some forms of rhyme awareness and alliteration awareness shows that these skills are not dependent on learning to read and write. (This does not rule out the possibility that the development of literacy skills may further enhance rhyme and alliteration skills.) Performance on phoneme awareness tasks usually becomes possible at about the same time that children begin to read and write. This has led some researchers to consider that the phoneme level of phonological awareness is a consequence of learning to read and write. The following discussion reviews studies that have examined this hypothesis. The studies have all focused on phoneme awareness and are organised according to research design into correlational, longitudinal, and experimental studies.

2.2.4.1 Correlational Studies

Where studies have found phoneme awareness and literacy skills developing in children at about the same time, it may be difficult to rule out the influence of intellectual maturation. It is possible that performance on phoneme awareness tasks occurs as a result of intellectual maturational factors, rather than as a consequence of learning to read and write. One way of avoiding the influence of maturational factors is to use participants who are all adults, and who are therefore all at the same general level of intellectual maturation.

This was the approach adopted by a team of researchers (Morais et al., 1979) who examined connections between phoneme awareness and literacy for a group of adults in Portugal who had not had opportunities to acquire literacy skills during childhood. Half of the adults had subsequently learnt to read and write in adult literacy classes. The other adults were all illiterate and had received either no schooling or very little. Morais et al. compared the performance of the literate and the illiterate groups on a range of phoneme awareness tasks, including phoneme addition, deletion, and reversal. The literate group scored at much higher levels than the illiterate group. Morais et al. interpreted the superior performance of the literate adults as evidence that phoneme awareness does not arise spontaneously with general cognitive development but is the result of learning to read and write.

Read, Zhang, Nie, and Ding (1986) extended the work of Morais et al. (1979) by using the same tasks to examine the phoneme addition and deletion skills of alphabetic and non-alphabetic readers in China. Read et al. found that a group of Chinese alphabetic readers scored at similar levels to the Portuguese who had learnt to read as adults. However, another group of Chinese readers who were only familiar with logographic script, found the phonological tasks to be very difficult and showed average scores very near those of the adults in Portugal who were illiterate. From these results, Read et al. claimed that phonological awareness is not an outcome of learning to read and write any language, but is instead restricted to the acquisition of an alphabetic literacy. Further evidence in support of this hypothesis comes from Mann's (1986) study of the phonological awareness of children in Japan and America. Mann found that first grade children in Japan - who initially learn to read in Kana, a syllabic language - showed delayed phonological awareness in comparison with first graders in America who were learning to read an alphabetic language.

Overall, the studies discussed above (Mann, 1986; Morais et al., 1979; Read et al., 1986) indicate that learning to read and write an alphabetic language has considerable influence on phoneme awareness skills. A study by Alegria, Pignot and Morais (1982) suggested that it may not only be the learning of alphabetic literacy that is significant, but the type of instruction used to foster that learning. These researchers tested the phoneme reversal skills of two groups of first graders who were being taught by either a "whole-word" method or a phonics approach. Alegria et al. found that the phonics group scored approximately four times higher on the phoneme reversal task than the whole word group. This suggested that reading instruction that focuses on the letter and sound components of words is more successful in increasing phoneme awareness than an approach that focuses on the word level. A problem with this study, however, is that reading achievement levels of the two groups were not reported. If the phonics group had higher reading skills than the whole word group then it is possible that their performance on the reversal task was higher, not because of higher levels of phonological awareness, but because their higher reading levels had resulted in gains in other skills that are useful for performing this task.

Tunmer and Rohl (1991) commented further on this issue. They noted that a number of studies that indicate that phonological awareness is a result of learning to read, such as those discussed above, all used the complex tasks of phoneme deletion or reversal, rather than what could be considered to be simpler measures of phoneme awareness, such as phoneme counting. Tunmer and Rohl considered that it was wise to be cautious when interpreting the results of these studies as performance on complex tasks may be dependent not only on particular types of phonological awareness, but also on other cognitive abilities that are positively influenced by learning to read. These "spinoff" skills of learning to read may be what is responsible for increased scores on complex segmentation tasks rather than being the result of any changes in levels of phonological awareness. The spinoff skills that may result from experience with reading include knowledge about the orthographic cipher and the ability to make use of this knowledge to generate orthographic images (see Ehri, 1987). Tunmer and Rohl also proposed that reading experiences may increase the efficiency of working memory by increasing automaticity of lexical access and by providing practise in blending, holding complex linguistic structures in working memory, and combining contextual information with grapho-phonic information. If reading experience does result in improvements in spinoff skills involving orthographic knowledge or working memory abilities, then it is likely that these improvements would enhance

performance on complex segmentation tasks which require those skills in addition to skills in certain types of phonological awareness.

Summary

The results of several correlational studies suggest that people who have not acquired alphabetic literacy skills perform poorly on phoneme awareness tasks (Morais et al., 1979; Read et al., 1986). One study found that reading instruction that includes a focus on the sound components of words is likely to result in higher phoneme awareness than instruction that focuses on whole words (Alegria et al., 1982).

Some complex phoneme awareness tasks may be demanding on other cognitive skills apart from phoneme awareness (e.g., working memory). It is possible that readers have an advantage on these tasks, not because of higher levels of phoneme awareness, but because reading experience may foster the other cognitive skills that are required to perform these tasks (Tunmer & Rohl, 1991).

2.2.4.2 Longitudinal Studies

Longitudinal research by Wimmer, Landerl, Linortner, and Hummer (1991) provided further evidence to support the notion that phoneme awareness is a consequence of reading instruction. The researchers conducted two studies that examined the development of children's phoneme awareness and literacy skills in the first year at school in Austria. Children in Austria do not begin school until they are 6- or 7-year-olds and generally have very few reading skills at school entry. This is because most kindergartens and parents in Austria have a philosophy of avoiding instruction in early reading skills. About a month after children had started school, and before literacy instruction had begun, Wimmer et al. administered tests of phoneme awareness, literacy skills, and IQ or verbal ability. The phoneme awareness and literacy tests were readministered towards the end of first grade. Phoneme awareness was measured with a phoneme substitution task that required children to substitute a vowel to change words into pseudowords.

Wimmer et al. (1991) concluded that "the acquisition of alphabetic reading and not intellectual maturation is the major determinant of the emergence of phonemic awareness" (p. 243). They highlighted three findings to support this claim:

1. Despite an age range of almost two years, nearly all children found the phoneme substitution task to be very difficult when they were first tested before reading instruction had begun. Towards the end of Grade 1, nearly all children scored at ceiling level on this task.
2. Phoneme substitution scores at the end of Grade 1 were strongly correlated to reading and spelling achievement at that time, and were only moderately correlated with phoneme substitution scores at the beginning of Grade 1.
3. The few children with early reading skills at the beginning of Grade 1 were much more likely to be able to perform the phoneme substitution task than were the other children. For the non-readers there was a significant correlation between phoneme substitution scores and letter-sound knowledge.

Wimmer et al. (1991) pointed out that all children with high phoneme awareness scores at the beginning of Grade 1 went on to develop high levels of literacy. They noted, however, that many children with negligible phoneme awareness at first testing also showed high levels of literacy by the end of Grade 1. Hence, early phoneme awareness should not be considered a prerequisite for beginning literacy instruction. Wimmer et al. acknowledged that phoneme awareness is important once children have started to learn to read and write. They suggested that differences between children in how readily phoneme awareness can be induced by learning to read may be a critical factor in separating out high and low progress readers.

Although Wimmer et al. (1991) agreed that early vowel substitution measures are somewhat predictive of later reading and spelling achievement, they concluded that the overall findings of their research were "in agreement with Morais, Alegria, and Content (1987) that the acquisition of alphabetic reading and not intellectual maturation is the major determinant of the emergence of phonemic awareness" (p. 243). They did acknowledge, however, that for "the presence of phonemic awareness after a few months of reading instruction it may be of particular importance that the present children were induced to reading via a phonics approach" (p.243-244). The phonics instruction given to the children emphasised letter sounds and blending and therefore closely matched the task demands of the vowel substitution task. This raises the question of whether performance on particular phonological awareness tasks is influenced not only by children's levels of phonological awareness, but also by whether they have been taught specific skills that match the demands of specific tasks. Another relevant consideration is the age of the sample. The first grade children in Wimmer et al.'s studies were nearly 7 years old at first testing. They would therefore have an advantage in

certain cognitive skills (e.g., working memory) that could assist their performance on phonological awareness tasks in comparison with the performance of the younger first graders used in other studies.

Summary

A longitudinal study (Wimmer et al., 1991) found that nearly all children were unable to perform a phoneme awareness task until they had begun to read. Once they had developed some literacy skills, phoneme awareness scores correlated strongly with reading and spelling achievement.

2.2.4.3 Experimental Studies

Bentin, Hamer and Cahan (1991) used a between grades quasi-experimental design to distinguish between the effects of aging and schooling on the development of phoneme awareness in a sample of 671 children in Israel. It is not possible to use a true experimental design to examine this area as it is impractical to manipulate the age at which children start school simply to fit with such a study. Instead, Bentin et al., used a regression discontinuity design that allowed them to measure the phoneme awareness of kindergarteners and first graders at one point (five months into the kindergarten or school year), and then estimate the growth of phoneme awareness for the entire age range that would normally be found within the kindergarten or first grade years.

Phoneme awareness was measured with a phoneme isolation task. Bentin et al. (1991) found that aging within the kindergarten year or the first grade year did have a significant effect on phoneme awareness skills, but the effect of five months of schooling on these skills was estimated to be four times as much as the aging effect. These results support the idea that learning to read and write is a major influence on phoneme awareness. Bentin et. al. also noted that the apparent aging effect may not simply reflect "pure" cognitive maturation but may be an indication of the increased linguistic experience, including informal exposure to written language, that is likely to accumulate with age.

Summary

A quasi-experimental study found that the effects of schooling (i.e., learning to read and write) on phoneme awareness in kindergarten and first grade was much greater than the effects of cognitive maturation during this time (Bentin et al., 1991).

2.2.5 Phonological Awareness has a Reciprocal Relationship with the Acquisition of Literacy Skills

Much of the apparent disagreement between research studies that support either a causal or a consequential connection between phonological awareness and literacy is a result of different studies focusing on different levels of phonological awareness. Studies that have focused on an awareness of intrasyllabic units, especially when this is measured indirectly (e.g., oddity tasks to assess awareness of rhyme or alliteration) have usually found evidence of this level of awareness in preliterate children and may have claimed it to be predictive of later literacy achievement. On the other hand, studies that have focused on an awareness of phonemes usually found this type of awareness only in older children who already had basic literacy skills, and may have suggested that the phonemic level of phonological awareness is a consequence of learning to read and write. The existence of reciprocal relationships between phonological awareness and literacy is therefore most likely to be seen in studies that (a) include measures of both intrasyllabic and phoneme awareness, and (b) include participants whose ages extend over the transition from preliteracy to literacy.

The following discussion of studies about whether there is a reciprocal relationship between phonological awareness and literacy is divided into three sections according to the design of the investigations: correlational, longitudinal, and experimental studies.

2.2.5.1 Correlational Studies

Correlational studies cannot show the direction of any causal relationships that may exist between phonological awareness and literacy. However, studies of this type can still support a reciprocal connection if their findings are consistent with the pattern that would be expected from a reciprocal relationship.

One such study was carried out by Bowey and Francis (1991) who examined the influence of age and literacy instruction on the phonological sensitivity of young children. The sample for their study was made up of three groups of children who were all assessed halfway through the school year. The first group consisted of the oldest children attending two kindergartens. The second group was made up of the youngest first graders from a nearby school and the third group was made up of the oldest first graders from the same school. These three groups were chosen to allow for some specific comparisons to be carried out. Comparison of the kindergarten group with the youngest first graders provided a contrast between two groups of children who were similar in age but who differed on whether or not they had been involved in literacy instruction. Comparison of the younger and older first grade groups provided a contrast between two groups of children who had similar exposure to literacy instruction (i.e., they had been in school the same length of time), but who differed in age and general linguistic maturity.

To ensure the kindergarten children were nonreaders, Bowey and Francis (1991) used all three of Clay's (1985) basic word lists as a screening test. Oddity tasks were used to assess awareness of rhyme, alliteration, and phonemes (- the phoneme oddity task required children to pay attention to medial phonemes, e.g., *m<u>a</u>t, m<u>o</u>p, m<u>a</u>n*). A test of receptive vocabulary (PPVT-R) was also given.

Bowey and Francis (1991) found evidence consistent with both a causal and a consequential connection between phonological awareness and reading. Consistent with a causal connection, rhyme awareness and alliteration awareness explained significant variance in the reading achievement of the first grade children, even after taking into account differences in receptive vocabulary. (However, the cross-sectional correlational nature of this study means that this result could also be explained by higher rhyme awareness and alliteration awareness being a result of reading.) Consistent with a consequential connection, performance on the rhyme, alliteration and phoneme tasks was higher for the first grade children who were all halfway through their first year of reading instruction, than for the kindergarten children who were all nonreaders. This was not an age effect as the younger first grade children scored significantly higher than the kindergarten children who were of a similar age. That no nonreaders were able to score above chance on the phoneme task supports the notion that phoneme awareness develops concomitantly with learning to read and write. Further support for this notion would have been obtained if phoneme awareness had been closely linked with reading achievement in first grade but this was not the case. First grade children scored at very low levels on the phoneme task - only 10 % of them scored above chance level - and

performance on this task was not significantly correlated with reading achievement after one subject who was classified as an outlier was excluded.

Bowey (1994) has suggested that the very difficult nature of the phoneme oddity task used by Bowey and Francis (1991) may have resulted in an underestimation of young children's sensitivity to phonemes. In support of her suggestion, Bowey reported the results of her study where a third of preschool nonreaders were able to achieve some success on a phoneme identity task. In each trial for this task, children were orally presented with three words along with pictures of these to reduce memory load. The children were told that the first word contained a particular sound, and were then asked to choose which of the other two words also contained that sound. (e.g., "Sock starts with /s/. Which of these starts with a /s/ sound, sun or ball?") The phoneme of interest was either in the initial or final position of the word, whereas it had been in the medial position in Bowey and Francis' study. Bowey found that the "phoneme identity tasks could be performed only by children who could focus on phonemes" (p142). That nonreaders could do these tasks would appear to question the idea that phoneme awareness is a consequence of acquiring literacy skills. But it is important to note that Bowey claimed only that these nonreaders may have a *sensitivity* to phonemes rather than an *awareness* . In her definition, *sensitivity* does not involve explicit isolation of phonemes whereas *awareness* refers to explicit analytical skills. Bowey's study is unclear as to what sensitivity to phonemes actually involved. The phoneme identity measure that was used to assess sensitivity to phonemes may in fact have been utilising other skills; half of the items in the phoneme identity measure focused on initial phonemes and could therefore have been answered on the basis of alliteration awareness, rather than requiring any other sensitivity to phonemes.

Another correlational study that suggests there is a reciprocal relationship between phonological awareness and literacy skills was conducted by Foorman, Jenkins, and Francis (1991). The study investigated the literacy and phoneme deletion skills of a group of first and second graders. The children were generally accomplished at the initial and final sound deletion tasks but found the medial deletion tasks to be considerably more difficult. Foorman et al. concluded that their results were "consistent with the view that awareness of beginning and ending sounds is a prerequisite to reading and spelling, but that awareness of medial sounds and consonant blends is a consequence of reading" (p. 13). They cautioned that they use the terms "beginning *sound*'" and "ending *sound*'" advisably as they could not determine whether the children had *phonemic awareness.* Foorman et al. speculated that the medial deletion task would be easier for children with more

advanced literacy skills as these children should be able to generate and manipulate orthographic images in order to carry out the required deletion.

One other correlational study provides further support for the idea of a reciprocal relationship between phonological awareness and literacy skills. Carillo (1994) studied a group of kindergarten and first grade children in Spain who were all learning to read. Testing was carried out at the end of the school year and involved the administration of a wide range of tests, including IQ, word decoding, rhyme oddity tasks, alliteration oddity tasks, and a variety of phoneme awareness tasks. Carillo compared patterns of scoring for children of different reading levels at each age group. In the kindergarten sample, the children who were reading outperformed the nonreaders on all phonological awareness tasks. Performance differences between the kindergarten readers and nonreaders were most apparent for a number of the phoneme awareness tasks in comparison with the differences found with the rhyme and alliteration tasks. A similar pattern was seen at first grade where performance differences between "good readers" and "average/poor readers" were much larger for the phoneme awareness tasks than for the phonological similarity tasks. Carillo concluded that these patterns suggested that awareness of rhyme and alliteration occurs before learning to read and is not greatly affected by experience with literacy, and that awareness of phonemes develops concomitantly with the acquisition of literacy. IQ was not partialled out in Carillo's analyses but it is unlikely to have had much effect as there was virtually no correlation between IQ and reading at kindergarten or first grade.

Summary

Several correlational studies have found that some types of phonological awareness, (e.g., rhyme awareness and alliteration awareness), occur before children learn to read and write while other types of awareness, (usually involving phonemes), occur after children have begun to acquire literacy skills (Bowey & Francis, 1991; Carillo, 1994; Foorman et al., 1991). Correlational studies cannot determine causality, but this pattern of results is consistent with what would be expected if rhyme awareness and alliteration awareness had a causal role in acquiring literacy skills, and phoneme awareness was a consequence of literacy skills.

2.2.5.2 Longitudinal Studies

The first longitudinal study to suggest that there may be a reciprocal connection between aspects of phonological awareness and learning to read was carried out by Perfetti, Beck, Bell, and Hughes (1987). Their study followed the progress of two groups of children during their first year at school. The first group ("direct code") consisted of children who were being taught to read with a phonics programme. The other group ("basal") consisted of children who were being taught with a basal reader series that did not include any systematic phonics instruction. All children were initially tested during the first week of school and were then assessed at three other points during their first grade year. Phonological awareness was measured on each occasion with three tasks requiring operations at the phoneme level: blending, tapping, and deletion. Reading was assessed with a pseudoword reading task that was given at each test point after initial testing. At the end of the year the children's word reading was assessed with a standardised reading test.

Perfetti et al. (1987) examined the correlations between the phoneme awareness tasks and end of year reading. The value of this analysis would have been greater if the possible influence of IQ was partialled out but there was no attempt to do this. Another problem with the analysis is that a number of children were already reading at the first testing point, thereby making it impossible to determine for the group results whether initial phonological awareness was a precursor and possible cause of reading or a concomitant and possible consequence of reading. As differences in letter knowledge were not assessed it is not known whether this contributed to the pattern of results.

Perfetti et al. (1987) found that tapping was the poorest predictor of word reading for both instructional groups. Tapping was the most difficult of the tasks, with many children still scoring poorly at the end of the year. For the children in the basal group, deletion was generally the best predictor of word reading. Blending was also a good predictor for the first two testing points but then declined in predictive value for the second half of first grade. A different pattern was seen for the direct code group. For these children, blending was generally a poor predictor of end of year word reading but deletion was a reasonably good predictor, especially on the second and third testing occasions. Perfetti et al. suggested that the reason why blending was a poorer predictor for the direct code group may have been that these children were taught blending skills as part of their reading programme. This instruction would have reduced variability in the children's blending skills, thereby reducing the predictive value of this factor. Blending was

a better predictor for the basal group because the children's individual differences in this skill were not lessened by the type of instruction they received.

Perfetti et al. (1987) used cross-lagged partial correlations (see Kenny, 1989) to further analyse the data. This technique involves first finding the correlation between scores on phonological awareness (for a particular task) at time n and reading at time n + 1 (partialling out the effects of reading at time n). If this correlation is larger than the correlation between reading at time n and scores on phonological awareness at time n + 1 (partialling out the effects of phonological awareness at time n) it can be inferred, according to the logic of cross-lagged partial correlations, that phonological awareness influences reading more than vice versa.

The results of the cross-lagged partial correlations suggested that blending influenced reading more than vice versa for both instructional groups. Generally, more of an interactive relationship appeared to exist for deletion and reading; for the direct code group reading predicted later deletion, but for the basal group there was evidence of a reciprocal pattern with reading predicting deletion which, once it reached a certain level, then predicted later reading.

Perfetti et al.'s (1987) results suggested that different relationships may exist between different aspects of phonological awareness and reading, and that these relationships may be influenced by type of instructional programme. However, there is a need for some caution when considering their findings as there are some difficulties with the design and measures used in the study. Wagner et al. (1994) pointed out that Perfetti et al. did not test for the significance of the differences between the partial correlations that their conclusions were based upon. Another issue is that cross-lagged correlations are sensitive to variations in the reliability of the measures that are used (Rogosa, 1980). No reliability information is provided on the measures used by Perfetti et al. but the nature of some of the tasks raises concerns about their suitability. The reading measure was a very short (four items) pseudoword reading test. Short tests are known to be less reliable than longer tests (Thorndike & Hagen, 1977). The test was made up of a different set of pseudowords for each test time. While this avoided practice effects, it also introduced additional variation which may have lessened the reliability of the task.

Although Perfetti et al. (1987) discussed the influence of different *types* of phonological awareness tasks, they also acknowledge that the pattern of predictions could be a result of the *difficulty levels* of the tasks. That is, another investigation of the same types of phonological awareness may find different

predictive patterns if the assessment tasks are of different difficulty levels to those used by Perfetti et al.. Even within a particular task there can be differences in the difficulty level of particular items. For example, Perfetti et al. found that deletion of initial phonemes was more difficult than deletion of final phonemes. It is possible that a different predictive pattern would have been found if time-lagged correlations had been done separately for initial and final deletion, rather than using total deletion scores.

An additional difficulty with Perfetti et al.'s (1987) study is that there was an extensive time period over which different children were assessed for some of the testing points. A longitudinal study should test all children within a short period for each testing occasion; it is not valid to compare the progress of children from one time to the next if the time intervals are unequal. But unequal time intervals appear to have occurred with Perfetti et al.'s study, particularly around the third testing point where the last child was tested more than 3 months after the first child.

Ellis and Large (1988) conducted a longitudinal study that also concluded that there was a reciprocal connection between phonological awareness and reading. In Ellis and Large's study the progress of a group of children was followed during their first two years at school. The children were first assessed as they reached 5 years of age and were then reassessed at yearly intervals when they were close to 6 and 7 years old. At each time the children were tested on a wide range of measures including IQ, letter recognition, word reading, rhyme awareness (oddity task), and phoneme awareness (tapping task).

Ellis and Large (1988) found that letter recognition was significantly correlated with reading at ages 5 and 6 years. However they did not control for the possible influence of letter knowledge when calculating predictive correlations between variables, although they did partial out the effects of IQ. For the period from age 5 years to age 6 years, initial reading predicted later phoneme counting, but initial phoneme counting or rhyme oddity did not significantly predict later reading. To get a clearer picture of possible causal connections at this time, Ellis and Large separated out the results for the eight children who could read no words at age 5 years. For these children, it was found that initial phoneme counting, but not rhyme oddity, was predictive of later reading. Although this result appears to support a causal connection from phoneme counting to reading, there is a need for some caution. The test that Ellis and Large used to screen for initial reading skills, the Schonell Reading Test (Schonell and Goodacre, 1971), is not intended to be a sensitive measure of early reading. It does not contain the high frequency words

that children would often first be able to identify.[8] Hence it is possible that some of the children classified as "nonreaders" on the Schonell Test could actually have had some early word identification skills, and that these skills may have influenced their performance on the phoneme tasks.

For the period from age 6 years to age 7 years, results from the full sample were used, and IQ was again controlled for. At age 6 years, phoneme counting, but not rhyme oddity, was significantly related to reading at age 7 years. There was evidence of a reciprocal relationship as reading at age 6 years was predictive of phoneme counting at age 7 years. Using cross-lagged correlations, Ellis and Large (1988) found that 6-year-old reading predicted 7-year-old phoneme counting more than 6-year-old phoneme counting predicted 7-year-old reading. Ellis and Large therefore concluded that although there appears to be a two way relationship, reading contributes more to phoneme awareness than vice versa over this period.

In order to gain insights into what may be happening in the more advanced stages of reading acquisition, Ellis and Large (1988) extracted the results of the 10 children who showed the highest reading scores at age 6 years and looked at which other abilities at age 6 years predicted reading at age 7 years. For this group of children, phoneme counting was not predictive of later reading, even prior to controlling for the effects of IQ. Ellis and Large suggested that this indicates that phonological awareness stops being a limiting factor when children develop more advanced reading skills. Ellis and Large believed that these children had already developed the phonological decoding skills that may be facilitated by phonological awareness, and were at a stage where the development of orthographic strategies became particularly important.

Cataldo and Ellis (1988) extended on the findings of Ellis and Large (1988) by providing not only an analysis of links between phonological awareness and reading, but also an analysis of connections with early spelling development. Cataldo and Ellis followed the progress of a group of children who were first seen near the time they entered school. The children were then reassessed at three later times; towards the end of their first year in school, near the beginning of their second school year, and near the beginning of their third year in school. Testing included measures of "implicit phonological awareness" (i.e., rhyme awareness and alliteration awareness as measured by oddity tasks), "explicit phoneme awareness" (i.e., phoneme awareness as measured by a segmentation task),

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[8] See the earlier discussion of the Schonell Reading Test in Section 2.2.3.2.1.

reading (real words and pseudowords), and spelling (real words and pseudowords).

The timing of the four testing occasions allowed for an examination of phonological awareness and literacy development over three periods. Phase One covered much of the first year of schooling. Phase Two covered the period from near the end of the first year to the time shortly after the beginning of the second year. Phase Three spanned the period from near the beginning of the second year to the start of the third year.

Cataldo and Ellis (1988) analysed their results with the LISREL causal modelling technique (Joreskog and Sorbom, 1986). Pathweights from this analysis suggested that spelling contributed far more to reading than vice versa in Phase One and Phase Two. Implicit phonological awareness predicted reading and spelling over the period of the first year at school (Phase One) but showed very little predictive connection with reading and spelling in later phases. Explicit phonological awareness was a strong predictor of spelling during Phase One and further increased in value as a predictor of spelling during the next two phases. A different relationship was seen for reading where explicit phonological awareness showed little predictive connection during the first two phases but became a strong predictor for Phase Three.

Cataldo and Ellis (1988) concluded that the pattern of their results indicates that implicit phonological awareness and reading are reciprocally related in the early stages of reading. Explicit phonological awareness did not directly affect reading during Phase One and Phase Two, but Cataldo and Ellis believed it had an influence through its significant effect on spelling which, in turn, affected reading. Practise with spelling was said to help children develop letter-sound knowledge that could then be used for reading. During Phase Three the influence of explicit phonological awareness on reading became more direct. By this time the children had generally developed sufficient letter-sound knowledge to enable them to combine letter-sound knowledge with explicit phonological awareness skills in order to adopt a phonological strategy for word reading.

The conclusions of Cataldo and Ellis (1988) provide an interesting picture of possible connections in the development of phonological awareness, reading, and spelling skills. The design of their study, however, means that there is a need for some caution about these conclusions. Cataldo and Ellis acknowledged that with small samples, such as in their study, LISREL can only be used for exploratory

purposes. Other methodological difficulties with the study are that IQ was not partialled out when calculating the predictive correlations, and that a number of children were already reading when the study began, thereby making it more difficult to determine the direction of the relationships between phonological awareness and literacy.

Further investigation of possible reciprocal relationships between phonological awareness, reading, and spelling was made by Foorman, Francis, Novy, and Liberman (1991). The sample of children in this study were given tests of phoneme deletion, word reading, and word spelling on three occasions during their first grade year. Foorman et al. used hierarchical linear modelling (Bryk & Raudenbush, 1987) to analyse the results and found that phoneme deletion scores at first testing were predictive of final reading and spelling achievement. Although initial spelling scores were predictive of final deletion skills, there was no significant connection between initial reading scores and final deletion. On the basis of these results, Foorman et al. suggested that there is a unidirectional relation from early deletion skills to later reading, and a bidirectional relation between deletion skills and spelling. This interpretation can be challenged, however, as many of the children were already reading at first testing. The inclusion of readers at the start of the study makes it impossible to determine the direction of any causal links that may exist between phoneme awareness and literacy. Furthermore it is also possible that differences in letter knowledge may have contributed to the pattern of results.

A longitudinal investigation conducted by Wagner et al. (1994) also included children who were reading when first tested. In this study the researchers took care to partial out the influence of initial reading when analysing the causal relationships between variables. The study followed the progress of a large group of children who were assessed near the beginning of their years in kindergarten (when their mean age was 5 years 8 months), first grade, and second grade. A wide range of measures was made at each assessment point, including general verbal ability, letter-name and letter-sound knowledge, word and non word reading, and phonological awareness. Earlier cross-sectional research by Wagner and his colleagues (Wagner et al., 1993) had indicated that phonological awareness could be divided into two latent abilities: phonological analysis (i.e., the ability to break a word into its component phonemes) and phonological synthesis (i.e., the ability to blend component phonemes into a word). A number of tests were used to make a composite measure of each of these abilities. Phonological analysis was assessed with three tests: phoneme deletion, a combined rhyme and alliteration

oddity task, and an onset matching task. (A phoneme segmentation task was initially included as a measure of phonological analysis but this test was dropped when it proved to be too difficult for the kindergarten assessment.) Phonological synthesis was assessed with three other tests: onset and rime blending, phoneme blending to make words, and phoneme blending to make nonwords.

The causal influence of phonological awareness abilities on decoding (a latent variable based on the word and nonword tests) was examined by using structural equation models that took the effects of verbal ability and prior decoding skills into account. Both types of phonological ability at kindergarten were significantly linked to decoding at first grade. A similar pattern existed from first grade phonological abilities to second grade decoding.

Causal influences from decoding to phonological abilities were also examined, but after taking verbal ability and prior phonological abilities into account, no significant connections were found. Wagner et al. (1994) noted that one reason for the lack of such a connection appeared to be the year to year stability of the phonological abilities. When prior phonological abilities were controlled for, there was little variance left to explain. Another possible explanation for the lack of a connection could be the limited variability in the decoding measure as a result of floor effects with the word and nonword tests in kindergarten and, to a lesser extent, in first grade. In particular, the nonword test proved to be very difficult for most children.

To further explore possible causal influences from developing literacy skills to phonological abilities, Wagner et al. (1994) looked at the predictive link from letter-name or letter-sound knowledge at kindergarten to decoding at Grade 1. The letter knowledge tests were not affected by floor effects, and after taking verbal ability and prior phonological abilities into account, a causal influence on phonological abilities was indicated for letter-name knowledge and, to a lesser extent, for letter-sound knowledge. A similar pattern was found from first grade letter knowledge to second grade phonological abilities. These findings emphasise the importance of considering letter knowledge as a contributing factor when examining connections between phonological awareness and literacy.

Wagner et al.'s (1994) use of latent abilities in their study was based on earlier evidence provided by Wagner et al. (1993) which supported the division of phonological awareness into the latent abilities of analysis and synthesis. There are, however, disadvantages in analysing the results on the basis of latent abilities

rather than as scores from specific tests. The tests that Wagner et al. (1994) used to assess each latent ability required children to either analyse words into phonological segments or synthesise phonological segments into words. While all the tests used in a particular composite measure required the same operation to be carried out (i.e., analysis or synthesis), there were differences between the tests with regard to the size of the phonological segment that was being focused on. Some tests required awareness at the onset/rime level while other tests required an awareness at the phoneme level. As previously noted in this review, a number of other studies have found onset/rime awareness and phoneme awareness to have quite different connections with literacy acquisition (e.g., Bowey and Francis, 1991; Carillo, 1994). Including both levels of awareness within the same composite measure reduces the interpretative value of Wagner et al.'s results.

Summary

Longitudinal studies have shown that different types of phonological awareness may have different relationships with literacy, and that the nature of these relationships may change as children acquire literacy skills. These studies have found certain types of phonological awareness skills have reciprocal relationships with literacy at particular times (Perfetti et al., 1987; Cataldo & Ellis, 1988; Ellis & Large, 1988; Foorman et al., 1991). The evidence from these studies indicates that rhyme awareness and alliteration awareness are more likely to play a role in the early stages of learning to read and write, after which time phoneme awareness becomes increasingly important. Methodological problems, including a failure to examine the possible influence of letter knowledge, limit the value of some of the studies that have suggested reciprocal relationships between phonological awareness and reading. A study that examined the role of letter knowledge found evidence for a causal connection from knowledge of letter names and sounds to phonological abilities (Wagner et al. 1994).

2.2.5.3 Experimental Studies

McGuinness, McGuinness and Donohoe (1995) claimed that the findings of their experimental study provide support for the existence of a reciprocal relationship between phonological awareness and literacy. Participants were three groups of first grade children who were aged from about six years to nearly eight years at the beginning of the study. In addition to their regular classroom programmes, two of the groups received systematic training in a number of phonological awareness skills, including pronouncing, identifying, deleting, substituting, and blending phonemes. The groups were also trained to link phonemes to single letters and digraphs. Training occurred over an eight month period, usually for 20 to 30 minutes each day. During this period the third group - the control - continued their classroom programme which included phonics and literature based materials.

Before the beginning of the training programme, there were no differences between the groups in reading level or phoneme awareness (as measured by a test of segmentation skills). At the end of the training period the trained groups had made significantly more progress in word identification and word decoding than the control group. The advantage was especially apparent for decoding skills, as would be expected considering that the training had focused on phoneme-grapheme relationships in regular orthography rather than sight reading of irregular words.

Regression analyses for the total sample showed that phoneme segmentation at the beginning of the study was able to explain significant variance (10%) in final word decoding, after first taking account of listening vocabulary and initial word decoding levels. This result supports a causal link from phoneme awareness to reading, but another finding from this study suggests that the relationship may also operate in the other direction. Trained and control groups were found to make the same gains in phoneme awareness over the training period, despite the trained group receiving special instruction in skills related to phoneme awareness. McGuinness et al. (1995) believed that this finding indicates that the process of learning to read (which was happening for the trained groups, and for the control group, albeit at a slower rate) assists with gains in phoneme awareness. The fact that the trained groups made greater progress than the control group in learning to

read indicated that reading instruction is optimised when training in phoneme skills is accompanied by instruction in making links with graphemes.[9]

The design of McGuinness et al.'s (1995) study did not allow for the separation of the effects of training in letter knowledge from the effects of training in phonological awareness. However, the finding that the trained and control groups had different levels of reading, but the same levels of phoneme awareness, at the end of the study suggests that phonological awareness training on its own would not result in additional gains in reading. It is possible, however, that the trained group may have had advantages in some phonological awareness skills but that these were not detected by the test used in the study. The test only focused on phoneme segmentation and did not assess some of the other phoneme awareness skills that had been part of the training programme.

Summary

Evidence in support of a reciprocal relationship between phoneme awareness and reading comes from a training study by McGuinness et al. (1995). In support of there being a causal link from phoneme awareness to reading, phoneme segmentation skills at the start of the study were predictive of later reading levels after first taking account of initial ability and reading levels. In support of there being a causal link from reading to phoneme awareness, it was found that children who were learning to read without additional training in phoneme awareness made as much of a gain in phoneme segmentation skills as children who were receiving additional training in these skills.

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[9] A similar conclusion was reached in this review after examining experimental studies that have suggested a causal connection between phonological awareness and literacy - see Section 2.2.3.3.2.2.

2.3 Letter Knowledge and Literacy

2.3.1 The Association Between Letter Knowledge and the Acquisition of Literacy

Many studies have reported that letter knowledge is one of the best predictors of children's early reading achievement (e.g., Bond & Dykstra, 1967; Chall, 1967; Durrell, 1958; Mason, 1980; Riley, 1996; Stainthorpe & Hughes, 1998; Stuart, 1995; Weinberger; 1996). As with studies of phonological awareness and reading, however, the finding of a relationship between two variables does not necessarily mean that there is a causal connection from one to the other. The connection could be the result of a confounding variable or could operate in the other direction. In order to help rule out such alternative explanations, studies need to include a measure of likely confounding variables (e.g., intelligence or verbal ability), and should first measure letter knowledge before children begin to read. Some of the earlier studies in this area did not include these design considerations, which means it is not possible to eliminate alternative explanations of the relationship between letter knowledge and reading (e.g., Share et al., 1984). Other studies have shown improved designs but methodological problems can still limit the causal interpretation of their results.

For example, Vellutino and Scanlon (1987) found high correlations between kindergarten children's letter-name and letter-sound knowledge, and their reading at the end of Grade 1 and Grade 2. The correlations remained significant after controlling for differences in IQ. However, although some children were already reading when first assessed at kindergarten, there was no attempt to control for initial reading levels. Hence causal direction is unclear as it is possible that the apparent connection from letter knowledge to reading may have operated in the other direction. It could be that early reading resulted in greater familiarity with letters. If this were so, then children with high early letter knowledge may have showed faster progress in reading, not as a result of their letter knowledge, but because they had a headstart with reading.

The same methodological problem of not controlling for pre-existing reading levels occurred in a study by Badian (1995). This longitudinal investigation found preschool letter naming skills to be significantly correlated with later word reading on each of a number of assessments made from Grade 1 through to Grade 6

(correlations ranged from .35 to .48). IQ and age, but not initial reading levels, were partialled out in the calculations.

An attempt to screen for initial reading levels was made in a study by Blatchford, Burke, Farquhar, Plewis and Tizard (1987). The researchers tested 343 children who had just begun school with a list of ten simple words and found that only nine children could read any of the words. The test contained some high frequency words but cannot be fully evaluated as Blatchford et al.'s paper provided only five of the ten words. (Although the test may have picked up children with some early reading skills, it does not appear to be as sensitive a screening measure as other researchers have recommended - see Bowey and Francis, 1991.) The children's ability to provide the name or sound of each letter was also assessed at school entry. These letter identification scores correlated very highly with reading levels measured three years later ($r = .61$). The relationship remained significant after controlling for IQ.

Grogan (1995) also reported a strong correlation between letter naming skills at school entry and reading nearly three years later. However, after controlling for the effects of intelligence, the relationship was no longer significant. Grogan did screen for initial reading ability but the test she used - the Schonell Word Reading Test - is not intended to be a sensitive measure of early reading skills.[10]

A more sensitive screening test was used by Stuart (1995) who assessed the reading levels of a group of children with one of Clay's (1985) basic word lists, as well as a list of the most frequent words from early school books. The children were initially tested during their first term at school, at which time a measure of letter-name knowledge was also made. Reading was again assessed at the end of the school year. After partialling out the effects of initial reading levels, Stuart found a high correlation between early letter-name knowledge and end of year word reading ($r = .75$). The possible influence of verbal ability was not considered.

A number of experimental studies have investigated whether teaching letter names to children results in greater progress with reading (Jenkins, Bausell, & Jenkins, 1972; Samuels, 1972; Silberberg, Silberberg & Iversen, 1972). These studies have generally been interpreted as showing that the teaching of letter names does not have a positive effect on reading (see, e.g., Gibson & Levin, 1975). However, in a review of these studies Ehri (1983) concluded that each of them had

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[10] See the earlier discussion of the Schonell Reading Test in Section 2.2.3.2.1.

methodological problems that affected the validity of their conclusions about the value of letter-name knowledge. Ehri argued that the studies had not investigated how thoroughly letter names needed to be known in order for this knowledge to be beneficial. She also pointed out that the studies had focused on letter-name knowledge but needed to also encompass letter-sound knowledge. Another of Ehri's criticisms was that the training studies did not investigate whether children required additional skills, such as phonological awareness, in order to make use of their letter knowledge for reading and spelling.

Ehri's (1983) criticism of the failure of some experimental studies to consider both letter-name and letter-sound knowledge can also be applied to other studies in this area. Investigators have often measured only letter-name knowledge, or have used tests that allow children to provide either the name or the sound of a letter. Letter-name knowledge and letter-sound knowledge are not the same thing and should always be assessed separately. Letter-name knowledge generally develops before letter-sound knowledge, and each type of letter knowledge may have a different role in the acquisition of literacy (see Bialystok, 1991; Mason, 1980).

Knowing the names of written letters will help children to learn letter sounds (Mason, 1980; Treiman, Tincoff, Rodrigues, Mousaki, & Francis, 1998). Some letter names are similar to the sound(s) represented by the letter, but even when the name is quite different from the sound(s), being familiar with its name will provide a useful label to associate with the sound(s). Knowledge of letter names and sounds will help young children to see that words are not simply whole units but are made up of patterns of letters. As children begin to acquire literacy skills their familiarity with letters will assist them in decoding unfamiliar words, and in their attempts to spell these words (Adams, 1990).

Children will often know the names of particular letters before they are able to identify these letters in written form. Knowing the names of letters is a useful first step for children as it makes them familiar with the labels that they will then learn to associate with particular written symbols. As children learn about written letters, they come to see that each letter is not represented by one distinct shape but by a variety of shapes. Mastering letter recognition requires that children learn to discriminate the particular features that distinguish one letter from another (Rayner and Pollatsek, 1989).

Another possible reason for the positive correlations that exist between letter knowledge and reading is that letter knowledge may be an indication of *naming*

speed, an ability to name items which is usually assessed by timing how long a child takes to name particular visual symbols. Naming speed may be important for reading as it is a measure of whether lower level processes show *automaticity* (i.e., the processes are fast, autonomous, and place little demand on cognitive resources). Automaticity is significant because it means that lower level processes, such as letter and high frequency word recognition, require fewer cognitive resources thereby allowing attention to go to higher level processes, such as decoding unfamiliar words and comprehension (Bowers, 1995; Wolf, 1991).

2.3.2 The Influence of Phonological Awareness on the Association Between Letter Knowledge and Literacy

Ehri and Wilce (1985) suggested that beginning readers require some level of sensitivity to phonemes in order to make use of their letter knowledge. Their research indicated that children are able to make use of letter knowledge during the earliest stages of word reading in order to make memory associations of the links between some of the letters in a word and some of the sounds in its pronunciation. This is called "phonetic cue" reading. For phonetic cue reading to occur, children must have phonological segmentation skills as well as letter knowledge. This allows them to be able to detect the sound segments in words that are associated with letter sounds. It also allows them to recognise that the names of many letters contain the phoneme that the letter frequently represents, e.g., "dee, jay, em" (see Durrell, 1980; Treiman et al., 1998). Ehri and Wilce provided evidence that teaching children to spell has superior effects on reading than simply teaching them about letter-sound connections. They suggested that this is because learning to spell provides practise not only with letter-sound knowledge but also with segmentation skills (Ehri & Wilce, 1987).

Other researchers have also provided evidence that letter knowledge is of most value for children who already have some phoneme awareness skills. Tunmer et al. (1988) [11] found that the product of phoneme tapping skills and letter-name knowledge at the end of Grade 1 was able to account for variance in pseudoword reading that was not explained by the sum of the two variables alone. An examination of the children's scores showed that the better readers had high levels of both phoneme tapping skills and letter-name knowledge. Tunmer et al. suggested that children require an awareness of phonemes before they can make

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[11] This study was discussed earlier in Section 2.2.3.2.2.

much use of their letter-name knowledge in order to decode unfamiliar words. An interactive effect for phoneme segmentation and letter-name knowledge was also found in a recent study by Muter et al., (1997). Hence it appears that children with phoneme awareness skills may be in a better position to make use of the "alphabetic principle", the proposition that letters relate systematically to sounds in words (see Byrne, 1998).

A number of training studies have found that instruction involving either letter skills alone or phonological awareness skills alone, was not as effective at improving reading as instruction that combined both types of skills (Ball & Blachman, 1991; Bradley & Bryant, 1983; Hatcher et al., 1994).[12] It appears that teaching these skills together allows for children to make clear links between how sounds occur within words and how these sounds can be represented by letters (see Fielding-Barnsley, 1997).

Additional evidence in support of the value of a combination of letter-sound knowledge and phoneme awareness comes from studies demonstrating that where children had similar levels of phoneme awareness, those who received additional letter-sound instruction made greater progress in reading (Foorman et al., 1991; McGuinness et al., 1995).

2.3.4 Letter Knowledge and the Knowledge Sources Account of Reading

A comprehensive model of how readers identify words has been developed by Thompson et al. (1996). (See also Thompson, 1999.) This description, known as the Knowledge Sources account, is supported by a number of experimental studies carried out by Thompson and colleagues (see Thompson & Fletcher-Flinn, 1993).

[12] See the discussion of these studies in Section 2.2.3.3.2.2.

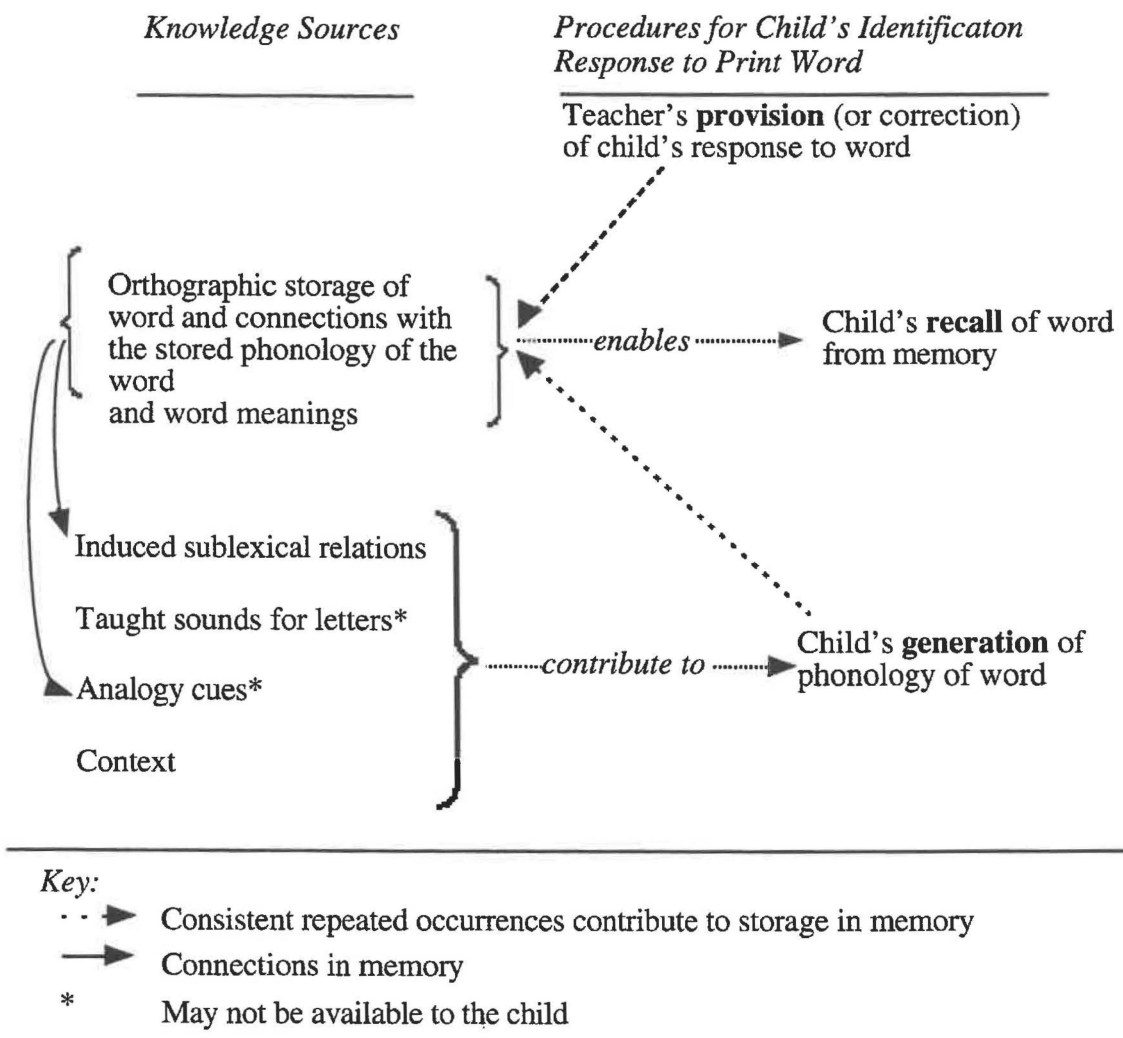


Figure 2.2. The Knowledge Sources account of reading (reproduced from Thompson, 1999).

The Knowledge Sources account is summarised in Figure 2.2. This shows that a reader can identify words by either "recall" or "generation". Recall, sometimes referred to as "sight word recognition", makes use of the reader's stored knowledge of the orthographic representations of words. The orthographic representation of a particular word is linked in memory with the word's meaning and sound. These memory linkages may initially be formed as a result of a teacher or parent providing the correct response for particular written words. Orthographic representations in memory are built up gradually. Representations will be facilitated as children develop skill at recognising the many written forms of each letter. In the early stages of learning to read a child may have only partial orthographic representations of a number of words, often based on knowledge about the left and right boundary portions of the words.

Recall procedures will only be successful for words that are familiar. A different approach is required for identifying unfamiliar words. This is known as generation as it requires the reader to generate a response to the unknown print word by making use of one or more of the following four sources of knowledge (see Figure 2.2).

1. Induced sublexical relations

"Induced sublexical relations" are the relations between the orthographic components of words and the corresponding phonological components stored in memory. Once beginning readers have had experience with a number of words that share particular orthographic and phonological units they may be able to implicitly induce the connection between these components. For example, a child who has some familiarity with words such as *cat, not, sit,* and *went* may induce that the final letter of these words, "-t," represents the final sound that is common to these words, /-t/.

Induced sublexical relations are sensitive to the position of the letters and sounds within words. The ability to induce connections will be affected by the reader's developing understanding of orthography and phonology. Readers will be advantaged in forming induced sublexical relations if they have a knowledge of letter recognition and letter group patterns, along with knowledge of the sound structure of words. Thompson et al. (1996) stated that children in the early stages of reading will have incomplete access to segments at the phoneme level, especially for positions other than at the beginning or end of a word. Because beginning readers are often aware of sound units at the onset and rime level, they may be more likely to be sensitive to consonant phonemes that occur as onsets, especially if they are singletons (e.g., /s/) rather than blends (e.g., /st/).

Thompson et al. (1996) suggested that children are able to induce increasingly complex sublexical relations as they develop higher levels of reading skill. Sublexical relations are formed that are sensitive not only to position within a word but also to the surrounding letters and corresponding sound units. Once children have sufficient exemplars in their reading vocabulary, they will be able to form sublexical relations for groups of letters that commonly occur together and corresponding sound units.

2. Taught sounds for letters

These are the sound labels for letters that children are taught by parents and teachers, for example, /duh/ for the letter "d". Children with an awareness of

phonemes may be advantaged in making the connection between the sound label of a letter and the phoneme that it represents in a word. Children who do not have complete phoneme awareness, but who are aware of rhyme and alliteration, may be able to acquire access to phonemes where the onset is a single consonant phoneme (i.e., a singleton).

Knowledge of letter names will help children learn letter sounds (Mason, 1980). Being able to recognise a letter in print, and knowing a letter name provides children with a useful label to associate with the letter's sound(s). A letter's name is sometimes similar to a sound represented by the letter (see Section 2.3.1 of the Literature Review).

Sound labels can be used to cue words in the child's memory which contain similar sounds. For example the letter "d" at the beginning of "dig" may cue /dig/ along with /dog/, /dip/, /dark/, and other words with a similar initial sound. Contextual information may then enable the child to choose the correct word. Sound labels for letters may also be used for sequential decoding in order to form a pronunciation of the unknown print word. This pronunciation may sometimes only approximate the usual spoken form of the word, especially for irregularly spelt words. However, approximate pronunciations may still provide a sufficient cue for the child to identify the correct word, especially when combined with contextual information (Tunmer & Chapman, 1997; 1999).

Thompson et al. (1996) noted that if a child provides correct sounds for letters, the source of this knowledge may not be clear. It may be from (1) induced sublexical relations, or (2) taught sounds for letters. Another source of knowledge of letter-sound labels could be the transfer from sound-letter knowledge learnt during spelling. Recent research by Thompson and colleagues, however, does not support the notion of spelling as a source of letter-sound information (Thompson, Fletcher-Flinn, & Cottrell, 1999).

3. Analogy Cues

In order to use analogy cues to identify an unfamiliar word, (e.g., might), the reader chooses a word from memory that shares the same orthographic component as the unknown word (e.g., light). To make use of the analogy between the common orthographic components the reader must be able to segment each word at the appropriate point so that the orthographic component is isolated (e.g., -ight). Often these segmentations may occur at the onset-rime division (see Goswami, 1993; Treiman, 1992). Onset-rime awareness, or phoneme awareness, assists with

such segmentations. Once the common orthographic component is isolated it can be used to cue pronunciation of the analogous part of the unfamiliar print word. The reader still needs to generate the part of the unfamiliar word that is not shared with the analogy word, (/l/ in the above example). The reader's knowledge of letters will assist with recognising the common orthographic component of words, and will be useful for generating a response for the nonshared part of the word.

Thompson et al. (1996) reported that available studies indicate that average progress readers are unable to spontaneously use analogy cues until they are at least 7 years old. Younger children, however, may be able to benefit from analogy cues when prompted by a teacher.

4. Context

Information about the meaning and syntax of a word may be available from its context within a sentence and text passage. This information can narrow the set of possible responses for an unknown word. On its own, context is usually insufficient to identify a word. It may be useful, however, in combination with other sources of knowledge (Nicholson, 1993a, 1993b; Tunmer and Chapman, 1997, 1999).

Thompson and colleagues have compared the Knowledge Sources account of reading with other recent theories of word identification (Thompson, 1999; Thompson et al., 1996). Some theories (e.g., Frith, 1985) propose a "developmental bypass hypothesis" whereby children must go through an early stage in which they learn to phonologically recode unfamiliar print words by making use of taught sound for letters. Only later are they able to "bypass" phonological recoding by making use of stored orthographic representations to identify familiar words. Thompson (1999) noted that the Knowledge Sources account does not limit early readers to the use of one knowledge source (i.e., taught sound for letters), as suggested by the developmental bypass hypothesis. The Knowledge Sources account states that induced sublexical relations and context may also assist children in the first few months of reading. However, children may not be able to make spontaneous use of analogy cues until their reading is more advanced.

Ehri (1992) proposed a theory of word identification that set out a sequence of developmental phases that children pass through as they develop into fluent readers. Ehri suggested that although children may first identify a small number of words logographically (i.e., by associating the visual features of a word with its meaning),

they are able to make use of letter-sound knowledge at a very early stage of reading. Initially their letter-sound knowledge will only be partial but it becomes more complete over time. Phonological information is not "bypassed" at later phases but used to help establish memory connections between the printed word and its phonology and meaning.

In contrast to Ehri's proposal for a sequence of phases in the overall development of children's word reading skills, the Knowledge Sources account sees learning progressions applying in large part to the individual print word level (Thompson, 1998). Developing an orthographic representation of a word in memory will generally be a gradual process. A child may have complete representation for some common words but only partial or nonexistent representations for less frequent words.

Goswami (1993) suggested an alternative account of how beginning readers identify words. The "interactive analogy model" proposed that beginning readers are able to make orthographic-phonological connections at the onset and rime level, but are unable to have access to the phoneme level within onsets (in the case of blends) or rimes until later. Thompson (1999) noted that in the Knowledge Sources account, however, "the formation of orthographic-phonological relations based on such phoneme segments can take place during the initial months of instruction" (p. 39). However, the evidence to support this claim is based on experimental trials that included children late in their first year, or in their second year, of reading instruction (Thompson et al., 1996).

Several theories of skilled reading have included the notion of a "dual-route" for word identification (e.g., Baron, 1977; Coltheart, 1978). These theories suggested that readers can identify words by either (a) a direct visual route that does not involve recoding from print to sound, or by (b) a phonological route that makes use of letter-sound correspondences. The direct visual route is thought to be necessary for reading words with irregular letter-sound correspondences while the phonological route is available for words with regular spellings. More recently, "connectionist" models of reading (e.g., Seidenberg & McClelland, 1989) have proposed that there are not two distinct routes but a unitary process for reading regular and irregular words.

Thompson (1999) noted that dual-route theories take account of implicit learning of letter-sound correspondences through reading experience. However, unlike the Knowledge Sources account, dual-route theories do not indicate how a reader's

knowledge of relations between letters and sounds is influenced by the frequency and recency of the reader's exposure to the print words from which the knowledge is induced. Connectionist models portray the movement of information from an input layer of orthographic units through a "hidden layer" to an output layer of phonological units. Interconnections between units in different layers are responsible for the activation and feedback patterns that lead to word recognition.

Thompson (1999) pointed out that dual-route theories usually provide for only one source of knowledge, the implicit letter-sound rules, for generating a response to an unfamiliar print word. In connectionist models there is also usually only one source of knowledge, namely, the orthographic-phonological connections derived from reading experience. Thompson noted that, in contrast, the Knowledge Sources account provides four possible sources of knowledge for generating responses to unfamiliar print words. Often one source may provide only partial information, making it necessary to use a combination of two or more knowledge sources to identify a word.

2.4 Phonological Memory and Literacy

2.4.1 What is Phonological Memory?

A model of working memory developed by Baddeley (1990) is useful for explaining the characteristics and developmental features of short term memory. Baddeley's model has a "central executive", an attentional control system that coordinates and supervises two subsidiary systems. One of these is known as the "visuo-spatial scratchpad" and is concerned with the short-term storage of visual information. The other subsidiary system is termed the "phonological loop" and involves the short-term storage of verbal information. The phonological loop is made up of two components: a phonological store that can hold speech-based or acoustic information for up to two seconds, and an articulatory rehearsal process that can prevent material in the store from decaying and can also encode non verbal material into a phonological form. The phonological loop is able to account for many research findings about memory such as the word length and phonological similarity effects (Baddeley, 1990, 1992; Gathercole, 1998).

The phonological loop is also known as "phonological memory" and is considered to have an important role in speech production, language comprehension, vocabulary acquisition, and learning to read. (Baddeley, Gathercole, & Papagno, 1998). There is variation among researchers about the labels used in relation to phonological memory. Some researchers refer to "verbal working memory" (e.g., Rohl and Pratt, 1995). Other researchers use the general term "working memory" without always specifying when they are focusing on the phonological system rather than the visual (e.g., Wagner et al., 1993).

2.4.2 The Measurement of Phonological Memory

Phonological memory has generally been measured by span tasks which require participants to recall progressively longer lists of words (most commonly, digits). Gathercole (1990, 1995) has promoted the use of a nonword repetition task as a useful way of assessing phonological memory skills in young children. This task requires children to repeat back nonwords immediately after they are spoken by a researcher. The nonwords vary in number of syllables and phonological complexity. Gathercole has suggested that nonword repetition appears to provide a more sensitive measure of phonological memory than span procedures (Gathercole,

1990). Nonword repetition and digit span have shown significant correlations in a number of studies (e.g., Gathercole, 1995; Gathercole & Adams, 1993) However, the nonword repetition technique has been criticised by other researchers for being affected by factors apart from phonological memory, such as articulation skills and the "wordlikeness" of the nonwords (see, e.g., Snowling, Chiat, & Hulme, 1991).

2.4.3 Phonological Memory and Reading

Concurrent correlational studies have reported mixed findings about the relationship between short term memory skills and reading. Some studies have reported that poor readers cannot be distinguished from good readers on the basis of memory span (e.g., Bowers, 1995; Bowers & Swanson, 1991). Other studies have found poor readers to have shorter memory spans for verbal information such as digits, letters, words, or names of objects (e.g., Katz, Healey, & Shankweiler, 1983; Nation & Hulme 1997), but to not have impaired memory for visual material (e.g., Katz, Shankweiler, & Liberman, 1981). These findings suggest that poor readers may have difficulties with the phonological loop but not with the visuo-spatial scratchpad component of working memory. Although poor readers have shown shorter spans in some studies, it appears that they are making use of the phonological loop to encode and hold memory items. Evidence for this comes from studies showing equivalent phonological similarity effects for good and poor readers when span length was adjusted to an appropriate size (Holligan & Johnston, 1988; Johnston, Rugg, & Scott, 1987).

The finding of phonological memory span differences between good and poor readers in some studies could indicate that phonological memory has a causal role in reading achievement. Tunmer and Hoover (1993) noted that there are several ways that such a causal connection could operate. Phonological memory may be important for understanding grapheme-phoneme correspondence rules, and for applying these rules to new words. It may also be important for allowing readers to identify words by means of combining graphophonic cues with the syntactic and semantic information available from sentence context. Although such links between phonological memory and reading appear quite plausible, Tunmer and Hoover cautioned against acceptance of a causal connection on the basis of studies which have found an association between the variables. They pointed out that much of the evidence in support of a phonological memory deficit hypothesis is based on studies that have compared poor readers with good readers of similar age. It is not possible to determine causal direction with this type of design as the lesser memory

skills of the poor readers could be a consequence of their reduced reading experience rather than a cause of their reading problems. Reading experience may enhance phonological memory by providing practice in operations that make use of the phonological loop, such as blending, holding complex linguistic structures in phonological memory, and combining contextual information with graphophonic information.

Hence it appears that plausible arguments can be made for phonological memory being either a cause or a consequence of reading. It is also possible that a reciprocal relationship could exist whereby phonological memory is required for, and is in turn enhanced by, reading related operations. In attempting to further clarify the nature of the relationship a number of researchers have used reading-age match designs. This approach compares a group of older children who are poor readers with younger children who are reading at the same level, thereby helping to rule out the possibility that differences between the groups are only a result of different amounts of reading experience. Studies of this type have generally found no difference in memory span between the poor readers and the younger reading matched children (e.g., Johnston, 1982). Unfortunately, a no difference finding is uninterpretable as it is consistent with both the cause and consequence possibilities for the connection between phonological memory and reading.

Longitudinal designs have also been used to investigate the phonological memory-reading connection. One such study that is widely cited as being supportive of a connection from phonological memory to later reading was conducted by Mann and Liberman (1984). They assessed the ability of kindergarten children to recall strings of nonrhyming words, and found that this was significantly related to the children's reading performance one year later. Although this result would appear to be consistent with a causal role for phonological memory, there are methodological concerns that limit the interpretation of Mann and Liberman's findings. No measure of initial reading skills was made at first testing. The results cannot therefore indicate causal direction as some children may have already been reading at the beginning of the study. If a longitudinal study is to show that memory difficulties precede reading problems, then memory measures must be made before reading begins. Although a measure of intelligence was made at first assessment, the children's scores on this test were not partialled out from the correlations between variables. This leaves open the possibility that a general ability factor may have contributed to the apparent connection between phonological memory and later reading.

Similar methodological concerns occur with other widely cited studies in this area (e.g., Share et al., 1984). However, the design of a recent study by Grogan (1995) goes some way to overcoming these problems. Grogan screened her sample at school entry to check for reading skills. She also assessed intelligence at this time, along with other measures including digit span. The children's reading skills were again assessed nearly three years later. Regression analyses showed that digit span accounted for significant variance in later reading performance, even after first taking into account the effects of intelligence. This result would appear to support a causal role for phonological memory in the development of reading skills. A possible problem with the study, however, is that the reading test used for the initial screening of the sample (the Schonell Word Reading Test) is not a sensitive measure of beginning reading skills. It is therefore possible that this test would not have identified children who were in the early stages of word reading. If the ability to read even a few words has positive effects on phonological memory (as Bowey and Francis, 1991, have suggested may be the case for phonological awareness), then causal direction cannot be determined in a study that did not rigorously screen for early reading skills.

The possibility that early reading could influence phonological memory, rather than vice versa, is emphasised by Ellis and Large (1988). Their longitudinal study followed a group of children from when they were 5 years of age to when they were 7 years of age. Three measures of phonological memory were used: auditory word span, auditory sentence span, and auditory digit span. At age 5 years, the children's auditory sentence span was significantly associated with word reading. At ages 6 and 7 years, all measures of the children's phonological memory were correlated with reading. The correlations remained significant after partialling out the effects of IQ. Cross-lagged correlations were also calculated in order to explore possible causal pathways. Ellis and Large suggested that the cross-lagged analyses indicated that learning to read contributes to phonological memory from age 5 to 6 years, and that a more reciprocal relationship between reading and memory then develops. A problem with this conclusion, however, is that the cross-lagged correlations were not adjusted for intelligence, making it difficult to rule out the influence of this possible confounding variable. Gathercole and Baddeley (1993) pointed out that there were inconsistencies in the pattern of cross-lagged correlations, depending on which of the three phonological memory measures are used. They also noted that the results cannot provide an unbiased estimate of the role of phonological memory in early reading as some of the children were already reading at first testing.

Gathercole, Emslie, and Baddeley (1990) carried out their own longitudinal study which suggested that phonological memory may influence reading achievement, but that this influence only occurs during a particular phase of learning to read. Nonword repetition was used to assess the phonological memory skills of a group of nonreading children soon after they started school. The children's phonological memory and reading skills were assessed again after the children had been at school for one and two years. Gathercole et al. found that phonological memory did not appear to be related to reading achievement during the first year of schooling. After about a year of instruction, however, there was a close association between phonological memory and reading. This association was no longer important by the end of the second year of instruction.

Gathercole et al. (1990) speculated on why phonological memory appeared to be most significant in the period when children have been reading for between one and two years. They suggested that phonological memory is not so important in the first year as this is when children are largely building up a basic sight vocabulary. After the first year children need to learn, and apply, simple grapheme-phoneme correspondences in order to work out unknown words and hence it is during this period that they are most assisted by good phonological memory skills. Subsequently, Gathercole et al. suggested, children will continue to learn and apply new orthographic knowledge but at a rate that is less demanding on phonological memory. Gathercole et al.'s explanation assumes that children progress through stages of reading development at about the same rate. In reality, however, low and high achievers may be at quite different stages of reading development at a particular point in schooling. This would reduce the expected correlations between phonological memory and reading for particular times. It is also possible that the correlations could be affected by the instructional programme that children are exposed to, especially with regard to the emphasis placed on letter knowledge and other decoding skills.

2.4.4 Phonological Memory, Phonological Awareness, and Reading

Although many studies have investigated the links between phonological awareness and reading, and numerous other studies have examined the connections between phonological memory and reading, few studies have considered the interrelationships between all three of these variables.

Two reasons have been given for expecting a close association between phonological awareness and phonological memory (Hansen & Bowey, 1994). First, phonological awareness tasks often appear to place strong demands on phonological memory. Second, phonological awareness and phonological memory may both stem from a single latent phonological processing ability. Researchers who support this latter view suggest that both types of skill may reflect the nature of underlying phonological representations. Differences in the quality of these representations are said to influence the ease or difficulty with which children learn to read (see Elbro, 1996; Snowling & Hulme, 1989; Swan & Goswami, 1997).

Studies that have investigated the connections between phonological awareness and phonological memory have come up with mixed findings but have generally found that although there is some overlap between these skills, each skill is able to explain additional independent variance in children's reading ability (e.g., Hansen & Bowey, 1994). However, it is difficult to come up with overall conclusions about the links between phonological awareness and phonological memory as different studies have used different measures and procedures to assess particular phonological skills. Interrelationships between the phonological skills are also likely to change with age and reading experience.

Some of the most comprehensive research in this area has been carried out by Wagner and colleagues (Wagner et al., 1993; Wagner et al., 1994). Their work on the connections between phonological awareness and reading was discussed earlier in this Literature Review. What is of interest at this point, however, is their examination of the relationship between different phonological skills, including awareness and memory. Wagner et al. (1993) carried out a cross-sectional study of kindergarten and second grade children in order to examine alternative models of phonological processing abilities. A wide range of tests was used, including different measures of phonological awareness and working memory. Confirmatory factor analysis found that slightly different models fitted the data for the kindergarten and second grade samples.

For the kindergarten sample, the factors of relevance to the present discussion were labelled "Analysis/Working Memory" (with loadings from tests of phonological analysis and working memory) and "Synthesis" (with loadings from blending tasks). The model for the kindergarten sample suggested that there is a single underlying source of individual differences for performance on the analysis and working memory tasks. Wagner et al. (1993) pointed out, however, that the

argument that phonological awareness tasks are simply proxy measures of memory is not supported by the model as the synthesis tasks loaded on a different factor.

The model for the second grade sample was similar to the kindergarten model. A Synthesis factor was still included but the Analysis/Working memory factor was now split into two separate factors. There was still a strong connection between working memory and analysis, however, with the factors bearing these names being highly correlated.

Wagner et al. (1993) interpreted the similar models for the kindergarten and second grade samples to suggest that individual differences in phonological processing abilities (including awareness and working memory), and the interrelationships between these abilities, are relatively stable over time. Further evidence in support of the stability of phonological processes was found in a longitudinal study by Wagner and colleagues (Wagner et al., 1994).

A different viewpoint comes from a longitudinal study by Rohl and Pratt (1995)[13]. Their study of children in the first two years at school revealed a changing pattern in the relationships between measures of verbal working memory and phonological awareness. One reason for the finding of change rather than stability may be that Rohl and Pratt distinguished between two types of tests of working memory. The first type, "simple repetition", required children to repeat back strings of letters or words in the same order as said by the researcher. Rohl and Pratt argued that this measures the articulatory loop, (also known as the phonological loop), - the component of working memory that is responsible for the short term storage and rehearsal of items. The second type of test, "backwards repetition", required children to repeat back letters or words in the reverse order to how they were said by the researcher. Rohl and Pratt claimed that this provides a measure of the central executive - the component of working memory that involves both storage and processing of material (see also Halford, Mayberry, O'Hare, and Grant, 1994).

The children were first assessed at the beginning of Grade 1. They found the phoneme tasks to be too difficult at this time but were able to score reliably on a rhyme and alliteration oddity task (given without the picture support that may have reduced the memory load of the task). Oddity scores loaded highly onto the same factor that backwards repetition loaded on. Simple repetition loaded on a separate factor (but was still significantly correlated with oddity scores). At the end of

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[13] This study was also discussed in Sections 2.2.3.2.1 and 2.2.3.2.2.

Grade 1, the oddity task again loaded on the backwards repetition factor, as did the phoneme awareness tasks (deletion and tapping). This time, however, the phonological awareness tasks also showed some loadings onto the simple repetition factor, especially the oddity task. Final measures were made towards the end of Grade 2. There was now evidence for a third factor, on which both the phoneme awareness tasks were highly loaded. Simple and backwards repetition were loaded on the other two factors at this time. These results led Rohl and Pratt (1995) to conclude that phonological awareness and verbal working memory are closely related at the beginning of Grade 1, but become more clearly differentiated as children acquire literacy skills.

Regression analyses were used by Rohl and Pratt (1995) to examine whether phonological awareness and verbal working memory made separate contributions to the acquisition of literacy skills. Some phonological awareness measures (notably, oddity scores at the beginning of Grade 1 and phoneme deletion scores at the end of Grade 1) were found to be significant predictors of later word reading and spelling, even after taking account of age, vocabulary, and simple and backwards repetition. Hence there was evidence that particular measures of phonological awareness were able to explain additional variance in literacy skills to that accounted for by verbal working memory. Of the measures of verbal working memory, backwards repetition was a stronger predictor of final literacy achievement than simple repetition. Neither measure of memory, however, explained significant additional variance after first controlling for the phonological awareness measures.

Several recent cross-sectional correlational studies have also examined the connection between phonological awareness, phonological memory, and reading. These studies are able to provide some additional insights into this area but their relevance to early literacy is restricted as they have focused on children beyond the beginning stages of learning to read.

Hansen and Bowey (1994), and Leather and Henry (1994), found that measures of phonological awareness and verbal working memory for groups of 7-year-old children had substantial overlap in tasks demands, but were also each able to account for unique variance in word reading skills. In addition, Leather and Henry found that complex memory span tasks (requiring processing as well as storage of information) shared more variance with phonological awareness measures than did simple memory tasks (e.g., word span).

McDougall et al. (1994) provided evidence that differences in the verbal working memory of their sample of 8-year-old children were explained by differences in speech rate. Working memory measures did not explain any additional variance in word reading skill after speech rate was taken into account. Additional variance in word reading, however, was explained by a measure of phonological awareness (phoneme deletion).

2.5 Summary of Literature Review

The Literature Review showed that there is research evidence for several alternative hypotheses about the relationship between phonological awareness and literacy. Most studies have claimed that there may be a causal relationship from phonological awareness to literacy. Some studies, however, have claimed that phonological awareness may be a consequence of acquiring literacy skills. Other studies suggest that there may be a reciprocal relationship between phonological awareness and literacy skills.

The Literature Review emphasised the importance of distinguishing between levels of phonological awareness. Studies suggesting a causal relationship from phonological awareness to literacy have included measures of rhyme awareness, alliteration awareness, and phoneme awareness. Studies suggesting that phonological awareness may be a consequence of literacy have focused on phoneme awareness. Where studies have supported a reciprocal relationship, this has often involved relationships from rhyme awareness and alliteration awareness to literacy, and from literacy to phoneme awareness.

The Literature Review showed that relationships between phonological awareness and literacy may differ not only according to the level of phonological awareness, but also according to the type of literacy being assessed (i.e., word reading and spelling, pseudoword reading and spelling). It was also apparent that other variables (especially verbal ability, letter knowledge, and phonological memory) may play important roles in relationships between phonological awareness and literacy.

Clarifying the nature of the relationship between phonological awareness and literacy has considerable theoretical and practical significance. Further knowledge about this area would contribute to a greater understanding of the cognitive processes involved in acquiring literacy skills and may have important implications for instructional programmes. The current study was designed to investigate the nature of the relationship between phonological awareness and literacy by examining the progress of a group of children during their first two years at school. The next chapter provides details of the research questions and design of the study, along with a description of the measures that were used.

3

METHOD

3.1 Research Questions

The following research questions focus on an examination of the relationships between phonological awareness and literacy, along with an examination of how other important variables may influence these relationships.

The primary question investigated by this study was the following:

> **What is the nature of the relationship between phonological awareness and literacy skills during the first two years at school?**

Related to the primary research question were the following subsidiary questions:

1. What developments occur in verbal ability, letter knowledge, and phonological memory during the first two years at school?

2. What developments occur in reading and spelling during the first two years at school, and are these developments related to verbal ability, letter knowledge, or phonological memory?

3. What developments occur in phonological awareness (syllable awareness, rhyme awareness, alliteration awareness, phoneme awareness) during the first two years at school, and are these developments related to verbal ability, letter knowledge, or phonological memory?

4. What relationships exist between each type of phonological awareness (i.e., syllable awareness, rhyme awareness, alliteration awareness, phoneme awareness) and reading and spelling during the first two years at school, and are these relationships associated with verbal ability, letter knowledge, phonological memory, or other types of phonological awareness?

3.2 Research Design

Although there has been a great deal of research in the area of phonological awareness and literacy, there is still a need for a study designed to overcome the shortcomings of many of the correlational, longitudinal and experimental studies in this area. As discussed in the Literature Review, previous investigations have often paid insufficient attention to distinguishing between particular levels of phonological awareness (especially the distinction between awareness of rhyme, awareness of alliteration, and awareness of phonemes). Past studies have also often failed to adequately control for variables that may affect relationships between phonological awareness and literacy (in particular, preexisting reading levels, verbal ability, phonological memory, and letter knowledge).

The current study was designed to overcome the shortcomings noted above. The study was longitudinal in design and followed the progress of a group of children during their first two years at school. The children were assessed with measures of different levels of phonological awareness as well as measures of variables that may affect the relationships between phonological awareness and literacy. At the beginning of the study all children were nonreaders.

Many previous longitudinal studies have assessed children only at the beginning and end of their first years at school. More frequent assessments were used in the current study in order to provide more information about the developmental changes in the relationships between phonological awareness and literacy during the first two years at school. Children were assessed at six time points in the first year and at three time points in the second year.

Generally the same tests were used at each of the nine time points in the study. Use of the same tests provided consistency in assessing the development of children's performance levels over time. There may, however, be problems with floor and ceiling effects when a particular test is used to assess an ability that develops from very low levels to very high levels during the period of the study (Keeves, 1997). The smaller range of scores that occurs as a result of floor or ceiling effects for a particular variable may have an adverse effect on the size of the correlations between that variable and other measures.

Another problem with repeated use of the same tests is that practice effects may occur (Keppel & Saufley, 1980). That is, children's scores on a test may improve

as they acquire skills resulting from repeated performance on the same task. Operating against the possibility of practice effects in the current study was the fact that the period between testing sessions was usually at least seven weeks in the first year of the study and at least fourteen weeks in the second year.

3.3 Participants

The participants in this study came from the new entrant classes of two schools in a large regional city of New Zealand. The schools were chosen for the study because they had the largest intakes of beginning pupils of any schools in the city. The sample was limited to these two schools as they provided the greatest number of children able to be assessed by the researcher within the time available at each point in the study. Socioeconomic level was not a factor in the selection of the schools but both of them were from lower socioeconomic areas. The schools were rated as 1 and 2 on the Ministry of Education's (1995) decile ratings of school area socioeconomic levels.[14] A total of 36 children had started at the schools in February of the year in which the study began, or in December of the previous year. All of these children spoke English as their first language. A letter requesting parental permission for children's participation in the study was sent to each child's family. (Another permission letter was also sent at the beginning of the second year). Permission was granted for 35 of the children. Data is reported for the 29 children (17 boys, 12 girls) who completed all assessments in the first year of the study, and for the 27 children (15 boys, 12 girls) who then completed all assessments in the second year of the study. The children who did not complete the assessments had transferred to schools out of the region. At the time of first testing, the children's ages ranged from 5 years 0 months, to 5 years 3 months (mean age = 5 years 1 month).

At the time of the study, reading instruction in New Zealand generally followed a "Whole Language" approach (Smith and Elley, 1994; Thompson, 1993). Official guidelines on the teaching of reading emphasised the importance of reading meaningful text and on making use of context cues for word identification. Children were taught the names of letters but were not exposed to systematic instruction in letter-sound relationships (Department of Education, 1985). Classroom writing

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[14] The decile rankings divide schools into ten socioeconomic levels. Each decile represents 10 per cent of the population: 1 being the lowest socioeconomic level, and 10 the highest socioeconomic level.

instruction included some teaching of sound to letter correspondences when teachers encouraged children to attempt the spellings of unfamiliar words (Ministry of Education, 1992).

3.4 Measures

3.4.1 Outline of Measures

The following tests were included in the assessments:

1. Screening for Reading Skills
   Clay Ready-to-Read Tests

2. Verbal Ability: Receptive Vocabulary Skills
   Peabody Picture Vocabulary Test (PPVT-R)

3. Phonological Awareness Tasks

3.1 Syllable Awareness
   TAAS-Syllables

3.2 Rhyme, Alliteration and Medial Phoneme Awareness
   Rhyme Categorization
   Alliteration Categorization
   Medial Phoneme Categorization

3.3 Phoneme Awareness
   Tapping
   TAAS-Phonemes

4. Phonological Memory Task
   Digit Span Task

5. Letter Knowledge Tasks
   Letter Name
   Letter Sound

6. Reading and Spelling Tasks
   Word Reading (Burt Read, and Burt Read Phonemes)
   Word Spelling (Burt Spell Phonemes)

Pseudoword Reading (Pseudoword Read Phonemes)
Pseudoword Spelling (Pseudoword Spell Phonemes)

7. Text Reading Accuracy and Comprehension Task
   Neale Analysis of Reading - Revised

3.4.2 Screening for Reading Skills: Clay Ready-to-Read Tests

Following the recommendations of Bowey and Francis (1991), the current study used the three *Ready-to-Read Word Tests* (Clay, 1985) to screen children for early reading skills at the time of first assessment. The tests contain a total of 48 high-frequency words and are much more likely to detect early readers than the more difficult tests (such as the Schonell Word Reading Test) that have sometimes been used as screening tests in earlier research. Children's performance was not scored for the two words in the Ready-to-Read tests that could also be read as letters (i.e., "I" and "A"). Of the initial sample, one child could read four words, five children could read one word, ("to"), and the remaining children could read no words. A criterion level of no more than one word correct was used to classify children as "nonreaders". On this basis, the child who could read four words was excluded from the sample.

3.4.3 Verbal Ability: Receptive Vocabulary Skills

Form M of the *Peabody Picture Vocabulary Test - Revised* (Dunn and Dunn, 1981) was used as a measure of verbal ability or, more specifically, receptive vocabulary. Each test item requires a child to indicate which of four pictures on a page corresponds to the word read aloud by the researcher. The PPVT-R was administered on the first and last test occasions of the first year (Times 1 and 6), and on the last test occasion of the second year (Time 9). The test was administered according to the guidelines in the PPVT-R manual.

3.4.4 Phonological Awareness Tasks

3.4.4.1 Syllable Awareness: TAAS-Syllables

Rosner's (1979) Test of Auditory Analysis Skills (TAAS) assesses whether children can delete particular sounds from words first spoken by the researcher.

The test begins with two demonstration items followed by three items that assess syllable deletion. The next ten items assess phoneme deletion. In its original format the TAAS provides a total score for performance on the syllable and phoneme items. In the current study, however, children were given two scores: (a) *TAAS-Syllables* for performance on the syllable items, and (b) *TAAS-Phonemes* for performance on the phoneme items (TAAS-Phonemes is discussed in more detail in Section 3.5.4.3.2).

3.4.4.1.1 Procedures for Introducing TAAS-Syllables

The following instructions were adapted from Rosner (1979).

Researcher: "Say 'cowboy'." (Pause to allow the child to respond. This lets the researcher know the child has heard the word.)
Researcher: Now say it again but don't say 'boy'." Give the child time to respond. The correct answer, of course, is cow. If the child does not get this item correct, the researcher asks the child again and, if necessary, demonstrates the correct answer.

The second demonstration item is then given.
Researcher: "Say 'spaceship'." (Pause to allow the child to respond.)
Researcher: "Now say it again but don't say 'space'." If the child is incorrect the item is repeated and, if necessary, demonstrated.

The test items are then given (see Appendix A.)

Testing was stopped when the child made two consecutive errors. The last item of the three syllable items scored correctly was taken as the child's TAAS-Syllable score.

3.4.4.2 Rhyme, Alliteration and Medial Phoneme Awareness: Rhyme Categorization, Alliteration Categorization, and Medial Phoneme Categorization

Awareness of rhyme, alliteration and medial phonemes was assessed with sound categorization tasks adapted from the tests used by MacLean, Bryant and Bradley (1987), and Bowey and Francis (1991).

Each of the three tests consisted of two practice trials, for which corrective feedback was given, followed by nine experimental trials for which there was no corrective feedback. In each trial a triplet of three words was said aloud to the children. Pictures representing each word were used to reduce the memory demands of the task (see Appendix A). The child's task for each trial was to identify the two words in each triplet that sounded "most the same". In previous research using these types of tasks children have been asked to identify the "odd one out" (e.g., Bradley & Bryant, 1978, 1983). This required a child to first work out which two words have similar sounds and then to identify the remaining word. Identifying the two words which "sound most the same" should be a simpler task that may more accurately reflect a child's ability to recognise particular sounds.

The *Rhyme Categorization* test in the current study required the child to identify the two words that shared the same rime unit (e.g., sail nail boot). For the *Alliteration Categorization* test the child needed to identify the two words that shared the same onset unit (e.g., cat car hen). The *Medial Phoneme Categorization* test required the child to identify the two words that shared the same medial-phoneme (e.g., mat mop man). (The full tests are included in Appendix A.)

Before each test was given the child was introduced to the task with procedures adapted from Bradley (1984).

3.4.4.2.1 Procedure for Introducing the Rhyme Categorization Test

The following procedures illustrate how the rhyme test was introduced:

Researcher: "Do you know 'Jack and Jill'? Jack and Jill went up the ..."
Child: "Hill." (The word is supplied if the child does not respond or makes an incorrect response.)
Researcher: Yes Jill, hill. Those words sound a bit the same. They rhyme. Can you think of another word that sounds like Jill?"
Child: "Fill."
Researcher: "Bill."
Child: "Will."

If the child is unable to provide any rhyming words the researcher supplies them and asks the child to repeat. The child is then asked to provide words that sound like "door", and "top". The researcher then introduces a word that does not rhyme.
Researcher: "Top, hop, nose."

If the child does not point out the error the researcher continues.
Researcher: "That doesn't sound right. Top and hop sound most the same but nose sounds different. I'm going to say some more words to you. Can you repeat these words and tell me which two words sound most the same? Low, truck, snow."
If the child is incorrect, he or she is given a second try.
Researcher: "Listen again. Low, truck, snow."
Child: "Low, snow." (If the child is again incorrect the researcher supplies the words)
Researcher: "That's right. Low and snow sound most the same."

The practise trials are then introduced.
Researcher: "This time I'm going to show you some pictures of the words when I say them. Listen carefully. Point to the pictures and say the words when I have finished. Sail, nail, boot." (The researcher places the individual cards in front of the child as each word is spoken. The child's attention is directed at the pictures so that he or she does not gain articulation cues from watching the researcher's mouth.[15]
Child: "Sail, nail, boot."
Researcher: Which two words sound most the same?
Child: "Sail and boot."
Corrective feedback is given at this point if required.
Researcher: "Now which two words sound most the same?" (The same picture cards are presented but in a different order so as to show the child that the order of the words did not affect which two sounded most the same.)

The second practice trial is then given along with corrective feedback if required. The nine test items are then administered with no corrective feedback. The child's Rhyme Categorization score was the total number of test items performed correctly.

3.4.4.2.2 Procedure for Introducing the Alliteration Categorization and Medial Phoneme Categorization Tests.

The same basic procedure as outlined above was followed but with exercises to focus the child's attention on the appropriate sound unit. In the transition between

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[15] The reason for having the child repeat the words was that trials of the test with a different group of children had shown that some children chose to repeat the words while others did not. To control for possible unevenness in task demands it was decided to ask all children to repeat the words.

tests the researcher explained to the child: "Now we're going to do something a bit different. Listen carefully and we'll try listening to some different sort of words"

Each test had two demonstration items and nine test items (see Appendix A). The number of items performed correctly on each test made up a child's Alliteration Categorization score and Medial Phoneme Categorization score.

3.4.4.3 Phoneme Awareness: Tapping and TAAS-Phonemes

Phoneme awareness was assessed with (a) a phoneme counting task (Tapping) and (b) a phoneme deletion task (TAAS-Phonemes).

3.4.4.3.1 Tapping

The *Tapping* task required children to tap once with the blunt end of a pencil for each sound (phoneme) they could hear in pseudowords spoken by the researcher. All 11 test items were single-syllable nondigraph pseudowords taken from a modified version of the pseudowords used by Tunmer et al. (1988). There were two single-phoneme items, three 2-phoneme items, three 3-phoneme items, two 4-phoneme items, and one 5-phoneme item (see Appendix A). The task was introduced with the same procedures outlined by Tunmer et al. (1988) except that the demonstration began with real words before pseudowords were introduced (as in Tunmer and Nesdale, 1982).

3.4.4.3.1.1 Procedures for Introducing the Tapping Task

Instructions are given as follows:

Researcher: "Now we're going to play a tapping game. I'm going to say some words and tap them with the pencil after I say them. Listen carefully so you'll find out how to play the game."

The researcher then demonstrates the first training triad ("oo", "boo", "boot").
Researcher: "Oo."
The researcher taps once.
Researcher: "Boo."
The researcher taps twice.
Researcher: "Boot."
The researcher taps three times.

Researcher: "Now I want you to do it. Say 'oo'. Good. Now, tap it. Say 'boo'. Now tap it. Say 'boot'. Now tap it." If the child makes an error on any item, corrective feedback is provided and the item repeated.
Researcher: "Now let's do it again to make sure you've got the idea. I'll mix them up and see if I can catch you." The items are presented again but in a different order. Corrective feedback is again provided

Pseudowords are then introduced.
Researcher: "We can play this game with pretend words. Pretend words are made-up. They are not real words but we can still say them. The first pretend word is 'sif'. " (The researcher taps three times.)

Researcher: "I tapped three times for sif because there were three sounds, 'sss', 'iii', and 'fff'. I tapped one time for 'sss' (tap), one time for 'iii' (tap), and one time for 'fff' (tap). Here's another one, 'ev'. (The experimenter taps twice.) I tapped two times for 'ev' because there were two sounds, 'eee', and 'vvv'. I tapped one time for 'eee' (tap), and one time for 'vvv' (tap). When the pretend word is 'i' (tap), I only tap one time, because there is only one sound. See the way the game is played? For every sound I say, I give a tap. Now I want you to do it. Say 'sif' and tap it. Good"

Corrective feedback is given for incorrect responses to the demonstration items. Children are then given three additional practice items: ip, smuf, and a, and again are given corrective feedback.

Researcher: "Now we'll play the real game. I'll say a pretend word, but I won't tap it because you know how to play the game yourself. So you say the word after me and then tap it."

Eleven test items follow for which no corrective feedback is given. A child's Tapping score was the total number of pseudowords tapped correctly.

3.4.4.3.2 TAAS-Phonemes

Rosner's (1979) Test of Auditory Analysis Skills (TAAS) was used to assess children's phoneme deletion skills. As discussed above, the TAAS begins with three syllable deletion items that were used in the current study to assess syllable awareness (TAAS-Syllables). Immediately following the syllable items, children

were presented with the ten phoneme deletion items that made up the *TAAS-Phonemes* task (e.g., "Say 'meat'. Now say it again but don't say /m/.). Rosner claimed that the difficulty of the phoneme deletion items increases as children progress through the test. There are three initial-phoneme items followed by three final-phoneme items, and then four medial phoneme items. Instructions were given as outlined in the description of the syllable awareness task (TAAS-Syllables - see Section 3.5.4.1.1). Testing was stopped when the child made two consecutive errors. The last item scored correctly was taken as the child's TAAS-Phonemes score. Test items are listed in Appendix A.

3.4.5 Phonological Memory Task: Digit Span

The forward *Digit Span* subtest of the WISC-R (Wechsler, 1974) was used as a measure of phonological memory. The test requires children to repeat back series of digits that are first spoken by the researcher. The test begins with items containing three digits The number of digits to be repeated increases from three digits for the first test item to nine digits for the last test item. Two trials are provided for each item.

3.4.5.1 Procedures for introducing the Digit Span test

Researcher: "I am going to say some numbers. Listen carefully, and when I am finished say them back to me."

The digits are presented at the rate of one per second. Both trials of each item are given. Testing is stopped if the child fails both trials. The child's Digit Span score was the total number of trials performed correctly (maximum = 14). A full list of test trials is in Appendix A.

3.4.6 Letter Knowledge Tasks

3.4.6.1 Letter Name

The *Letter Name* test required children to give the name of each letter from a sequence of the 26 lower case letters printed in random order on a card (Clay, 1985). The total number of correct items was the child's Letter Name score.

3.4.6.2 Letter Sound

The *Letter Sound* test used the same letter card that was used for the Letter Name test. Children were asked to name the sound of each letter. (The letter x was omitted. The sound "qw" was accepted for q.) The total number of correct items was the child's Letter Sound score.

3.4.7 Measures of Reading and Spelling

3.4.7.1 Word Reading

The Burt Word Reading Test (Gilmore, Croft, & Reid, 1981) was used as a measure of children's word reading knowledge at each testing occasion. The *Burt Read* score was the total number of words that a child could read correctly. The first 20 words were also scored according to how many phonemes were read correctly out of a possible 51: this is referred to as the *Burt Read Phonemes* score. Words from the Burt Word Reading Test are included in Appendix A.

Word reading was used as the main measure of reading in the current study because word recognition skills are fundamental to reading (Adams, 1990). Hoover and Gough's (1990) *simple view* of reading suggests that reading comprehension is the product of word decoding skills and listening comprehension. The vocabulary and style of the books that young readers encounter in the first years at school are such that most children would comprehend the stories if they heard them being read aloud. Hence, listening comprehension is seldom a limiting factor in the early years of reading. Instead it is likely to be word recognition skills that explain much of the variation in young children's literacy achievement (see Nicholson, 1999c; Tunmer & Hoover, 1993).

3.4.7.2 Word Spelling

At Time 2 the first 10 words from the Burt Word Reading Test were used to test the children's word spelling. From Time 3 on, the first 20 words were used. Children were encouraged to attempt to write any part of the word they thought they might know. The test was scored out of 23 at Time 1 and out of 51 at Time 2 according to how many phonemes were correctly spelt: this is referred to as the *Burt Spell Phonemes* Score

The spelling test was marked by the researcher. A randomly chosen sample of tests from 15 children at Times 3, 5, 7, and 9 were marked independently by a trained

teacher. Intermarker reliability, according to the exact agreement method, was at least 97% for each of these times.

3.4.7.3 Pseudoword Reading

This test was not administered at the first test time as all but five children were unable to read even one word on the Burt Word Reading test at that point. At the second test time, children were asked to read aloud six pseudowords. At subsequent test times an additional six pseudowords were also used. All pseudowords were single syllable and ranged from three to five phonemes long. A full list of the pseudowords is in Appendix A.

3.4.7.3.1 Procedures for Introducing the Pseudoword Reading Test

Researcher: "Now we're going to look at some pretend words. Pretend words are not real words but we can still have a go at reading them. Let's look at this one." The researcher shows a card with "sab" written on it. "This word starts with a sss sound. SSS aaa bbb." The researcher pronounces the word slowly, moving finger underneath appropriate letter. "Sab" (pronounces word again, this time at normal rate) "Can you say sab?"

Child: "Sab"

Researcher: "Good, now let's have a go at another one." The researcher shows a card with "det" written on it. "Have a go at reading this" If the child is incorrect the researcher shows the child how to say each part of the word slowly and then at a normal rate.

The test items are then given with no corrective feedback.

Scoring was based on the number of phonemes that were pronounced: this is referred to as the *Pseudoword Read Phonemes* score. A maximum score of 18 was available at Time 2 (when only 6 pseudowords were used) and a maximum score of 40 was possible for the following test points (when 12 pseudowords were used).

3.4.7.4 Pseudoword Spelling

The same pseudowords that were used for the pseudoword reading test were used to test pseudoword spelling. Children were told that the test items were pretend

words. They were encouraged to attempt to write any part of the word they thought they might be able to spell. Scoring was based on the number of phonemes that were correctly represented: this is referred to as the *Pseudoword Spell Phonemes* score. A maximum score of 18 was possible at Time 2 (when 6 pseudowords were used), and a maximum score of 40 was possible at the following times (when 12 pseudowords were used). (See Appendix A for a list of the pseudoword items.)

The pseudoword spelling test was marked by the researcher. Intermarker reliability was checked using the same procedures as had been used for the word spelling tests. The second marker independently scored the pseudoword spelling tests of the same children who had been randomly chosen for checking the marking reliability of the word spelling tests. According to the exact agreement method, intermarker reliability for each of the pseudoword spelling tests at Times 3, 5, 7, and 9, was at least 95%.

3.4.8 Text Reading Accuracy and Comprehension

At the end of the second year, children were assessed with Form 1 of the Neale Analysis of Reading Ability - Revised (Neale, 1988). The test was administered according to the procedures outlined in the test manual. The Neale Analysis consists of a set of graded passages with accompanying comprehension questions. Children's oral reading performance on the passages provided the *Neale Accuracy* score, and their responses to the comprehension questions provided the *Neale Comprehension* score.

3.4.9 Reliability

Several approaches were used to provide information about the reliability of the tests used in the study (Table 3.1).

When published tests were used, reliability information was taken from the test manuals: PPVT-R (Dunn and Dunn, 1981), Burt Word Reading Test (Gilmore et al., 1981), and Neale Analysis of Reading - Revised (Neale, 1988).

Kuder-Richardson Formulas 20 or 21 can be used to estimate the reliability of tests when it can be assumed that items in a test have approximately the same level of difficulty (Guilford & Fruchter, 1978). In the current study, Kuder-Richardson Formula 21 (K-R 21) was used for the following tests: Letter Name; Letter Sound; Rhyme Categorization; Alliteration Categorization; and Medial Phoneme

Categorization. Separate reliability coefficients were calculated for each of the nine test points that a particular test was administered. A "Mean KR- 21 Reliability Coefficient" was then calculated to provide an overall indication of a test's reliability during the study.

When tests contain items that become progressively more difficult, the Kuder Richardson Formulas should not be used (Guilford & Fruchter, 1978). It is possible, however, to calculate test-retest reliability for these tests. When tests are given on multiple occasions a "Mean Test-Retest Reliability Coefficient" can be calculated by taking the average of the correlations between adjacent test times. These procedures were used for the following tests in the current study: Burt Read Phonemes; Burt Spell Phonemes; Pseudoword Read Phonemes; Pseudoword Spell Phonemes; TAAS-Syllables; TAAS-Phonemes; and Digit Span. A Mean Test-Retest Reliability Coefficient was also used to provide a second estimate of reliability for the tests where reliability had first been estimated by the Kuder Richardson Formula 21.

Table 3.1
Reliability of Tests

Test	Reliability Coefficient From Test Manual	Mean K-R 21 Reliability Coefficient	Mean Test-Retest Reliability Coefficient
PPVT-R	.81		
TAAS-Syllables			.71
Rhyme Categorization		.77	.75
Alliteration Categorization		.57	.53
Medial Phoneme Categorization		.46	.43
Phoneme Tapping			.39
TAAS-Phonemes			.64
Digit Span			.80
Letter Name		.86	.79
Letter Sound		.89	.79
Burt Word Reading	.96		.92
Burt Read Phonemes			.85
Burt Spell Phonemes			.84
Pseudoword Read Phonemes			.79
Pseudoword Spell Phonemes			.77
Neale Analysis: Text Accuracy	.78		
Neale Analysis: Comprehension	.93		

3.5 Procedures

Assessments were carried out by the researcher on six occasions during the first year of the study and on three occasions during the second year. Testing periods were spaced to give as even a gap as possible between sessions in each year. In the first year there was a gap of seven or eight weeks between the first five testing sessions, with a five week gap between the fifth and sixth sessions. In the second year testing was carried out at the end of each of the three school terms, meaning that there was a fourteen or fifteen week gap between testing sessions[16] (see Table 3.2). On each occasion the children in the first school were usually assessed in one week, followed by the children in the second school during the next week. Each child was assessed individually in a quiet room in their school. The child and the researcher were seated at opposite sides on one corner of a table.

Table 3.2
Test Times for Year One and Year Two.

Year One		Year Two	
Weeks	Test Time	Weeks	Test Time
1 - 6 Holidays		1 - 6 Holidays	
6 - 19 Term 1	Time 1 (Weeks 9 - 10) Time 2 (Weeks 18 - 19)	6 - 19 Term 1	Time 7 (Weeks 18 -1 9)
20 - 21 Holidays		20 - 21 Holidays	
23 - 35 Term 2	Time 3 (Weeks 26 - 27) Time 4 (Weeks 34 - 35)	23 - 35 Term 2	Time 8 (Weeks 34 - 35)
36 - 37 Holidays		36 - 37 Holidays	
38 - 51 Term 3	Time 5 (Weeks 43 - 44) Time 6 (Weeks 49 - 50)	38 - 51 Term 3	Time 9 (Weeks 49 - 50)
52 Holidays		52 Holidays	

[16] When data was collected for this study, New Zealand schools had a three term year. They now have four terms each year.

Order of Task Administration

The tasks were usually administered in two sessions, each lasting approximately 20 to 25 minutes. Generally sessions were held on successive days. Child absences occasionally meant that there was a longer gap between sessions. An additional session was held when the PPVT-R, or the Neale Analysis of Reading Ability were also administered (Times 1, 6, and 9). The tasks were administered in the following order:

First session if three sessions required

1. PPVT-R (Times 1, 6, and 9 only)
2. Neale Analysis of Reading Ability (Time 9 only)

First session if two sessions required, or middle session if three sessions required

1. Digit Span
2. Letter Name and Letter Sound .[17]
3. Word Reading
4. Pseudoword Reading
5. Sound Categorization Tests (in the following order: Rhyme, Alliteration, Medial Phoneme)

Last Session

1. TAAS (i.e., TAAS-Syllables and TAAS-Phonemes)
2. Tapping
3. Word Spelling[18]
4. Pseudoword Spelling

3.6 Analysis of Results

The data collected in a longitudinal study provides information about the relationships between variables at one point in time (concurrent correlations) and across time (predictive correlations). The finding of a significant correlation

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[17] If a child scored 100% on the Letter Name test, he or she was not given the test at the next test time.

[18] At Time 1, when no children were reading, spelling was not assessed. At the other times, the spelling tasks were administered on a separate day from the reading tasks in order to minimise the possibility that seeing the words in the reading task would influence children's spelling of the words.

between variables does not mean that there is a causal connection but simply establishes a statistical association. However, longitudinal data also provides information about the sequence of development. Keeves (1997) notes the importance of this for interpreting causality. He writes:

> Perhaps the most significant characteristic of time lies in its relationship to causal influence since earlier events influence later events but not vice versa. Thus while it cannot be assumed that measurements made on a variable obtained at an initial point in time can be causally related to an outcome measure obtained at a later time, it is clear that unless the appropriate time sequence exists it is not possible to argue logically for a possible causal relationship (p. 140).

Mark (1979) reviewed major strategies for the statistical analysis of correlational data from longitudinal studies. His review noted that each approach has particular shortcomings, and that none of the approaches provide complete confidence for making causal inferences.

Although correlational analysis cannot establish causality, a number of statistical techniques can be used to examine the relationships between variables in a correlational study. In order to decide whether a correlation between variables is significant, or is simply due to chance, it is necessary to carry out a statistical test of the relationship. The test is used to determine whether to reject, or fail to reject, the *null hypothesis* (the hypothesis that states there is no relationship between the variables).

Two types of errors can occur when testing the null hypothesis. A Type 1 error is when the null hypothesis of no relationship is rejected when it is true. That is, a relationship is said to exist when it does not. A Type 2 error occurs when the null hypothesis is not rejected when it is false. The choice of a significance level involves striking a balance between Type 1 and Type 2 errors. In the current study, significance was tested at three levels: $p < .05$, $p < .01$, and $p < .0005$. The .05 level is widely used in quantitative research (Gall, Borg and Gall, 1996). The .01 level, and particularly the .0005 level are more conservative in that they minimise the chance of a Type 1 error. Minimising Type 1 error, however, increases the possibility of Type 2 error.

When multiple correlations are calculated for a group of variables there is an increase in the likelihood of making a Type 1 error. The chance of a Type 1 error occurring within the total set of calculations is in direct proportion to the number of

tests that are made. To overcome this problem, some statisticians have suggested that the *p*-value for any correlation be multiplied by the number of tests (- the *Bonferroni* approach, see Howell, 1992). This, however, makes it much harder to achieve significance, thereby increasing the likelihood of Type 2 errors.

The Bonferroni approach was not used in the current study because the large number of variables being correlated would result in a high chance of Type 2 error. In adopting a level of $p < .05$ for significance testing, the possibility of Type 1 error in multiple correlations was a problem. However, some protection against this was provided by the use of repeated measures over time in the current study. This allowed for an examination of the trends in correlations between particular variables. Although type 1 error may be responsible for the labelling of a correlation between two variables as "significant" when in fact no relationship exists, it is less likely to be a problem when examining the overall pattern of correlations between the two variables throughout the length of the study.

Whether or not a correlation is deemed significant will be affected by the size of a sample in a study. As sample size increases there is a reduction in the minimum size of correlation needed to achieve significance. Ideally, samples in quantitative research should be as large as possible. In the current study, however, sample size was limited by the time needed for the researcher to individually assess children at each testing point. Smaller samples do have some advantages for exploratory work. Isaac and Michael (1981, p.96) make the following comment with regard to sample sizes between 10 and 30:

> "Samples of this size are large enough to test the null hypothesis, yet small enough to overlook weak treatment effects. Remembering that statistically significant findings for any relevant variable appear simply by increasing the sample size toward the universe, such findings are not apt to be *educationally significant* since the variable in question is too diluted to make a practical difference."

Another issue in significance testing is deciding on whether to use a one or two tailed test of the null hypothesis. A two tailed test is used when the correlation could be negative or positive. A one tailed test may be used when it is possible to hypothesise (on the basis of theory or prior research) that the correlation between variables will be *either* negative *or* positive. The research reviewed in the Literature Review showed that although there is debate about the direction of links between some variables (i.e., whether A influences B or B influences A) there is general agreement that any relationships that exist will be positive. For this reason,

one tailed tests were used to evaluate the significance of correlations in the current study.

A potential problem with correlational studies is that a significant correlation between two variables may be the result of the influence of a third variable. The technique of partial correlation can be used to help protect against this problem. Partial correlation removes the influence of one variable on the relationship between two other variables. In the current study partial correlation was used to control for variables that may impact on relationships between phonological awareness and literacy. An examination of past research (as discussed in the Literature Review) indicated that verbal ability, phonological memory, and letter knowledge are variables that should be taken into account when examining links between phonological awareness and literacy.

Use of partial correlation may show that a significant correlation from Variable A at Time 1 to Variable B at Time 2 is reduced to a nonsignificant level after taking account of the influence of Variable C at Time 1. It is important to note, however, that this does not necessarily mean that the relationship from Variable A to Variable B is unimportant. Rather it indicates that Variable C and Variable B overlap in the variance they explain in Variable A.

A criticism of much longitudinal research on phonological awareness and literacy is that studies have often only examined connections from phonological awareness to literacy and not vice versa. Because the current study assessed phonological awareness and literacy at each time point it was possible to examine relationships in both directions. If significant correlations are found from phonological awareness to literacy and from literacy to phonological awareness, the technique of Cross-Lagged Correlation (Kenny, 1979) is supposed to establish whether causal influence in one direction is greater than in the other. In Cross-Lagged Correlation the size of the correlation from Variable A at Time 1 to Variable B at Time 2 is compared with the size of the correlation from Variable B at Time 1 to Variable A at Time 2. If the correlation in one direction is significantly higher than the correlation in the other direction then, according to the logic of Cross-Lagged Correlation, the direction with the larger correlation is the stronger causal influence.

Cross-lagged correlation has been used in a number of studies of phonological awareness and literacy (e.g., Ellis & Large, 1988; Gathercole, Willis, Emslie, & Baddeley, 1992; Perfetti et al., 1987; Tunmer et al., 1988). It is a useful technique for illustrating that relationships between measures of phonological awareness and

literacy may operate in both directions. Contrary to its original purpose, however, the technique cannot establish causality. Critics of Cross-lagged correlation have presented evidence to show that cross-lagged correlation may provide misleading information about causal influence and causal predominance (Cook & Campbell, 1977; Rogosa, 1980). In the current study the technique was not used to establish causality but was used to examine whether it was plausible to model the relationship between measures of phonological awareness and literacy in both directions (ie., from phonological awareness to literacy and from literacy to phonological awareness).

Another statistical technique that can be used to analyse correlational data is multiple regression. This technique was used in the current study to determine the combination of variables at one time that best predicted measures of literacy at the next time. Multiple regression was also used to examine whether the interaction of letter knowledge and phoneme awareness explained additional variance in reading to that explained by the sum of letter knowledge and phoneme awareness.

As a large number of tests were used in the current study, factor analysis was used to investigate whether the results from the set of measures at each time point could be reduced to a smaller number of factors. This provided information about whether there were changes over time in the number of underlying factors, and in the combination of measures that loaded on to factors.

Other multivariate analysis techniques were considered for use with data from the current study but were found to be unsuitable. Path analysis is sometimes used to examine the nature of relationships between variables in correlational studies. This technique, however, requires that a theory about causal links be formulated before data is gathered (Tuijnman & Keeves, 1997). Because the current study did not begin with such a theory it would have been inappropriate to have used path analysis after the data had been collected.

Latent variable causal modelling (eg., LISREL, Joreskog & Sorbom, 1986) was not used because factor analysis showed there were changes over time in the number of underlying factors and in the combination of measures that loaded on to factors. In addition, the relatively small sample size for the current study was insufficient to make use of this approach

PART TWO:
RESULTS AND DISCUSSION

4

THE DEVELOPMENT OF LITERACY AND PHONOLOGICAL SKILLS

Overview of Chapter 4

This chapter focuses on the development of particular skills in the sample children during their first two years at school. The chapter is divided into three main parts. Part One discusses receptive vocabulary, phonological memory, and letter knowledge, Part Two discusses reading and spelling, and Part Three discusses phonological awareness. (Relationships between phonological awareness and reading and spelling will be examined in the next chapter.)

4.1 Receptive Vocabulary, Letter Knowledge, and Phonological Memory.

Overview of Part One

Part One discusses the development of the children's receptive vocabulary, letter knowledge, and phonological memory during their first two years of school. Previous research has found that each of these variables may be associated with the development of literacy and phonological awareness skills. (Later sections of the Results and Discussion will examine whether verbal ability, phonological memory, and letter knowledge contributed to the development of literacy and phonological awareness in the current study.)

The average scores of children on the receptive vocabulary test were within the ranges expected for their age. Children's receptive vocabulary scores were highly correlated across testing times as were their phonological memory and letter knowledge scores.

Most children knew few letter names at the beginning of the study but had usually mastered them by the end of the first year at school. Letter-sound knowledge lagged behind letter-name knowledge with children knowing, on average, only

about half the letter sounds at the end of the first year, and about three quarters by the end of the second year at school.

4.1.1 Receptive Vocabulary

The Peabody Picture Vocabulary Test - Revised was used as a measure of receptive vocabulary, an aspect of verbal ability. The age adjusted mean scores on the PPVT-R were 97 at initial testing, 100 at the end of the first year, and 103 at the end of the second year (Table 4.1). These scores all fit within the expected range for average performance of children of similar ages (Dunn and Dunn, 1981). Strong correlations were found between adjacent testing times (Time 1 to Time 6: r = .83; Time 6 to Time 9: r = .88) (Appendix B: Table 1).

Table 4.1
Mean Scores and Standard Scores for PPVT-R

Time	M (raw score)	SD	Standard Score
1	54.7	11.2	97
6	67.7	11.8	100
9	81.5	11.2	103

Note. Times 1 & 6, n = 29; Time 9, n = 27.

4.1.2 Letter Knowledge

Letter-name knowledge grew rapidly during the children's first term at school (Table 4.2 & Figure 4.1). The average number of letters children could name was 4.1 at first testing, rising to 13.8 at Time 2, nine weeks later. By the end of the first year most children could name nearly all the letters. The most frequently confused letters at this stage were those that required attention to orientation (i.e., b and d, p and q). High correlations were found between the children's letter-name knowledge at adjacent testing times in the first year, particularly from Time 2 onwards (r ranged from .80 to .93. Appendix B: Table 2).

Table 4.2
Mean Scores for Letter Name and Letter Sound Tests

Time	Letter Name[a]		Letter Sound[b]	
	M	SD	M	SD
1	4.14	4.81	0.17	0.38
2	13.79	7.19	3.21	4.15
3	17.62	6.46	4.76	5.60
4	20.83	4.55	8.10	7.48
5	21.93	4.48	11.03	7.77
6	23.83	2.94	12.59	8.27
7	24.96	1.02	15.11	6.33
8	25.44	0.85	18.67	5.42
9	25.93	0.27	19.22	4.20

Note. Times 1 - 6, n = 29; Times 7 - 9, n = 27.
a Maximum score = 26
b Maximum score = 25 (x excluded)

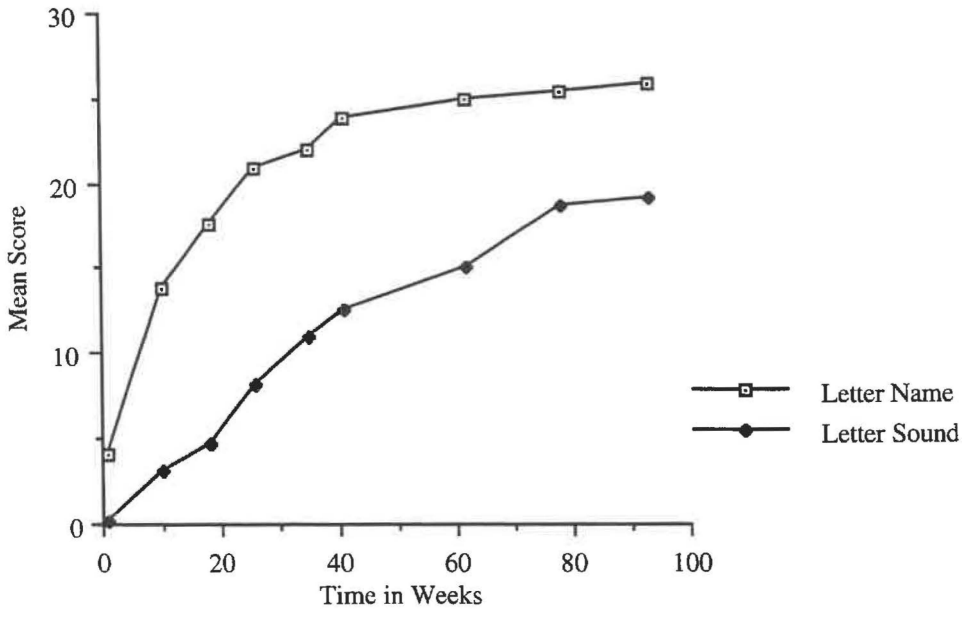


Figure 4.1. Change in mean scores for Letter Name and Letter Sound. (Maximum score for Letter Name = 26. Maximum score for Letter Sound = 25 [x excluded].)

Scores for letter-sound knowledge lagged behind scores for letter-name knowledge throughout the study (Table 4.2 and Figure 4.1). Of the 29 children at first testing, 24 knew no letter sounds. The remaining children knew just one sound. Letter-sound knowledge increased throughout the study period, with an average of 12.6 letter sounds known at the end of the first year and 19.2 at the end of the second

year. From Time 2 onwards, there were high correlations between letter-sound knowledge at adjacent testing times (r ranged from .69 to .85. Appendix B: Table 3), a similar pattern to that found for letter-name knowledge. Letter-sound knowledge showed significant correlations with letter-name knowledge throughout the first year (r ranged from .48 to .65 Appendix B: Table 4).

Although nearly all children knew all the letter names by the end of the first year, they knew on average only about half the letter sounds. The range of scores for letter-sound knowledge at any particular time was generally much higher than for letter-name knowledge. The finding of higher scores for letter-name knowledge is consistent with other studies that have found that young children's knowledge of letter names to be higher than their knowledge of letter sounds (Mason, 1980; Treiman et al., 1998).

The concurrent correlation between letter-name knowledge and receptive vocabulary skills (PPVT-R) was nonsignificant at the beginning of the study (r = .14), but was considerably larger and significant at the end of the first year (r = .51) (Appendix B: Table 4). A possible explanation for the increase in correlation is that differences in letter-name knowledge at school entry may have been largely related to differences in children's preschool exposure to the alphabet. However, after the children started school, and received a more equal level of exposure to letters, their acquisition of letter names was more likely to be associated with differences in verbal ability than had been the case before school instruction began.

The concurrent correlation between letter-sound knowledge and PPVT-R was nonsignificant at the beginning of the study (r = .25) when most children knew no letter sounds (Appendix B: Table 5). However, there were significant correlations at the end of the first (r = .31) and second years (r = .40). Thus, as with letter-name knowledge, it appears that the acquisition of letter sounds was associated with receptive vocabulary skills after the children had started school.

4.1.3 Phonological Memory

Mean scores for number of successful trials on the Digit Span task showed an increase from 5.8 to 8.2 during the period of the study (Table 4.3).

Table 4.3
Mean Scores for Digit Span Test

Time	M	SD
1	5.79	1.42
2	6.28	1.13
3	6.17	1.47
4	6.83	1.77
5	7.07	1.62
6	7.31	1.95
7	7.26	2.09
8	7.96	2.05
9	8.22	1.87

Note. Mean scores represent the number of trials on the Digit Span task. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

High correlations were found between Digit Span scores at adjacent test times (r ranged from .75 to .92. Appendix B: Table 6). This indicates that there was considerable stability in children's relative achievement levels on the Digit Span measure during the period of the study.

Concurrent correlations between Digit Span and PPVT-R were calculated for each of the three times that the PPVT-R was administered (Appendix B: Table 7). The correlation was nonsignificant at Time 1 ($r = .21$) but increased to significant levels at Times 6 ($r = .32$) and 9 ($r = .40$). Other studies have also found significant correlations between Digit Span and receptive vocabulary skills for young children (Bowey, 1996; Gathercole, Willis, & Baddeley, 1991). Gathercole et al. suggested that the reason for this connection is that children with higher phonological memory skills retain and learn sounds of new words with greater ease than children with poorer phonological memory skills.

Correlations between Digit Span and Letter Name scores were significant at the first two test times, ($r = .41$ and $r = .33$) but showed a pattern of declining values throughout the first year (At Time 6, $r = .21$ Appendix B: Table 7). One factor contributing to the decline may have been the decrease in the variance in Letter Name scores as children became more familiar with the alphabet during the year.

Correlations between Digit Span and Letter Sound scores were higher than the equivalent Letter Name correlations but, as with the letter-name correlations, there was a pattern of declining values throughout the first year (correlations declined from $r = .49$ at Time 2 to $r = .21$ at Time 6, Appendix B: Table 7) Correlations

between Digit Span and Letter Sound scores continued to decline in value at the beginning of the second year (at Time 7: $r = .15$) and then increased in value at Times 8 and 9 ($r = .48$ and .46 respectively). The jump in value occurred even though ceiling effects were resulting in a reduction of variance in Letter Sound scores at these times. The higher correlations indicate that children with good phonological memory skills have an advantage in developing more advanced letter sound knowledge towards the end of the second year at school.

The results indicate that phonological memory has a positive relationship with receptive vocabulary skills and letter knowledge. This is consistent with current theories that suggest children's ability to acquire verbal information is associated with phonological memory skills (Gathercole, 1990; Gathercole et al., 1992).

4.2 Reading and Spelling

Overview of Part Two

Part Two discusses the development of children's reading and spelling skills. Most children showed considerable gains in these skills during the first two years at school. There were, however, large differences between the achievement levels of individual children and these differences increased over time.

Each measure of literacy showed high correlations between testing times. The different measures of literacy were also highly correlated with each other. Receptive vocabulary skills usually showed only small concurrent and predictive correlations with measures of literacy. Letter knowledge often showed moderately high concurrent and predictive correlations with the literacy measures. Controlling for receptive vocabulary skills made little difference to the size of the correlations between letter knowledge and literacy.

Predictive correlations from letter knowledge at the start of the study are of special interest because all children were nonreaders at this point. This simplifies the interpretation of the predictive correlations as any connection from letter knowledge to later literacy can not be due to a preexisting association between letter knowledge and literacy at the initial test point. Small but significant correlations were found between letter-name knowledge at Time 1 and some later measures of literacy, indicating that entry level letter skills could be a factor in the development of children's literacy skills. It was not possible to make correlations from letter-sound knowledge at the start of the study because most children knew no letter sounds at this time.

The size of the correlations between letter-name knowledge and later literacy increased considerably after children had been at school for several months. The children who quickly learnt letter names were more likely to show progress in reading and spelling than the children who struggled with letter-name knowledge. A similar pattern was found for letter-sound knowledge although this variable did not become a significant predictor of literacy until half way through the first year at school. Letter-sound knowledge continued to be a significant predictor of literacy during the second year of school.

Phonological memory generally showed low and nonsignificant correlations with measures of reading, but higher, and often significant, correlations with spelling. The different patterns of correlations may be related to the different demands of reading and spelling on phonological memory.

The following sections describe the growth in children's reading and spelling skills during the first two years at school, and examine relationships between these skills and (a) receptive vocabulary, (b) letter knowledge, and (c) phonological memory.

4.2.1 The Development of Reading and Spelling

The children's mean performance levels on the Burt word reading test (Burt Read) are shown in Table 4.4. Five children were able to read one of the test words ("to") at the beginning of the study. By the end of the first year, the mean score on the Burt test was 14.1. By the end of the second year, when the children's mean age was 6 years 11 months, their mean score on the Burt test was 27.2. This score has an Equivalent Age Band of 6 years 5 months to 6 years 11 months on the New Zealand norms for the Burt test (Gilmore et al., 1981), and shows that the sample children were within the range of scores expected for their age group.

Table 4.4
Mean Scores for Burt Read, Neale Accuracy and Neale Comprehension Tests

	Burt Read		Neale Accuracy		Neale Comprehension	
Time	M	SD	M	SD	M	SD
1	0.17	0.38				
2	3.59	2.63				
3	6.34	4.13				
4	7.90	5.30				
5	12.00	6.45				
6	14.07	7.27				
7	17.78	8.03				
8	22.56	10.15				
9	27.19	9.17	18.33	11.70	5.89	4.33

Note. Times 1 - 6, n = 29; Times 7 - 9, n = 27.

The children's performance levels on the Neale Analysis of Reading Ability - Revised (Neale, 1988), administered only at the end of the second year, were also within the expected range for their age group (Table 4.4). New Zealand norms are not available for the test but it has been standardised for Australian children. Using

the Australian norms, the sample children's mean accuracy score translates to an Equivalent Age Range of 5 years 11 months to 7 years 1 month, while their comprehension mean score translates to an Equivalent Age Range of 5 years 10 months to 7 years 7 months.

Although the children's mean achievement levels for the Burt and Neale tests are within the range expected for their age group, they are towards the lower ends of this range. This pattern may be associated with the lower than average socioeconomic status of the two schools that the children attended. (See Nicholson, 1999b for a discussion of research on socioeconomic level and reading achievement.)

The relatively large standard deviations for the tests indicate the wide spread of test scores at each occasion. Children showed large and increasing differences in levels of reading achievement. For example, at the end of the first year the range of scores on the Burt word reading test was from 3 to 28; by the end of the second year the range was from 10 to 48. This pattern of increasing variance in reading achievement is similar to that found in other longitudinal studies (e.g., Francis, 1992; Jorm, Share, Maclean, and Mathews, 1984; Juel, 1988). (See also Stanovich, 1986).

Children's reading of the first 20 words of the Burt test was also scored according to how many phonemes they read correctly (- shown as the Burt Read Phonemes score on Table 4.5). From Time 2 on, the same 20 words were used as a spelling test which was scored according to how many phonemes were spelt correctly (- shown at the Burt Spell Phonemes score on Table 4.5). It is therefore possible to compare the children's reading and spelling performance for the same list of words. Table 4.5 shows that mean reading scores were almost always higher than mean spelling scores, the difference being significant at Times 5, 6, 7, and 9 (see also Figure 4.2). (Ceiling effects were apparent at Times 8 and 9, especially for Burt Read Phonemes). This finding is consistent with other studies which have reported that children show higher performance for reading in comparison with spelling (e.g., Cossu, Gugliotta, & Marshall, 1995; Foorman, Jenkins, & Francis, 1993). Cossu et al. suggested this pattern occurs because it is easier to acquire and deploy input orthographic representations (i.e., a visual "sight" vocabulary) than output representations (i.e., spelling).

Table 4.5
Mean Scores for Burt Read Phonemes and Burt Spell Phonemes, and Tests of Differences Between Means

	Burt Read Phonemes (max = 51)		Burt Spell Phonemes (max = 51)		t
Time	M	SD	M	SD	
2	7.59	5.93	7.14	4.21	0.55
3	14.48	9.23	14.62	8.30	-0.10
4	18.72	12.78	17.62	10.41	0.73
5	26.97	13.72	23.17	10.07	2.15*
6	30.97	13.38	25.10	9.86	4.19***
7	38.48	13.09	33.33	10.08	3.16***
8	43.07	10.16	41.56	8.39	1.17
9	47.63	6.52	44.22	6.71	3.82***

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
two tailed tests: $*p < .05$. $**p < .01$. $***p < .0005$

A list of pseudowords was used to provide additional measures of children's reading and spelling. Performance was scored according to the number of phonemes that were read or spelled correctly (Table 4.6). Pseudoword spelling scores (Pseudoword Spell Phonemes) were consistently higher than pseudoword reading scores (Pseudoword Read Phonemes), the difference being significant at Times 4, 7 and 8 (see also Figure 4.2). This is the opposite pattern to that found for word reading and spelling.

One explanation for the different pattern is that children's pseudoword reading, unlike their word reading, cannot be assisted by their "sight" or "recall" vocabulary. The pattern may also have been influenced by the type of literacy instruction emphasised in New Zealand classrooms where children are encouraged to attempt to spell unknown words but are less likely to be told to "sound out" an unfamiliar word when reading (see Thompson, 1993).

Table 4.6
Mean Scores for Pseudoword Read Phonemes and Pseudoword Spell Phonemes, and Tests of Differences Between Means

	Pseudoword Read Phonemes		Pseudoword Spell Phonemes		t
Time	M	SD	M	SD	
2	1.38	3.11	1.38	2.90	0.00
3	1.79	3.20	2.14	3.23	-0.82
4	4.41	6.18	6.86	6.27	- 2.8**
5	7.93	8.46	9.97	7.38	-1.73
6	9.07	9.51	11.38	7.95	-1.68
7	13.00	10.28	16.59	8.89	- 2.14*
8	18.48	11.68	22.48	7.59	- 2.22*
9	24.41	10.10	26.00	6.84	-1.38

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
two tailed tests: $*p < .05$. $**p < .01$. $***p < .0005$

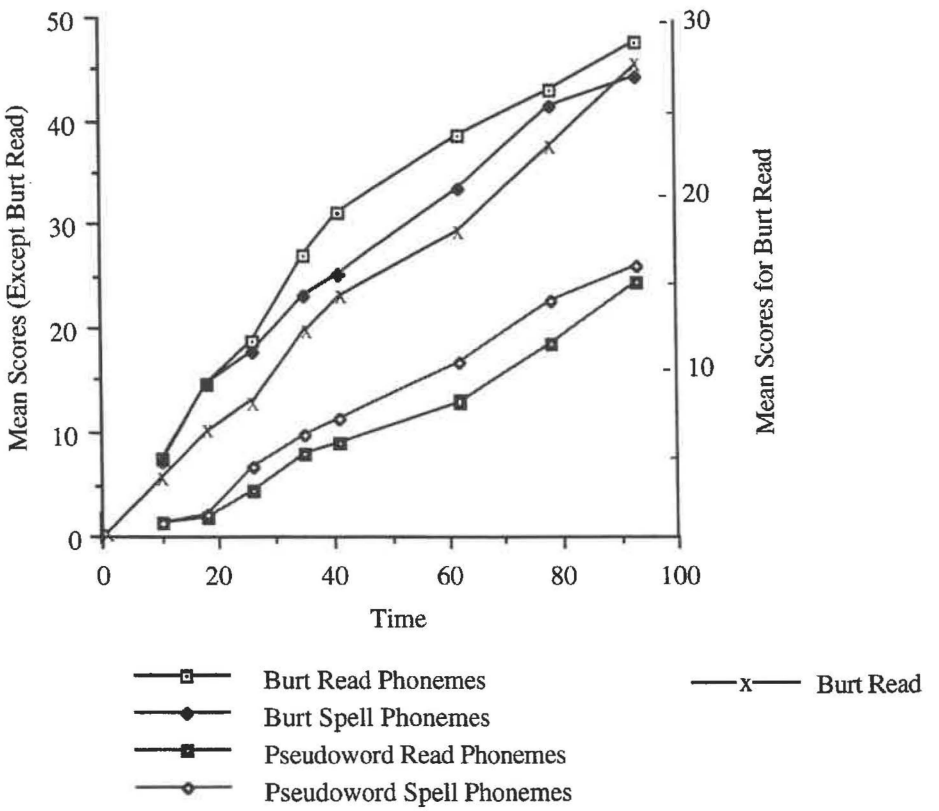


Figure 4.2. Change in mean scores for word reading and spelling, and pseudoword reading and spelling.

Figure 4.2 shows that there were similarities in the patterns of development for all measures of literacy, but children scored at higher levels on the word measures than on the pseudoword measures.

Each measure of word or pseudoword reading and spelling showed high correlations between testing times (Appendix C: Tables 1 - 5). Correlations between adjacent testing times were particularly high. For example, from Time 2 on, the correlation between adjacent Burt word reading scores was at least .86 (Appendix C: Table 1).

High correlations were frequently found between word reading and the measures of word spelling, pseudoword reading, and pseudoword spelling that were made at the same test time. (Appendix C: Table 6). Burt Read was highly correlated with Burt Spell Phonemes at each time (minimum $r = .68$). Burt Read was highly correlated with pseudoword reading from the time that a reasonable number of children were able to score on the pseudoword reading task (- from Time 4 on, r ranged from .67 to .91). Burt Read was also highly correlated with pseudoword spelling, though to a lesser extent than with pseudoword reading (from Time 4 on, r ranged from .51 to .79).

Burt word reading also showed high correlations with measures of text reading accuracy and comprehension (Appendix C: Table 6). When the Neale Analysis of Reading Ability - Revised (Neale, 1988) was administered at the end of the second year of the study, Burt word reading was highly correlated with text reading accuracy (r=.94) and text comprehension ($r = .84$)[19]. The high correlations between Burt Read and the other measures of literacy, along with the lack of floor and ceiling effects for Burt Read mean that it is appropriate to use Burt Read as the principal outcome measure when discussing the results of the current study.

Large gender differences were found for performance on the Burt word reading test. From Time 3 on, girls scored significantly higher than boys (Appendix : Table 7). The size of the difference was substantial at each measurement time. For example, about halfway through the first year the mean score for boys was 4.9 whereas the mean score for girls was 8.1. At the end of the first year the boys' and girls' mean scores were 10.6 and 18.4 respectively, and at the end of the second

[19] For further discussion of the relationship between word reading and text reading accuracy and comprehension see Blaiklock (1997), and Nicholson (1999c).

year the relevant scores were 21.9 and 32.9. These gender differences are consistent with that found in numerous other studies of reading achievement (see, e.g., Elley, 1994; Wilkinson, 1998).

4.2.2 Reading and Spelling, and Receptive Vocabulary

The correlation between Burt word reading and PPVT-R was .30 at the end of the first year and .42 at the end of the second year (Appendix C: Table 8). These correlations are within the .3 to .5 range that Stanovich, Cunningham and Feeman (1984) found to be typical of studies that have investigated the concurrent correlation between intelligence and reading. Significant correlations were found between PPVT-R and word spelling both at the end of the first year (r = .31) and at the end of the second year (r = .51). Correlations with pseudoword measures were nonsignificant at the end of the first year, but significant at the end of the second year (r = .39 and .49 for pseudoword reading and spelling respectively).

PPVT-R score at the beginning of the first year was a poor predictor of each measure of literacy at the end of the first year (all correlations were below . 25. Appendix C: Table 9). These findings are consistent with other studies which have found verbal intelligence to be a poor predictor of reading (e.g., Byrne and Fielding-Barnsley, 1993a; Carillo, 1994; Juel et al., 1986; Tunmer et al., 1988).

PPVT-R score at the beginning of the first year was also a poor predictor of reading at the end of the second year. However, there were significant correlations from initial PPVT-R scores to word spelling (r = .41) and pseudoword spelling (r = .32) at the end of the second year.

Correlations from PPVT-R at the end of the first year to later reading were nonsignificant but significant predictive correlations were found for measures of spelling (r ranged from .37 to .49).

4.2.3 Reading and Spelling, and Letter Knowledge

4.2.3.1 Concurrent Correlations between Letter Knowledge and Reading and Spelling

4.2.3.1.1 Concurrent Correlations between Letter Name and Reading and Spelling

Letter-name knowledge showed significant concurrent correlations with all reading and spelling measures during the first year of the study (Appendix C: Tables 11 and 12). Correlations with Burt Read increased throughout the first year from .54 to .70. Correlations with the other measures of literacy mostly ranged from about .45 to about .60. Controlling for receptive vocabulary skills made little difference to the size of correlations between Letter Name and literacy. The results are consistent with other studies that have found a close association between letter name skills and early literacy (see Adams, 1990). (Correlations with letter-name knowledge during the second year were not calculated as nearly all children knew all the letter names by this time.)

4.2.3.1.2 Concurrent Correlations between Letter Sound and Reading and Spelling

Concurrent correlations between letter-sound knowledge and measures of reading and spelling were significant at nearly all time points during the two years of the study (Appendix C: Tables 13 and 14). Partialling out PPVT-R made little difference to the size of the correlations. Low correlations were found with Burt Read (and Burt Read Phonemes) up till Time 5 but these correlations may have been affected by the large numbers of children scoring at low levels on Letter Sound up till this point. From Time 5 on, correlations with Burt Read ranged from .59 to .61. Correlations with Burt Spell Phonemes were higher, ranging from .68 to .78, except at Time 9 when ceiling effects were impacting on the Burt Spell Phonemes measure. Correlations between Letter Sound and pseudoword reading and spelling were almost always above .6 despite floor effects for the measures in the earlier parts of the study.

The general pattern of higher correlations between Letter Sound and Burt Spell Phonemes than between Letter Sound and Burt Read Phonemes might suggest that letter-sound knowledge is more directly related to spelling than to reading. However, spelling an unfamiliar word actually requires sound-to-letter knowledge

rather than letter-to-sound. The child must hold the word in phonological memory and then convert each sound to the appropriate sequence of letters. Sound-to-letter knowledge was not assessed in the present study but could be expected to be even more strongly correlated with spelling than letter-sound knowledge was.

Because letter-sound knowledge was assessed in the present study it might be thought that correlations with reading should be higher than correlations with spelling. The finding of the opposite pattern suggests that other factors are involved in reading and spelling apart from knowledge of letter sounds. It is likely that the high frequency words in the Burt Read list became part of many of the children's orthographic lexicon (i.e., "recall" or "sight" vocabulary) from early on and could therefore be identified without making use of letter-sound knowledge for phonological recoding on each occasion. (Phonological recoding, however, may play an important role in establishing the word in the child's orthographic lexicon in the first place - see Ehri, 1992; Thompson et al., 1996). The use of a recall strategy for reading some of the words would lower the correlation between letter-sound knowledge and reading. Some support for this explanation is seen in the pattern of lower correlations between letter-sound knowledge and word reading compared to the correlations between letter sound knowledge and pseudoword reading (which requires phonological recoding rather than recall).

Word spelling may also involve recall of the visual representation of a word without recourse to recoding its spoken form. As children develop in spelling skill, their orthographic memory of words becomes increasingly important (Treiman, 1993). In the current study, however, children were often unfamiliar with the spellings of many of the test words, meaning that they needed to make use of their knowledge of relationships between letters and sounds when attempting to write words.

Although it is possible for children's orthographic lexicon to influence word reading and spelling, this is not the case for pseudowords. By definition these are unfamiliar to children. It is therefore necessary for children to use knowledge of letters and sounds for both pseudoword reading and spelling. This may explain why there were moderately high correlations between Letter Sound, and measures of pseudoword reading and spelling.

4.2.3.2 Predictive Correlations from Letter Knowledge to Reading and Spelling

4.2.3.2.1 Predictive Correlations from Letter Name to Reading and Spelling

Predictive correlations from Time 1 in the present study are of special interest because this was the only time that all children were nonreaders. Being nonreaders means that any connection from letter-name knowledge at this time to later reading will not simply be a result of the fact that children with higher letter-name knowledge are likely to have higher reading skills (as shown in the concurrent correlations from Time 2 onwards) and that reading skills are highly correlated from one time to the next.

Correlations from letter-name knowledge at Time 1 were lower than for any of the other test times (Appendix C: Tables 15 - 19). No significant correlations were found from Letter Name at Time 1 to any of the literacy measures at the end of the second year, nor to the pseudoword measures at the next test time (Time 2) or at the end of the first year. However, small but significant correlations were found from Letter Name at Time 1 to word reading (r = .42) and spelling at Time 2 (r = .41), and to word reading at the end of the first year (r = .33). The size of the correlations from Letter Name at Time 1 indicates that letter-name knowledge at school entry explains only a small, albeit significant, amount of variance in later word reading and spelling.

Children's letter-name knowledge grew rapidly during the first term at school (from a mean score of 4.1 at Time 1 to a mean score of 13.8 at Time 2). Predictive correlations from Letter Name at Time 2 to later literacy were markedly higher than from Time 1. For example, Time 2 Letter Name was significantly correlated with Burt Read (r = .68) and Burt Spell Phonemes (r = .58) at the end of the first year and with Burt Read at the end of the second year (r = .41) (Appendix C: Tables 15 and 17). The correlations were little changed by controlling for PPVT-R. However, as previously noted, it is not possible to make a causal interpretation of the predictive correlations from letter-name knowledge once children have begun to read because these correlations will reflect the high concurrent correlations that existed between letter knowledge and literacy.

From Time 2 on, most of the correlations from letter-name knowledge during the first year to later literacy measures were significant. Correlations to later Burt Read were usually at least .60 from Time 2 onwards. Correlations of a similar size were

also often found for the other measures of literacy. These results are in agreement with other studies that have found letter-name knowledge to be a strong predictor of reading achievement (e.g., Bond and Dykstra, 1967; Chall, 1967; Durrell, 1958; Mason, 1980; Weinberger; 1996). (Predictive correlations were not calculated from Letter Name during the second year because of extreme ceiling effects.)

4.2.3.2.2 Predictive Correlations from Letter Sound to Reading and Spelling

Because all but five children knew no letter sounds at first testing, it was not possible to provide predictive correlations for Letter Sound from a time when children were nonreaders. Many children were still scoring at low levels for Letter Sound at Time 2, and no significant correlations with later word reading were found from this time. There were, however, some significant links with Time 3 word spelling ($r = .42$), pseudoword reading ($r = .57$) and pseudoword spelling ($r = .70$) (Appendix C: Tables 20 - 24). The size of the correlations for the pseudoword measures suggests a close association between letter-sound knowledge and performance on these tasks.

From Time 3 on, nearly all correlations from Letter Sound to later measures of literacy were significant. Correlations to literacy measures at the next test time, and to the end of the first year, typically ranged from about .60 to about .75 (Appendix C: Tables 20 - 24). The finding of significant predictive correlations is consistent with the results of other research on letter-sound knowledge and reading (e.g., Mason, 1980; Vellutino and Scanlon, 1987). However, because children were already reading when the significant predictive correlations from Letter Sound were made, it is not possible to establish the direction of the relationship with literacy.

Correlations from letter-sound knowledge to later word spelling (Burt Spell Phonemes) were nearly always higher than the comparable correlations from letter-sound knowledge to later word reading (Burt Read Phonemes). The general pattern of higher correlations with word spelling reflects the pattern that was seen for the concurrent correlations with letter-sound knowledge. The possible explanations that were provided for the concurrent pattern of higher correlations with word spelling also apply to the predictive situation: that is, the use of a recall strategy for word reading and the instructional emphasis of the children's classroom programmes.

The correlations between letter-sound knowledge and later pseudoword reading and spelling also reflect the pattern seen for the concurrent correlations of these variables: the pattern of correlations for pseudoword reading and pseudoword spelling tended to be similar. As was noted for the concurrent correlations, these results may reflect the more even use of letter-sound knowledge for pseudoword reading and spelling than had been the case for word reading and spelling.

Another finding for the predictive correlations, similar to the pattern for the concurrent correlations, was that correlations between Letter Sound and word reading were generally lower than correlations between Letter Sound and pseudoword reading. Again the explanation may be that word reading can be achieved by a recall or a phonological recoding strategy, whereas pseudoword reading is more dependent on knowledge of letter-sound correspondences.

The above discussion has focused on relationships from letter-sound knowledge to reading and spelling. Relationships may also operate in the other direction. That is, children may learn about letter-sound knowledge while being engaged in reading and spelling at the word level. In New Zealand classrooms, children are usually encouraged to attempt to read and spell words before they have full alphabet knowledge (Department of Education, 1985). A child who is learning to read his or her first words as whole units may nevertheless give attention to the letters that occur in them and be more likely to recognise these letters in other contexts. According to the Knowledge Sources Account of reading[20], children may be able to induce information about the correspondences between letters and phonemes as a result of their reading experience (Thompson et al., 1996). It has also been suggested that the use of "attempted" or "self-generated" spelling in beginning writing may assist children in learning the letters associated with particular sounds (Adams, 1990). A recent study, however, indicates that children may be unable to transform the phoneme-to-letter knowledge learnt in spelling to the letter-to-phoneme knowledge needed for reading (Thompson et al., 1999).

[20] The Knowledge Sources account was described in Section 2.3.4 of the Literature Review.

4.2.4 Reading and Spelling, and Phonological Memory

4.2.4.1 Concurrent Correlations between Digit Span and Reading and Spelling

4.2.4.1.1 Concurrent Correlations between Digit Span and Reading

Digit Span scores showed small and generally nonsignificant correlations with word reading at each test time (Appendix C: Table 25). A significant correlation was found for Burt Read at Time 3 (r = .34) and for Burt Read Phonemes at Time 9 (r = .32) but these fell to nonsignificant levels after controlling for PPVT-R (Appendix C: Table 25). Some higher correlations were found for Pseudoword Read Phonemes at Times 2 (r = .39) and 3 (r = .41). These correlations remained significant after controlling for PPVT-R (Appendix C: Table 26).

Most children were unable to perform the pseudoword reading task at Times 2 and 3, thus the significant correlations that occurred at these times were the result of the small number of children who were scoring on the task also performing well on Digit Span. Correlations between Digit Span and pseudoword reading were nonsignificant from Times 4 to 8. A significant correlation was found at Time 9 (r = .35) but this was no longer significant after controlling for PPVT-R.

The generally low correlations between Digit Span and reading indicate that phonological memory accounts for little variance in the reading achievement of the children in this study. Previous research has shown a variety of findings in relation to Digit Span and reading, with some studies reporting no memory span differences between good and poor readers (e.g., Bowers, 1995), while others have found shorter spans to be linked with lower reading scores (e.g., Ellis and Large, 1988) (See the earlier discussion in Section 2.4.3 of the Literature Review.)

Although there were few significant correlations between Digit Span and reading, it is interesting to look at the changing pattern of the correlations over the two years of the study. During the time of the study, the correlations between Digit Span and each of the reading measures showed the same general trends; the correlations declined during the first year and then rose towards the end of the second year. This is different to the pattern found in a longitudinal study by Gathercole et al. (1990). They found that phonological memory, as measured by nonword repetition, was not related to reading achievement during the first year of school, but became closely associated to reading near the beginning of the second year. By

the end of the second year the association was again no longer important. Gathercole et al. suggested that this pattern occurred because phonological memory is not so influential in the first year because this is when children are largely building up a basic sight vocabulary. However, at the beginning of the second year, phonological memory is required for children to learn and apply letter-sound correspondences in order to work out unknown words. Children continue to learn and apply new orthographic rules later in the second year, but at a rate that was less demanding on phonological memory.

There are a number of possible explanations for the different pattern of results in Gathercole et al.'s (1990) research and the current study. The large range of reading levels of children at each time in the current study means that even if phonological memory was associated with particular stages of literacy, it may be difficult to see this in group results. Differences in emphasis and timing of reading instruction between the New Zealand children in the current study and the English children in Gathercole et al.'s study may also have contributed to the different pattern of results. Another important consideration in comparing the results of the studies is that Gathercole et al. used nonword repetition whereas the present study used a digit span task. Although research has found these two measures to be significantly correlated (Gathercole, 1995), they have also been found to have different relationships with reading (Hansen and Bowey, 1994).

If phonological memory is important for learning and applying grapheme-phoneme correspondence rules, as Gathercole et al. (1990) suggested, then reasonable correlations could be expected between measures of phonological memory and letter-sound knowledge[21]. The current study provides support for a connection between phonological memory and letter-sound knowledge as there were significant correlations between Digit Span and Letter Sound for Times 2 to 6 (r ranged from .33 to .49), and for Times 8 (r = .48) and 9 (r = .46) (Appendix B: Table 7).

4.2.4.1.2 Concurrent Correlations between Digit Span and Spelling

Nearly all of the correlations between Digit Span and measures of spelling were larger than for the comparable reading measures (Appendix C: Table 25). Significant correlations between Digit Span and Burt Spell Phonemes were found

[21] However, knowledge of letter sounds is only one part of learning and applying grapheme-phoneme correspondences (see Thompson, 1999).

for Times 2 to 4, (r = .61, .43, .36) and Times 8 and 9 (r = .41, .38). After partialling out PPVT-R the correlations for Times 2 to 4 remained significant (Appendix C: Table 25). Significant correlations were found between Digit Span and Pseudoword Spell Phonemes throughout the first year (r ranged from .35 to .57) and at the end of the second year (r = .44). The first year correlations remained significant after partialling out PPVT-R (Appendix C: Table 26).

The finding of higher correlations between Digit Span and spelling than between Digit Span and reading may relate to the different demands that reading and spelling make on phonological memory (Cossu et al., 1995). Reading an unfamiliar word requires little memory load at the input as the word is available for viewing. There is, however, a demand on phonological memory at the output if the sounds are to be blended. Spelling an unfamiliar word requires phonological memory at the input as a child must remember a sound representation of the word while they attempt to convert it into letters. Spelling, however, places little demand on phonological memory at output as letters can be written down as they are worked out.

4.2.4.2 Predictive Correlations from Digit Span to Reading and Spelling

Predictive correlations between Digit Span and measures of literacy reflect the patterns seen for the concurrent correlations. Digit Span was a poor predictor of reading but a somewhat better predictor of spelling. There were almost no significant predictive correlations from Digit Span to word or pseudoword reading, even before controlling for PPVT-R (Appendix C: Tables 27, 28, and 30). These results are not consistent with studies that have found an association between phonological memory and later reading (e.g., Grogan, 1995; Mann & Liberman, 1984). There were, however, numerous small but significant correlations from Digit Span to measures of spelling at the following test time, the end of the first year, and the end of the second year. Most of these correlations ranged from . 31 to .40. Some of them were not significant after controlling for PPVT-R.

Because all of the children were nonreaders at Time 1, predictive correlations from this time are of special value for examining whether there is a causal connection from phonological memory to later literacy. At later times children had developed some reading (and spelling) skills, making it impossible to provide evidence about whether any possible causal connection was from phonological memory to literacy, from literacy to phonological memory, or in both directions. No evidence of a significant connection was found from Digit Span at Time 1 to any of the measures

of later reading (Appendix C: Tables 27, 28, and 30). There were, however, significant correlations to pseudoword spelling at the next test time (Time 2), to word and pseudoword spelling at the end of the first year, and to pseudoword spelling at the end of the second year (correlations ranged from . 31 to .46) (Appendix C: Tables 29 and 31). The correlations to Time 2 and to the end of the first year remained significant after controlling for PPVT-R. These results suggest that phonological memory at school entry may contribute to the acquisition of spelling. The difference in results for spelling and reading highlights the value of assessing both these skills when studying the acquisition of literacy.

4.3 Phonological Awareness

Overview of Part Three

Part Three discusses the development of several different types of phonological awareness: syllable awareness, rhyme awareness, alliteration awareness, and phoneme awareness. Each measure of phonological awareness generally showed moderate to high levels of correlation between adjacent testing times.

Syllable awareness was the easiest of the phonological awareness tasks; nearly half the children were at ceiling level on this task at the beginning of the study. Almost all children were at ceiling level after six months at school. Syllable awareness showed some significant concurrent correlations with letter-name knowledge and phonological memory but not with receptive vocabulary skills.

Rhyme awareness and alliteration awareness tasks were more difficult for children than the syllable awareness task. However, a number of children showed successful performance on these tasks at the beginning of the study. The mean scores of children on these tasks increased throughout the first year at school, with most children approaching ceiling levels by the end of the year. Rhyme awareness and alliteration awareness generally showed nonsignificant concurrent correlations with receptive vocabulary skills, letter knowledge, and phonological memory. Possible explanations for this pattern of results are discussed.

Phoneme awareness was measured with a deletion task and a tapping task. The different demands of these tasks meant that children showed different patterns of performance on them. Both tasks were very difficult for children, especially in the first six months of the study. Average scores on the phoneme awareness tasks showed a marked increase after half way through the first year at school, and continued to increase throughout the study.

The phoneme awareness tasks showed inconsistent patterns of correlation with measures of receptive vocabulary skills and phonological memory. Generally it appeared that these measures could account for only a small amount of the differences in children's performance on the phoneme awareness tasks.

Phoneme awareness task scores showed generally low and nonsignificant concurrent correlations with letter-name knowledge. This pattern may have been

influenced by the fact that letter-name knowledge was starting to be affected by ceiling effects at the time that children began to show higher scores on the phoneme awareness tasks. Correlations with letter-sound knowledge were higher than for letter-name knowledge. Most of the correlations between phoneme awareness and letter-sound knowledge remained significant after controlling for receptive vocabulary skills.

The following discussion is divided into three main sections dealing firstly with syllable awareness, secondly with rhyme awareness and alliteration awareness, and finally with phoneme awareness. The influence of receptive vocabulary, letter knowledge, and phonological memory is considered for each type of phonological awareness.

4.3.1 The Development of Syllable Awareness

Children's performance on the three-item syllable deletion task (TAAS-Syllables) showed a bimodal distribution at Time 1 (mean =1.59, Table 4.7). Nearly half the children were at ceiling level but about a third of the children were unable to perform any items. At Time 2, 21 of the 29 children were at ceiling level. By Time 4, 27 of the 29 children had reached the maximum score (mean = 2.83).

Table 4.7
Means Scores for Syllable Awareness (TAAS-Syllables)

Time	M	SD
1	1.59	1.38
2	2.34	1.11
3	2.55	0.87
4	2.83	0.66
5	2.97	0.19
6	2.93	0.37
7	2.96	0.19
8	2.96	0.19
9	3.00	0.00

Note. Times 1 - 6, n = 29; Times 7 - 9, n = 27.

Strong correlations were found between scores on syllable deletion at adjacent test times (Appendix D: Table 1). No significant correlation was found between syllable deletion and PPVT-R. However, syllable deletion was significantly correlated with Letter Name at Time 1 (r = .47) and Time 2 (r = .33), and with Digit

Span at Time 2 (r = .43) (Appendix D: Table 2). Controlling for PPVT-R usually made little difference to the size of the correlations between syllable deletion and letter knowledge or Digit Span (Appendix D: Table 3).

4.3.2 The Development of Rhyme Awareness and Alliteration Awareness

Children's mean scores for the rhyme task and the alliteration task are shown in Table 4.8. The maximum possible score for each task was 9, with a score of 3 to be expected for children operating at chance level. The mean score for the rhyme task was 4.8 at first testing, rising steadily to 8.1 at the end of the first year and near maximum scores during the second year. A similar pattern was seen for the alliteration mean score with a rise from 5.3 to 8.0 during the first year and to near maximum scores during the second year. Ceiling effects meant that frequency distributions for these tasks were negatively skewed from half way through the first year. The negative skew became extreme for the second year scores (e.g., at Time 7, 21 of the 27 children were at ceiling level for rhyme awareness, and 17 children were at ceiling level for alliteration awareness). The ceiling effects meant that the second year scores were not used in further analyses.

Table 4.8
Mean Scores for Rhyme Categorization and Alliteration Categorization

	Rhyme Categorization		Alliteration Categorization	
Time	M	SD	M	SD
1	4.76	2.37	5.34	2.09
2	6.21	2.53	6.03	1.82
3	6.62	2.26	6.48	1.90
4	7.34	2.04	7.10	1.65
5	7.97	1.88	7.76	1.55
6	8.14	1.71	8.00	1.44
7	8.41	1.39	8.19	1.33
8	8.63	1.57	8.89	0.32
9	8.96	0.19	9.00	0.00

Note. Times 1 - 6, n = 29; Times 7 - 9, n = 27.

At each test point during the study, rhyme awareness and alliteration awareness showed very similar scores to each other (Figure 4.3). Initial performance levels on the rhyme and alliteration tasks are comparable to that found in other studies

where categorization tasks have been used (e.g., Bradley and Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990). Because the words with similar sounds in the alliteration task shared the same vowel as well as the same initial consonant (e.g., dog, doll, sun), it is possible that children's performance on the task was influenced by the global similarity of the two words, and not just by their awareness of the common sound of the first consonant (see Byrne & Fielding-Barnsley, 1993b).

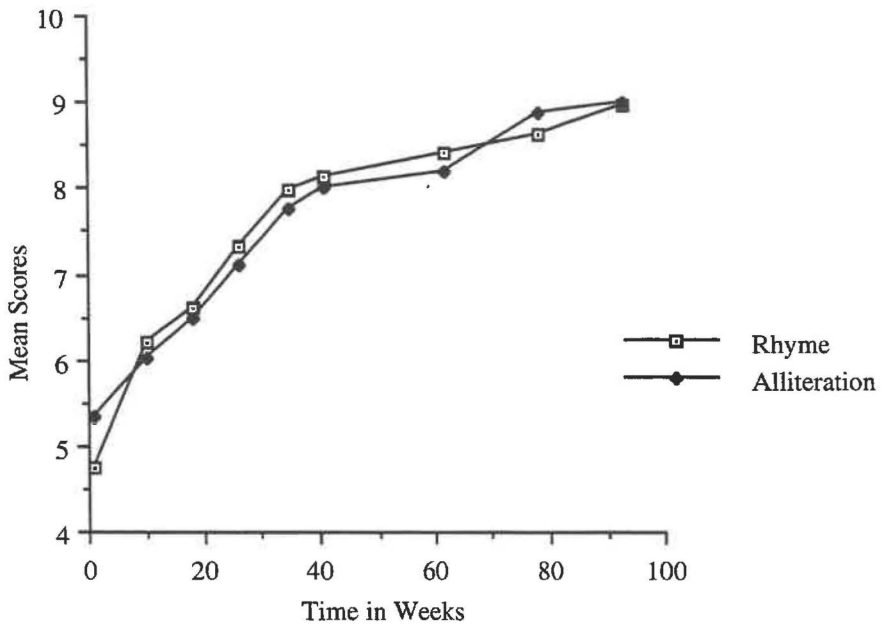


Figure 4.3. Change in mean scores for Rhyme Categorization and Alliteration Categorization.

Correlations between testing times during the first year showed reasonable levels of stability for the rhyme and alliteration measures from one test time to the next (Appendix D: Tables 4 and 5). The correlations ranged from .60 to .87, except for Alliteration Categorization from Time 4 to Time 5 (Appendix D: Table 5).

4.3.2.1 Correlations Between Rhyme Awareness and Alliteration Awareness

During the first half of the first year, Rhyme Categorization showed concurrent correlations of at least .71 with Alliteration Categorization (Appendix D: Table 6). Correlations were virtually unchanged after partialling out the influence of PPVT-R (Appendix D: Table 7). The high correlations between rhyme awareness and

alliteration awareness may reflect the fact that both tasks assess subsyllabic awareness. The correlations may also reflect the common demands of the type of task (i.e., categorization) that was used to assess both rhyme awareness and alliteration awareness.

Correlations between rhyme awareness and alliteration awareness during the second half of the first year were smaller than in the first half of the year, a result that may be associated with the occurrence of ceiling effects.

4.3.2.2 Rhyme Awareness and Alliteration Awareness, and Receptive Vocabulary

Small concurrent correlations were found between measures of rhyme and alliteration awareness, and PPVT-R scores (Appendix D: Tables 6 and 8). Correlations with PPVT-R were significant only for Rhyme Categorization at Time 1 ($r = .41$) and for Alliteration Categorization at Time 6 ($r = .37$). The size of the correlations indicates that receptive vocabulary skill explains only a small amount of variance in the children's awareness of rhyme or alliteration.

4.3.2.3 Rhyme Awareness and Alliteration Awareness, and Letter Knowledge

There was considerable variability in the correlations between letter knowledge and the rhyme and alliteration tasks (Appendix D: Tables 6 and 8). Correlations with rhyme awareness ranged from .00 to .49 during the first year of the study. Three of the correlations between Rhyme Categorization and Letter Name were significant but there were only small insignificant correlations between Letter Sound and Rhyme Categorization. Alliteration awareness showed mostly small correlations with letter knowledge (ranging from -.01 to .39); only one correlation with Letter Name was significant and a significant link with Letter Sound was found for only two test times. Correlations between rhyme and alliteration tasks and letter knowledge showed only small reductions after controlling for PPVT-R (Appendix D: Tables 7 and 9).

A child who is knowledgable about letter names, and especially letter sounds, might be expected to use this knowledge for identifying common sounds in the categorization tasks. The finding of some significant correlations between letter knowledge and rhyme and alliteration tasks in the current study provides some support for this expectation. However, the lack of significant correlations on a

majority of occasions could be interpreted as providing evidence that performance on the categorization tasks does not require an analytic knowledge of the sound components of words (see Cardoso-Martins, 1994; Morais, 1991a, 1991b).

4.3.2.4 Rhyme Awareness and Alliteration Awareness, and Phonological Memory

Concurrent correlations between awareness of rhyme or alliteration, and Digit Span, showed a fluctuating pattern during the first year of the study (Appendix D: Tables 6 and 8). Most correlations were nonsignificant, except for Rhyme Categorization at Time 2 ($r = .57$), and Time 6 ($r = .36$), and Alliteration Categorization at Time 2 ($r = .43$). The correlations at Time 2, but not at Time 6, remained significant after partialling out PPVT-R (Appendix D: Tables 7 and 9). The generally small size of the correlations suggests that there was usually little connection between awareness of rhyme or alliteration, and Digit Span for the children in the current study.

Researchers have previously suggested two reasons for expecting a close association between phonological awareness and phonological memory (see Hansen and Bowey, 1994). First, measures of phonological awareness often appear to place demands on phonological memory, and second, phonological awareness and phonological memory may both stem from a single latent phonological processing ability. Although these suggestions are not supported by the present study's findings on Digit Span and awareness of rhyme or alliteration, they have received support in studies that used different measures of phonological memory and phonological awareness. It is therefore useful to compare the findings of the current study with other studies in order to discover possible reasons for the different findings.

Wagner et al. (1993) found evidence of a strong connection between phonological awareness and phonological memory in samples of kindergarten and second grade children. This finding was based on correlations of the latent variables that resulted from factor analysis of a wide range of measures of phonological awareness (including rhyme and phoneme awareness) and phonological memory. An examination of the correlations between individual tests shows these to be smaller than the correlations found for the latent variables. For example, the correlation between Digit Span and a phonological categorization task was .30 for the kindergarten sample and .19 for the second grade sample. The size of these correlations is comparable to that found for similar tasks in the present study. A

higher correlation between Digit Span and oddity scores at Grade 2 (r = .37) was found in a later longitudinal study by Wagner and colleagues (Wagner et al., 1994).

Rohl and Pratt (1995) concluded from their longitudinal study that phonological awareness and phonological memory are closely related at the beginning of Grade 1 but become more clearly differentiated as children develop literacy skills during the first two years at school. This conclusion was based on children's scores on rhyme oddity and alliteration oddity tasks, phoneme deletion tasks, and two types of memory tasks - forwards and backwards repetition. A comparison of Rohl and Pratt's findings with the current study can be made by examining the correlation patterns for the tasks that are most similar for both studies. The Digit Span task used in the current study is comparable to Rohl and Pratt's forwards repetition tasks, although these tasks had children recall letters and words rather than digits.[22] Rohl and Pratt found that forwards repetition was significantly correlated with oddity task scores at the beginning of Grade 1 (r = .54) and at the end of Grade 1 (r = .63). (Their paper does not provide correlations for the tests given at the end of Grade 2.) These correlations are considerably higher than the correlations between Digit span and Sound Categorization that were found in the current study.

A reason for the generally lower correlation between phonological memory and awareness of rhyme or alliteration in the current study may relate to the phonological memory demands of the rhyme and alliteration tasks. There are two ways in which the tasks used in the current study may have been less demanding on phonological memory than tasks used in the other studies. Firstly, the current study used pictures to illustrate each of the words in the tasks. Children therefore did not have to rely on memory rehearsal in order to remember the words. Secondly, children in the current study identified which words sounded most the same rather than identifying the odd one out as in other studies. Identifying similarities should place less demand on memory than identifying the odd one out. The latter task requires that children first identify similarities and then hold this information in memory while they recall the remaining item.

4.3.3 The Development of Phoneme Awareness

Three measures were used to assess phoneme awareness: Medial Phoneme Categorization, TAAS-Phonemes, and Phoneme Tapping.

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[22] See the discussion of the assessment of phonological memory in Section 2.4.2.

4.3.3.1 Medial Phoneme Categorization

Children's mean scores on the Medial Phoneme Categorization task showed little change throughout the study (Table 4.9). During the first and second years, the mean score fluctuated from about 4.5 to about 5.5. A mean score of 3, out of a maximum score of 9, could have been expected if children were operating only at chance level when making their responses. Correlations between tests at adjacent times ranged from .27 to .69 and were often at only moderate levels (Appendix D: Table 10).

Table 4.9
Mean Scores for Medial Phoneme Categorization

Time	M	SD
1	4.38	2.00
2	4.69	2.22
3	4.97	2.41
4	4.72	1.71
5	5.45	1.99
6	4.59	1.66
7	5.26	2.03
8	4.67	1.66
9	5.41	2.29

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

The lack of change in the mean scores for the Medial Phoneme Categorization task, along with the low reliability of this task (see Table 3.1), indicated that the task may have been of limited value for inclusion in the study. In order to find out more about what the task may have been measuring, concurrent correlations with all other measures were examined (Appendix D: Tables 11 & 12). Significant correlations were found between Medial Phoneme Categorization, and the other two categorization tasks (rhyme and alliteration). The significant correlations may have been the result of the use of a common operation, (identifying two similar sounding words out groups of three words), for each of these tasks. However the correlations between the tasks varied considerably from time to time. Correlations between Medial Phoneme Categorization and Rhyme Categorization ranged from .39 to .73. Correlations between Medial Phoneme Categorization and Alliteration Categorization ranged from .10 to .78. Only one significant correlation was found between Medial Phoneme Categorization and phoneme tapping. No significant correlations were found between Medial Phoneme Categorization and measures of receptive vocabulary, digit span, letter knowledge, syllable awareness, phoneme deletion, word reading or spelling, and pseudoword reading or spelling.

In summary, the results for the medial phoneme categorization task suggest that there are problems with this measure. The task has low reliability and children showed little change in mean performance levels throughout the study. Although the task was correlated with other categorization tasks, correlations showed large variations at different test times. Almost no significant concurrent correlations were found with other measures, apart from the categorization tasks, during the study. It was therefore decided to not include the medial phoneme categorization task in further analyses for the current study. (Two other measures of phoneme awareness remained: TAAS-Phonemes and Tapping.)

4.3.3.2 TAAS-Phonemes

The TAAS-Phonemes deletion task was very difficult for many children, especially in the first year of the study. No children scored above zero for the first two test times and only one child scored above zero at Time 3. The numbers of children scoring above zero increased to 9 by the end of the first year and to 20 by the end of the second year. Mean scores increased from 1.6 at the end of the first year to 4.6 at the end of the second year (Table 4.10). From Time 4 to Time 9, strong correlations were found between TAAS-Phonemes scores at adjacent test times (*r* ranged from .57 to .73) (Appendix D: Table 13).

Table 4.10
Mean Scores for TAAS-Phonemes

Time	M	SD
1	0.00	0.00
2	0.00	0.00
3	0.10	0.56
4	0.83	2.16
5	1.14	2.46
6	1.59	2.63
7	1.96	2.39
8	3.04	3.11
9	4.56	3.25

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

Other studies that have used phoneme deletion tasks have found children to be more proficient at deleting final sounds than initial sounds (e.g., Content et al., 1986; Rosner and Simon, 1971; Johnston et al., 1996). The opposite result was found in the present study. This result, however, may have been due to the procedures that

were used for administering the TAAS. The current study followed the published guidelines for this test which state that testing should be stopped after two successive errors (Rosner, 1979). The first three phoneme items of the test are initial deletion, followed by three final deletion items. Testing was stopped if the child made two successive errors on the initial deletion items but this meant that he or she was not given the opportunity to attempt the, possibly easier, final deletion items. Johnston et al. also used the TAAS measure but it appears that they may not have followed the guidelines on when to stop testing. If they had followed the guidelines, it would not have been possible for them to have made the finding that children scored higher for final deletion than for initial deletion.

If final deletion was easier than initial deletion, then it would be expected that children who were able to perform initial deletion would also be able to perform final deletion. This pattern of scoring was not apparent in the present study. There were many children who scored correctly on the initial deletion items but were then unable to perform the final deletion items.

There is considerable debate over whether initial and final phoneme deletion items do represent phoneme awareness. Initial phoneme deletion (e.g., "say coat but don't say /k/") coincides with division into onset and rime and may therefore not necessarily require awareness at the phoneme level (Foorman et al., 1993). Final phoneme deletion (e.g., "say game but don't say /m/") could possibly be performed by children who have enough articulatory control to say just the first part of a word, but who do not have a reflective knowledge of phonemes (Goswami and Bryant, 1990). Medial phoneme deletion (e.g., "say clap but don't say /l/") provides the strongest evidence that children can carry out operations at the phoneme level. Only 9 of the 27 children in the current study at the end of the second year were able to perform successfully at the medial phoneme level.

4.3.3.3 Tapping task

Children found the Tapping task to be very difficult, especially during the first year of the study (Table 4.11). Although children showed a range of positive scores at the first test time, there may have been a chance element in this; the nature of the task meant that a child who responded with a random number of taps could occasionally be correct for an item. Mean scores for the first three test times were very similar, perhaps reflecting a baseline chance level of response. Mean scores began to increase at Time 4 as a small number of children started to perform at a higher level. This is also when some children started to succeed on the TAAS-

Phoneme task. A jump in the mean scores of both phoneme tasks after Time 3 can be seen in Figure 4.4.)

Table 4.11
Mean Scores for Tapping

Time	M	SD
1	2.55	1.12
2	2.66	1.74
3	2.83	1.28
4	3.76	1.48
5	4.10	1.86
6	4.59	1.50
7	4.59	1.58
8	5.04	1.43
9	5.63	1.60

Note. Times 1 - 6, n = 29; Times 7 - 9, n = 27.

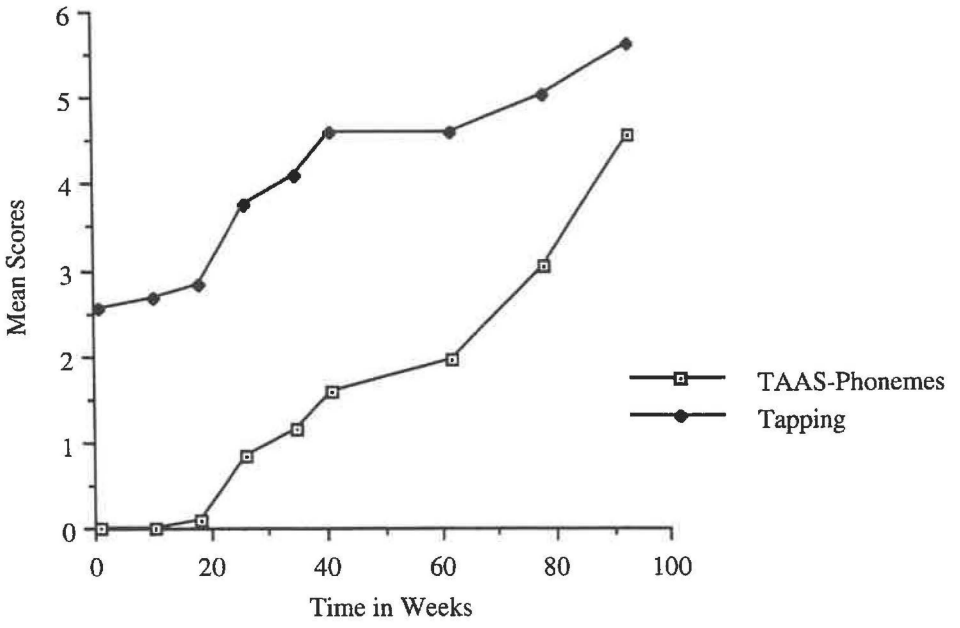


Figure 4.4. Change in mean scores for TAAS-Phonemes and Tapping.

The Tapping task showed a wide range of correlations between adjacent test times (Appendix D: Table 14). Low correlations were found in the first half of the first year (r ranged from . 18 to .27). Correlations after this time were higher (r ranged from . 29 to .69).

The use of pseudowords in the tapping task ruled out the possibility that children's responses could have been affected by their familiarity with the spelling of the items. Using pseudowords, however, contributed to the "strangeness" of the task and may have resulted in additional confusion for some children (see Lenchner et al., 1990).

It is possible that children's performance on the tapping task was influenced by their attention to duration cues (Morais, 1991b). This is because there is a relationship between the number of phonemes in a pseudoword and the duration of its acoustic speech signal. The practice items at the start of the tapping task may have alerted some children to this relationship. These children may then have been more likely to provide more taps for longer duration pseudowords (e.g., "skŭb") than shorter duration items (e.g.,"ĭ").

4.3.3.4 Correlations between TAAS and Tapping

Concurrent correlations between TAAS-Phonemes and Tapping showed an increase in size from Time 4 (r = .17) to Time 8 (r = .68), followed by a decline at Time 9 (r = .44) (Appendix D: Table 15). The general pattern of higher correlations occurred as more children started to perform at higher levels on the tasks after Time 3. Although TAAS-Phonemes and Tapping are both considered to be measures of phoneme awareness, the low correlations between these tasks at a number of test times suggests they may be measuring different aspects of phoneme awareness. Each task requires children to carry out a different operation in order to demonstrate phoneme awareness. The tapping task requires segmentation of phonemes whereas TAAS-Phonemes requires phoneme deletion. It is also likely that extraneous task characteristics (e.g., memory demands, linguistic features of items) differentially affected children's performance on each of the tasks. Differences in children's performance on the TAAS-Phonemes task and the Tapping task mean that it would be inappropriate to combine these tasks into an aggregate measure of phoneme awareness. Consequently the following discussion deals separately with the pattern of results for each measure, while also noting similarities and differences where pertinent.

4.3.3.5 Phoneme Awareness and Receptive Vocabulary

Concurrent correlations between phoneme awareness and receptive vocabulary skills can only be calculated for Times 1, 6 and 9 because the PPVT-R was

administered only at these times. No correlation can be made for TAAS-Phonemes at Time 1 as no children were scoring on this measure at that time. At Time 6 (when nine children were scoring on the TAAS-phoneme measure) there was almost no correlation between TAAS-Phonemes and PPVT-R (r = -.06). At the end of the second year, however, there was a significant correlation of .49 (Appendix D: Table 15).

A different pattern of correlations was found between Tapping and PPVT-R. The correlation was nonsignificant at Time 1(r = .20) but significant at Time 6 (r = .57). At the end of the second year the correlation was again nonsignificant (r = .31) (Appendix D: Table 17).

Other studies have reported mixed findings with regard to correlations between measures of phoneme awareness and verbal or general ability. Some researchers have found phoneme awareness skills to be relatively independent of verbal ability (e.g., Stanovich, 1988; Tunmer, Herriman and Nesdale, 1988). Other researchers have found performance on various phoneme awareness tasks to be significantly correlated with measures of general ability (e.g., Wagner et al., 1993; Wagner et al., 1994). A possible explanation for the discrepant findings is that correlations of this type are affected by not only the phonological and cognitive skills of the participants, but also differences in the type of tasks used to measure phoneme awareness and ability.

4.3.3.6 Phoneme Awareness and Letter Knowledge

Concurrent correlations between TAAS-Phonemes (phoneme deletion) and letter knowledge are not reported for the first three test times as no more than one child was able to carry out the deletion task until Time 4. TAAS-Phonemes showed small nonsignificant correlations with Letter Name from Times 4 to 6 (Appendix D: Table 15). (Correlations with Letter Name are not reported for the second year because of extreme ceiling effects on the letter name measure during this time.) Higher correlations were found between TAAS-Phonemes and Letter Sound. These correlations ranged from .30 to .60. Almost all of the correlations were significant, even after partialling out PPVT-R (Appendix D: Table 16).

Tapping, like TAAS-Phonemes, showed low concurrent correlations with letter-name knowledge. Only one correlation remained significant after controlling for PPVT-R. Correlations between phoneme tapping and Letter-Sound ranged from

.32 to .60 and were all significant. Most of these correlations remained significant after controlling for PPVT-R (Appendix D: Table 18).

For both phoneme deletion and phoneme tapping, the pattern of concurrent correlations with letter-sound knowledge suggests that children with good letter-sound knowledge during the first year of the study were more likely to be able to demonstrate some level of phoneme awareness. The results are consistent with other studies that have reported significant correlations between letter knowledge and phoneme awareness (e.g., Badian, 1995; Wagner et al., 1994). However, an experimental study by Lundberg, Frost and Peterson (1988), found no effect of phoneme awareness training (that did not make use of letters) on letter knowledge. The results of the current study lend some support to the notion of a connection between letter-sound knowledge and phoneme awareness, but the direction of the connection cannot be ascertained from the concurrent correlational data.

An explanation of why there may be a connection from phoneme awareness to letter-sound knowledge is found in the Knowledge Sources account of reading.[23] Thompson et al. (1996) noted that children's knowledge of letter sounds could stem from (1) induced sublexical relations[24], or (2) taught sounds for letters. Phoneme awareness will assist children in forming induced sublexical relations, and therefore may have a positive effect on knowledge of letter sounds.

It is also possible to provide an explanation for why there may be a connection in the other direction, that is, from letter-sound knowledge to phoneme awareness. Some previous research has suggested that learning letter names and letter sounds could encourage children to gain insights into the phonemic structure of words (Johnston et al., 1996; Wagner et al., 1994).

4.3.3.7 Phoneme Awareness and Phonological Memory

Phoneme deletion (TAAS-phonemes) showed nonsignificant concurrent correlations with Digit Span during most of the study period (Appendix D: Table 15). Only at Times 8 (r = .36) and 9 (r = .34) were significant correlations found,

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[23] See Section 2.3.4 of the Literature Review.

[24] Induced sublexical relations are the relations between the orthographic components of words and the corresponding phonological components stored in memory.

but neither of these remained significant after controlling for PPVT-R (Appendix D: Table 16).

Phoneme tapping and Digit Span usually showed higher concurrent correlations than were found for phoneme deletion (r ranged from .18 to .59. Appendix D: Table 17). During the first year several of the correlations between Tapping and Digit Span remained significant after partialling out the influence of PPVT-R. However, the one significant correlation in the second year (Time 8, $r = .41$) was reduced to a nonsignificant level after controlling for PPVT-R (Appendix D: Table 18).

The items in the deletion task were real words, both before and after deletion. The tapping task, however, made use of pseudowords. It is possible that the greater demands of holding pseudowords in phonological memory may explain why correlations with Digit Span were usually higher for the tapping task than for the deletion task.

The results of the current study indicate that differences in phoneme awareness are often unassociated with differences in phonological memory. (A similar lack of association was found between awareness of rhyme or alliteration, and Digit Span. See the earlier discussion in Section 4.3.2.4.) Some other studies have found small to moderate significant correlations between memory span measures and phoneme awareness (Hansen & Bowey, 1994; McDougall et al., 1994; Rohl & Pratt, 1995; Wagner et al., 1993; Wagner et al., 1994). A possible explanation for the difference in findings between studies is that the association between phoneme awareness and phonological memory is affected by specific task and subject characteristics.

4.3.3.8 Phoneme Awareness and Awareness of Rhyme or Alliteration

No significant concurrent correlations were found between TAAS-Phonemes and awareness of rhyme or alliteration (Appendix D: Table 15). The likelihood of finding a significant correlation was limited, however, by the fact that children only began to score on TAAS-Phonemes at the same time that they were reaching ceiling level on the rhyme and alliteration measures.

Concurrent correlations between Tapping and awareness of rhyme or alliteration were almost always markedly higher than was the case for the TAAS-Phonemes correlations with the same variables (Appendix D: Table 17). Over half of the correlations between Tapping and awareness of rhyme or alliteration were significant. The significant correlations were still significant after partialling out the influence of PPVT-R (Appendix D: Table 18).

5

RELATIONSHIPS BETWEEN PHONOLOGICAL AWARENESS AND LITERACY

Overview of Chapter 5

This chapter examines relationships between phonological awareness and literacy. The first four parts of the chapter are organised according to the type of phonological awareness that is under focus: (1) syllable awareness; (2) rhyme awareness; (3) alliteration awareness; and (4) phoneme awareness. The fifth part of the chapter describes the results of factor analysis and multiple regression analysis for data from the study.

5.1 Relationships between Syllable Awareness and Literacy

Overview of Part One

This section discusses relationships between syllable awareness and literacy. The largest significant correlations between syllable awareness and literacy were from syllable awareness at the beginning of the study to measures of literacy at the next test time and at the end of the first and second years of school. Controlling for receptive vocabulary skills or letter-name knowledge made little difference to the size of these correlations. An explanation for the connection between early syllable awareness and literacy is that syllable awareness may provide an indication of the ability of children to pay attention to the sound structure of words.

5.1.1 Concurrent and Predictive Correlations Between Syllable Awareness and Literacy

As nearly all children were at ceiling level on TAAS-Syllables at Time 4, correlations with this measure were calculated only for Times 1 to 3. Concurrent correlations between TAAS-Syllables and Burt Read were small but significant at

Time 2 (r = .39) and Time 3 (r = .37) (Appendix E: Table 1). A significant correlation was also found with word spelling at Time 2 (r = .37) (Appendix E: Table 3). Controlling for PPVT-R, Digit Span or letter knowledge usually resulted in small reductions in the size of these correlations but this often reduced the correlations to nonsignificant levels (Appendix E: Tables 1 and 3). In the first half of the first year, children were scoring at low levels on the pseudoword tasks. During this time the correlations between TAAS-Syllables and pseudoword measures were all low and nonsignificant (Appendix E: Tables 4 and 5).

TAAS-Syllables at Times 1, 2 and 3 was often significantly correlated with later measures of literacy[25] (Appendix E: Tables 6 - 9). The predictive correlations from TAAS-Syllables at Time 1 are of particular interest as all children were nonreaders at this time. TAAS-Syllables at Time 1 was significantly correlated with each literacy measure (word reading and spelling, pseudoword reading and spelling) at the next test time, at the end of the first year, and at the end of the second year (r ranged from .34 to .56). Most predictive correlations were little affected by adjusting for PPVT-R and usually showed only small reductions when letter-name knowledge was controlled.[26]

The results are consistent with the findings of Fletcher-Flinn and Snelson (1997) Lundberg et al. (1980), and Mann and Liberman (1984) and suggest an advantage for children who have syllable awareness prior to school, or soon after starting school. Syllable awareness is generally regarded as the most accessible form of phonological awareness. The value of early syllable awareness for predicting later literacy may be because it is an indication of children's ability to attend to the sound structure of speech, and not just its meaning. Adams (1990) suggests that syllable awareness may be a step along the way to phoneme awareness.

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[25] Predictive correlations were not made to Burt Read Phonemes. It was decided not to include predictive correlations to Burt Read Phonemes as this measure was very highly correlated with Burt Read (a minimum r of .96 in the first year). Concurrent correlations between measures of phonological awareness and Burt Read Phonemes were very similar to the correlations with Burt Read. Some differences were found from the end of Year One as ceiling effects started to impact on the Burt Read Phoneme measure.

[26] Digit span was not controlled in the predictive correlations but was controlled in the concurrent correlations between each measure of phonological awareness and literacy. Controlling for Digit Span usually made little difference to the size of these correlations.

The connection between syllable awareness and literacy can be examined in relation to the Knowledge Sources account of reading (Thompson et al., 1996). The Knowledge Sources account suggests that reading experience enables children to form induced sublexical relations that can then be used to help identify unknown print words. Thompson et al. pointed out that awareness of phonemes, and onset and rime units, may facilitate the development of induced sublexical relations. The Knowledge Sources Account does not specifically mention syllable awareness, perhaps because the research evidence for this theory has focused on single syllable words. However it is possible that an early awareness of syllables would assist children in developing induced sublexical relations when encountering multisyllabic words. Thompson et al. noted that beginning readers may not have developed a complete awareness of phonemes but may be sensitive to single consonant phonemes (i.e., a "singleton" onset)[27] at the start of one syllable words. A child who is able to divide a multisyllabic word into syllables may be able to recognise more than one singleton onset and will therefore have an advantage in comparison to a child who does not have syllable awareness.

[27] See the description of onsets in Section 2.2.1.

5.2 Relationships between Rhyme Awareness and Literacy

Overview of Part Two

This section explores relationships between rhyme awareness and literacy by first examining concurrent correlations between measures, and then examining predictive correlations from rhyme awareness to literacy and from literacy to rhyme awareness.

Some significant concurrent correlations were found between rhyme awareness and word reading and spelling in the first year of the study. Controlling for receptive vocabulary skills or phonological memory made little difference to the size of these correlations but they were often reduced to nonsignificant levels when letter-name knowledge was taken into account.

Rhyme awareness at the start of the study was not significantly correlated with word reading at the end of the first or second year. However, it was significantly correlated with word reading after several months of school, and with some of the other measures of first year literacy. These correlations generally remained significant after partialling out receptive vocabulary skills but were usually reduced to nonsignificant levels when letter-name knowledge was controlled for.

Correlations from rhyme awareness to word reading at the next test time were nearly always smaller than the comparable correlations from word reading to rhyme awareness at the next test time, but the differences between the comparable correlations were not significant. Little difference was found between the size of the correlations from rhyme awareness to word spelling at the next test time compared to the correlations from word spelling to rhyme awareness at the next test time. The finding of significant correlations from rhyme awareness to literacy and from literacy to rhyme awareness indicates that it is important to consider relationships in both directions when investigating connections between phonological awareness and literacy.

5.2.1 Concurrent Correlations between Rhyme Awareness and Literacy

Concurrent correlations between rhyme awareness and Burt Read and Burt Spell Phonemes were all significant at Times 2, 3, and 4 (Appendix F: Tables 1 & 3). Correlations at these times ranged from .34 to .59 and showed similar values for reading and spelling at each time. After Time 4 there was a decline in the size of correlations that may have been due to increasing ceiling effects for the rhyme awareness measure. Correlations with pseudoword reading and spelling were low and nonsignificant at all times except Time 4 (Appendix F: Tables 4 and 5). The low correlations, (ranging from -.05 to .26 except at Time 4), may have been due to the occurrence of floor effects for the pseudoword measures in the first half of the year and ceiling effects for the rhyme awareness measure in the second half of the year. Only at Time 4, when both rhyme and pseudoword measures show a reasonable spread of scores, were significant correlations found (r = .35 and .37 for pseudoword reading and spelling respectively).

Controlling for receptive vocabulary skills made little difference to the size of the correlations between rhyme awareness and reading or spelling (Appendix F: Tables 1 - 5). Controlling for Digit Span also usually made little difference. The largest declines in correlations between rhyme awareness and literacy were generally seen when letter-name knowledge was controlled for. This resulted in a number of significant correlations being reduced to nonsignificant levels.

5.2.2 Predictive Correlations from Rhyme Awareness to Literacy

Predictive correlations from rhyme awareness to later reading and spelling were mostly nonsignificant, even before controlling for PPVT-R, Digit Span, or letter-name knowledge (Appendix F: Tables 35 6 - 9). Correlations with literacy measures at the end of the first year were generally higher than for the end of the second year, but were still mostly nonsignificant.

No significant correlations were found between rhyme awareness at Time 1 and Burt word reading at the end of the first or second years. This finding is of particular interest because Time 1 was the only time in the study that rhyme awareness was measured before the children had begun to read. The absence of a

significant correlation between rhyme awareness at school entry, and word reading after one or two years of schooling, does not provide support to studies that have proposed a connection between early rhyme awareness and the acquisition of reading skills (e.g., Bradley and Bryant, 1983; Lundberg et al., 1980).

On the other hand, some support for a connection between rhyme awareness and literacy is available from the correlations that exist from rhyme awareness at Time 1 to literacy measures a short time later. Rhyme awareness at Time 1 was significantly correlated with all literacy measures at Time 2: word reading ($r = .41$), word spelling ($r = .57$), pseudoword reading ($r = .38$), and pseudoword spelling ($r = .37$). All correlations except with word reading, remained significant after controlling for PPVT-R or Letter Name.

Time 1 rhyme awareness also showed some significant predictive correlations over longer periods of time. Significant correlations were found from rhyme awareness at Time 1 to word spelling ($r = .37$) and pseudoword reading ($r = .37$) at the end of the first year. These correlations remained significant after controlling for PPVT-R, but not after controlling for Letter Name.

The largest correlations between rhyme awareness and later literacy occurred when there was only a small interval between the assessment of rhyme awareness and the assessment of literacy. Rhyme awareness at Times 1 to 4 was always significantly related to word reading at the next test time (r ranged from .39 to .44). Correlations were even stronger for word spelling from Times 1 to 3 (where r ranged from .44 to .57). Controlling for receptive vocabulary skills had little effect, but partialling out the influence of letter-name knowledge reduced most of these correlations to nonsignificant levels. Correlations from rhyme awareness to pseudoword measures at the next test point were mostly small and nonsignificant. Floor effects for the pseudoword tasks may have contributed to this finding.

In summary, significant correlations between rhyme awareness and later measures of literacy were found on a limited number of occasions, particularly over short time intervals. Partialling out the influence of receptive vocabulary skills usually made little difference to the size of these correlations, but partialling out letter-name knowledge reduced them to nonsignificant levels in nearly all cases.

5.2.3 Predictive Correlations from Literacy to Rhyme Awareness

Burt Reading from Times 2 to 5, and Burt Spelling from Times 2 to 4, were all significantly correlated with rhyme awareness at the next test time, and at the end of the first year (*r* was often above .50). (Appendix F: Tables 10 and 11). Most of these correlations remained significant after partialling out PPVT-R or Letter Name. Correlations from the pseudoword measures were smaller than for the word measures. All but one of the correlations from pseudoword reading or spelling to later measures of rhyme awareness were nonsignificant (Appendix F: Tables 12 and 13). Floor effects for the pseudoword measures, especially in the first half of the year, may have contributed to this pattern of results.

5.2.4 Cross-Lagged Correlations for Rhyme Awareness and Literacy

Cross-lagged correlational analysis (Kenny, 1979) was used to compare the correlations from rhyme awareness to word reading and spelling with the correlations from word reading and spelling to rhyme awareness.[28] The cross-lagged technique cannot determine causal direction (Cook and Campbell, 1979; Rogosa, 1980) but can provide a useful way of examining correlational patterns (see the discussion of cross-lagged correlational analysis in Section 3.7).

5.2.4.1 Cross-Lagged Correlations for Rhyme Awareness and Word Reading

Figures 5.2 and 5.3 show that the correlations from reading to rhyme are nearly always higher than the equivalent correlations from rhyme to reading. This applies to the unadjusted correlations and to the correlations where Letter Name is controlled[29]. Unadjusted correlations from rhyme awareness during the first year to reading at the

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[28] Cross-lagged correlational analysis was not used with the pseudoword measures. Many children had scored at low levels on the pseudoword measures during the first year.

[29] PPVT-R was not controlled in the cross-lagged analysis as it was found to make little difference to the size of the predictive correlations from rhyme awareness to literacy, or from literacy to rhyme awareness (see Appendix F, Tables 6, 7, 10, & 11).

next test time ranged from .19 to .41 The equivalent correlations from reading to rhyme awareness ranged from .36 to .51.

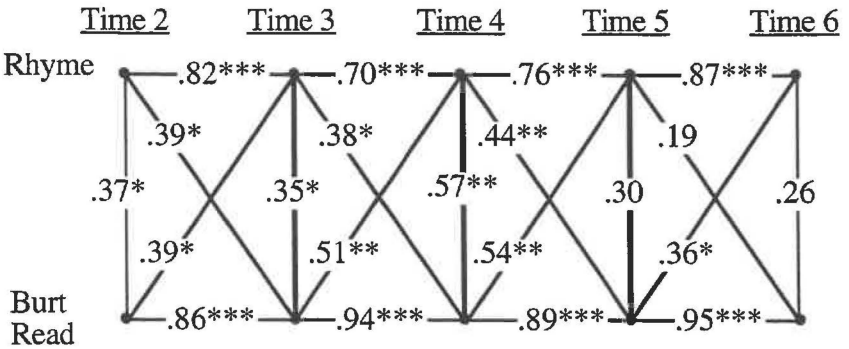


Figure 5.1. Cross-Lagged correlations between Rhyme Categorization and Burt Read. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

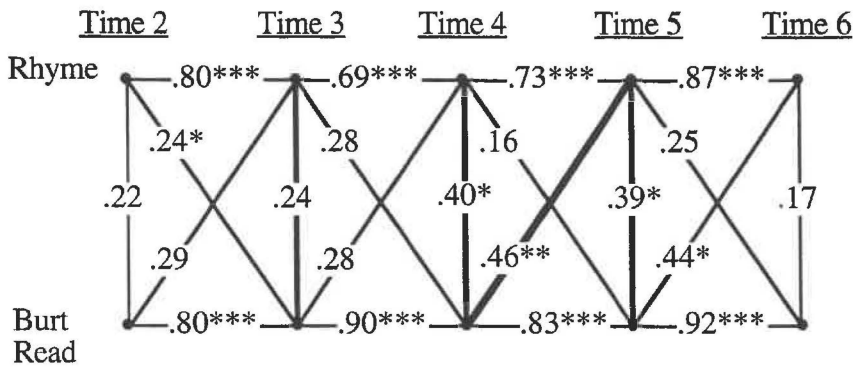


Figure 5.2. Cross-Lagged correlations between Rhyme Categorization and Burt Read: adjusted for Letter Name. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

Although the results appear to suggest that the connection from reading to later rhyme awareness is more important than the connection from rhyme awareness to later reading, the only significant difference between converse pairs of correlations was that, after controlling for letter-name knowledge, the correlation from Burt Read at Time 4 to Rhyme Categorization at Time 5 was significantly higher than the correlation from Rhyme Categorization at Time 4 to Burt Read at Time 5.[30] However, the results do show that the connection from reading to later rhyme awareness is, on the face of it, no less plausible than the oft-posited connection from

[30] The formula developed by Raghunathan, Rosenthal, and Rubin (1996) was used to test for significant differences between converse correlations [one tailed tests].

rhyme to later reading.[31] The findings of the current study reinforce the importance of examining the possibility of relationships in both directions when investigating connections between rhyme and reading. Past studies have generally neglected to do this. When earlier studies have talked of reciprocal relationships between phonological awareness and literacy, they have usually been referring to the notion that rhyme awareness may be causally related to literacy acquisition, whereas phoneme awareness may be a consequence of literacy acquisition (see the discussion in Section 2.2.5 of the Literature Review).

5.2.4.2 Cross-Lagged Correlations for Rhyme Awareness and Word Spelling

Figures 5.3 and 5.4 show the cross-lagged correlations for rhyme awareness and word spelling. There is generally little difference between the correlations in either direction, whether unadjusted or adjusted for Letter Name. The only significant difference between converse pairs of correlations was that, after adjusting for Letter Name, the correlation from Burt Spell Phonemes at Time 4 to Rhyme at Time 5 was significantly larger than the correlation from Rhyme Categorization at Time 4 to Burt Spell Phonemes at Time 5.

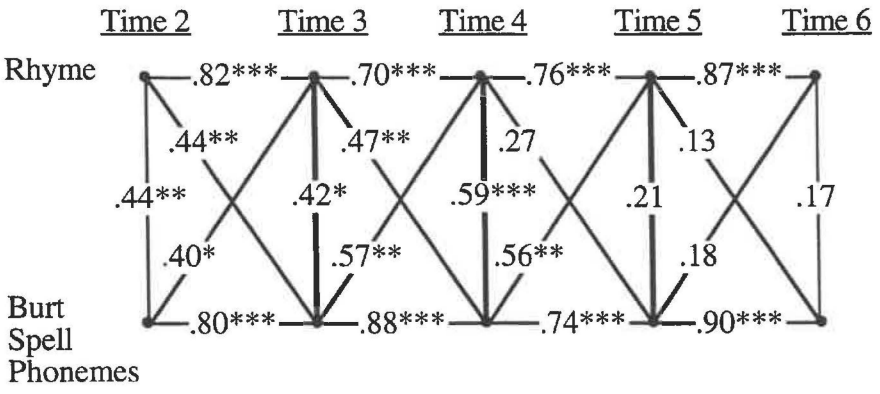


Figure 5.3. Cross-Lagged correlations between Rhyme Categorization and Burt Spell Phonemes. Times 2 - 6, $n = 29$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .0005$ (one tailed tests).

[31] See Section 2.2.3.2.1 of the Literature Review for discussion of studies that suggest a connection from rhyme awareness to reading.

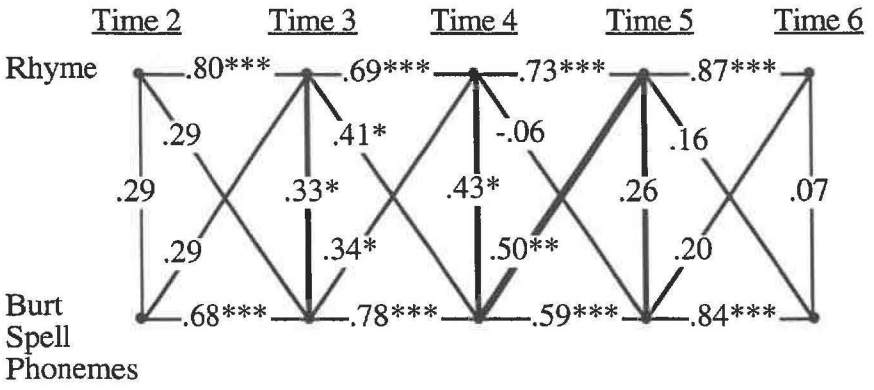


Figure 5.4. Cross-Lagged correlations between Rhyme Categorization and Burt Spell Phonemes: adjusted for Letter Name. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

5.3 Relationships Between Alliteration Awareness and Literacy

Overview of Part Three

This section examines relationships between alliteration awareness and literacy. The discussion first examines concurrent correlations between the measures and then examines predictive correlations from alliteration awareness to literacy, and from literacy to alliteration awareness.

Concurrent correlations between alliteration awareness and measures of literacy were not significant until near the end of the first year of the study. These correlations showed little change after partialling out receptive vocabulary skills or phonological memory but were usually reduced to nonsignificant levels when letter-name knowledge was controlled.

Predictive correlations from alliteration awareness to later measures of literacy were mostly nonsignificant. Larger correlations, a number of which were significant, were found from literacy measures to later alliteration awareness. However, the differences between the comparable correlations in each direction were seldom significant. Correlations in both directions showed little change after controlling for receptive vocabulary skills but showed greater reductions when letter knowledge was taken into account.

5.3.1 Concurrent Correlations between Alliteration Awareness and Literacy

Concurrent correlations between alliteration awareness and measures of literacy were generally small and nonsignificant from Times 2 to 4 (r was usually in the range of .20 to .35) but slightly higher, and nearly always significant, at Times 5 and 6 (mostly ranging from .32 to .44. Appendix G: Tables 37 1 - 5).

The patterns seen when controlling for the influence of other variables on correlations between alliteration awareness and literacy were similar to that found for rhyme awareness and literacy. Controlling for PPVT-R or Digit Span usually made little difference to the size of the correlations but partialling out the influence of Letter Name generally resulted in larger reductions in the correlations.

Controlling for Letter Name reduced nearly all of the significant correlations to nonsignificant levels.

5.3.2 Predictive Correlations from Alliteration Awareness to Literacy

Predictive correlations from alliteration awareness to later measures of literacy were mostly low in value and nonsignificant, even before controlling for PPVT-R or Letter Name (Appendix G: Tables 6 - 9). At Time 1, when all children were nonreaders, alliteration awareness was significantly correlated with Burt Spell Phonemes at Time 2 (r = .40) but not with any other literacy measures at this time, nor at the end of first or second years. The correlation with Burt Spell Phonemes remained significant after partialling out Letter Name.

Burt Spell Phonemes was the literacy measure that alliteration awareness most frequently showed a significant predictive correlation with. On 4 of the 6 test times during the first year, alliteration awareness was significantly correlated with Burt Spell Phonemes at the next test time (correlations ranged from .16 to .40). Most significant correlations remained significant after partialling out Letter Name (Appendix G: Table 7). Alliteration awareness showed lower correlations with word reading at the next test time than with word spelling at the next test time. Correlations from alliteration awareness to word reading at the next test time ranged from .03 to .28 except for Time 5 where a significant correlation of .43 was found. This correlation remained significant after controlling for PPVT-R but not after controlling for Letter Name (Appendix G: Table 6).

Unadjusted correlations from alliteration awareness to pseudoword measures at the next test time were significant only from Time 5 for pseudoword spelling (r = .32) and from Times 5 and 6 for pseudoword reading (r = .49 and .43 respectively). These correlations were virtually unchanged by controlling for PPVT-R but showed a greater reduction when adjusted for Letter Name (Appendix G: Tables 7 and 8).

5.3.3 Predictive Correlations from Literacy to Alliteration Awareness

A number of significant correlations were found from reading and spelling to later alliteration awareness, particularly in the second half of the first year (Appendix G:

Tables 10 - 13). Most predictive correlations from the literacy measures to alliteration awareness at the next test time or at the end of the first year were significant (*r* ranged from .23 to .59). These correlations showed greater reductions after controlling for Letter Name than after controlling for PPVT-R, but often remained significant in both instances.

5.3.4 Cross-Lagged Correlations for Alliteration Awareness and Literacy

5.3.4.1 Cross-Lagged Analysis for Alliteration Awareness and Word Reading

Figures 5.5 and 5.6 present cross-lagged correlations for alliteration awareness and Burt Read.[32] There was no consistent advantage of correlations in one direction over the other. However, three of the four correlations (adjusted for Letter Name), from Burt Read to alliteration awareness were higher than the converse correlations from alliteration awareness to Burt Read. Only one of the differences between converse pairs of correlations was significant. The unadjusted correlation from Burt Read at Time 4 to Alliteration Categorization at Time 5 was significantly higher than the correlation from Alliteration Categorization at Time 4 to Burt Read at Time 5.

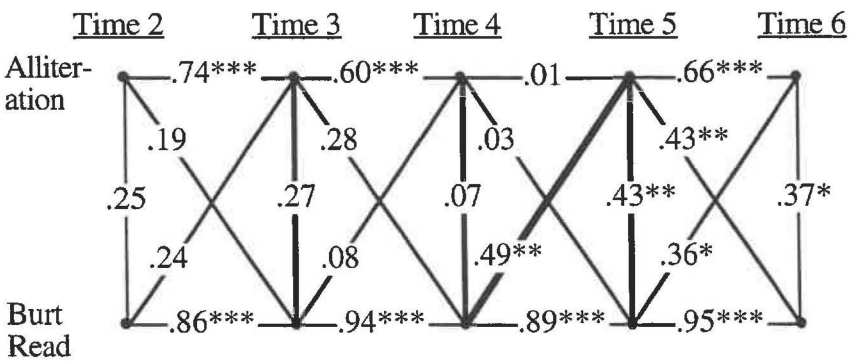


Figure 5.5. Cross-Lagged correlations between Alliteration Categorization and Burt Read. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

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[32] PPVT-R was not controlled in the cross-lagged analysis as it was found to make little difference to the size of the predictive correlations from alliteration awareness to literacy, or from literacy to alliteration awareness (see Appendix F, Tables 6, 7, 10, & 11).

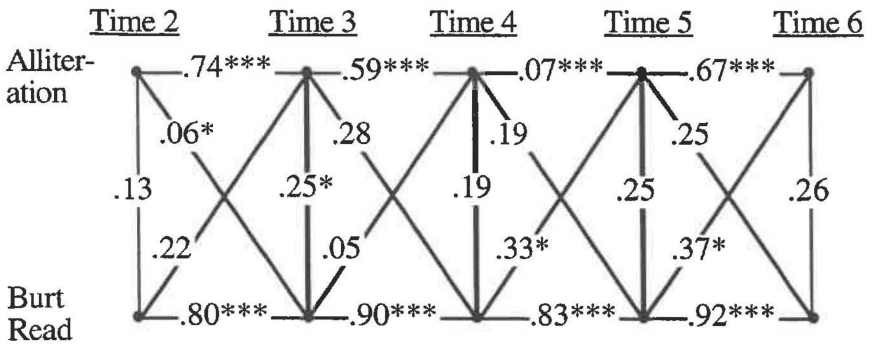


Figure 5.6. Cross-Lagged correlations between Alliteration Categorization and Burt Read: adjusted for Letter Name. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

5.3.4.2 Cross-Lagged Analysis for Alliteration Awareness and Word Spelling

Cross-lagged correlations for alliteration awareness and word spelling are shown in Figures 5.7 and 5.8. No clear advantage can be seen for one direction over the other. On two occasions correlations (unadjusted or adjusted for Letter Name) were larger from word spelling to alliteration awareness than from alliteration awareness to spelling. On the two other occasions the opposite pattern was found. The only significant difference between converse pairs of correlations was that the correlation from word spelling at Time 4 to Alliteration Categorization at Time 5 was significantly higher than the correlation from Alliteration Categorization at Time 4 to word spelling at Time 5. The significant difference was found for unadjusted correlations but not after controlling for Letter Name.

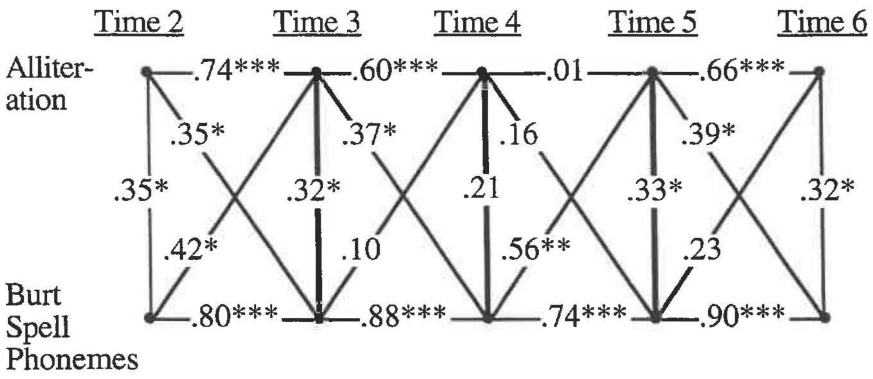


Figure 5.7. Cross-Lagged correlations between Alliteration Categorization and Burt Spell Phonemes. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

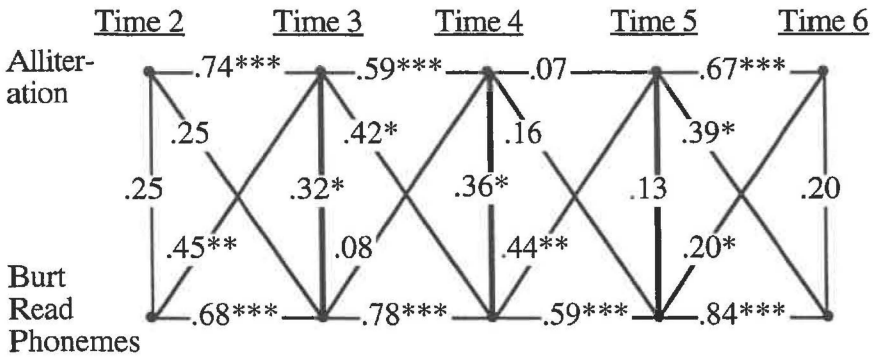


Figure 5.8. Cross-Lagged correlations between Alliteration Categorization and Burt Spell Phonemes: adjusted for Letter Name. Times 2 - 6, $n = 29$. $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

5.4 Relationships Between Phoneme Awareness and Literacy

Overview of Part Four

This section investigates relationships between phoneme awareness and literacy. Concurrent correlations are first considered, followed by an examination of predictive correlations from phoneme awareness to literacy, and from literacy to phoneme awareness. As two tasks - deletion and tapping - were used to assess phoneme awareness, each section of Part Four is further divided into three subsections. The first subsection describes the results pertaining to the deletion task. The second subsection describes the results pertaining to the tapping task. The third subsection contains a general discussion of the overall results for both measures of phoneme awareness.

Concurrent correlations between measures of phoneme awareness and literacy were often significant. They generally showed little reduction when receptive vocabulary skills or phonological memory were controlled for. Larger reductions occurred when letter-sound knowledge was controlled for. This finding emphasises the importance of taking letter knowledge into account in order to check that a significant correlation between phoneme awareness and literacy is not simply a reflection of the common association of these variables with letter knowledge.

Rhyme and alliteration awareness were also controlled for in the concurrent correlations. These controls showed that the correlations between phoneme awareness and literacy were largely independent of any variance that was explained by awareness of rhyme or alliteration.

Phoneme tapping scores at the start of the study, when all children were nonreaders, were significantly correlated with some of the measures of literacy that were made after the children had been at school for several months. This finding supports the notion that the phoneme awareness skills that children have before they begin to read facilitate the acquisition of literacy skills. Some caution, however, is needed when interpreting this result. The predictive correlations were significant only over a short time period and most children initially scored at very low levels on the tapping task. Children were unable to score on the other measure of phoneme awareness - the deletion task - until later in the first year at school by

which time they had begun to read. The differences in early performance of the two phoneme awareness tasks suggests that performance on the tapping task may have been influenced by factors apart from phoneme awareness, such as attention to speech duration cues.

Children's scores on both phoneme awareness tasks increased after the first half of the first year of the study. From this time forward, there were a number of significant predictive correlations from phoneme awareness scores to measures of literacy. Controlling for receptive vocabulary skills, rhyme awareness, or alliteration awareness made little difference to the size of these correlations. Controlling for letter-sound knowledge usually resulted in larger reductions.

Many of the correlations from measures of literacy to later phoneme awareness were significant. These findings provide support for the suggestion that phoneme awareness may be a consequence of literacy skills. Of special interest are the correlations made from literacy measures taken at a time before children had begun to score on the phoneme deletion task. These early literacy measures were significantly correlated with later performance on the deletion task. Because children were not scoring on the deletion task at the time that these predictor measures of literacy were made, their prior performance on the deletion task does not need to be considered as a confounding variable.

Receptive vocabulary skills, rhyme awareness, or alliteration awareness made little difference to the size of the correlations from literacy skills to phoneme awareness. Larger reductions were found when letter-sound knowledge was controlled, especially in the second year of the study.

Predictive correlations from literacy to phoneme awareness were of a similar size, or occasionally significantly larger, than the comparable correlations from phoneme awareness to literacy. These findings are consistent with there being a reciprocal relationship between literacy and phoneme awareness.

5.4.1 Concurrent Correlations between Phoneme Awareness and Literacy

5.4.1.1 Concurrent Correlations between TAAS-Phonemes and Literacy: Results

No correlations were calculated for TAAS-Phonemes and Literacy for the first three test times as no children were scoring on the TAAS-Phonemes task at Times 1 and 2, and only one child was scoring at Time 3. Four children showed positive scores on the TAAS-Phonemes task at Time 4. These four children also showed advanced literacy skills at Time 4 and there were moderately high and significant unadjusted correlations between TAAS-Phonemes and reading and spelling at this time (*r* ranged from .53 to .74 depending on the particular measure of literacy). As more children began to score on the TAAS-Phonemes task (six children at Time 5 and nine children at Time 6) there was a decline in the value of the correlations with literacy (At Time 6, *r* ranged from .27 to. 55 depending on the measure of literacy). The correlations increased during the second year where there was a continuing increase in the number of children scoring on the task, (14 at Time 7, 16 at Time 8, and 20 at Time 9). All unadjusted concurrent correlations between TAAS-Phonemes and each measure of literacy in the second year were significant (*r* ranged from .38 to .74). (Appendix H: Tables 1 - 5.)

No child began to score on the TAAS-Phonemes task until he or she was able to read a number of words on the Burt word reading test. An examination of scores for individuals showed that two children were reading from 5 to 7 words on Burt Read when they first began to score on the TAAS-Phonemes task. Eighteen other children were reading at least 11 words when they first succeeded on the TAAS-Phonemes task. The remaining children who were still in the study at the end of the second year never gained a positive score on the task. (Final scores on Burt Read for these children ranged from 10 - 28.)

Unadjusted concurrent correlations between TAAS-Phonemes and word reading (*r* ranged from .27 to .53) were less than the correlations between TAAS-Phonemes and word spelling (*r* ranged from .50 to .64) (Appendix H: Tables 1 and 3). The correlations between TAAS-Phonemes and word reading were also less than the correlations between TAAS-Phonemes and pseudoword reading (*r* ranged from .38 to .74) (Appendix H: Table 4). Unadjusted correlations between TAAS Phonemes and pseudoword reading were mostly about the same size as the correlations

between TAAS-Phonemes and pseudoword spelling (*r* ranged from .52 to .70) (Appendix H: Table 5).

Controlling for PPVT-R, Digit Span, Rhyme Awareness, or Alliteration Awareness usually made little difference to the size of the concurrent correlations between TAAS-Phonemes and measures of literacy (Appendix H: Tables 1 -5). A larger reduction was seen when letter-sound knowledge was taken into account. For example, five of the six unadjusted concurrent correlations between TAAS-Phonemes and word reading were significant, but after partialling out the influence of letter-sound knowledge only two of these correlations remained at significant levels. (Letter-sound knowledge was used as the controlling variable because letter-name knowledge, which had been used as the controlling variable for rhyme awareness and alliteration awareness during the first year was at ceiling level for most children during the second year.)

5.4.1.2 Concurrent Correlations between Phoneme Tapping and Literacy: Results

Although mean scores were very low for Tapping and for measures of literacy at Time 2, the occurrence of some high correlations at this time indicates that the children who were able to perform at higher levels on the Tapping measure were more likely to be among the small group of children who had begun to score on the word spelling ($r = .53$), and pseudoword reading ($r = .71$) and spelling ($r = .58$) measures (Appendix H: Tables 6 - 10). Similar to the pattern seen for TAAS-Phonemes, there was a decline in the size of correlations between Tapping and the spelling and pseudoword measures towards the end of the first year (- at Time 6 these correlations ranged from .24 to .39). This was followed by a rise in correlations during the second year. (At Time 9 these correlations ranged from .56 to .67).

Early correlations (Times 2 to 4) between tapping and Burt Read were small and nonsignificant (*r* ranged from .14 to .24) (Appendix H: Table 6). This result is similar to the pattern that was seen for TAAS-Phonemes where concurrent correlations with word reading were also generally lower than for the other literacy measures.

As was found for TAAS-Phonemes, controlling for PPVT-R, Digit Span, rhyme awareness, and alliteration awareness, usually made little difference to the size of

the concurrent correlations between TAAS-Phonemes and measures of literacy (Appendix H: Tables 6 - 10). Also similar to the results for TAAS-Phonemes was the finding of a larger reduction in correlations when Letter Sound was controlled for.

5.4.1.3 Concurrent Correlations between Phoneme Awareness and Literacy: Discussion

Concurrent correlations between phoneme awareness and literacy could be calculated from Time 2 for Tapping, but not until Time 4 for the TAAS-Phonemes measure. This was because children showed a range of scores on Tapping from the start of the study, but only one child could succeed on TAAS-Phonemes before Time 4. Differences in early performance levels for the two phoneme awareness tasks can be seen in Figure 5.9. The graph also shows the development of children's Burt Read scores during the study period. However, because the graph shows only mean scores it does not reveal the minimum score that individual children showed on the Burt Read test at the time they first succeeded on the TAAS-Phonemes task. An examination of individual scores (as described in Section 5.4.1.1) showed that no child could score on the TAAS-Phonemes task until after he or she could read a number of words. This finding is consistent with performance on this measure of phoneme awareness being a consequence of learning to read.

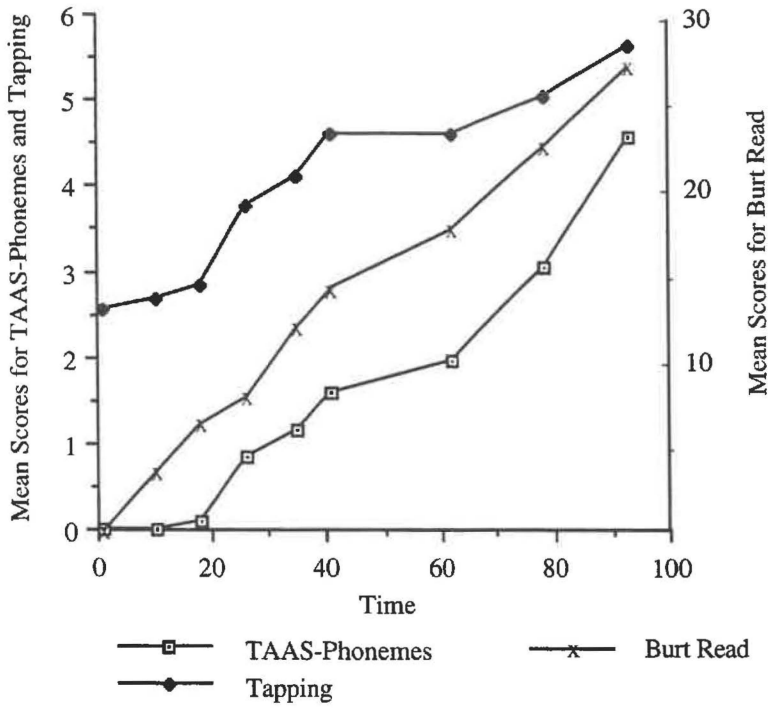


Figure 5.9. Changes in mean scores for TAAS-Phonemes, Tapping, and Burt Read.

From Time 4 on, there were often large differences between the size of the correlations found for TAAS-Phonemes and literacy at a particular time, and the correlations of Tapping and Literacy at the same time (see Appendix H: Tables: 1 - 10) The differences between the correlations were less during the second year, especially at Times 8 and 9. The move towards greater similarity of correlations between TAAS-Phonemes and literacy, and Tapping and literacy, is similar to the general pattern of increased correlation between the TAAS-Phonemes task and the Tapping task as the study progressed (Appendix D: Table 14).

Although there were differences in correlations with reading for TAAS-Phonemes and Tapping in the present study, neither of the measures showed consistently higher correlations than the other. In other correlational studies that used both phoneme deletion tasks (with similarities to TAAS-Phonemes) and counting tasks (with similarities to Tapping) the deletion tasks have shown higher correlations with reading (Leather and Henry, 1994: Lenchner et al., 1990). The difference in results between the present study and the other studies may have been linked to the older age of the participants in the other studies. It is also possible that the different pattern of findings was linked to specific characteristics of the measures that were used in the different studies.

Correlations for TAAS-Phonemes and for Tapping were frequently lower with Burt Reading than with the other measures of literacy, especially in the first year of the study. Although the differences between the correlations with the various literacy measures were usually small, the general pattern of results fits with the notion that phoneme awareness skills are particularly important for literacy tasks that are most dependent on phonological recoding, either from letter-to-sound or from sound-to-letter. (Hansen and Bowey, 1994; McDougall et al., 1994). Phoneme awareness skills are important for phonological recoding because they may assist children to develop induced sublexical relations, that is, stored memory connections of the relations between letters and sounds in words. Phoneme awareness skills may also be useful for phonological recoding by helping children to make connections between the sound labels of letters and the phonemes they represent.[33] (see Thompson, 1999; Thompson et al., 1996). Phonological recoding is necessary for performing the pseudoword tasks and is also important for word spelling, especially for unfamiliar words. Word reading, however, is less dependent on phonological recoding because familiar words can be read by "recall" without the need to make use of letter-sound information for phonological recoding.

If phoneme awareness skills are most important for tasks requiring phonological recoding, it might be expected that phoneme awareness would show higher correlations with pseudoword spelling than with word spelling. This is because children are able to make use of visual (i.e., orthographic memory) and phonological strategies for the spelling of familiar words but are more dependent on phonological strategies alone for pseudoword spelling (Castles, Holmes, and Wong, 1997). In the current study, however, there was no clear pattern of higher correlations between phoneme awareness and pseudoword reading than between phoneme awareness and pseudoword spelling. This may have been because the word spelling test contained many words whose spelling the children were unfamiliar with. When attempting to spell unfamiliar words children may have tried to write down the sounds they could hear, a technique that is encouraged in New Zealand classroom programmes (Department of Education, 1985). They may have used the same "invented spelling" approach when attempting to write the pseudowords. Use of the same strategy to spell unfamiliar words and pseudowords may explain the lack of difference in the correlations between phoneme awareness and word spelling, and phoneme awareness and pseudoword spelling.

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[33] See the discussion of the Knowledge Sources account of reading in Section 2.3.4.

Controlling for receptive vocabulary skills (PPVT-R) usually resulted in only a small reduction to the size of the correlations between either of the phoneme awareness tasks and the measures of literacy during the first year (Appendix H: Tables 1 - 10). Other studies have reported mixed findings in relation to the effect of ability factors on connections between phoneme awareness and literacy. Some research has found that controlling for ability factors has little effect (see, for example, Wagner and Torgesen's (1987) re-analysis of the work of Mann (1984) and Lundberg et al. (1980). Other studies have found that controlling for ability factors can eliminate otherwise significant correlations between phoneme awareness and literacy (e.g., Ellis & Large, 1988; Rohl & Pratt, 1995). Disagreement between studies may be due to differences in task and subject characteristics and study design. Although studies should always check for the possible effects of ability on the connection between phoneme awareness and literacy, the results may depend on the specific characteristics of assessment tasks, and the phonological and cognitive skills of the children at the time of testing.

Controlling for Digit Span made little difference to the size of the concurrent correlations between measures of phoneme awareness and literacy (Appendix H: Tables 1 - 10). Almost all significant correlations remained significant after taking account of Digit Span.

Some earlier correlational studies found that measures of phonological memory were able to explain variance in word reading skills that was additional to that explained by phoneme awareness measures (Hansen & Bowey, 1994; Leather & Henry, 1994). This possibility was not tested in the current study as the correlation between Digit Span and reading was nearly always nonsignificant, even before controlling for phoneme awareness. It is possible that the difference between the findings of the earlier studies and the current study was due to the older age (mean age =7 years 5 months) and associated higher reading levels of the participants in the earlier studies. Links between phonological memory, phoneme awareness, and reading may be more apparent in children who are older and have higher reading levels than in the present study. Another possible explanation for differences in findings is the differences in the tasks used to assess particular variables. The specific characteristics of particular tasks will affect the amount of variance they display in common with other tasks.

Letter Sound, rather than Letter Name, was used as the controlling variable to examine the influence of letter knowledge on the concurrent correlations between

phoneme awareness and literacy. The early ceiling effects for Letter Name meant that it was inappropriate to use it as a controlling variable for the full length of the study.

Compared to controlling for PPVT-R or Digit Span, adjusting for Letter Sound resulted in larger reductions to the correlations between phoneme awareness and literacy (Appendix H: Tables 1 - 10). The effect of controlling for Letter Sound meant that a number of significant correlations between measures of phoneme awareness and literacy were reduced to nonsignificant levels (especially for Burt Read). For example, from Time 5 on, all unadjusted correlations between Tapping and Burt Read were significant, but only one of these remained significant after controlling for Letter Sound.

The findings of the current study on the influence of controlling for letter knowledge emphasise the importance of taking this variable into account when examining relationships between phoneme awareness and literacy. As was noted in the Literature Review, most studies in this area have not considered the possible influence of letter knowledge. In such studies it is possible that a significant connection between phoneme awareness and literacy may simply be a reflection of the common association of these variables with letter knowledge.

Assessing letter knowledge in a study of phoneme awareness and literacy also allows for an examination of whether the interaction of letter knowledge and phoneme awareness skills explains more variance in literacy achievement than is explained by the combination of the separate effects of the two variables. Two previous studies found evidence to support this possibility. Tunmer et al. (1988) found that the product of letter identification and phoneme segmentation skills at the end of Grade 1 was able to explain significant additional variance in pseudoword reading beyond that which was explained by the sum of each variable. Muter et al. (1997) made a similar finding for word reading at the end of the Grade 2. In addition, Muter et al. found that the interaction of letter identification and phoneme segmentation skills made a greater contribution to word spelling at the end of Grade 2 than was the case for reading.

Analyses in the current study made use of stepwise regression to examine whether an additional interactive effect of letter-name or letter-sound knowledge and

phoneme awareness existed for Burt Reading and Burt Spelling[34] (Appendix H: Tables 11 - 14). Although letter knowledge and phoneme awareness measures were often able to explain significant variance in Burt Reading and Burt Spelling at each test time, the product of letter knowledge and phoneme awareness measures never accounted for significant additional variance. The current study therefore does not provide evidence to support the existence of an additional interactive effect of phoneme awareness and letter knowledge on reading and spelling.

The stepwise regression analyses were all in the order of (1) phoneme awareness, (2) letter knowledge, and (3) product term. Of interest in the results of these analyses is that letter knowledge (i.e., Letter Name in the first year and Letter Sound in the second year) in all but one case, (Burt Spelling at Time 9), was able to explain significant additional variance in reading and spelling to that explained by phoneme awareness.

Controlling for the influence of rhyme awareness or alliteration awareness made little difference to the size of the concurrent correlations between measures of phoneme awareness and literacy during the first year (Appendix H: Tables 1 -10). This finding shows that where phoneme awareness and literacy were significantly related in the first year of the current study, the contribution of phoneme awareness to literacy was largely independent of the variance that was explained by rhyme awareness or alliteration awareness. This differs from the findings of Hansen and Bowey's (1994) concurrent correlational study. They found that a measure of phoneme awareness and a combined measure of rhyme and alliteration awareness each explained significant variance in word and pseudoword reading, but that phoneme awareness did not explain additional significant variance if rhyme and alliteration awareness was first controlled for. One reason for the difference in findings between the current study and Hansen and Bowey's is that they used tasks that required children to carry out the same type of operation (oddity detection) in order to show rhyme and alliteration awareness and phoneme awareness. The use of tasks requiring the same type of operation may have meant that Hansen and Bowey's tasks shared more variance than in the current study where oddity detection was used to assess rhyme awareness and alliteration awareness, but different operations (deletion and segmentation) were required for performance of the phoneme awareness tasks.

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[34] Letter Name was used as the measure of letter knowledge in the first year. Letter Sound was used in the second year because of ceiling effects for Letter Name.

5.4.2 Predictive Correlations from Phoneme Awareness to Literacy

5.4.2.1 Predictive Correlations from TAAS-Phonemes to Literacy: Results

As children were unable to score on the TAAS-Phonemes task until after they had begun to read words, it was not possible to make predictive correlations from a point when children showed phoneme awareness on this task but were not yet reading.

From Time 4 on, the unadjusted predictive correlations from TAAS-Phonemes to later literacy measures were nearly all significant, and tended to increase in size during the second year (Appendix H: Tables 15 - 26). During the second year, the correlations were typically in the range or $r = .40$ to .60. Correlations with later word reading were generally less than with later word spelling measures but the differences were small. Correlations with later pseudoword measures were usually larger than found for the comparable word measures, but again the differences were small.

Controlling for PPVT-R, rhyme awareness, or alliteration awareness made little difference to the size of the correlations between TAAS-Phonemes and later literacy.[35] However, as was seen for the concurrent correlations, controlling for Letter Sound resulted in a larger decline in the size of the correlations. This meant that a number of correlations that had remained significant after controlling for PPVT-R were no longer significant after controlling for Letter Sound.

5.4.2.2 Predictive Correlations from Tapping to Literacy: Results

In contrast to the findings for TAAS-Phonemes, where no scores were recorded for the first two test times, children showed a range of scores on the tapping task at Time 1. Although there may have been a chance element in children's early performance on this task, the occurrence of a range of scores allowed for predictive correlations to

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[35] Digit Span was not controlled for in the predictive correlations between phoneme awareness and literacy. Controlling for Digit Span had made little difference to the size of the concurrent correlations between phoneme awareness and literacy (see Appendix H: Tables 1 - 10).

be made from a time when children were showing positive scores on a test of phoneme awareness, but were not yet reading words.

Correlations from Tapping at Time 1 to Burt Read at Time 2, or at the end of the first or second years, were all nonsignificant (r was less than .20 for each time) (Appendix H: Tables 27 - 29). However, correlations from Tapping at Time 1 to the other measures of literacy at Time 2 were all significant, (Burt Spell Phonemes: r = .39; Pseudoword Read Phonemes: r = .35; Pseudoword Spell Phonemes: r = .39), and nearly always remained so after adjusting for PPVT-R, rhyme awareness, alliteration awareness, or letter-name knowledge (Appendix H: Tables 30 - 38). Correlations from Tapping at Time 1 to literacy measures at the end of the first and second years were all nonsignificant.

From Time 2 to Time 6, there was only one significant unadjusted correlation from Tapping to Burt Read at the next test time or at the end of the first and second years (Appendix H: Tables 27 - 29). This correlation (from Time 5 Tapping to Time 6 Burt Read) was no longer significant after adjusting for either PPVT-R, rhyme awareness, alliteration awareness, or Letter Sound. A greater occurrence of significant correlations from Tapping at Times 2 to 6 was found for the other measures of literacy, especially for pseudoword spelling (Appendix H: Tables 30 - 38). All of the unadjusted correlations from Tapping at Times 2 to 6 were significantly correlated with pseudoword spelling at the next Test Time . For some of these test times, Tapping was also significantly correlated with pseudoword spelling at the end of the first and second years. The correlations to pseudoword spelling were mostly unaffected by adjusting for PPVT-R, rhyme awareness, or alliteration awareness, but often showed a greater reduction when Letter Sound was controlled for.

Unadjusted predictive correlations from Tapping at Times 7 and 8 to particular literacy measures at the next test time were all higher than the comparable correlations from Tapping at Time 6. All of these correlations were significant and showed only small reductions when adjusted for PPVT-R. Larger reductions were seen when Letter Sound was controlled for, reducing some of the correlations with Burt Read or pseudoword reading to nonsignificant levels. However, all correlations from Tapping at Times 7 and 8 to later measures of word Spelling or pseudoword spelling remained significant after controlling for Letter Sound.

5.4.2.3 Predictive Correlations from Phoneme Awareness to Literacy: Discussion

At the first test time, children were unable to perform the TAAS-Phonemes task but showed a range of scores on the Tapping task. The predictive correlations from Tapping at Time 1 are of special importance as all children were then nonreaders, meaning that their performance on the Tapping task could not have been influenced by their word reading skills at that stage.

Tapping at Time 1 was not significantly related to any literacy measures at the end of the first and second years (Appendix H: Tables 28, 29, 31, 32, 34, 35, 37, 38). However, some significant correlations with literacy were evident over a shorter time span (Appendix H: Tables 27, 30, 33, 36). Tapping at Time 1 was significantly correlated with three measures of literacy at Time 2: word spelling (r = .39), pseudoword reading (r = .35), and pseudoword spelling (r = .37), but not with Burt Read. The significant correlations remained significant after controlling for PPVT-R, Letter Name, rhyme awareness, or alliteration awareness.

To investigate whether significant predictive correlations from Tapping at Time 1 went beyond Time 2, correlations were also calculated for other literacy measures at Times 2 to 5 (see Appendix H: Table 39). Significant correlations were found with word spelling at Time 3 (r = .33), pseudoword reading at Time 3 (r = .42), and with Burt Read at Time 4 (r = .32). Only pseudoword reading at Time 3 remained significant after controlling for PPVT-R, Letter Name, rhyme awareness, or alliteration awareness. No significant correlations were found from Tapping at Time 1 to any measures of literacy at Time 5.

The finding of significant correlations between a measure of phoneme awareness in nonreaders and some later measures of literacy, provides support for the notion that phoneme awareness in nonreaders facilitates the acquisition of literacy skills. This finding is important because there are only two other longitudinal studies of phoneme awareness and literacy that have carefully screened their initial samples to ensure children are nonreaders (Muter et al. 1997; Rohl and Pratt, 1995). Of these two studies, Rohl and Pratt (1995) found that a phoneme tapping task was too difficult for their nonreading sample. They were therefore unable to calculate a predictive correlation from phoneme awareness until after children had begun to read. The other study, Muter et al. (1997) found that prereading segmentation was not significantly correlated with later reading or spelling (although they did find an indirect connection through later segmentation). Hence the current study appears to

be the only longitudinal investigation that has found significant correlations between a measure of phoneme awareness in nonreaders and their later achievement in literacy.

Some caution is needed, however, in interpreting the connection between prereading performance on the Tapping task and later literacy. Most children scored at very low levels on the Tapping task at Time 1 (mean score = 2.55 out of 11, SD = 1.12). No children were able to demonstrate phoneme awareness on the other measure of phoneme awareness, TAAS-Phonemes, at Time 1 or Time 2, and only one child scored on this task at Time 3. Children did not begin to score on the TAAS-Phonemes task until they could read at least 5 words on the Burt Read test. Eighteen of the 29 children in the study did not begin to score on TAAS-Phonemes until they were reading at least 11 words on the Burt Read test. The differences in performance levels between the two phoneme awareness tasks indicates that success on the tasks may be influenced by other factors apart from phoneme awareness. For example, Morais (1991b) has suggested that performance on the tapping task is affected by children's sensitivity to speech duration cues. If this is so, the task is still of interest as sensitivity to the form of speech may be important for literacy acquisition.

Children's scores on both phoneme awareness tasks increased in the second half of the first year and during the second year. There were also increases in the predictive correlations to literacy measures during this period. Differences between the size of predictive correlations from the two measures of phoneme awareness tended to become smaller during the second year and the two tasks became more highly correlated.

From Time 4 on, there were a number of significant predictive correlations from the phoneme awareness tasks to later measures of literacy. The predictive correlations were more likely to be larger for word spelling than for word reading, a similar finding to that made in other studies in this area (Cataldo and Ellis, 1988; Nation and Hulme, 1997; Muter et al, 1997). Correlations were also generally larger for the pseudoword measures than for word reading. Although the differences between correlations for different measures of literacy were often small, the overall pattern suggests that the word spelling, and pseudoword reading and spelling, of children are more likely to be affected by their prior knowledge of the sound components of words than is their early word reading. As was discussed for the

concurrent correlations of phoneme awareness and literacy[36], it may be that phoneme awareness is most important for those literacy tasks that demand phonological recoding.

The existence of predictive correlations to later literacy from phoneme awareness at Time 4 onwards is consistent with the idea that phoneme awareness facilitates the acquisition of reading and spelling. However, unlike predictions from Time 1 when all children were nonreaders, nearly all children had developed word reading and spelling skills by Time 4. It is thus possible that these correlations between phoneme awareness and literacy were a reflection of the confounding effects of prior literacy skills.

One way to try to rule out these possibly confounding effects would be to partial out literacy levels at the point from where the predictor measures of phoneme awareness are assessed. However, because each literacy measure was highly correlated from one time to the next in the current study, (see Appendix C: Tables 1-5), partialling out prior literacy may remove most of the variance from the later measure of literacy,[37] thereby greatly reducing the size of any correlations between phoneme awareness and literacy.

Other possibly confounding variables were partialled out of the predictive correlations. Controlling for PPVT-R, rhyme awareness, or alliteration awareness resulted in only small reductions in the size of the correlations between phoneme awareness and later literacy. Controlling for letter-sound knowledge generally resulted in larger reductions, meaning that a number of previously significant predictive correlations from phoneme awareness to later literacy were reduced to nonsignificant levels.

It appears that only one earlier correlational study (Muter et al., 1997) has taken account of the influence of letter knowledge on the relationship between phoneme awareness and literacy. Consistent with the findings of the current study, Muter et al. found that controlling for letter-name knowledge resulted in a substantial reduction in the size of correlations between phoneme awareness and measures of literacy near the end of the first year at school. In Muter et al.'s study the controls for letter knowledge were made only for concurrent correlations rather than also for predictive relationships as in the current study.

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[36] See Section 5.4.1.3.

[37] Assuming there were noncorrelated errors.

Taken together, the results of Muter et al.'s study and the current study, emphasise the importance of controlling for letter knowledge when examining relationships between phoneme awareness and literacy. If letter knowledge is not taken into account, then an incomplete, and somewhat misleading, picture of the relationships between phoneme awareness and literacy may be presented. Ideally studies should assess both letter-name and letter-sound skills as these areas of knowledge develop at different rates and may have different connections with phoneme awareness. Assessing letter-name and letter-sound skills in the current study allowed for the use of letter-name knowledge as the controlling variable at Time 1, when most children knew some names but no sounds. Letter-sound knowledge could then be used as the controlling variable for the rest of the study as it was much less affected by ceiling effects than was letter-name knowledge.

5.4.3 Predictive Correlations from Literacy to Phoneme Awareness

5.4.3.1 Predictive Correlations from Literacy to TAAS-Phonemes: Results

As all children were nonreaders at Time 1, predictive correlations from measures of literacy to TAAS-Phonemes cannot be made until Time 2 (Appendix H: Tables 40 - 51). From Time 2 on, nearly all of the correlations from the different measures of literacy to TAAS-Phonemes at the next test time, and at the end of the first and second years, were significant (*r* typically showed values from .40 to .60). Correlations from the spelling measures (word or pseudoword) were nearly always larger than the correlations from the respective reading measures. However, the differences between correlations were usually small. Correlations from the pseudoword reading or spelling measures were more likely to be larger than the equivalent word reading or spelling measure. However, again, the differences were small.

Controlling for PPVT-R, rhyme awareness, alliteration awareness, or Letter Sound had similar effects to those seen for the predictive correlations from TAAS-Phonemes to literacy measures. Adjusting for PPVT-R, rhyme awareness, or alliteration awareness usually made little difference to the size of the correlations, but a greater reduction was seen when adjusting for Letter Sound. This reduced a

number of previously significant correlations to nonsignificant levels (Appendix H: Tables 40 - 51).

Because children did not begin to score on the TAAS-Phonemes task until later in the first year, it was not possible to attempt to predict later literacy from a time when children showed positive scores on the TAAS-Phonemes task but had no word reading skills. It was possible, however, to examine predictions of later TAAS-Phonemes performance from a time when children had word reading skills but were not yet scoring on the TAAS-Phonemes task. Predictive correlations that fit these criteria include those from the literacy measures at Times 2 and 3 to TAAS-Phonemes at the end of the second year. (The one child who scored positively on TAAS-phonemes at Time 3 was not included in the correlations with TAAS-Phonemes at the end of the second year as he was lost to the sample in the second year.) Nearly all of these correlations were significant and most remained so after controlling for PPVT-R, rhyme awareness, alliteration awareness, or Letter Sound.

5.4.3.2 Predictive Correlations from Literacy to Tapping: Results

Many significant predictive correlations were found from literacy to Tapping, especially for Tapping during the second year where most correlations were within the range of $r = .45$ to .70 (Appendix H: Tables 52 - 63). Controlling for PPVT-R generally made only a small difference to the size of the correlations. Controlling for rhyme awareness or alliteration awareness showed a mixed pattern of effects. Often correlations were reduced by only a small amount but large reductions occurred for some correlations. Adjusting for Letter Sound usually resulted in larger reductions than were seen with the other controlling variables.

Correlations from the spelling measures (word or pseudoword) were generally of the same magnitude as the correlations from the respective reading measures. The correlations from the pseudoword reading or spelling measures were of a similar size to the correlations from the pseudoword reading or spelling measures.

One pattern of note amongst the predictive correlations from the measures of literacy is the consistently high correlations from Burt Reading at all times to Tapping at the end of the second year (Appendix H: Table 54). The unadjusted correlations ranged from .62 to .74, and most of these showed only a small reduction after controlling for PPVT-R, rhyme awareness, alliteration awareness or Letter Sound.

5.4.3.3 Predictive Correlations from Literacy to Phoneme Awareness: Discussion

Correlations from measures of literacy to later phoneme awareness varied according to which measure of phoneme awareness was being used as the outcome variable. As more children began to achieve success on both tasks during the second year, the differences in predictive correlations became smaller. Predictive correlations to TAAS-Phonemes at the end of the second year, and Tapping at the end of the second year, were often of comparable magnitude. There are exceptions to this pattern, most notably in the correlations from Burt Read, which were always higher for later Tapping (ranging from .62 to .74) than for later TAAS-Phonemes (ranging from .43 to .55).

Correlations from measures of literacy to later phoneme awareness also varied according to the measure of literacy being used as the predictor variable. However there was no consistent pattern of larger correlations from one measure of literacy that applied to both the measures of phoneme awareness. For example, the spelling measures showed higher correlations than the reading measures for predicting TAAS-Phonemes but this pattern was not evident for Tapping.

The large number of significant predictive correlations from different measures of literacy to the two measures of phoneme awareness is supportive of the finding in a number of other studies that phoneme awareness is, at least in part, a consequence of the acquisition of literacy (Algeria et al., 1982; Bentin et al. 1991; Bowey and Francis, 1991; Carillo, 1994; Ellis and Large, 1998; Foorman et al., 1991; Morais et al., 1979; Read et al., 1986; Wimmer et al., 1991). In relation to this notion, the significant predictive correlations from literacy at Times 2 and 3 to TAAS-Phonemes are of special interest because children were unable to score on the TAAS-Phonemes task until after they had begun to read. (This differs from the situation with the Tapping task where children showed a range of scores from first testing, although most found it very difficult during the first year.) Because children were not scoring on the TAAS-Phonemes task at the early test points their prior performance on this task does not need to be considered as a possible confounding variable of literacy measured at the same time points. The results indicate that those children who were first to develop literacy skills were, at a later time, the first children able to perform a phoneme deletion task.

Controlling for PPVT-R made little difference to the size of the correlations from literacy to either measure of phoneme awareness. Similarly, controlling for rhyme

awareness or alliteration awareness made little difference for correlations to TAAS-Phonemes and showed no clear pattern of reductions for correlations to Tapping. Hence it would appear that the connection from literacy skills to phoneme awareness is not being mediated by PPVT-R, rhyme awareness or alliteration awareness.

Letter-sound knowledge, however, did play a role in the relationships between literacy and phoneme awareness. Controlling for Letter Sound resulted in a number of substantial reductions in the correlations from literacy to phoneme awareness, especially for the second year results. This finding is similar to that which was seen for the correlations in the other direction - from phoneme awareness to literacy - where Letter Sound was also found to be the controlling variable of most influence.

5.4.4 Cross-Lagged Correlations for Phoneme Awareness and Literacy

Cross-lagged correlational analysis[38] (Kenny, 1979) was used to compare the correlations from phoneme awareness to word reading and spelling with the correlations from word reading and spelling to phoneme awareness.[39]

5.4.4.1 Cross-Lagged Correlations for TAAS-Phonemes and Literacy: Results

Figures 5.10 and 5.11 show the cross-lagged correlations for TAAS-Phonemes and Burt Read. Correlations were sometimes larger in one direction, and sometimes larger in the other. However none of the differences between the relevant correlations, unadjusted or adjusted for Letter Sound, were significant.[40]

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[38] See the discussion of cross-lagged correlational analysis in Section 3.7

[39] Cross-lagged correlational analysis was not used with the pseudoword measures. Many children had scored at low levels on the pseudoword measures during the first year.

[40] PPVT-R, rhyme awareness, or alliteration awareness were not controlled in the cross-lag analysis as they were found to make little difference to the size of the predictive correlations from phoneme awareness to literacy, or from literacy to phoneme awareness. (For TAAS-Phonemes and reading and spelling, see Appendix H: Tables 15, 18, 40, & 43. For Tapping and reading and spelling, see Appendix H: Tables 27, 30, 52, & 53).

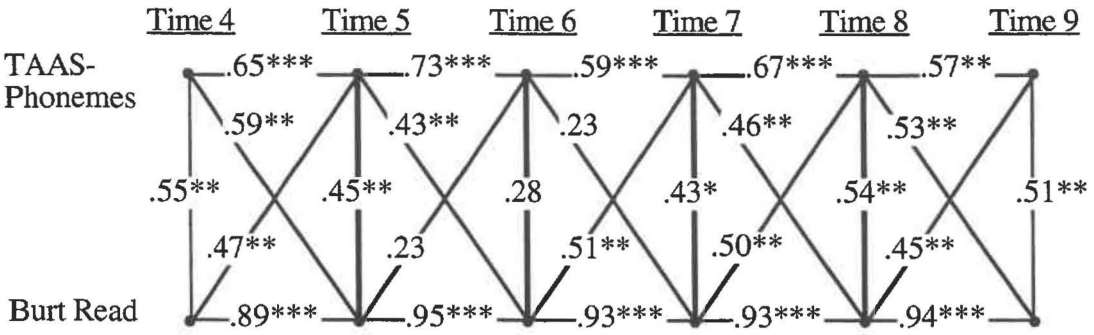


Figure 5.10. Cross-Lagged correlations between TAAS-Phonemes and Burt Read. Times 4 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

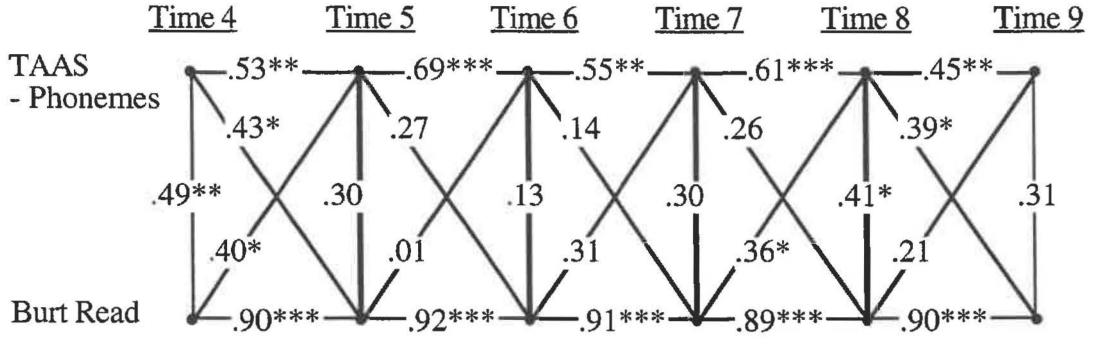


Figure 5.11. Cross-Lagged correlations between TAAS-Phonemes and Burt Read: adjusted for Letter Name. Times 4 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

Cross lagged correlations for TAAS-Phonemes and Burt Spell-Phonemes are shown in Figures 5.12 and 5.13. Correlations from spelling to TAAS-Phonemes were usually larger than in the other direction. The same pattern was found whether the correlations were unadjusted or adjusted for Letter Sound. Differences between comparable correlations in each direction were significant for only one instance with the unadjusted cross-lagged correlations, and for one instance with the cross-lagged correlations that were adjusted for Letter Sound.

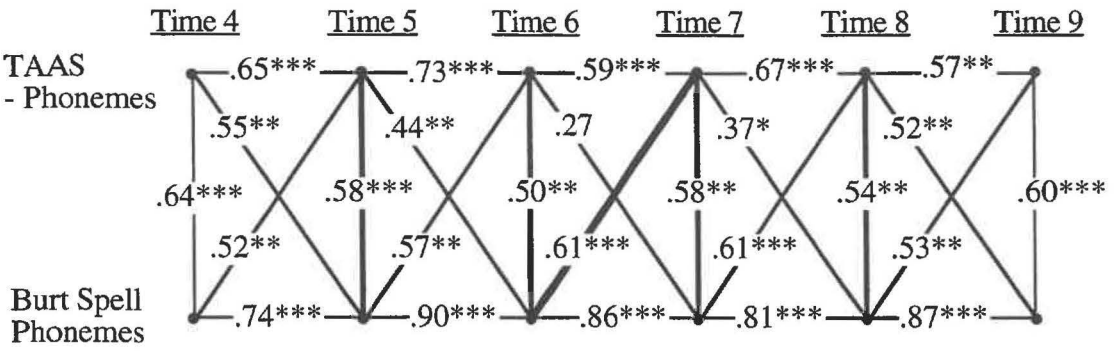


Figure 5.12. Cross-Lagged correlations between TAAS-Phonemes and Burt Spell Phonemes. Times 4 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

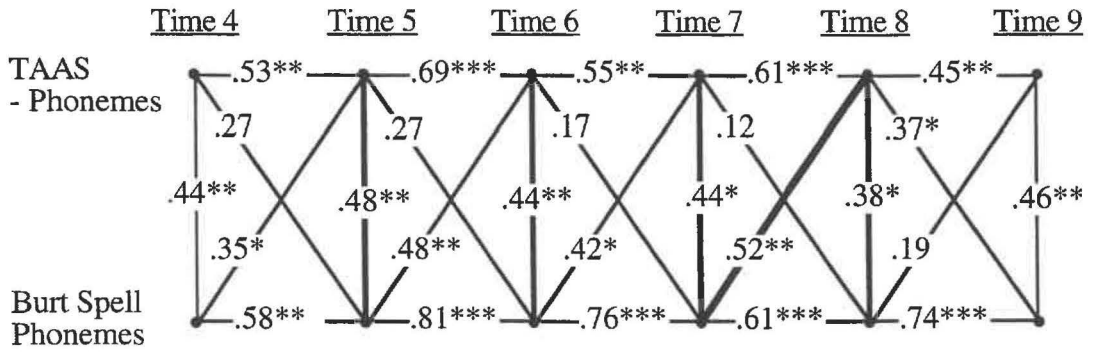


Figure 5.13. Cross-Lagged correlations between TAAS-Phonemes and Burt Spell Phonemes: adjusted for Letter Name. Times 4 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

5.4.4.2 Cross -Lagged Correlations for Tapping and Literacy: Results

Cross-Lagged correlations for Tapping and Burt Read are shown in Figures 5.14 and 5.15. At a number of time points the correlations showed similar levels for both directions. Where there were large differences between correlations (either unadjusted or adjusted for Letter Sound) an advantage was found from Burt Read to Tapping rather than in the other direction. However, the differences were seldom significant.

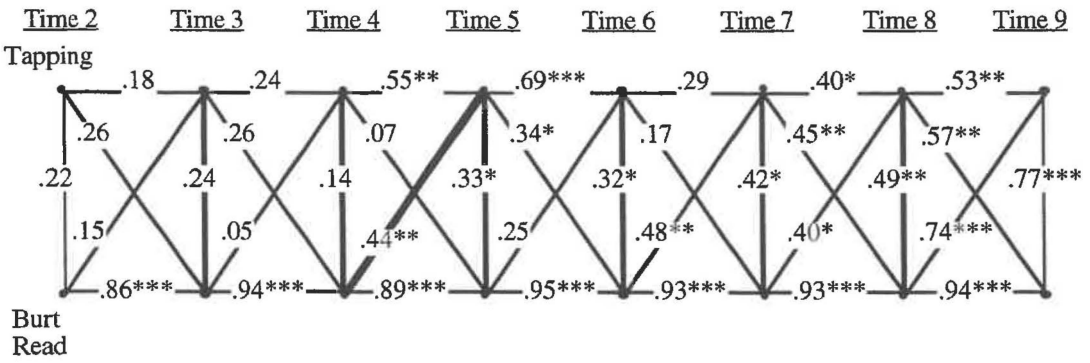


Figure 5.14. Cross-Lagged correlations between Tapping and Burt Read. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

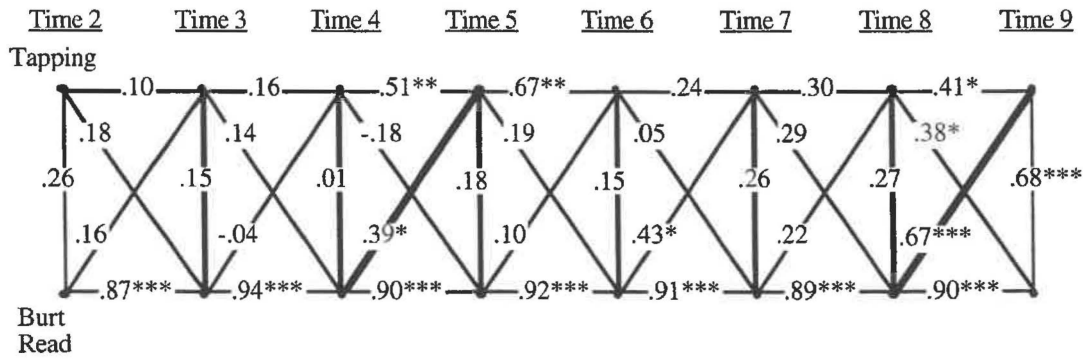


Figure 5.15. Cross-Lagged correlations between Tapping and Burt Read: adjusted for Letter Name. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests). (Lines shown in bold denote cross-lagged correlations that are significantly greater than the converse correlation, $p < .05$.)

Figures 5.16 and 5.17 show cross-lagged correlations for Tapping and Burt Spell-Phonemes. Generally the correlations for particular time points are of similar size for both directions. Where the differences between correlations (either unadjusted or adjusted for Letter Sound) were larger, there was no consistent advantage for one direction over the other. None of the differences between comparable correlations in each direction were significant.

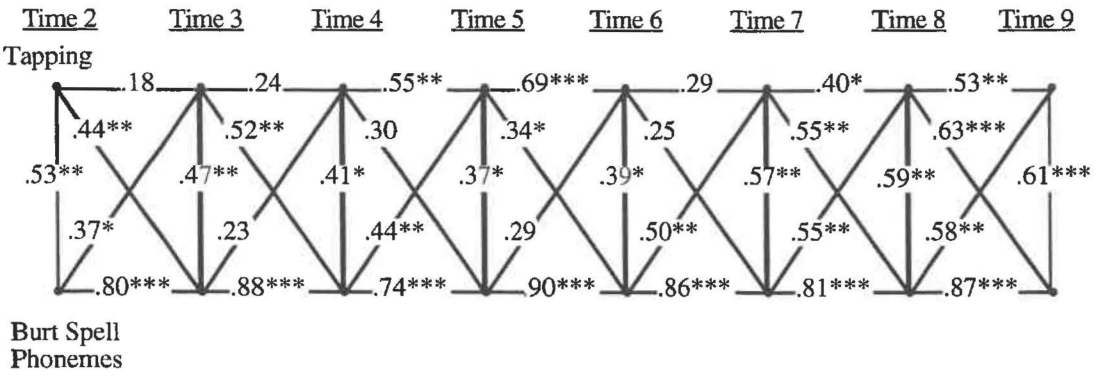


Figure 5.16. Cross-Lagged correlations between Tapping and Burt Spell Phonemes. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

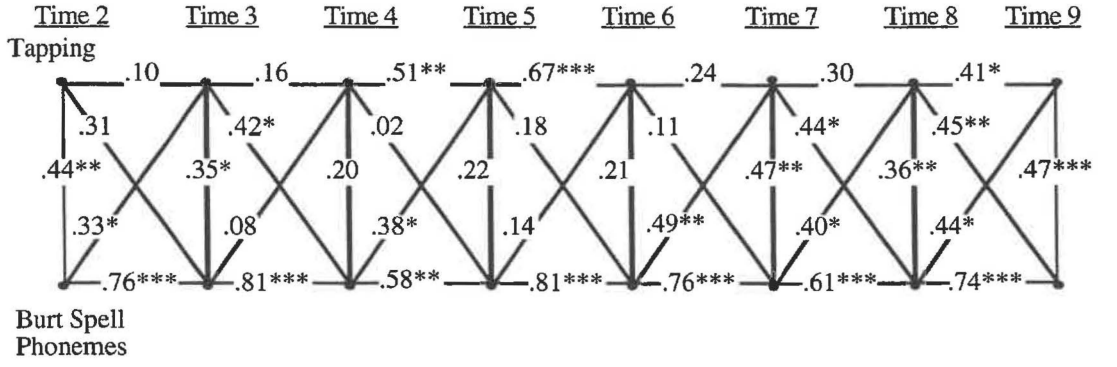


Figure 5.17. Cross-Lagged correlations between TAAS-Phonemes and Burt Spell Phonemes: adjusted for Letter Name. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$ $*p < .05$. $**p < .01$. $***p < .0005$ (one tailed tests).

5.4.4.3 Cross-Lagged Correlations for Phoneme Awareness and Literacy: Discussion

The cross-lagged correlations show that often there was no significant difference between the size of the correlations from phoneme awareness to literacy and the correlations from literacy to phoneme awareness. However, when significant differences were found - for TAAS-Phonemes and Burt Spell Phonemes, and Tapping and Burt Read - the larger correlations were all from literacy to phoneme awareness rather than in the other direction.

These results suggest that, according to the logic of cross-lagged correlation, the connection from literacy to phoneme awareness may sometimes be more important than the connection from phoneme awareness to literacy. The finding of significant correlations in both directions indicates that there may be a reciprocal relationship

between phoneme awareness and literacy, as measured in the current study. Past studies that have only examined the possibility of a connection in one direction may have presented an incomplete picture of the relationships between phoneme awareness and literacy.

5.5 Multivariate Correlational Analysis

Overview of Part Five

The first four parts of this chapter have made use of correlational analysis (concurrent, predictive, and cross-lagged) in order to examine relationships between each type of phonological awareness and literacy. The fifth part of the chapter will make use of multivariate correlational techniques to provide additional information about the nature of the relationships between variables over the two years of the study. Factor analysis was used to investigate patterns of underlying factors in the variables at each time. Multiple regression analysis provided information on which combination of variables best predicted later literacy.

5.5.1 Factor Analysis

The Statview 2 computer programme (Abacus Concepts, 1987) was used to carry out factor analyses on the raw scores of all measures for each test time in the study. Principal Components Analyses with Varimax Rotation was used. The orthogonal components were then rotated using the Statview Orthotran option to obtain an oblique solution. The factor loadings and proportionate variance contributions for each Time are shown in Appendix H: Tables 64 - 72. The factor analyses showed that the particular combination of measures that loaded onto various factors changed at each test time. There was also a trend, especially in the second year, for the largest factor at each test time to account for an increasing proportion of the variance. At Time 1, the largest factor accounted for 40% of the variance. During the rest of the first year, the largest factor accounted for 46% -47% of the variance. In the second year, the amount of variance explained by the largest factor increased to 65% at the final test time.

Individual measures showed different associations with other measures at each test time. However, all of the measures of literacy often loaded onto the same factor at a particular time. Generally this was the largest factor in terms of variance accounted for at each test time. The following discussion examines patterns of factor loadings for major groups of variables in the study, and notes how these were associated with the factors on which the literacy measures were most heavily loaded.

Letter Knowledge

Letter Name and Letter Sound showed heavy loadings on the same factor at each time during the first year except Time 4. Letter Name during the first year, and Letter Sound during both years, loaded most heavily at each time on the factor that also had the most measures of literacy loaded on it. The frequent grouping of letter knowledge and literacy measures on the same factor is indicative of the close association between these variables during much of the study.

Syllable Awareness

The factor loadings for syllable awareness indicate a close association between this measure and early letter knowledge and literacy skills. At Times 1 and 2, TAAS-Syllables loaded most heavily on to the same factor as Letter Name. Burt Read and Burt Spell Phonemes also loaded most heavily on this factor at Time 2. (Ceiling effects for TAAS-Syllables meant that it was not entered into the factor analyses from Time 4 on.)

Rhyme Awareness and Alliteration Awareness

Rhyme Categorization and Alliteration Categorization loaded most heavily on the same factor at each test time during the first year except for Time 4. At Times 1 and 3 no other measures had their heaviest loadings on the same factor as Rhyme and Alliteration. At Times 2, 5, and 6 there was only one additional measure (either Digit Span or Tapping), that loaded most heavily on the same factor as Rhyme and Alliteration. At only one test point (Time 4) did the rhyme and alliteration tests load most heavily on the same factor as did Letter Name, Letter Sound, or any of the literacy measures. Overall, the pattern of loadings for rhyme awareness and alliteration awareness during the first year indicate that these variables often had little variance in common with measures of letter knowledge and literacy.

Phoneme Awareness

It was not until later in the first year that a reasonable number of children began to perform both the Tapping and the TAAS-Phonemes task. From Times 5 to 7, Tapping and TAAS-Phonemes each loaded most heavily on different factors. At Times 8 and 9 both of these measures loaded on the same factor.

At Times 5 and 6, Tapping, but not TAAS-Phonemes, loaded most heavily on the same factors as did rhyme awareness and alliteration awareness. None of the literacy measures loaded most heavily onto those factors. At Times 7 and 8, no other variables loaded most heavily on the factors that the phoneme awareness measures loaded most heavily on. At Time 9 both measures of phoneme

awareness, along with Letter Sound and all measures of literacy, loaded most heavily on the same factor (which accounted for 65% of the variance).

At Time 5, TAAS-Phonemes loaded most heavily on the same factor as all of the literacy measures. Tapping loaded onto a different factor at this time. From Times 5 to 8 neither of the phoneme awareness measures loaded most heavily onto the same factors that the literacy measures were loaded on. Only at Time 9 were Tapping and TAAS-Phonemes loaded onto the same factor as the literacy measures.

Overall, the results of the factor analyses show that the phoneme awareness measures shared variance with measures of rhyme and alliteration during the latter part of the first year, but had little association with any other variables during the second year until the final test time. It was only at this time that an association between phoneme awareness and literacy was evident in the patterns of factor loadings.

Factor analyses are useful for showing some of the patterns of relationships between variables, as discussed above. However, the factor analyses also showed that the number of underlying factors, and the combination of measures that loaded on to factors, changed at different time points in the study. Because of this it was decided not to use factors as variables in other data analyses for the current study. As was noted in the Literature Review, the results of any study are influenced by the specific characteristics of the measures used in that study. Combining scores from different measures, or using factors as the basis for further analyses, may lead to a reduction in the interpretative value of the results. Use of individual test scores can provide a clearer picture of the interrelationships between variables.

5.5.2 Stepwise Multiple Regression

Stepwise multiple regression provides information about the combination of variables that predict a particular criterion variable. With longitudinal data it becomes possible to find the combination of variables at one time that predict a particular criterion variable at a later time. Data in the current study was examined to see which combination of variables predicted each of four measures of literacy at the next test time (i.e., word reading, word spelling, pseudoword reading, pseudoword spelling). Analysis was carried out with Student SYSTAT (Berk, 1994). The stepwise procedure first enters the predictor variable that has the highest correlation with the criterion variable. The next predictor variable to be entered is

the one that can explain the greatest amount of additional variance in the criterion variable. This process continues until no other variables can explain significant additional variance.

Initial regression analyses focused on one measure of literacy at a time and did not include other measures of literacy among the predictor variables. (This was because the combination of the four literacy measures explained virtually all the variance in any one of the literacy measures at the next test time.) Regression was first carried out by entering all variables that were assessed at one test time (including the literacy measure of interest) as potential predictor variables of the criterion measure of literacy at the next test time[41]. It was found, however, that including the literacy measure as a predictor variable, even without the other measures of literacy, meant there was still little variance to explain in the criterion literacy measure. This problem is illustrated in Figure 5.18 which shows the results of regression analysis used to predict Burt Read at each time, when Burt Read at the prior time is included as a predictor variable. Prior Burt Read explains a very large proportion of the variance, making it difficult for other variables to show a significant additional contribution.[42]

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[41] As PPVT-R was not assessed at each time, the measure from the nearest previous time was used.

[42] There are times when other variables were able to explain variance in addition to that explained by prior Burt Read. The contributions of these variables is also seen in the next regression analysis (Figure 5.19) where prior Burt Read is not included as a predictor variable.

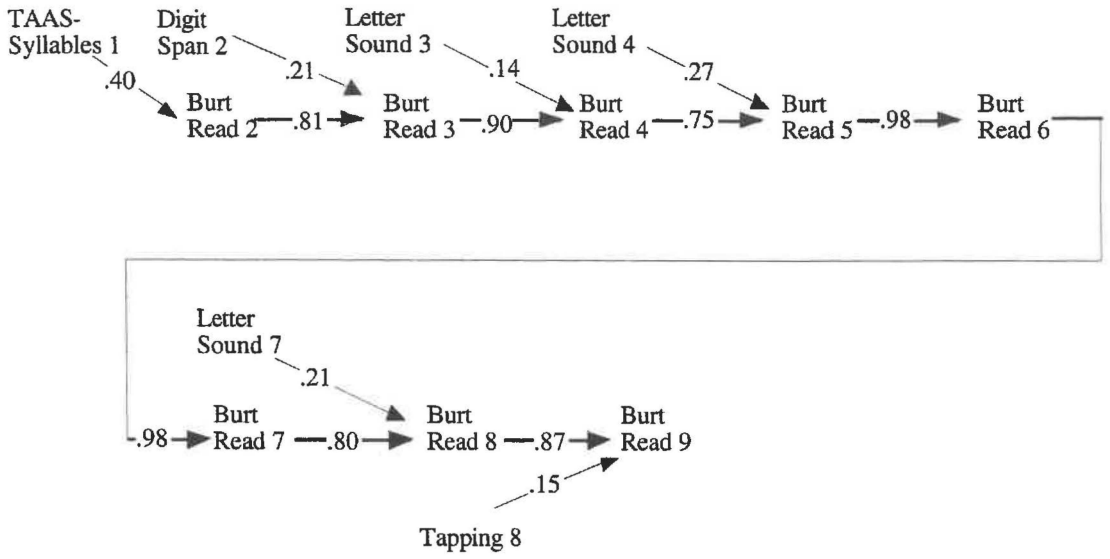


Figure 5.18. Diagram showing results of stepwise regression analysis using all variables (including Burt Read) to predict Burt Read at the next Test Time. (Standardised beta weights: $p < .05$, one tailed tests. Nonsignificant paths are not shown.)

This poses a dilemma for the researcher trying to investigate the pattern of relationships between variables over time. Many studies have found that prior literacy achievement is a very powerful predictor of later literacy achievement (Adams, 1990). It can therefore be argued that prior literacy should be taken into account when looking at contributions to literacy at a particular time. Indeed, if prior literacy is ignored, predictive correlations may be misleading. For example, Variable X at Time 1 may predict literacy at Time 2, not because Variable X makes an independent contribution to later literacy, but because Variable X is correlated with literacy at Time 1. If prior literacy is omitted from a regression analysis the remaining predictor variables will not provide the full picture. Nevertheless, it can still be of interest to examine which variables apart from literacy will predict literacy at a future time. Omitting prior literacy means that the remaining variables often have a much greater amount of variance to explain, thereby providing some additional information about links between variables at one time and literacy at the next.

It was therefore decided to omit prior literacy when carrying out further regression analyses for each measure of literacy in the current study. All other variables at a particular test point were entered into a stepwise regression equation in order to

predict measures of literacy at the next test point. The results of these analyses are shown in Figures 5.19 - 5.22.[43]

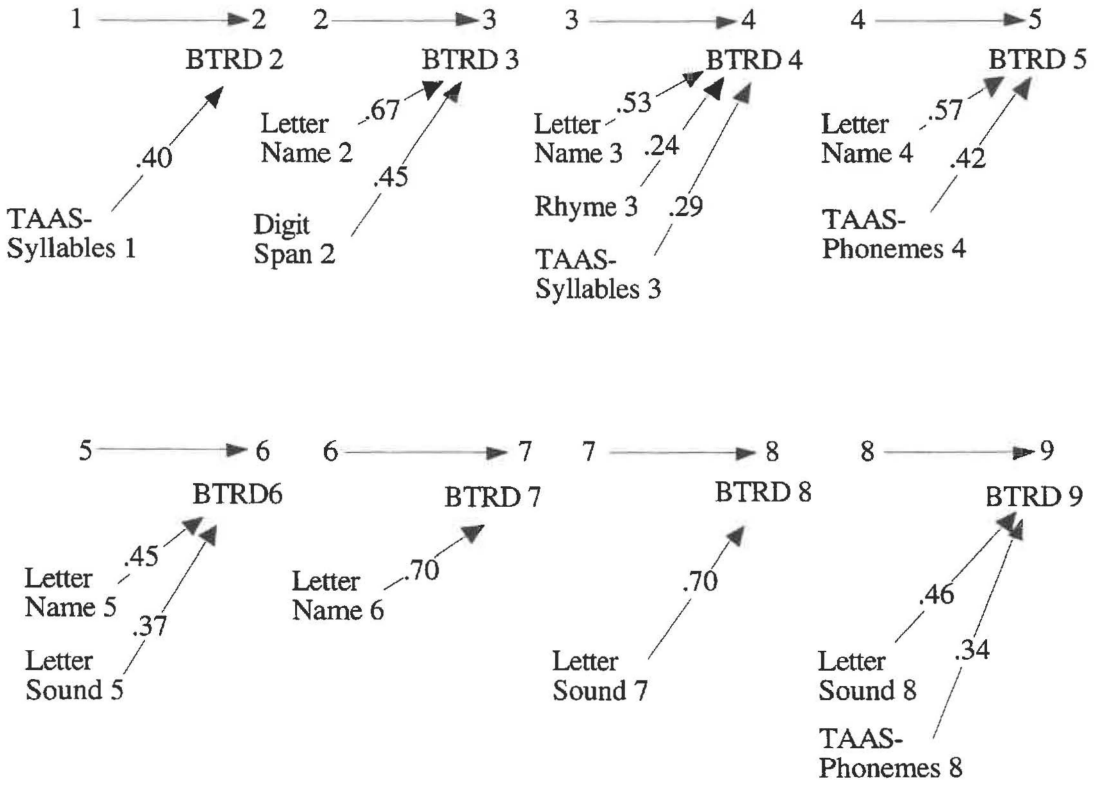


Figure 5.19. Diagram showing results of stepwise regression analysis using all variables (except Burt Read) to predict Burt Read (BTRD) at the next Test Time. (Standardised beta weights: $p < .05$, one tailed tests.)

[43] The beta coefficients are shown only for each variable that was found to make a significant additional contribution to explaining variance in literacy at the next test point. Nonsignificant paths are not shown.

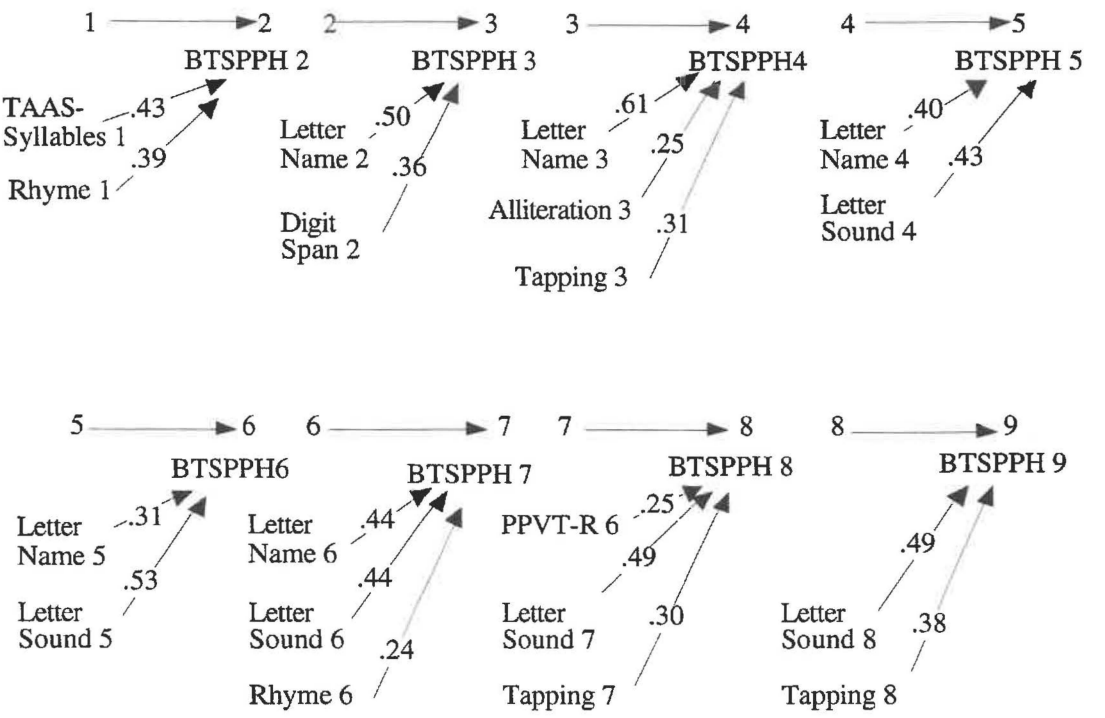


Figure 5.20. Diagram showing results of stepwise regression analysis using all variables (except Burt Spell Phonemes) to predict Burt Spell Phonemes (BTSPPH) at the next Test Time. (Standardised beta weights: $p < .05$, one tailed tests.)

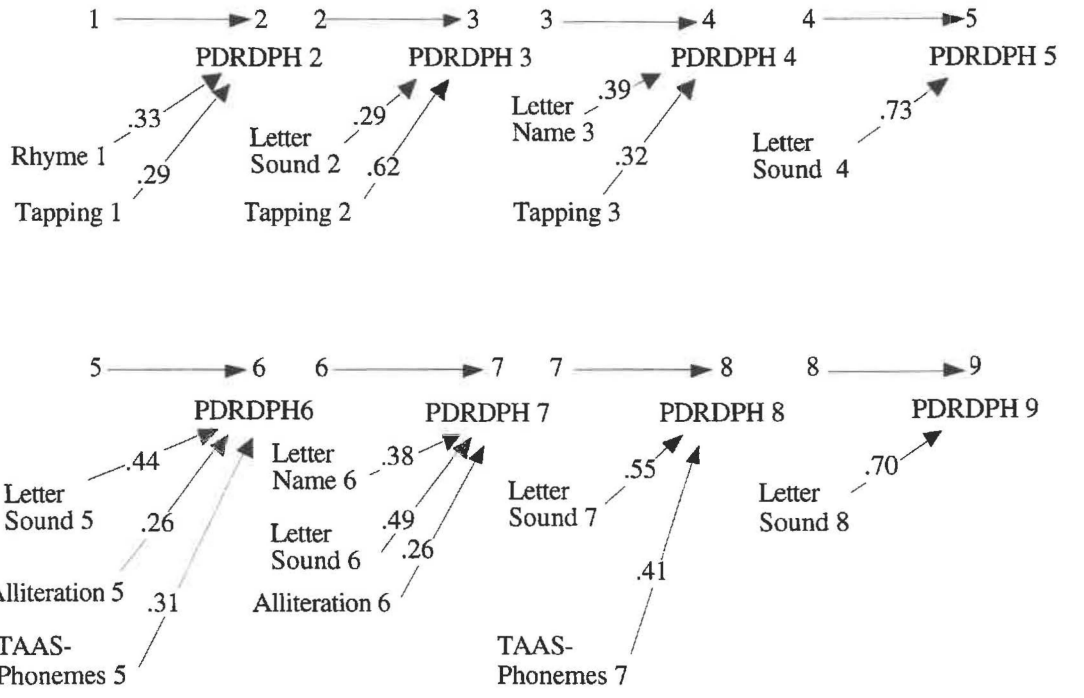


Figure 5.21. Diagram showing results of stepwise regression analysis using all variables (except Pseudoword Read Phonemes) to predict Pseudoword Read Phonemes (PDRDPH) at the next Test Time. (Standardised beta weights: $p < 05$, one tailed tests.)

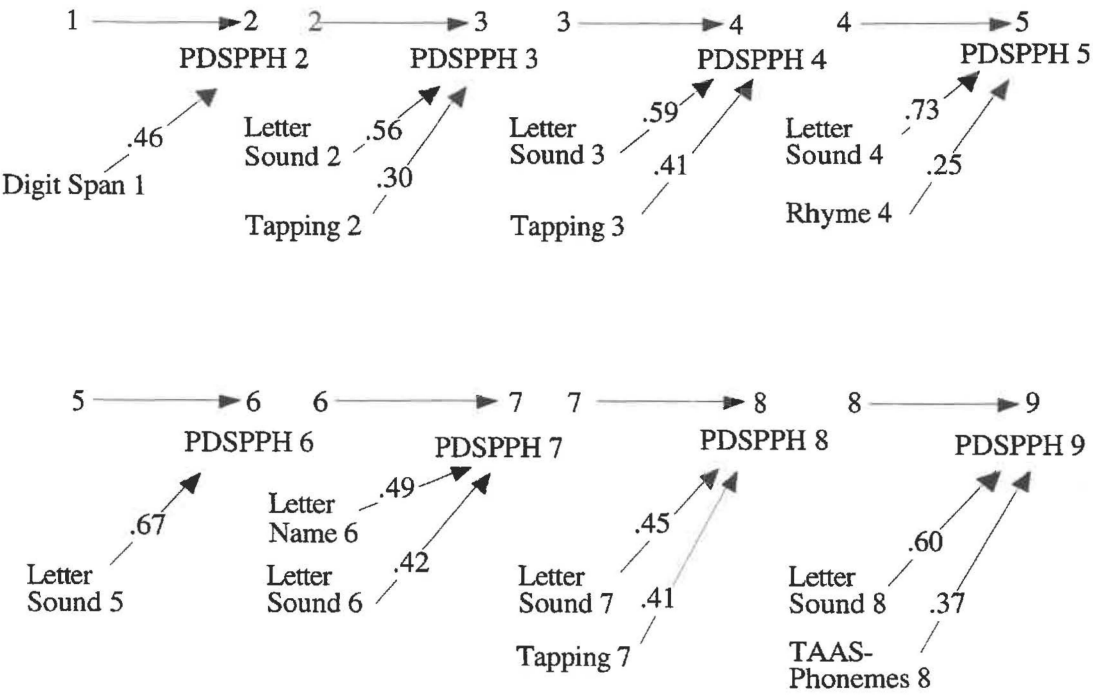


Figure 5.22. Diagram showing results of stepwise regression analysis using all variables (including Pseudoword Spell Phonemes) to predict Pseudoword Spell Phonemes (PDSPPH) at the next Test Time. (Standardised beta weights: $p < 05$, one tailed tests.)

An examination of Figures 5.19 - 5.22 shows that the particular variable, or combination of variables, that best predict literacy at one time differs according to the type of literacy under focus (i.e., word reading, word spelling, pseudoword reading, or pseudoword spelling). However, there is no clear pattern of different sets of variables being associated with different types of literacy. Rather, while there are differences between the sets of predictors, there are also some common patterns that are apparent across all four measures of literacy.

At Time 1, when all children were nonreaders, syllable awareness was the largest predictor of word reading and spelling at Time 2. (Syllable awareness was not a significant predictor of the pseudoword measures at Time 2 but most children were scoring at very low levels on these measures at that time.) During much of the first year, letter knowledge (Letter Name and Letter Sound) was nearly always the largest predictor of each of the measures of literacy at the next time point. Other significant contributors to literacy during the first year included the occasional measure of rhyme awareness or alliteration awareness, and often the Tapping task at Times 1 to 3. (As discussed in Section 4.3.3.3, performance on the Tapping task may have been affected by factors apart from phoneme awareness.) During the second year, letter knowledge, especially Letter Sound, continued to be the largest predictor of later literacy. At Times 7 and 8, TAAS Phonemes or Tapping usually

explained additional significant variance in measures of literacy at the next time point.

The regression analyses are valuable for making clear that letter knowledge was frequently the most powerful predictor of measures of literacy at the next time point.[44] Because a measure of letter knowledge was always the largest predictor of literacy from Time 3 to Time 8, other variables could be classified as predictors only if they could explain significant additional variance to that which was already explained by letter knowledge. However, although measures of phonological awareness were often unable to explain significant additional variance, this does not mean that the relationship between those measures of phonological awareness and later literacy is unimportant. It is possible that measures of phonological awareness and measures of letter knowledge overlap in the variance that they explain in later literacy.

[44] From Time 2 to Time 8 the only instance where a measure of letter knowledge was not the largest predictor was the correlation from Time 2 to Time 3 pseudoword reading when syllable awareness was the largest predictor.

6

SUMMARY AND CONCLUSIONS

Overview of Chapter 6

This chapter outlines the key findings of the current study with regard to the development of phonological and literacy skills and the relationships between these skills. The chapter is divided into four parts. Part One summarises the findings about the development of phonological and literacy skills. Part Two outlines the findings about the relationships between different types of phonological awareness (syllable awareness, rhyme awareness, alliteration awareness, phoneme awareness) and literacy. Part Three discusses the instructional implications of the findings, and Part Four provides recommendations for future research.

6.1 The Development of Literacy and Phonological skills

6.1.1 Receptive Vocabulary, Letter Knowledge and Phonological Memory

Children's average scores on a measure of receptive vocabulary increased over the time of the current study and were within the range expected for their age. Phonological memory, as assessed with a digit span measure, also increased during the study period. Receptive vocabulary scores were highly correlated across testing times as were Digit Span scores. Children's relative performance on the letter knowledge tests also showed stability over time. Most children knew few letter names at the beginning of the study but usually knew all letter names by the end of the first year. Letter-sound knowledge lagged behind letter-name knowledge with children knowing, on average, only about half the letter sounds at the end of the first year, and about three quarters by the end of the second year.

6.1.2 Reading and Spelling

Nearly all of the children in the current study made substantial gains in reading and spelling during their first two years at school. There were, however, large

differences between the achievement levels of individual children and these differences increased over time.

Each measure of reading and spelling showed high correlations between testing times. The different measures of literacy were also highly correlated with each other. Receptive vocabulary skills usually showed only small concurrent and predictive correlations with measures of literacy. Letter knowledge often showed moderately high concurrent and predictive correlations with the literacy measures. Controlling for receptive vocabulary skills made little difference to the size of the correlations between letter knowledge and literacy.

Predictive correlations from letter knowledge at the start of the study are of special interest because all children were nonreaders at this point. This simplifies the interpretation of the predictive correlations as any connection from letter knowledge to later literacy can not be due to a preexisting association between letter knowledge and literacy at the initial test point. Small but significant correlations were found between letter-name knowledge at the beginning of the study and some later measures of literacy, indicating that entry level letter skills could be a factor in the development of children's literacy skills. It was not possible to make correlations from letter-sound knowledge at the start of the study because most children knew no letter sounds at this time.

The size of the correlations between letter-name knowledge and later literacy increased considerably after children had been at school for several months. The children who quickly learnt letter names were more likely to show progress in reading and spelling than the children who struggled with letter-name knowledge. A similar pattern was found for letter-sound knowledge although this variable did not become a significant predictor of literacy until half way through the first year at school. Letter-sound knowledge continued to be a significant predictor of literacy during the second year of school.

Phonological memory generally showed low and nonsignificant correlations with measures of reading, but higher, and often significant, correlations with spelling. The different patterns of correlations may be related to the different demands of reading and spelling on phonological memory (Cossu et al., 1995).

6.1.3 Phonological Awareness

The current study found differences in the difficulty level of different tests of phonological awareness. Each measure of phonological awareness generally showed moderate to high levels of correlation between adjacent testing times.

Syllable awareness was the easiest of the phonological awareness tasks; nearly half the children were at ceiling level on this task at the beginning of the study. Almost all children were at ceiling level after six months at school. Syllable awareness showed some significant concurrent correlations with letter-name knowledge and phonological memory but not with receptive vocabulary skills.

Rhyme awareness and alliteration awareness tasks were more difficult for children than the syllable awareness task. However, a number of children showed successful performance on these tasks at the beginning of the study. The mean scores of children on these tasks increased throughout the first year at school, with most children approaching ceiling levels by the end of the year. Rhyme awareness and alliteration awareness tasks were often highly correlated with each other during the first year. This pattern of correlations was seen in the results of Factor Analysis where rhyme and alliteration tasks loaded most heavily on the same factor on 5 of the 6 first year test points. Rhyme awareness and alliteration awareness generally showed nonsignificant concurrent correlations with receptive vocabulary skills, letter knowledge, and phonological memory.

Phoneme awareness was measured with a deletion task (TAAS-Phonemes) and a counting task (Tapping). The different demands of these tasks meant that children showed different patterns of performance on them. Both tasks were very difficult for children, especially in the first six months of the study. Average scores on the phoneme awareness tasks showed a marked increase after half way through the first year at school, and continued to increase throughout the study. Factor analyses showed that TAAS-Phonemes and Tapping each loaded most heavily on different factors during the first year and at the start of the second year. At Times 8 and 9, both phoneme awareness tasks loaded on the same factor.

The phoneme awareness tasks showed inconsistent patterns of correlation with measures of receptive vocabulary skills and phonological memory. Generally it appeared that these measures could account for only a small amount of the differences in children's performance on the phoneme awareness tasks.

Scores on the phoneme awareness tasks showed generally low and nonsignificant concurrent correlations with letter-name knowledge. This pattern may have been influenced by the fact that letter-name knowledge was starting to be affected by ceiling effects at the time that children began to show higher scores on the phoneme awareness tasks. Correlations with letter-sound knowledge were higher than for letter-name knowledge. Most of the correlations with letter-sound knowledge remained significant after controlling for receptive vocabulary skills. It is possible that phoneme awareness may assist children to develop knowledge of letter sounds (e.g., a child with an awareness of phonemes may be advantaged in making the connection between the sound label of a letter and the phoneme that it represents in a word). It is also possible that letter knowledge may help children to gain insights into the phonemic structure of words (Johnston et al., 1996; Wagner et al., 1994).

6.2 Relationships Between Phonological Awareness and Literacy

6.2.1 Syllable Awareness and Literacy

At the beginning of the study, when all children were nonreaders, performance on the syllable deletion task showed higher correlations with later literacy than did any of the other predictor variables. Regression analysis showed that syllable awareness near the start of school was the strongest predictor of word reading and spelling nine weeks later (Time 2). Syllable awareness at the start of the study was able to predict literacy achievements over a long time period. Significant correlations were found between syllable awareness at Time 1 and all measures of literacy at the end of the first and second years of school. Most of the correlations between syllable awareness and later literacy were little affected by adjusting for PPVT-R and usually showed only small reductions when letter-name knowledge was controlled. Correlations between syllable awareness and literacy declined during the first months at school. By halfway through the first year almost all children were at ceiling level on the syllable awareness task and correlations with literacy were nearly all nonsignificant.

An explanation for the association between early syllable awareness and literacy may be that syllable awareness is an indication that attention is being given to the form of speech and not just its meaning. The ability to give attention to the form of speech may assist children in making links between the spoken and written representations of words (see Adams, 1990).

The Knowledge Sources Account of reading (Thompson et al., 1996) suggests that beginning readers may be able to make use of the single consonant sounds at the start of syllables in order to form induced sublexical relations that can then be used to help identify unknown print words. In relation to the findings of the current study, it is possible that a child who is able to divide a multisyllabic word into syllables would be able to recognise more than one singleton onset and would therefore have an advantage in comparison to a child who does not have syllable awareness.

6.2.2 Rhyme Awareness and Alliteration Awareness, and Literacy

Children's scores on the rhyme and alliteration tasks often showed small but significant concurrent correlations with measures of reading and spelling. These findings are consistent with other correlational studies that have found significant correlations between awareness of rhyme or alliteration, and literacy (e.g., Hansen and Bowey, 1994; Kirtley et al., 1989).

Controlling for receptive vocabulary skills or phonological memory usually made little difference to the size of the concurrent correlations between measures of rhyme and alliteration awareness and measures of reading and spelling. Controlling for letter-name knowledge, however, generally resulted in larger reductions in the size of the correlations. This meant that most of the previously significant concurrent correlations between awareness of rhyme or alliteration, and literacy were reduced to nonsignificant levels.

Predictive correlations from rhyme awareness or alliteration awareness to later measures of literacy were often nonsignificant, even before controlling for the influence of receptive vocabulary skills or letter-name knowledge. Where significant correlations did exist, they were usually only for correlations over a short interval (i.e., from one test time to the next). These correlations often remained significant after controlling for receptive vocabulary skills but were generally reduced to nonsignificant levels when letter-name knowledge was controlled for.

Predictive correlations from rhyme awareness and alliteration awareness at Time 1 are of special interest as all children were nonreaders at this time. Previous research in this area has often not taken sufficient care to check that children are nonreaders at the start of a study, leaving open the possibility that predictive correlations to later literacy could be the result of unassessed differences in reading levels at first testing. In the current study, Time 1 alliteration awareness was not significantly correlated with any literacy measures at the end of the first or second years. Time 1 rhyme awareness was not significantly correlated with any literacy measures at the end of the second year, or with word reading or pseudoword spelling at the end of the first year. However, small but significant correlations were found from Time 1 rhyme awareness to word spelling and pseudoword reading at the end of the first

year. These correlations remained significant after controlling for receptive vocabulary skills but not after controlling for letter-name knowledge.

The findings suggest that there is little connection between individual differences in rhyme awareness and alliteration awareness of nonreading children at school entry, and their progress in literacy after one or two years at school. Furthermore, the findings show that where significant predictive correlations from early rhyme awareness to later literacy did exist, they may have been mediated by an association with letter knowledge. However, although there was little connection between awareness of rhyme or alliteration at Time 1, and literacy levels at the end of the first or second years at school, significant predictive correlations were found from Time 1 rhyme awareness to each of the first measures of literacy which were assessed nine weeks later at Time 2. Most of these correlations remained significant after controlling for PPVT-R or Letter Name. Correlations from Alliteration awareness at Time 1 were smaller than from rhyme awareness. The only significant correlation between alliteration awareness at Time 1 and literacy at Time 2 was for word spelling. This correlation remained significant after controlling for PPVT-R or Letter Name.

Hence it appears that rhyme awareness at school entry (and alliteration awareness to a lesser extent) may have had a small facilitative effect on literacy during the first months of schooling. Researchers who have made similar findings have suggested that children who are aware of rhyme and alliteration will have an advantage in coming to understand that words that share common sounds will often share common letter patterns (Bryant, MacLean, Bradley, & Crossland, 1990; Goswami & Bryant, 1990, 1992; Walton, 1995; Wimmer et al., 1994). Goswami and Bryant (1990) refer to the ability to make links between common sounds and common spellings as the ability to make *orthographic analogies.* They claimed that the use of orthographic analogies explains the link that some research has found between the rhyme and reading skills of beginning readers (e.g., Bradley & Bryant, 1983).

The Knowledge Sources account of reading also provides an explanation of why rhyme awareness and alliteration awareness may be of value for early reading. Thompson et al. (1996) note that beginning readers who have not developed a complete awareness of phonemes may be able to acquire access to phonemes within onset and rime units. Initially children are most likely to be sensitive to single consonant phonemes at the start of a word (i.e., singleton onsets). Knowledge of such phoneme segments could be useful to (a) facilitate the development of induced sublexical relations (i.e., knowledge of the relationships between orthographic

components of words and the corresponding phonological components), (b) help children to make connections between the sound labels of letters and the phonemes they represent, and (c) help children to segment words into onset and rime units in order to be able to make analogies with a word from memory that shares the same orthographic component as the unknown word. The latter point is similar to what Goswami and Bryant (1990) described as the use of orthographic analogies. Thompson et al., however, suggest that analogy use is not available to beginning readers. They cite research that indicates children are unable to spontaneously use analogy cues until after 7 years of age, but may be able to make use of analogy at 6 years of age when prompted by a teacher.

Rhyme awareness and alliteration awareness at later time points in the first year (i.e., Times 2 to 6) continued to show significant predictive correlations to literacy at the next test time but, unlike the situation for Time 1, nearly all of these predictive correlations were reduced to nonsignificant levels after controlling for letter-name knowledge.

Earlier studies that did not control for letter knowledge may have provided an incomplete picture of the connections between awareness of rhyme or alliteration, and literacy. Significant correlations that were found in these studies may have reflected the association between awareness of rhyme or alliteration, and letter knowledge which in turn is associated with literacy. Letter knowledge is known to be a strong predictor of literacy development (Adams, 1990). In the current study, letter-name and letter-sound knowledge showed consistently high correlations with literacy at the same time and at future times. Some researchers have suggested that letter knowledge may also be linked with phonological awareness skills by helping children to gain insights into the phonological structure of words (Burgess & Lonigan 1998; Johnston et al., 1996).

Although controlling for letter-name knowledge reduced many of the correlations between rhyme and alliteration tasks and literacy to nonsignificant levels, this does not necessarily mean that the relationship between awareness of rhyme or alliteration, and literacy, is unimportant. Rather, it indicates that letter-name knowledge, and rhyme awareness or alliteration awareness, overlap in the variance that they explain in literacy development. However, stepwise regression analyses showed that although there was overlap amongst the first year predictors of literacy, a measure of letter knowledge (either Letter Name or Letter Sound) was nearly always a stronger predictor of literacy at the next test point than was rhyme awareness or alliteration awareness.

Most studies of rhyme or alliteration awareness, and literacy, have only considered the possibility of the relationship between variables operating in one direction; that is, from rhyme awareness or alliteration awareness to later literacy (see, e.g., Bradley and Bryant, 1983; Wimmer et al., 1994). The current study was designed to also provide an examination of relationships in the other direction, that is, from literacy to later rhyme awareness or alliteration awareness. Cross-lagged correlational analysis showed that correlations from word reading to rhyme awareness or alliteration awareness were mostly higher than the equivalent correlations in the other direction (whether correlations were unadjusted or adjusted for Letter Name). However, the difference between converse pairs of correlations was seldom significant. Correlations from word spelling to rhyme awareness or alliteration awareness generally showed no consistent advantage over correlations in the other direction.

Although the differences between correlations in one direction and the equivalent correlations in the other direction were nearly all nonsignificant, the finding of predictive correlations in both directions shows that it is important to examine the possibility of two-way connections when investigating relationships between awareness of rhyme or alliteration, and literacy. Although previous research in this area has generally only looked for the possibility of a connection from early awareness of rhyme or alliteration to later literacy, the results of the current study show that it is at least as plausible to model the connection in the other direction. It may be that experience with word reading and spelling increases children's attention to the orthographic and phonological components of words. If this is so, then children may more readily become aware that words that share spelling patterns are likely to share common sounds. This is the reverse process to that emphasised by Goswami and Bryant (1990, 1992) who suggested that children who are aware of common sounds within particular words (i.e., rhyme and alliteration) are advantaged in discovering that these words may also share common spelling patterns.

6.2.3 Phoneme Awareness and Literacy

Children found the phoneme awareness tasks to be considerably more difficult than the rhyme and alliteration tasks. This pattern of results has been found in many other studies (e.g., Stanovich, Cunningham, & Cramer, 1984; Yopp, 1988). However, because the tasks in the current study varied not only in the size of the

phonological unit (i.e., phonemes or rimes and onsets), but also in the type of operations required (i.e., deletion and tapping or categorization) it is not possible to state that phoneme tasks will always be more difficult than rhyme awareness and alliteration awareness tasks (see Nation and Hulme 1997; Seymour and Evans, 1994).

Nonreading children were able to score positively on one phoneme awareness task, phoneme tapping, at Time 1 but there was a chance element in their performance. Successful performance on this task may also have been due to attention to duration cues rather than requiring an awareness of phonemes. No children were able to score on the other phoneme awareness task, phoneme deletion, until near half way through the first year of the study, by which time they had developed some reading and spelling skills. Performance on both phoneme awareness tasks increased during the second half of the first year and continued to increase during the second year but no child showed complete mastery of these tasks by the end of the study period.

As children were unable to perform the phoneme deletion task at Time 1, it was not possible to calculate correlations from phoneme deletion scores when children were nonreaders, to measures of literacy at a later time. It was possible, however, to calculate predictive correlations from phoneme tapping scores at Time 1. Although these scores may have been influenced by factors apart from phoneme awareness, they nevertheless did show small significant correlations with measures of word spelling and pseudoword reading and spelling at the next test time (Time 2). These correlations remained significant after controlling for initial receptive vocabulary skills or letter-name knowledge. No significant correlations were found between phoneme tapping at Time 1 and any literacy measures at the end of the first and second years.

The finding of some significant correlations from Time 1 phoneme tapping to certain measures of literacy a short time later suggests that whatever it is that is being measured by phoneme tapping at Time 1, it does have some relevance to the early stages of literacy acquisition. If performance on this task was due to factors apart from phoneme awareness, (such as sensitivity to speech duration), it may still have been providing a measure of children's attention to speech sounds. Children who are more attentive to speech sounds may have an advantage in the early stages of literacy (Adams, 1990). A similar explanation was put forward when explaining why children's syllable awareness at the start of the study was significantly correlated with later literacy.

It was not until after half way through the first year at school that there was a marked increase in mean scores for phoneme tapping, suggesting that some children may then have been starting to develop the type of phoneme awareness skills needed to perform at higher levels on the tapping task. Children also began to score on the phoneme deletion task after half way through the first year. Together the results for the two phoneme awareness tasks suggest that children were unable to perform at a level that clearly indicated an awareness of phonemes until after they had developed some reading and spelling skills.

These findings are consistent with those made by Wimmer et al. (1991) and are supportive of the hypothesis that phoneme awareness is initially a consequence of learning to read and write. The findings of the current study are not consistent with a number of studies that have claimed that the phoneme awareness skills of children can be assessed before they begin to read in order to predict their progress in literacy after a year or two of schooling (e.g., Cataldo & Ellis, 1988; Hurford et al., 1994). The conclusions of some of these studies may have been limited by methodological problems, such as neglecting to take account of the effects of preexisting reading skills or letter knowledge (see the earlier discussion in the Literature Review Section 2.2.3.2.2).

By about half way through the first year of the current study, after children had begun to acquire some literacy skills and were starting to succeed on both tests of phoneme awareness, significant concurrent and predictive correlations were often found between measures of phoneme awareness and measures of literacy. Correlations generally increased in value to moderately high levels during the second year of the study.

Concurrent and predictive correlations between phoneme awareness and literacy were higher, and more often significant, for word spelling and the pseudoword measures than for word reading. The lower frequency of significant correlations for word reading fits with the notion that phoneme awareness is particularly important for those literacy tasks that are most dependent on phonological recoding (Hansen and Bowey, 1994; McDougall et al., 1994). The Knowledge Sources account of reading indicates that phoneme awareness may assist children to develop phonological recoding skills by (a) facilitating the development of induced sublexical relations, (b) helping children to make connections between the sound labels of letters and the phonemes they represent, and (c) assisting children to make

the segmentations required when making analogies.[45] Phonological recoding is necessary for children to read and spell pseudowords, and is also important for word spelling, especially for unfamiliar words. Word reading, however, may be less dependent on phonological recoding because familiar words can be read by "recall" without the need to make use of letter-sound information for phonological recoding (Thompson et al., 1996). [46]

Connections between phoneme awareness and literacy were largely independent of differences in the children's receptive vocabulary skills, phonological memory, rhyme awareness, or alliteration awareness. Controlling for PPVT-R, Digit Span, Rhyme Categorization, or Alliteration Categorization usually made little difference to the size of the correlations (either concurrent or predictive) between measures of phoneme awareness and literacy. Other studies have produced mixed findings about the influence of these variables.[47]

The finding of significant correlations between the phoneme awareness of beginning readers and their present and future literacy skills is consistent with the evidence of numerous other studies (e.g., Cataldo & Ellis, 1988; Leather and Henry, 1994; Vandervelden & Siegel, 1995). However, as noted in the Literature Review, the conclusions of many of these studies are limited by methodological problems. Often studies have given insufficient attention to the influence of possible confounding variables. In particular it appears that very few studies have taken adequate account of the influence of letter knowledge on the relationships between phoneme awareness and literacy. The only correlational study to have controlled for letter knowledge (Muter et al., 1997) found that this resulted in a substantial reduction in concurrent correlations between measures of phoneme awareness and literacy near the end of the first year at school. Experimental studies have usually been designed in a way that does not allow for the effects of phoneme awareness training to be separated from the effects of the additional exposure to letters that accompanies training. The few experimental studies that have controlled for additional exposure to letters found that phoneme awareness training without the involvement of letters did not result in significant gains in literacy (Defior & Tudela, 1994; Hatcher et al., 1994).

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[45] Note, however, that Thompson et al. (1996) cite research indicating that 6-year-old children may be able to make use of analogy when prompted by a teacher but are unable to spontaneously use analogy cues until after 7 years of age.

[46] See the discussion of the Knowledge Sources account of reading in Section 2.3.4.

[47] See Sections 2.2.3.1.2 and 2.2.3.2.2 of the Literature Review.

Letter knowledge was taken into account in the current study and was often found to have a considerable influence on the statistical relationships between phoneme awareness and literacy. For phoneme awareness per se to be regarded as a locus of later literacy, it is necessary to check that any significant association between phoneme awareness and literacy is not only due to the effects of letter knowledge. Studies that have not controlled for letter knowledge (e.g., Mann et al., 1987; Stuart, 1995) present an incomplete picture of the relationships between phoneme awareness and literacy. Of the variables that were controlled for in the current study, it was letter knowledge that generally resulted in the largest reductions in the correlations between phoneme awareness and literacy. This suggests that letter knowledge is an important factor to consider when examining relationships between phoneme awareness and literacy.

The finding that controlling for letter knowledge reduced the size of the correlations between phoneme awareness and literacy (often to nonsignificant levels) does not mean that the relationship between phoneme awareness and literacy is unimportant. Rather it indicates that letter knowledge and phoneme awareness overlap in the variance that they explain in literacy. Although phoneme awareness and letter knowledge may both contribute to literacy development, the stepwise regression analyses show that once children had started to perform on both measures of phoneme awareness, a measure of letter knowledge was always a stronger predictor of literacy at the next test point than was a measure of phoneme awareness. As previously discussed, the primacy of letter knowledge was also apparent in relation to rhyme awareness and alliteration awareness. Overall, the stepwise regression analyses show that letter knowledge was usually the strongest predictor of literacy during the first year of the study, but that there were also occasional additional contributions from rhyme awareness and alliteration awareness in this period. During the second year, letter knowledge continued to be the strongest predictor of literacy. There were also some additional significant contributions from measures of phoneme awareness, especially towards the end of the second year.

As with studies of the role of rhyme awareness and alliteration awareness, most studies of phoneme awareness have only considered the possibility that phonological awareness influences literacy and not vice versa. The current study examined the data for evidence of relationships in both directions. Word reading and spelling were found to have numerous significant correlations with later phoneme awareness. Comparisons of the size of correlations in each direction revealed a mixed pattern. Cross-lagged correlational analyses showed that there

were few significant differences between comparable correlations, whether unadjusted or adjusted for letter-sound knowledge. Where significant differences did occur, they were in favour of a connection from word reading or spelling to later phoneme awareness. Although cross-lagged correlational analysis cannot establish causality, the finding of significant correlations in both directions shows that it is plausible to model predictive relationships from phoneme awareness to literacy, and from literacy to phoneme awareness.

Hence the current study provides evidence consistent with (a) phoneme awareness having a causal role in the development of literacy, and (b) phoneme awareness being a consequence of the development of literacy. Numerous other studies have provided evidence in support of each of these alternatives (see Section 2.2 of the Literature Review). A smaller number of studies have suggested that there is a reciprocal relationship between phoneme awareness and literacy (e.g., Cataldo & Ellis, 1988; McGuinness et al., 1995).

By beginning with nonreaders, and tracking progress during the first two years at school, the current study has shown that different types of phonological awareness have different patterns of relationships with literacy. The study provides evidence that reciprocal relationships may exist not only for phoneme awareness and literacy, but also for awareness of rhyme or alliteration, and literacy (as noted in the previous Section: 6.2.2). Children usually had rhyme awareness and alliteration awareness skills before they began to read. These skills appeared to have a small facilitative effect on the first stages of literacy development. In support of a reciprocal relationship between awareness of rhyme or alliteration, and literacy during the first year at school, some significant predictive correlations were found from rhyme awareness and alliteration awareness to later literacy and from literacy to later rhyme awareness and alliteration awareness. Children were unable to score on both phoneme awareness tasks until they had developed some reading and spelling skills. This finding indicates that phoneme awareness may initially be a consequence of literacy development. After half way through the first year at school, there was evidence consistent with a reciprocal relationship between phoneme awareness and literacy. Significant predictive correlations were found from phoneme awareness to later literacy and from literacy to later phoneme awareness.

A number of the findings of the current study are consistent with the Knowledge Sources account of reading (Thompson et al, 1996). The current study found some significant correlations from rhyme awareness, alliteration awareness, and phoneme

awareness, to later measures of literacy. Strong correlations were often found between letter knowledge and later measures of literacy. The Knowledge Sources account indicates that letter knowledge, phoneme awareness, and awareness of rhyme and alliteration (where this includes an awareness of phonemes when they occur as singleton onsets) may assist children with three sources of knowledge that can be used to generate responses to unknown print words: induced sublexical relations; taught sounds for letters, and analogy cues.[48] The current study also found significant correlations from measures of literacy to later measures of rhyme, alliteration, and phoneme awareness. The Knowledge Sources account does not specifically describe such connections. However, it does provide for orthographic representations of words in memory to be built up, along with stored knowledge of the phonology of the word, as a result of children's repeated experience in generating or being told unknown words (see Figure 2.2 in Section 2.3.4). It may be that experiences with reading (and spelling) increase children's knowledge of the orthography and phonology of words, thereby helping them to become aware that words that share common letter patterns are likely to share common sounds. Hence print experience could plausibly result in gains in awareness of rhyme, alliteration, and phoneme awareness.

[48] A fourth source of knowledge, context, does not directly involve letter knowledge and phonological skills but is usually insufficient to identify a word on its own and is therefore used in combination with the other knowledge sources.

6.3 Instructional Implications

The results of this study have a number of implications for literacy instruction. The finding of significant correlations between syllable awareness at school entry, and reading and spelling after the first months of school and at the end of the first and second years at school, indicates that it may be useful to direct the attention of preschool children to the syllabic nature of speech. This can be achieved through activities such as clapping once for each syllable in sentences, and "robot talk" which requires a child to pause brief-ly be-tween each syll-a-ble when they speak (see Lundberg et al., 1988, & McCabe, 1992, for a description of these activities).

The current study found that awareness of rhyme (and alliteration to a lesser extent) at the beginning of school may have a small facilitative effect on the first months of learning to read and spell. This finding supports the use of activities that enhance preschool children's awareness of rhyme and alliteration. Recommended activities include the use of nursery rhymes[49], and the reading of books that make extensive use of rhyme and alliteration (e.g., see the list of books in Appendix 3 of Nicholson, 1999a) Young children often enjoy games that involve playing with words, such as making up nonsense words that rhyme with other words (see McCabe, 1992). There are also interactive computer programmes that teach children about rhyming words (eg., Microsoft, 1998)

After a couple of months at school the correlations from rhyme awareness and alliteration awareness to later literacy were mostly nonsignificant. The significant correlations that did occur were generally reduced to nonsignificant levels when letter knowledge was controlled for. These findings indicate that there would be little benefit in training school children in activities that focus only on rhyme and alliteration. Evidence from other studies, however, indicates that effective instruction can be provided by making use of rhyme to encourage school children to learn more about letter patterns in words. (Greaney & Tunmer, 1996; Greaney, Tunmer, & Chapman, 1997).

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[49] See Bryant, Bradley, MacLean, and Crossland (1989) for evidence that exposure to nursery rhymes can enhance children's sensitivity to sounds.

Evidence from the current study indicates that phoneme awareness does not develop in children until after they have gained early reading and spelling skills.[50] There is therefore no reason to delay literacy instruction until after children have developed a certain level of phoneme awareness. After children have moved beyond the early stages of reading and spelling, there is evidence of a reciprocal relationship between phoneme awareness and literacy. There is also evidence of the involvement of letter knowledge in the connection between these variables. The study does not address the issue of whether training in phoneme awareness would result in more rapid gains in literacy development. However, the finding that letter knowledge is involved in the relationships between phoneme awareness and literacy is compatible with the findings of other studies that showed training in phoneme awareness was of little benefit unless it was done in conjunction with instruction that included letter knowledge activities (e.g., Defior & Tudela, 1994; Hatcher et al., 1994). (For further description of activities to enhance children's phoneme awareness and letter knowledge, see Nicholson, 1999a.)

Although the current study focused on the relationships between phonological awareness and literacy, the importance of letter knowledge came through in a number of the results. High concurrent and predictive correlations were frequently found between letter knowledge and literacy. Controlling for letter knowledge often resulted in considerable reduction in the size of the correlations between measures of phonological awareness and literacy. The prominence of letter knowledge in the current study, along with numerous research studies showing positive effects of instruction involving letter knowledge (see Adams, 1990), suggests that early literacy programmes should include an emphasis on letter names and sounds. Such an emphasis can be included as part of a programme that also emphasises the use of quality literature and plenty of meaningful text reading and writing for children (see Adams, 1990; Pressley, Wharton-McDonald, & Mistretta, 1998; Snow, Burns, & Griffin, 1998; Stahl, Duffy-Hester, and Stahl, 1998).

Children can begin to develop knowledge about letters in the preschool years. A variety of games and activities can be used to introduce children to letter names and sounds (see Bear, Invernizzi, Templeton, & Johnston, 1996). Learning about the spelling of their own names helps young children to gain understandings about letters and the communicative role of print (see Treiman and Broderick, 1998). The

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[50] This does not mean that nonreaders can't be trained in phoneme awareness skills. However, evidence from Lundberg et al. (1988) suggests that considerable amounts of training are required for nonreading children to show gains in phoneme awareness.

New Zealand early childhood curriculum, Te Whāriki , (Ministry of Education, 1996a) notes the importance of reading to children but makes no specific mention of letters or the alphabet. The goal of most relevance to literacy in Te Whāriki is *Communication, Goal 3:* "Children experience an environment where they experience the stories and symbols of their own and other cultures" (p.78). Letters can be defined as symbols, but it would have been useful if Te Whāriki had more clearly stated the value of providing children with experiences that develop knowledge about letters.

The English curriculum for New Zealand schools (Ministry of Education, 1994) implicitly acknowledges the importance of letter knowledge in its achievement objective for Reading in the first years of school. The level 1 achievement objective states that children should be "beginning to use semantic, syntactic, visual, and grapho-phonic cues to gain meaning" (p.76). However, there has been considerable debate in New Zealand about the relative emphasis that teachers should give to each of these cues (see Nicholson, 1991; Smith & Elley, 1994; Tunmer and Chapman, 1999). In addition to the English curriculum, the Ministry of Education provides schools with guidelines for the teaching of literacy skills. Recent guidelines (Ministry of Education, 1996b) have provided a greater emphasis on the value of learning about letter names and letter-sound correspondences than was evident in the earlier guidelines (Department of Education, 1985).

6.4 Recommendations for Future Research

The design and findings of the current study provide useful information for future research on phonological awareness and literacy. The study was designed to overcome some of the problems of past research and provides useful features to incorporate into the design of future studies. The following discussion will also note the limitations of the current study.

The findings of the current study showed how important it is that longitudinal studies begin with nonreaders. This simplifies the causal interpretation of any predictive measures that are made at the start of an investigation. It is also important that studies take account of variables that may contribute to relationships between measures of phonological awareness and literacy. In the current study measures were made of verbal skills (receptive vocabulary) phonological memory (digit span) and letter knowledge (names and sounds). Although verbal skills and phonological memory were often found to have little connection with phonological awareness and literacy, it is worthwhile for studies to check for the influence of these variables as some previous research has indicated they may play a role (e.g., Hansen & Bowey, 1994, Rohl & Pratt, 1995). Future studies might consider using different measures of phonological memory and verbal skills than used in the current study. More specifically, it may be useful to include a measure of phonological memory that includes processing as well as storage because this may reflect the operations involved in some phonological awareness tasks (see Rohl & Pratt, 1995). Assessing a range of verbal skills, and not just receptive vocabulary as in the current study, may be useful for discovering more about the relationships between phonological awareness and literacy. Bowey (1990) suggested that researchers assess both receptive vocabulary and sentence imitation skills when taking account of the influence of general language ability on performance on phonological awareness tasks. Future research could also examine links between speech perception, articulation, and phonological awareness as this may increase understanding about common underlying processes (see Brady, 1997; Gibbs, 1996).

Future research needs to pay close attention to issues concerned with the measurement of phonological awareness. The current study showed the importance of distinguishing between tasks on the basis of the size of phonological segment. Different relationships were found between each type of phonological awareness (syllable, rhyme, alliteration, and phoneme) and literacy. However, the tasks

sometimes varied not only in the size of phonological segment but also in the type of operation required to show awareness of a segment (A notable difference was that the rhyme and alliteration tasks required categorization whereas the phoneme awareness tasks required segmentation or deletion). Future studies should ideally use tasks that require children to use the same operation to show awareness of segments of different size (see Stahl & Murray, 1994). Such tasks would simplify the comparison of performance levels on different tasks. An additional measurement factor that should be considered in more detail in future studies is how the linguistic characteristics of test items may affect performance (see McBride-Chang, 1995).

Future research also needs to consider how to best assess literacy skills. Most studies have only looked at connections between phonological awareness and reading. The current study made assessments of reading and spelling for both words and pseudowords. This enabled an examination of the different patterns of relationships between types of phonological awareness and different measures of literacy. All measures of literacy were highly intercorrelated, with the findings for word reading generally indicative of the findings for the other measures.

The findings of the current study highlight the need for future research on causal links in both directions - that is from phonological awareness to literacy, and from literacy to phonological awareness. To carry out such analyses in longitudinal research it is preferable that all measures are given at each assessment occasion. This enables correlations between variables to be calculated in both directions over any particular time period. However, as found in the current study, floor and ceiling effects can occur when the same test is used to assess an ability that develops from very low levels to very high levels during the length of a study.

Assessing children with the same tests on each occasion in the current study provided valuable information about their growth in particular skills. However, repeated use of the same tests may have resulted in practice effects. Operating against the possibility of practice effects in the current study was the fact that the period between testing sessions was at least seven weeks in the first year of the study and at least fourteen weeks in the second year. Future longitudinal studies could include alternative forms of a test to minimise the possibility of practise effects.

The current study did not include observations of the children's classroom instructional programmes. Collection of such information in a longitudinal study

would be useful for examining whether links could be made between the development of particular skills in phonological awareness and literacy, and what is occurring in the classroom. If a study involved a large number of children in different classrooms it may be possible to observe if differences in the acquisition of particular skills are related to the content of different classroom programmes. Comparative research of Scottish and New Zealand children suggests that type of instruction may influence the level of phonological recoding skill, but not the level of phoneme awareness, for 7 and 8 year old children. Connelly, Johnston, and Thompson (1999) found that phonics taught children in Scotland had higher levels of phonological recoding skill, but similar levels of phoneme awareness, to children taught in a nonphonics programme in New Zealand. Future studies could also consider how home literacy practises may influence skills in phonological awareness and literacy, and the interactive effects that may occur between home practises and classroom programmes.

The correlational design of the current study places limits on its causal interpretation. The large number of variables that were correlated meant that the possibility of Type 1 error was a problem. Some protection against this was provided by the repeated assessment of each variable over the course of the study. This enabled an examination of trends in correlations between particular variables. Although type 1 error may have been responsible for the labelling of a correlation between two variables as "significant" when in fact no relationship existed, it was less likely to have been a problem when examining the overall pattern of correlations between the two variables throughout the length of the study.

The relatively small size of the sample in the current study meant that it was inappropriate to use latent variable causal modelling (e.g., LISREL, Joreskog & Sorbom, 1986). This multivariate correlational method requires a sample size that is large in comparison to the number of parameters being assessed. If future studies are able to assess large groups of children, then latent variable causal modelling can provide a powerful test of causal theories.

Some of the findings of the current study would benefit from further investigation using an experimental design. The finding that syllable awareness in nonreaders was the strongest predictor of later literacy indicates that it would be worthwhile to investigate whether or not preschool syllable awareness could be trained, and what effect this has on literacy development. The finding that rhyme awareness (and alliteration awareness to a lesser extent) in nonreaders was significantly correlated with some measures of literacy in the first months of schooling indicates that

experimental investigations of preschool training in rhyme and alliteration awareness are warranted. One previous study (Lundberg et al., 1988) trained preschool children with rhyme activities, but syllable and phoneme activities were also part of the training.

The current study found evidence that phoneme awareness did not develop until after children had gained early reading and spelling skills. It is still possible, however, that early training in phoneme awareness could enhance the rate of literacy acquisition. Experimental studies could investigate whether or not the provision of phoneme awareness training to preschoolers, and to children in the first or second years of school, results in improved progress in literacy.

The finding that relationships between different types of phonological awareness and literacy may be influenced by letter knowledge suggests that close attention be given to the role of letter knowledge in any training programmes. The treatment condition in an experimental study should differ from the control condition only in the provision of training in a particular type of phonological awareness and not in exposure to activities that may affect letter knowledge. Experimental and control groups should have their letter knowledge assessed before and after training. Both letter-name and letter-sound knowledge should be measured because there was evidence in the current study that names and sounds make different contributions to the relationships between phonological awareness and literacy.

The strong influence of letter knowledge on literacy in the current study indicates that it would be valuable to carry out experimental studies which focus on the effects of providing activities to increase young children's familiarity with letter names and sounds. Although past experimental work in this area has not produced positive results, this may have been because the design of these studies was inadequate (see Ehri, 1983). Since this earlier work, mostly over 20 years ago, there has been little research that isolates the effects of teaching children about letter knowledge. Learning about letter names and sounds is only one aspect of learning to read and spell, but the current study indicates that it has a central role.

APPENDICES

Appendix A Test Information

This appendix contains lists of items for each test. For information on how the tests were administered, see Section 3.5

TAAS-Syllables Test

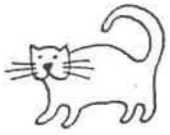
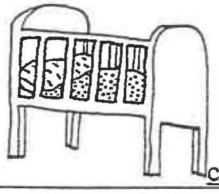
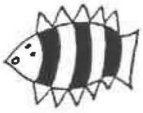
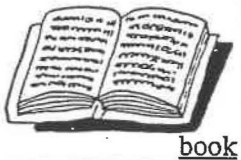
Item	Question	Correct Response
Demonstration Items		
A Say cowboy	Now say it again but don't say boy	cow
B Say spaceship	Now say it again but don't say space	ship
Test Items		
1 Say sunshine	Now say it again but don't say shine	sun
2 Say picnic	Now say it again but don't say pic	nic
3 Say cucumber	Now say it again but don't say cu (q)	cumber

Rhyme Categorization

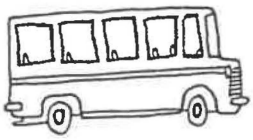
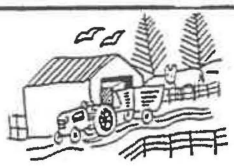
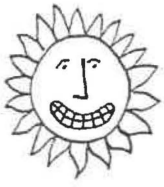
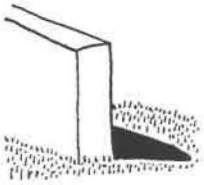
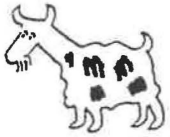
The test items for the rhyme categorization test were developed by MacLean, Bryant and Bradley (1987). Gregory O'Brien drew the pictures that were used to accompany the task in the current study. No numbers or words were on the pictures shown to the children.

A	sail	nail	boot
B	cat	bell	hat
1.	sock	hay	tray
2.	peg	cot	leg
3.	fish	dish	book
4.	bus	arm	farm
5.	cup	sand	hand
6.	hen	car	pen
7.	gun	sun	tap
8.	wall	dog	ball
9.	paw	boat	goat

Rhyme Categorization

A  sail	 nail	 boot
B  cat	 bell	 hat
1.  sock	 tray	 hay
2.  peg	 cot	 leg
3.  fish	 dish	 book

Rhyme Categorization

4.  bus	 arm	 farm
5.  cup	 sand	 hand
6.  hen	 car	 pen
7.  gun	 sun	 tap
8.  wall	 dog	 ball
9.  paw	 boat	 goat

Alliteration Categorization

The test items for the alliteration categorization test were developed by MacLean et al. (1987). Gregory O'Brien drew the pictures that were used to accompany the task in the current study. No numbers or words were on the pictures shown to the children.

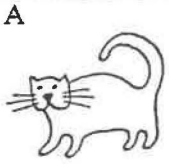
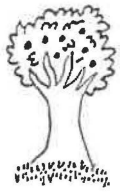
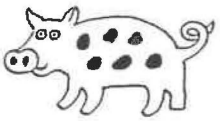
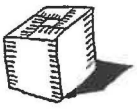
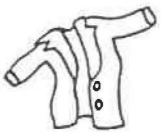
A	cat	car	hen
B	pin	tree	pig
1.	bed	hair	bell
2.	box	tray	train
3.	coach	farm	coat
4.	dog	doll	sun
5.	book	hand	hat
6.	man	fish	mat
7.	nail	peg	pen
8.	toad	toast	girl
9.	rain	bag	bat

Medial Phoneme Categorization

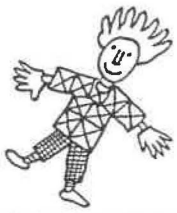
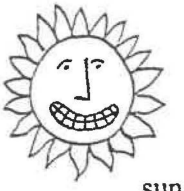
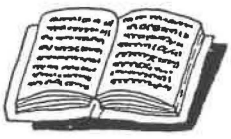
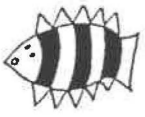
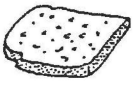
Some of the items for the Phoneme Categorization test were adapted from those used by Bowey and Francis (1991). Other items were developed for the current study. Gregory O'Brien drew the pictures that were used with this task. No numbers or words were on the pictures shown to the children.

A	mat	mop	man
B	cat	can	cup
1.	bed	bag	bat
2.	peg	pen	pad
3.	lid	leg	lip
4.	pin	pig	pot
5.	hat	hen	head
6.	neck	net	knob
7.	sack	sun	sad
8.	duck	dog	dot
9.	bun	bat	bug

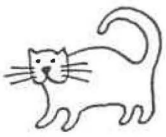
Alliteration Categorization

A  cat	 car	 hen
B  pin	 tree	 pig
1.  bed	 hair	 bell
2.  box	 tray	 train
3.  coach	 farm	 coat

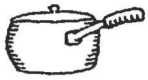
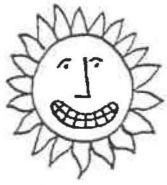
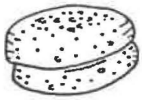
Alliteration Categorization

4.  dog	 doll	 sun
5.  book	 hand	 hat
6.  man	 fish	 mat
7.  nail	 peg	 pen
8.  toad	 toast	 girl
9.  rain	 bag	 bat

Medial Phoneme Categorization

A  mat	 mop	 man
B  cat	 can	 cup
1.  bed	 bag	 bat
2.  peg	 pen	 pad
3.  lid	 leg	 lip

Medial Phoneme Categorization

4.  pin	 pig	 pot
5.  hat	 hen	 head
6.  neck	 net	 knob
7.  sack	 sun	 sad
8.  duck	 dog	 dot
9.  bun	 bat	 bug

Tapping Task

All items for the tapping task were taken from a modified version of those used by Tunmer et al. (1988).

Demonstration items: oo, boo, boot, sĭf

Practice items: ĭp, smŭf, ă

Test items		Number of phonemes
1.	ĕz	2
2.	zĭf	3
3.	skŭb	4
4.	ĭ (as in sit)	1
5.	dăst	4
6.	kă	2
7.	vŏs	3
8.	ŭ (as in cut)	1
9.	splŭd	5
10.	ŏb	2
11.	gŭd	3

TAAS-Phonemes Test

Item	Question	Correct Response
1 Say coat	Now say it again but don't say /k/	oat
2 Say meat	Now say it again but don't say /m/	eat
3 Say take	Now say it again but don't say /t//	ache
4 Say game	Now say it again but don't say /m/	gay
5 Say wrote	Now say it again but don't say /t/	row
6 Say please	Now say it again but don't say /z/	plea
7 Say clap	Now say it again but don't say /k/	lap
8 Say play	Now say it again but don't say /p/	lay
9 Say stale	Now say it again but don't say /t/	sale
10 Say smack	Now say it again but don't say /m/	sack

Phonological Memory: Digit Span

The following items make up the forward Digit Span subtest of the WISC-R (Wechsler, 1974).

Item	Trial 1	Trial 2
1.	3-8-6	6-1-2
2.	3-4-1-7	6-1-5-8
3.	8-4-2-3-9	5-2-1-8-6
4.	3-8-9-1-7-4	9-8-5-2-1-6-3
5.	5-1-7-4-2-3-8	9-8-5-2-1-6-3
6.	1-6-4-5-9-7-6-3	2-9-7-6-3-1-5-4
7.	5-3-8-7-1-2-4-6-9	4-2-6-9-1-7-8-3-5

Word Reading

The following list contains the first 55 word from the Burt Word Reading Test (Gilmore et al., 1981). (The Burt test contains a total of 110 words but the maximum score in the current study was 48)

1-5	to	is	up	for	big
6-10	he	at	one	my	sun
11-15	went	girl	boys	day	some
16-20	his	that	of	an	wet
21-25	love	water	no	just	pot
26-30	or	now	things	told	sad
31-35	carry	village	quickly	nurse	beware
36-40	return	scramble	twisted	journey	luncheon
41-45	known	shelves	explorer	tongue	projecting
45-50	terror	serious	belief	events	emergency
51-55	refrigerator	steadiness	obtain	overwhelmed	universal

Burt Read Phonemes and Burt Spell Phonemes

The first 20 words of the Burt Test were used for the Burt Read Phonemes and Burt Spell Phonemes tests. The numbers of phonemes in each word is noted in brackets after each word.

to (2)	is (2)	up (2)	for (2)	big (3)
he (2)	at (2)	one (3)	my (2	sun (3)
went (4)	girl (3)	boys (3)	day (2)	some (3)
his (3)	that (3)	of (2)	an (2)	wet (3)

Pseudoword Read Phonemes and Pseudoword Spell Phonemes

The pseudowords were sourced from a subtest of the Interactive Reading Assessment System (Calfee & Calfee, 1981). The numbers of phonemes in each word is noted in brackets after each word.

1-6	cod (3)	gof (3)	hig (3)	nep (3)	rus (3)	tav (3)
7-12	hin (3)	nelp (4)	flass (4)	scrong (5)	pame (3)	vute (3)

Appendix B
Receptive Vocabulary, Phonological Memory, and Letter Knowledge

Table 1
Correlations Between PPVT-R at Different Times

Time	1	6	9
1	-		
6	.83***	-	
9	.86***	.88***	-

Note. Times 1 & 6, $n = 29$; Time 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 2
Correlations Between Letter Name at Different Times

Time	1	2	3	4	5	6
1	-					
2	.58***	-				
3	.48**	.93***	-			
4	.44**	.77***	.82***	-		
5	.37*	.57**	.61***	.80***	-	
6	.43**	.59***	.69***	.84***	.83***	-

Note. Times 1 - 6, $n = 29$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 3
Correlations Between Letter Sound at Different Times

Time	1	2	3	4	5	6	7	8	9
1	-								
2	-.09	-							
3	-.06	.69***	-						
4	-.20	.60***	.79***	-					
5	-.16	.38*	.60***	.75***	-				
6	-.33	.45**	.57**	.81***	.85***	-			
7	-.12	.33*	.55**	.70***	.70***	.79***	-		
8	-.02	.28	.49**	.63***	.68***	.75***	.89***	-	
9	-.05	.42*	.61***	.52**	.43**	.52**	.67***	.74***	-

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 4
Concurrent Correlations Between Letter Name, and PPVT-R and Letter Sound

Time	PPVT-R	Letter Sound
1	.14	
2		.54**
3		.65***
4		.52**
5		.55**
6	.51**	.48**

Note. Times 1 - 6, $n = 29$.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .0005$.

Table 5
Concurrent Correlations Between Letter Sound, and PPVT-R and Letter Name

Time	PPVT-R	Letter Name
1	.25	
2		.54**
3		.65***
4		.52**
5		.55**
6	.31*	.48**
7		
8		
9	.40*	

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .0005$.

Table 6
Correlations Between Digit Span Tests at Different Times

Time	1	2	3	4	5	6	7	8	9
1	-								
2	.75***	-							
3	.84***	.81***	-						
4	.75***	.81***	.81***	-					
5	.78***	.85***	.79***	.92***	-				
6	.81***	.71***	.72**	.77***	.79***	-			
7	.58	.83***	.66***	.84***	.82***	.69***	-		
8	.62***	.71***	.65***	.80***	.85***	.75***	.82***	-	
9	.55**	.50**	.59**	.67***	.69***	.72***	.73***	.81***	-

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .0005$.

Table 7

Concurrent Correlations Between Digit Span, and PPVT-R and Letter Knowledge

Time	PPVT-R	Letter Name	Letter Sound
1	.21	.41*	-
2		.33*	.49**
3		.23	.34*
4		.22	.33*
5		.21	.37*
6	.32*	.21	.21
7			.15
8			.48**
9	.40*		.46**

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$

*$p < .05$. **$p < .01$. ***$p < .0005$.

Appendix C
Reading and Spelling

Table 1
Correlations Between Burt Read at Different Test Times

Time	2	3	4	5	6	7	8	9
2	-							
3	.86***	-						
4	.83***	.94***	-					
5	.70***	.81***	.89***	-				
6	.71***	.75***	.85***	.95***	-			
7	.59**	.70***	.76***	.88***	.93***	-		
7	.67***	.71***	.79***	.88***	.93***	.93***	-	
9	.67***	.71***	.78***	.83***	.87***	.88***	.94***	-

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 2
Correlations Between Burt Read Phonemes at Different Test Times

Time	2	3	4	5	6	7	8	9
2	-							
3	.83***	-						
4	.86***	.90***	-					
5	.61***	.70***	.83***	-				
6	.63***	.64***	.81***	.92***	-			
7	.44*	.61***	.68***	.86***	.88***	-		
8	.50**	.55**	.66***	.80***	.87***	.86***	-	
9	.39*	.38*	.48**	.52**	.61***	.62***	.75***	-

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 3
Correlations between Burt Spell Phonemes at Different Test Times

Time	2	3	4	5	6	7	8	9
2	-							
3	.80***	-						
4	.74***	.88***	-					
5	.51**	.65***	.74***	-				
6	.52**	.65***	.72***	.90***	-			
7	.52**	.68***	.70***	.81***	.86***	-		
8	.41*	.47**	.55**	.61***	.69***	.81***	-	
9	.36*	.44*	.45**	.63***	.69***	.80***	.87***	-

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 4
Correlations Between Pseudoword Read Phonemes at Different Test Times

Time	2	3	4	5	6	7	8	9
2	-							
3	.85***	-						
4	.53**	.61***	-					
5	.67***	.77***	.68***	-				
6	.60***	.66***	.72***	.80***	-			
7	.49**	.65***	.65***	.84***	.90***	-		
8	.39*	.56**	.60***	.72***	.81***	.88***	-	
9	.38*	.48**	.51**	.61***	.64***	.71***	.84***	-

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 5
Correlations Between Pseudoword Spell Phonemes at Different Test Times

Time	2	3	4	5	6	7	8	9
2	-							
3	.85***	-						
4	.78***	.75***	-					
5	.65***	.53**	.78***	-				
6	.67***	.53**	.75***	.85***	-			
7	.49**	.41*	.72***	.67***	.66***	-		
8	.38*	.27	.57**	.58**	.57**	.78***	-	
9	.29	.20	.52**	.58**	.45**	.78***	.74***	-

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 6
Concurrent Correlations Between Burt Read and Other Reading and Spelling Tests

Time	Burt Read Phonemes	Burt Spell Phonemes	Pseudo-word Read Phonemes	Pseudo-word Spell Phonemes	Neale Accuracy	Neale Compre-hension
2	.99***	.68***	.09	.09		
3	.96***	.74***	.41*	.23		
4	.99***	.76***	.69***	.58***		
5	.97***	.76***	.67***	.55***		
6	.97***	.84***	.78***	.69***		
7	.92***	.82***	.72***	.71***		
8	.85***	.72***	.91***	.51**		
9	.74***	.80***	.82***	.79***	.94**	.84**

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 7
Tests of Significant Differences Between Males and Females for Burt Read

	Burt Read-Males		Burt Read - Females		t
Time	M	SD	M	SD	
2	3.00	2.19	4.31	3.01	1.35
3	4.94	3.53	8.08	4.29	2.16*
4	5.88	4.51	10.38	5.28	2.48**
5	8.88	5.07	15.55	5.98	3.40***
6	10.56	5.45	18.38	7.03	3.38***
7	12.57	6.05	23.38	5.85	4.71***
8	16.71	7.24	28.85	9.15	3.83***
9	21.93	6.89	32.85	7.98	3.81***

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8
Concurrent Correlations Between PPVT-R, and Reading and Spelling

Time	Burt Read	Burt Read Phonemes	Burt Spell Phonemes	Pseudoword Read Phonemes	Pseudoword Spell Phonemes
6	.30	.30	.31*	.13	.20
9	.42*	.35*	.51**	.39*	.49*

Note. Time 6, $n = 29$; Time 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9
Predictive Correlations From Time 1 PPVT-R to Reading and Spelling

	Correlation from Time 1 PPVT-R to:				
Time	Burt Read	Burt Read Phonemes	Burt Spell Phonemes	Pseudoword Read Phonemes	Pseudoword Spell Phonemes
2	.35*	.31*	.41*	.01	.03
3	.33*	.23	.23	.17	-.03
4	.35*	.31*	.16	.-05	.11
5	.27	.21	.11	.09	.02
6	.24	.23	.20	-.08	.00
7	.19	.24	.40	.11	.33*
8	.26	.41*	.43*	.18	.12
9	.27	.27	.41*	.18	.32*

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 10
Predictive Correlations From PPVT-R at end of Year One to Reading and Spelling

	Correlation from PPVT-R at end of Year One (Time 6) to:				
Time	Burt Read	Burt Read Phonemes	Burt Spell Phonemes	Pseudoword Read Phonemes	Pseudoword Spell Phonemes
7	.17	.17	.42*	.23	.40*
8	.30	.28	.49**	.30	.37*
9	.26	.28	.49**	.29	.45**

Note. Time 6, $n = 29$; Times 7 - 9, $n = 27$
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 11
Concurrent Correlations Between Letter Name, and Reading and Spelling: Unadjusted and Adjusted for PPVT-R

Time	Burt Read		Burt Read Phonemes		Burt Spell Phonemes	
	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.54**	.53**	.55**	.53**	.61***	.61***
3	.59***	.56**	.55**	.53**	.65***	.63***
4	.59***	.55**	.63***	.60***	.58***	.56**
5	.63***	.60***	.67***	.65***	.60***	.59***
6	.70***	.67***	.72***	.69***	.55**	.48**

Note. Times 2 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 12
Concurrent Correlations Between Letter Name and Pseudoword Reading and Spelling: Unadjusted and Adjusted for PPVT-R

	Pseudoword Read Phonemes		Pseudoword Spell Phonemes	
Time	Unadjusted	Adjusted for PPVT-R[a]	Unadjusted	Adjusted for PPVT-R[a]
2	.54**	.55**	.46**	.46**
3	.53**	.52**	.52**	.53**
4	.39*	.42*	.48**	.47**
5	.53**	.56**	.43**	.44**
6	.48**	.49**	.36*	.31

Note. Times 2 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 13
Concurrent Correlations Between Letter Sound, and Reading and Spelling: Unadjusted and Adjusted for PPVT-R

	Burt Read		Burt Read Phonemes		Burt Spell Phonemes	
Time	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	-.03	-.10	-.03	-.09	.37*	.34
3	.30	.24	.25	.20	.62***	.59***
4	.28	.25	.31	.28	.59***	.58**
5	.61***	.59***	.64***	.63***	.68***	.67***
6	.62***	.58**	.66***	.63***	.75***	.73***
7	.61***	.60**	.61***	.60**	.73***	.68***
8	.59***	.53**	.71***	.64***	.78***	.71***
9	.61***	.53**	.54**	.47**	.55***	.45**

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
[a] PPVT-R was administered at Times 1, 6, and 9.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 14
Concurrent Correlations Between Letter Sound and Pseudoword Reading and Spelling: Unadjusted and Adjusted for PPVT-R

	Pseudoword Read Phonemes		Pseudoword Spell Phonemes	
Time	Unadjusted	Adjusted for PPVT-R[a]	Unadjusted	Adjusted for PPVT-R[a]
2	.70***	.71***	.63***	.64***
3	.63***	.62***	.73***	.76***
4	.45**	.46**	.78***	.78***
5	.60***	.71***	.62***	.63***
6	.66***	.66***	.63***	.61***
7	.68***	.66***	.73***	.68***
8	.62***	.57**	.66***	.59**
9	.79***	.75***	.76***	.70***

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.
[a] PPVT-R was administered at Times 1, 6, and 9.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 15

Predictive Correlations from Letter Name at Time (t) to Burt Read at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for PPVT-R

	Burt Read at Time (t+1)		Burt Read at end of Year One (Time 6)		Burt Read at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.42*	.40*	.33*	.31	.22	.19
2	.54***	.53**	.68***	.67***	.41*	.38*
3	.65***	.63***	.73***	.72***	.53**	.50**
4	.70***	.67***	.73***	.72***	.61***	.58**
5	.65***	.63***	.65***	.63***	.57**	.53**
6	.70***	.72***			.69***	.65***

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 16

Predictive Correlations from Letter Name at Time (t) to Burt Read Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Burt Read Phonemes at Time (t+1)		Burt Read Phonemes at end of Year One (Time 6)		Burt Read Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.41*	.39*	.35*	.33*	.20	.16
2	.50**	.48**	.66***	.65***	.17	.12
3	.69***	.68***	.71***	.69***	.26	.21
4	.75***	.74***	.74***	.72***	.44*	.38*
5	.67***	.64***	.67***	.64***	.54**	.51**
6	.72***	.71***			.67***	.63***

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 17

Predictive Correlations from Letter Name at Time (t) to Burt Spell Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Burt Spell Phonemes at next Time (t+1)		Burt Spell Phonemes at end of Year One (Time 6)		Burt Spell Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.41*	.39*	.25	.23	.20	.15
2	.62***	.60***	.58***	.56**	.12	.04
3	.73***	.72***	.65***	.64***	.29	.22
4	.62***	.62***	.64***	.62***	.45**	.37*
5	.60***	.58**	.60***	.58**	.54**	.48**
6	.69**	.61***			.68***	.58***

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 18

Predictive Correlations from Letter Name at Time (t) to Pseudoword Read Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Pseudoword Read Phonemes at next Time (t+1)		Pseudoword Read Phonemes at end of Year One (Time 6)		Pseudoword Read Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.22	.22	.26	.27	.17	.15
2	.55**	.54**	.65***	.67***	.47**	.45**
3	.49**	.51**	.65***	.68***	.67***	.65***
4	.50**	.52**	.54**	.59***	.65***	.63***
5	.52**	.56**	.52**	.56**	.64***	.62***
6	.58**	.55**			.71***	.68***

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 19

Predictive Correlations from Letter Name at Time (t) to Pseudoword Spell Phonemes at next Time (t+1), end of Year One , and end of Year Two

	Pseudoword Spell Phonemes at next Time (t+1)		Pseudoword Spell Phonemes at end of Year One (Time 6)		Pseudoword Spell Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.11	.11	.15	.15	.29	.25
2	.57**	.59***	.58***	.59***	.32*	.28
3	.64***	.63***	.63***	.65***	.54**	.50**
4	.54**	.55**	.49**	.52**	.57**	.51**
5	.34*	.36*	.34*	.36*	.47**	.42*
6	.72***	.68***			.73***	.69***

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 20

Predictive Correlations from Letter Sound at Time (t) to Burt Read at next Time (t+1), end of Year One, and end of Year Two

	Burt Read at next Time (t+1)		Burt Read at end of Year One (Time 6)		Burt Read at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.08	.03	.25	.22	.11	.06
3	.41*	.35*	.54**	.51**	.48**	.43*
4	.48**	.46**	.56**	.54**	.39*	.36*
5	.62***	.60***	.62***	.60***	.51**	.48**
6	.47**	.45**			.45**	.40*
7	.70***	.67***			.63***	.59**
8	.60***	.54**			.60***	.54**

Note. Times 2 - 6, $n = 29$; Time 7 - 9, $n = 27$. Correlations are not shown from Time 1 Letter Sound because 24 of the 29 children knew no letter sounds at that time.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 21

Predictive Correlations from Letter Sound at Time (t) to Burt Read Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Burt Read Phonemes at next Time (t+1)		Burt Read Phonemes at end of Year One (Time 6)		Burt Read Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.05	.02	.31*	.28	.01	-.05
3	.44**	.39*	.52**	.49**	.34*	.28
4	.52**	.51**	.58***	.56**	.31	.28
5	.62***	.61***	.62***	.61***	.32*	.28
6	.43*	.41*			.31	.25
7	.74***	.70***			.42*	.36*
8	.54**	.48**			.54**	.48**

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$. Correlations are not shown from Time 1 Letter Sound because 24 of the 29 children knew no letter sounds at that time.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 22

Predictive Correlations from Letter Sound at Time (t) to Burt Spell Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Burt Spell Phonemes at next Time (t+1)		Burt Spell Phonemes at end of Year One (Time 6)		Burt Spell Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.42*	.40*	.28	.26	.02	-.06
3	.62***	.61***	.57**	.55**	.27	.18
4	.64***	.63***	.72***	.71***	.35*	.30
5	.70***	.69***	.70***	.69***	.43*	.38*
6	.61***	.57**			.41*	.32*
7	.70***	.63***			.64***	.56**
8	.69***	.59**			.69***	.59**

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$. Correlations are not shown from Time 1 Letter Sound because 24 of the 29 children knew no letter sounds at that time.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 23

Predictive Correlations from Letter Sound at Time (t) to Pseudoword Read Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Pseudoword Read Phonemes at next Time (t+1)		Pseudoword Read Phonemes at end of Year One (Time 6)		Pseudoword Read Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.57**	.56**	.41*	.43**	.22	.19
3	.43**	.45**	.68***	.72***	.53**	.51**
4	.73***	.74***	.64***	.66***	.54**	.53**
5	.65***	.68***	.65***	.68***	.62***	.60***
6	.68***	.66***			.65***	.62***
7	.72***	.69***			.72***	.69***
8	.70***	.67***			.70***	.67***

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$. Correlations are not shown from Time 1 Letter Sound because 24 of the 29 children knew no letter sounds at that time.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 24

Predictive Correlations from Letter Sound at Time (t) to Pseudoword Spell Phonemes at next Time (t+1), end of Year One, and end of Year Two

	Pseudoword Spell Phonemes at next Time (t+1)		Pseudoword Spell Phonemes at end of Year One (Time 6)		Pseudoword Spell Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.70***	.71***	.29	.29	.15	.09
3	.73***	.73***	.55**	.55**	.46**	.41*
4	.74***	.75***	.70***	.70***	.45**	.42*
5	.67***	.68***	.67***	.68***	.39*	.35*
6	.61***	.57**			.42*	.34*
7	.60***	.53**			.64***	.57**
8	.75***	.68***			.75***	.68***

Note. Times 2 - 6, $n = 29$; Time 7 - 9, $n = 27$. Correlations are not shown from Time 1 Letter Sound because 24 of the 29 children knew no letter sounds at that time.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 25

Concurrent Correlations Between Digit Span and Burt Reading and Spelling: Unadjusted and Adjusted for PPVT-R

	Burt Read		Burt Read Phonemes		Burt Spell Phonemes	
Time	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
2	.27	.14	.26	.15	.61***	.53**
3	.34*	.30	.27	.23	.43**	.40*
4	.26	.15	.24	.14	.36*	.33*
5	.21	.10	.21	.13	.26	.24
6	.10	.00	.14	.05	.29	.21
7	.02	-.14	.01	-.16	.20	-.15
8	.18	.02	.25	.05	.41*	.19
9	.26	.11	.32*	.21	.38*	.22

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 26

Concurrent Correlations Between Digit Span and Pseudoword Reading and Spelling: Unadjusted and Adjusted for PPVT-R

	Pseudoword Read Phonemes		Pseudoword Spell Phonemes	
Time	Unadjusted	Adjusted for PPVT-R[a]	Unadjusted	Adjusted for PPVT-R[a]
2	.39*	.42*	.57**	.61***
3	.41*	.39*	.39*	.40*
4	.16	.19	.35*	.34*
5	.17	.23	.41*	.45**
6	-.01	-.05	.35*	.30
7	-.22	-.56	.29	.01
8	.14	-.03	.29	.12
9	.35	.25	.44*	.31

Note. Times 2 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 27

Predictive Correlations between Digit Span at Time (t) to Burt Read at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for PPVT-R

	Burt Read at next Time (t+1)		Burt Read at end of Year One (Time 6)		Burt Read at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.13	.06	.14	.10	.20	.14
2	.43**	.34*	.15	.06	.12	-.05
3	.29	.24	.09	.05	.13	.04
4	.21	.12	.13	.04	.07	-.07
5	.17	.07	.17	.07	.12	-.06
6	.08	.02			.12	.03
7	.12	-.14			.14	-.10
8	.19	.04			.19	.04

Note. Times 1 - 6, $n = 29$; Time 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 28

Predictive Correlations between Digit Span at Time (t) to Burt Read Phonemes at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for PPVT-R

	Burt Read Phonemes at next Time (t+1)		Burt Read Phonemes at end of Year One (Time 6)		Burt Read Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.12	.06	.22	.18	.18	.11
2	.33*	.27	.18	.09	.19	.03
3	.25	.21	.12	.08	.24	.16
4	.21	.15	.16	.08	.18	.06
5	.23	.14	.23	.14	.25	.11
6	.08	.02			.04	-.05
7	.22	-.08			.24	.06
8	.31	.20			.31	.20

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 29

Predictive Correlations between Digit Span at Time (t) to Burt Spell Phonemes at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for PPVT-R

	Burt Spell Phonemes at next Time (t+1)		Burt Spell Phonemes at end of Year One (Time 6)		Burt Spell Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.26	.20	.37*	.34*	.27	.18
2	.52**	.48**	.33*	.28	.35*	.15
3	.39*	.37*	.30	.28	.32*	.20
4	.25	.23	.27	.22	.15	-.05
5	.35*	.29	.35*	.29	.22	-.03
6	.10	-.04			.16	.01
7	.37*	.01			.33*	-.02
8	.31	.06			.31	.06

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 30

Predictive Correlations between Digit Span at Time (t) to Pseudoword Read Phonemes at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for PPVT-R

	Pseudoword Read Phonemes at next Time (t+1)		Pseudoword Read Phonemes at end of Year One (Time 6)		Pseudoword Read Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.26	.26	.08	.10	.18	.14
2	.42*	.39*	.12	.17	.17	.08
3	.24	.26	.07	.09	.07	.01
4	.11	.12	.04	.08	.10	.01
5	.06	.11	.06	.11	.13	.03
6	-.25	-.35			.23	.16
7	.05	-.23			.15	-.08
8	.25	.11			.25	.11

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 31

Predictive Correlations between Digit Span at Time (t) to Pseudoword Spell Phonemes at next Time (t+1), end of Year One, and end of Year Two: Unadjusted and Adjusted for PPVT-R

	Pseudoword Spell Phonemes at next Time (t+1)		Pseudoword Spell Phonemes at end of Year One (Time 6)		Pseudoword Spell Phonemes at end of Year Two (Time 9)	
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]	Un-adjusted	Adjusted for PPVT-R[a]
1	.46**	.46**	.37*	.38*	.32*	.25
2	.39*	.44**	.25	.27	.40*	.28
3	.36*	.35*	.31*	.31	.35*	.27
4	.35*	.37*	.20	.21	.20	.06
5	.28	.31	.28	.31	.32*	.17
6	.28	.18			.33*	.22
7	.23	-.05			.34*	.04
8	.39*	.19			.39*	.19

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Appendix D
Phonological Awareness (Syllable Awareness, Rhyme Awareness, Alliteration Awareness, and Phoneme Awareness)

Table 1
Correlations Between TAAS-Syllables at Different Test Times

Time	1	2	3
1	-		
2	.66***	-	
3	.47**	.76***	-

Note. Times 1 - 3, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 2
Concurrent Correlations between TAAS-Syllables and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span
1	.30	.47**	.07	.28
2		.33*	.25	.43**
3		.21	.07	.34*

Note. Times 1 - 3, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 3
Concurrent Correlations between TAAS-Syllables and Other Variables: Adjusted for PPVT-R

Time	Letter Name	Letter Sound	Digit Span
1	.45**		.24
2	.29	.21	.33*
3	.14	-.03	.30

Note. Times 1 - 3, $n = 27$.
PPVT-R was administered at Time 1.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 4
Correlations between Rhyme Categorization at Different Test Times

Time	1	2	3	4	5	6	7	8	9
1	-								
2	.60**	-							
3	.67***	.82***	-						
4	.51**	.83***	.70***	-					
5	.49**	.67***	.71***	.76***	-				
6	.47**	.75***	.72***	.82***	.87***	-			

Note. Times 1 - 6, $n = 29$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 5
Correlations between Alliteration Categorization at Different Test Times

Time	1	2	3	4	5	6	7	8	9
1	-								
2	.64***	-							
3	.59***	.74***	-						
4	.38*	.50**	.60***	-					
5	.47**	.36*	.34*	.01	-				
6	.40*	.20	.34*	.12	.66***	-			

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 6
Concurrent Correlations Between Rhyme and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span	TAAS-Syllables	Allit-eration
1	.41*	.41*	-	.24	.28	.75***
2		.36*	.21	.57**	.19	.71***
3		.28	.18	.25	-.02	.75***
4		.49**	.08	.24		.26
5		.00	.08	.14		.35*
6	.28	.20	-.07	.36*		.45**

Note. Times 1 - 6, $n = 29$..
$*p < .05$. $**p < .01$. $***p < .0005$.

Table 7
Concurrent Correlations Between Rhyme and Other Variables: Adjusted for PPVT-R

Time	Letter Name	Letter Sound	Digit Span	TAAS-Syllables	Alliteration
1	.39*		.17	.19	.73***
2	.34*	.18	.54**	.12	.71***
3	.26	.17	.25	-.06	.75***
4	.45**	.04	.17		.24
5	-.05	.05	.08		.35*
6	.08	-.17	.30		.39*

Note. Times 1 - 6, $n = 29$.
PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8
Concurrent Correlations Between Alliteration and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span	TAAS-Syllables	Rhyme
1	.28	.13		.14	.09	.75***
2		.26	.35*	.43**	.06	.71***
3		.11	-.01	.28		.75***
4		-.14	.15	.16		.26
5		.39*	.34*	-.04		.35*
6	.37*	.28	.28	.04		.45***

Note. Times 1 - 6, $n = 29$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9
Concurrent Correlations Between Alliteration and Other Variables: Adjusted for PPVT-R

Time	Letter Name	Letter Sound	Digit Span	TAAS-Syllables	Alliteration
1	.10		.09	.01	.73***
2	.25	.34*	.42*	.03	.71***
3	.09	-.04	.26	.00	.75***
4	-.19	.13	.12		.24
5	.40*	.34*	-.05		.35*
6	.12	.18	-.09		.39*

Note. Times 1 - 6, $n = 29$.
PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 10
Correlations between testing times: Medial Phoneme

Time	1	2	3	4	5	6	7	8	9
1	-								
2	.51**	-							
3	.53**	.69***	-						
4	.41*	.53**	.63***	-					
5	.36*	.65***	.71***	.50**	-				
6	.36*	.56**	.48**	.39*	.42*	-			
7	.17	.22	.33*	.26	.27	.51**	-		
8	.43*	.40*	.14	.14	.12	.42*	.31	-	
9	.10	.14	.16	.35*	.22	.14	.09	.27	-

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 11
Concurrent Correlations Between Medial Phoneme and Other Variables

Time	PPVT	TAAS -Syll-ables	Rhyme	Allit-eration	Tapp-ing	TAAS -Pho-nemes	Letter Name	Letter Sound	Digit Span
1	.10	.01	.73***	.78***	.32*		-.23	.00	.09
2		.18	.62***	.60***	.15		.09	-.04	.11
3		.06	.49**	.56**	.07		.18	-.23	.01
4			.39*	.10	.06	-.23	.08	-.10	-.30
5			.58***	.28	.4	.04	-.18	-.29	-.16
6	-.08		.60***	.25	.01	.04	-.12	-.26	-.04
7			-	-	.09	-.06		-.37	-.19
8			-	-	-.12	-.03		-.19	-.18
9	.40		-	-	.08	-.08		-.26	-.25

Note. Times 1 - 6, $n = 29$; Time 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 12
Concurrent Correlations Between Medial Phoneme and Reading and Spelling

Time	Burt Read	Burt Read Phonemes	Burt Spell Phonemes	Pseudoword Read Phonemes	Pseudoword Spell Phonemes
2	.24	.21	.04	-.18	-.27
3	.00	.02	.06	-.08	-.06
4	-.07	-.07	.13	-.13	.11
5	-.14	-.22	-.07	-.34	.03
6	-.12	-.18	-.17	-.08	-.26
7	-.13	-.02	-.32	-.39	-.23
8	.03	-.01	-.01	.06	.03
9	-.14	-.38	-.28	-.08	-.22

Note. Times 2 - 6, $n = 29$; Time 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 13
Correlations Between TAAS-Phonemes at Different Test Times

Time	4	5	6	7	8	9
4	-					
5	.65***	-				
6	.44**	.73***	-			
7	.27	.52**	.59**	-		
8	.24	.33*	.42*	.67***	-	
9	.22	.22	.33*	.59**	.57**	-

Note. Times 4 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 14
Correlations Between Tapping at Different Test Times

Time	1	2	3	4	5	6	7	8	9
1	-								
2	.27	-							
3	.32*	.18	-						
4	.10	.34*	.24	-					
5	.23	.46**	.10	.55**	-				
6	.29	.42*	.22	.42*	.69***	-			
7	.23	.38*	.49**	.15	.31	.29	-		
8	.12	.02	.32*	.14	.22	.26	.40*	-	
9	.06	.12	.21	-.06	.25	.21	.46**	.53**	-

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 15
Concurrent Correlations between TAAS-Phonemes and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span	Rhyme	Allit-eration	Tapping
4		.30	.60***	.15	.28	.12	.17
5		.23	.37*	.08	.12	.23	.19
6	-.06	.18	.30	.19	.19	.26	.24
7			.41*	-.13			.37*
8			.41*	.36*			.68***
9	.49**		.48**	.32*			.44*

Note. Times 1 - 6, $n = 29$; Time 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 16
Concurrent Correlations between TAAS-Phonemes and Other Variables: Adjusted for PPVT-R

Time	Letter Name	Letter Sound	Digit Span	Rhyme	Allit-eration	Tapping
4	.30	.61***	.15	.29	.11	.17
5	.26	.39*	.11	.13	.23	.23
6	.24	.34*	.22	.21	.31	.33*
7		.46**	-.15			.40*
8		.31	.24			.65***
9		.36**	.16			.36*

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
PPVT-R was administered at Times 1, 6, and 9.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 17
Concurrent Correlations between Tapping and Other Variables

Time	PPVT-R	Letter Name	Letter Sound	Digit Span	Rhyme	Allit-eration	TAAS-Phonemes
1	.20	.21		.28	.17	.17	
2		.47**	.47**	.40*	.38*	.43**	
3		.29	.35*	.59***	.32*	.15	
4		.22	.45**	.32*	.10	.14	.17
5		.32*	.32*	.21	.44**	.53**	.19
6	.57**	.36*	.34*	.45**	.48**	.46**	.24
7			.37*	.27			.37*
8			.50**	.41*			.68***
9	.31		.48**	.18			.44**

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 18
Concurrent Correlations between Tapping and Other Variables: Adjusted for PPVT-R

Time	Letter Name	Letter Sound	Digit Span	Rhyme	Allit-eration	TAAS-Phonemes
1	.19		.24	.10	.13	
2	.47**	.46**	.39	.37*	.43*	
3	.29	.35*	.59***	.32*	.15	
4	.15	.43*	.24	.03	.11	.17
5	.25	.28	.04	.42*	.57**	.23
6	.09	.21	.34*	.41*	.33*	.33*
7		.30	.12			.40**
8		.42**	.30			.65***
9		.41**	.07			.36*

Note. Times 1 - 6, $n = 29$; Time 7 - 9, $n = 27$.
PPVT-R was administered at Times 1, 6, and 9.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Appendix E
Relationships between Syllable Awareness and Reading and Spelling

Table 1
Concurrent Correlations Between TAAS - Syllables and Burt Read: Unadjusted and Adjusted for Key Variables

	Burt Read-	Burt Read: Adjusted for -			
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.39*	.30	.32*	.27	.42*
3	.37*	.28	.29	.31	.37*

Note. Times 2 & 3, $n = 29$.
PPVT-R was administered at Time 1.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 2
Concurrent Correlations Between TAAS-Syllables and Burt Read Phonemes: Unadjusted and Adjusted for Key Variables

	Burt Read Phonemes -	Burt Read Phonemes: Adjusted for -			
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.39*	.31	.32*	.27	.41*
3	.30	.24	.23	.23	.30

Note. Times 2 & 3, n = 29.
[a] PPVT-R was administered at Time 1.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 3
Concurrent Correlations Between TAAS-Syllables and Burt Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes -	Burt Spell Phonemes: Adjusted for -			
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.36*	.25	.14	.22	.30
3	.17	.09	.03	.04	.16

Note. Times 2 & 3, $n = 29$.
[a] PPVT-R was administered at Time 1.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 4

Concurrent Correlations Between TAAS-Syllables and Pseudoword Read Phonemes: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes -	Pseudoword Read Phonemes: Adjusted for -			
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.17	.18	.00	-.01	-.01
3	.20	.14	.06	.10	.20

Note. Times 2 & 3, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 5

Concurrent Correlations Between TAAS-Syllables and Pseudoword Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes -	Pseudoword Spell Phonemes: Adjusted for -			
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.17	.17	-.10	.02	.02
3	-.12	-.11	-.29	-.27	-.25

Note. Times 2 & 3, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 6

Predictive Correlations from TAAS-Syllables at Time (t) to Burt Read at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Read at next Time (t+1)			Burt Read at end of Year One (Time 6)			Burt Read at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.48**	.42*	.36*	.50**	.46**	.42*	.49**	.44**	.45**
2	.37*	.28	.24	.34*	.28	.17	.41*	.34*	.35*
3	.39*	.29	.34*	.16	.07	.01	.33*	.24	.33*

Note. Times 2 & 3, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 7

Predictive Correlations from TAAS-Syllables at Time (t) to Burt Spell Phonemes at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at next Time (t+1)			Burt Spell Phonemes at end of Year One (Time 6)			Burt Spell Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.56**	.50**	.45**	.37*	.33*	.30	.42*	.33*	.37*
2	.24	.17	.05	.41*	.37*	.29	.50**	.40*	.49**
3	.30	.26	.23	.28	.22	.19	.49**	.38*	.48**

Note. Times 2 & 3, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8

Predictive Correlations from TAAS-Syllables at Time (t) to Pseudoword Read Phonemes at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at next Time (t+1)			Pseudoword Read Phonemes at end of Year One (Time 6)			Pseudoword Read Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.36*	.37*	.29	.48**	.54**	.42*	.37*	.34*	.34*
2	.30	.26	.16	.25	.31	.06	.38*	.34*	.30
3	.12	.15	.02	.03	.07	-.14	.27	.22	.29

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9

Predictive Correlations from TAAS-Syllables at Time (t) to Pseudoword Spell Phonemes at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at next Time (t+1)			Pseudoword Spell Phonemes at end of Year One (Time 6)			Pseudoword Spell Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.34*	.34*	.32*	.40*	.42*	.37*	.44*	.38*	.37*
2	.05	.06	-.18	.29	.31	.13	.58**	.52**	.54**
3	.20	.17	.08	.18	.19	.06	.49**	.41*	.52**

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Appendix F
Relationships between Rhyme Awareness and Reading and Spelling

Table 1
Concurrent Correlations Between Rhyme and Burt Read: Unadjusted and Adjusted for Key Variables

	Burt Read: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.37*	.32*	.27	.22	.38*
3	.35*	.34*	.29	.24	.31
4	.57**	.54**	.55**	.40*	.58**
5	.30	.27	.28	.39*	.32*
6	.26	.20	.24	.17	.39*

Note. Times 2 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 2
Concurrent Correlations Between Rhyme and Burt Read Phonemes: Unadjusted and Adjusted for Key Variables

	Burt Read Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.34*	.29	.24	.18	.35*
3	.38*	.37*	.33*	.28	.35*
4	.57**	.54**	.54**	.39*	.58**
5	.23	.20	.21	.31	.23
6	.15	.07	.10	.00	.26

Note. Times 2 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 3
Concurrent Correlations Between Rhyme and Burt Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.44**	.39*	.14	.29	.40*
3	.42*	.42*	.36*	.33*	.40*
4	.59***	.58**	.56**	.43*	.68***
5	.21	.19	.18	.26	.21
6	.17	.09	.08	.07	.35*

Note. Times 2 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 4

Concurrent Correlations Between Rhyme and Pseudoword Read Phonemes-Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.20	.20	-.03	.01	.08
3	.23	.22	.14	.10	.36*
4	.35*	.38*	.33*	.20	.35*
5	-.05	-.05	-.08	-.06	-.15
6	.21	.18	.23	.13	.34*

Note. Times 2 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 5

Concurrent Correlations Between Rhyme and Pseudoword Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.26	.26	-.09	.12	.17
3	.19	.20	.11	.06	.09
4	.37*	.36*	.32*	.18	.50**
5	.18	.18	.14	.20	.17
6	.15	.10	.03	.09	.26

Note. Times 2 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 6

Predictive Correlations from Rhyme Categorization at Time (t) to Burt Reading at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Read at next Time (t+1)			Burt Read at end of Year One (Time 6)			Burt Read at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.41*	.31	.28	.28	.21	.17	.05	-.09	-.04
2	.39*	.34*	.24	.25	.21	.01	.02	-.04	-.12
3	.38*	.38*	.28	.22	.20	.02	-.01	-.03	-.16
4	.44**	.40*	.16	.40*	.36*	.06	.23	.17	-.12
5	.19	.16	.25	.19	.16	.25	.03	-.02	.08
6	.18	.13	-.01	.26			.19	.11	.01

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 7

Predictive Correlations from Rhyme Categorization at Time (t) to Burt Spell Phonemes at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at next Time (t+1)			Burt Spell Phonemes at end of Year One (Time 6)			Burt Spell Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.57**	.48**	.48**	.37*	.32*	.30	.16	-.03	.10
2	.44**	.41*	.29	.31*	.28	.14	.05	-.05	.02
3	.47**	.46**	.41*	.25	.23	.09	.04	.00	-.03
4	.27	.25	-.06	.29	.25	-.04	.23	.14	.01
5	.13	.10	.16	.13	.10	.16	.06	-.02	.12
6	.32*						.19	.06	.02

Note. Times 1 - 6, $n = 29$; Time 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8

Predictive Correlations from Rhyme Categorization at Time (t) to Pseudoword Read Phonemes at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at next Time (t+1)			Pseudoword Read Phonemes at end of Year One (Time 6)			Pseudoword Read Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.38*	.41*	.32*	.37*	.45**	.30	.15	.07	.09
2	.18	.15	-.02	.18	.20	-.07	.14	.10	-.01
3	.22	.22	.10	.26	.27	.11	.08	.06	-.11
4	.18	.19	-.09	.34*	.37*	.10	.38*	.35*	.08
5	.20	.22	.24	.20	.22	.24	.03	.00	.10
6	.02			.21			.20	.12	.01

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9

Predictive Correlations from Rhyme Categorization at Time (t) to Pseudoword Spell Phonemes at next Time (t+1), end of Year One , and end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at next Time (t+1)			Pseudoword Spell Phonemes at end of Year One (Time 6)			Pseudoword Spell Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.37*	.39*	.35*	.16	.18	.11	.27	.14	.18
2	.12	.13	-.11	.24	.25	.04	.29	.23	.21
3	.32*	.31	.20	.23	.23	.08	.19	.17	.07
4	.30	.31	.05	.26	.27	.03	.47**	.42*	.26
5	.18	.18	.19	.18	.18	.19	.14	.09	.20
6	.30	.21	.17				.30	.20	.17

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 10

Predictive Correlations from Burt Reading at Time (t) to Rhyme Categorization at next Time (t+1) and end of Year One: Unadjusted and Adjusted for Key Variables

	Rhyme Categorization at next Time (t+1)			Rhyme Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.39*	.39*	.29	.49**	.43*	.43*
3	.51**	.47**	.28	.56**	.51**	.49**
4	.54**	.52**	.46**	.57**	.52**	.55**
5	.36*	.30	.44**	.36*	.30	.44**

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 11

Predictive Correlations from Burt Spell Phonemes at Time (t) to Rhyme Categorization at Time (t)+ 1 and end of Year One: Unadjusted and Adjusted for Key Variables

	Rhyme Categorization at next Time (t+1)			Rhyme Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.40*	.40*	.29	.51**	.45**	.46**
3	.57**	.54**	.34*	.53**	.49**	.45**
4	.56**	.55**	.50**	.54**	.53**	.50**
5	.18	.15	.20	.18	.15	.20

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 12

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to Rhyme Categorization at Time (t)+ 1 and end of Year One: Unadjusted and Adjusted for Key Variables

	Rhyme Categorization at next Time (t+1)			Rhyme Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.28	.28	.14	.23	.23	.10
3	.30	.26	.01	.25	.21	.10
4	.27	.29	.18	.27	.29	.19
5	-.03	-.02	-.05	-.03	-.02	-.05

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

$*p < .05$. $**p < .01$. $***p < .0005$.

Table 13

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to Rhyme Categorization at Time (t)+ 1 and end of Year One: Unadjusted and Adjusted for Key Variables

	Rhyme Categorization at next Time (t+1)			Rhyme Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.27	.27	.16	.23	.24	.13
3	.25	.27	-.04	.17	.18	.00
4	.34*	.33*	.23	.35*	.33*	.27
5	.15	.15	.16	.15	.15	.16

Note. Times 1 - 6, $n = 29$; Times 7, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

$*p < .05$. $**p < .01$. $***p < .0005$.

Appendix G
Relationships Between Alliteration Awareness and Reading and Spelling

Table 1
Concurrent Correlations Between Alliteration and Burt Read- Unadjusted and Adjusted for Key Variables

	Burt Read: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.25	.23	.15	.13	.28
3	.27	.25	.19	.25	.28
4	.07	.02	.02	.19	.02
5	.43**	.44**	.44**	.25	.29
6	.37*	.29	.37*	.26	.27

Note. Times 1 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 2
Concurrent Correlations Between Alliteration and Burt Read Phonemes: Unadjusted and Adjusted for Key Variables

	Burt Read Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.25	.23	.16	.13	.28
3	.32*	.31	.27	.32*	.34*
4	.08	.04	.04	.22	.04
5	.36*	.36*	.37*	.14	.19
6	.31*	.22	.31	.16	.17

Note. Times 1 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 3
Concurrent Correlations Between Alliteration and Burt Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.35*	.34*	.13	.25	.25
3	.32*	.30	.23	.32*	.40*
4	.21	.19	.17	.36*	.15
5	.33*	.33*	.35*	.13	.14
6	.32*	.23	.32*	.20	.17

Note. Times 1 - 6, $n = 29$.
[a] PPVT-R was administered at Times 1 and 6.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 4

Concurrent Correlations Between Alliteration and Pseudoword Read Phonemes-Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.34*	.34*	.21	.24	.14
3	.20	.19	.10	.13	.27
4	.11	.12	.09	.18	.05
5	.40*	.40*	.42*	.20	.24
6	.44**	.43*	.44**	.37*	.36*

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 5

Concurrent Correlations Between Alliteration and Pseudoword Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes: Adjusted for -				
Time	Unadjusted	PPVT-R[a]	Digit Span	Letter Name	Letter Sound
2	.35*	.35*	.14	.27	.17
3	.13	.14	.03	.09	.20
4	.19	.18	.15	.30	.12
5	.37*	.37*	.42*	.25	.21
6	.26	.20	.26	.17	.11

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 6

Predictive Correlations from Alliteration Categorization at Time (t) to Burt Reading at Time (t)+ 1, end of Year One , and the end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Read at next Time (t+1)			Burt Read at end of Year One (Time 6)			Burt Read at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.21	.13	.17	.13	.07	.09	-.04	-.13	-.07
2	.19	.17	.06	.23	.21	.07	-.02	-.06	-.12
3	.28	.26	.28	.05	.02	-.04	-.13	-.18	-.21
4	.03	.00	.19	-.01	-.05	.13	-.22	-.27	-.25
5	.43**	.44**	.25	.43**	.44**	.25	.24	.24	.04
6	.17	.14	-.01	.37*			.27	.18	.13

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 7

Predictive Correlations from Alliteration Categorization at Time (t) to Burt Spell Phonemes at Time (t)+ 1, end of Year One , and the end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at next Time (t+1)			Burt Spell Phonemes at end of Year One (Time 6)			Burt Spell Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.40*	.33*	.39*	.29	.25	.26	.19	.08	.18
2	.35*	.34*	.25	.32*	.30	.21	.08	.03	-.06
3	.37*	.36*	.42*	.04	.02	-.03	-.09	-.16	-.12
4	.16	.15	.32*	.15	.13	.31	-.05	-.13	-.04
5	.39*	.39*	.21	.39*	.39*	.21	-.02	-.03	-.28
6	.20	.07	.04				.13	-.05	-.06

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8

Predictive Correlations from Alliteration Categorization at Time (t) to Pseudoword Read Phonemes at Time (t)+ 1, end of Year One , and the end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at next Time (t+1)			Pseudoword Read Phonemes at end of Year One (Time 6)			Pseudoword Read Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.21	.22	.19	.15	.18	.12	.21	.16	.19
2	.20	.19	.24	.29	.31	.17	.05	.02	-.06
3	.19	.19	.15	.07	.08	.00	-.11	-.14	-.22
4	.15	.15	.25	.03	.04	.13	-.14	-.17	-.16
5	.49**	.49**	.36*	.49**	.49**	.36*	.39*	.39*	.21
6	.43*	.38*	.36*				.32	.25	.21

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9

Predictive Correlations from Alliteration Categorization at Time (t) to Pseudoword Spell Phonemes at Time (t)+ 1, end of Year One , and the end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at next Time (t+1)			Pseudoword Spell Phonemes at end of Year One (Time 6)			Pseudoword Spell Phonemes at end of Year Two (Time 9)		
Time (t)	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name	Unadj	Adj for PPVT-R[a]	Adj for Letter Name
1	.27	.27	.26	.14	.15	.13	.23	.15	.21
2	.20	.20	.06	.20	.21	.07	.07	.03	.01
3	.19	.18	.16	.01	.01	-.07	-.01	-.05	-.06
4	.12	.12	.24	.06	.06	.15	-.02	-.07	.00
5	.32*	.32*	.21	.32*	.32*	.21	.12	.12	-.06
6	.19	.15	.01				.42*	.32	.36*

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 10

Predictive Correlations from Burt Reading at Time (t) to Alliteration Categorization at Time (t)+ 1 and end of Year One: Unadjusted and Adjusted for Key Variables

	Alliteration Categorization at next Time (t+1)			Alliteration Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.24	.22	.22	.48**	.46**	.32*
3	.08	.04	.05	.43**	.40*	.18
4	.49**	.51**	.33*	.50**	.49**	.39*
5	.36*	.33*	.37*	.36*	.33*	.37*
6						

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 11

Predictive Correlations from Burt Spell Phonemes at Time (t) to Alliteration Categorization at Time (t)+ 1, and end of Year One: Unadjusted and Adjusted for Key Variables

	Alliteration Categorization at next Time (t+1)			Alliteration Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.42*	.41*	.45**	.57**	.56**	.41*
3	.10	.07	.08	.49**	.48**	.25
4	.56**	.57**	.44**	.59***	.58**	.51**
5	.23	.22	.20	.23	.22	.20
6						

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 12

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to Alliteration Categorization at Time (t)+ 1 and at end of Year One: Unadjusted and Adjusted for Key Variables

	Alliteration Categorization at next Time (t+1)			Alliteration Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.24	.24	.22	.30	.31	.08
3	.36*	.35*	.39*	.32*	.30	.06
4	.36*	.37*	.25	.31*	.32*	.21
5	.38*	.39*	.38*	.38*	.39*	.38*
6						

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 13

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to Alliteration Categorization at next Time (t+1) and at end of Year One: Unadjusted and Adjusted for Key Variables

	Alliteration Categorization at next Time (t+1)			Alliteration Categorization at end of Year One (Time 6)		
Time (t)	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name	Un-adjusted	Adjusted for PPVT-R[a]	Adjusted for Letter Name
1						
2	.28	.28	.26	.28	.28	.10
3	.14	.14	.12	.32*	.33*	.08
4	.48**	.48**	.35*	.44**	.43*	.34*
5	.32*	.32*	.30	.32*	.32*	.30
6						

Note. Times 1 - 6, $n = 29$; Time 7, $n = 27$.

[a] PPVT-R was administered at Times 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Appendix H
Relationships Between Phoneme Awareness and Reading and Spelling

Table 1
Concurrent Correlations Between TAAS - Phonemes and Burt Read: Unadjusted and Adjusted for Key Variables

	Correlation Between TAAS-Phonemes and Burt Read: Adjusted for -					
Time	Unadj	PPVT- R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
4	.55**	.58**	.53**	.49**	.49**	.54**
5	.45**	.48**	.44**	.30	.44**	.40*
6	.28	.32	.27	.13	.25	.21
7	.43*	.48**	.47**	.30		
8	.54**	.49**	.52**	.41*		
9	.51**	.38*	.46**	.31		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
[a] PPVT-R was administered at Times 1, 6, and 9.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 2
Concurrent Correlations Between TAAS - Phonemes and Burt Read Phonemes -Unadjusted and Adjusted for Key Variables

	Correlation Between TAAS-Phonemes and Burt Read Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
4	.53**	.55**	.52**	.46**	.47**	.53**
5	.45**	.47**	.45**	.30	.44**	.40*
6	.27	.31	.25	.10	.25	.21
7	.38*	.46**	.45**	.27		
8	.47**	.39*	.42*	.28		
9	.39*	.27	.32	.18		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
[a] PPVT-R was administered at Times 1, 6, and 9.
*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 3

Concurrent Correlations Between TAAS - Phonemes and Burt Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Correlation Between TAAS-Phonemes and Burt Spell Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit eration
4	.64***	.64***	.63***	.44**	.61***	.63***
5	.58***	.59***	.58**	.48**	.57**	.55**
6	.50**	.55**	.48**	.44**	.49**	.46**
7	.58**	.65***	.62**	.44*		
8	.54**	.46**	.46**	.38*		
9	.60***	.47**	.54**	.46**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 4

Concurrent Correlations Between TAAS - Phonemes and Pseudoword Read Phonemes: Unadjusted and Adjusted for Key Variables

	Correlation Between TAAS-Phonemes and Pseudoword Read Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
4	.74***	.74***	.74***	.66***	.72***	.74***
5	.55**	.55**	.55**	.43*	.56**	.51**
6	.38*	.39*	.39*	.25	.35*	.30
7	.64***	.67***	.63***	.54**		
8	.53**	.48**	.52**	.39*		
9	.61***	.52**	.56**	.42*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 5

Concurrent Correlations Between TAAS - Phonemes and Pseudoword Spell Phonemes -Unadjusted and Adjusted for Key Variables

	Correlation Between TAAS-Phonemes and Pseudoword Spell Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
4	.70***	.71***	.70***	.47**	.67***	.70***
5	.56**	.56**	.58***	.45**	.55**	.53**
6	.55**	.57**	.52**	.48**	.53**	.51**
7	.56**	.62***	.63***	.41*		
8	.52**	.45**	.46**	.36*		
9	.68***	.58**	.63***	.55**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 6

Concurrent Correlations Between Tapping and Burt Read: Unadjusted and Adjusted for Key Variables

	Correlation Between Tapping and Burt Read: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
1						
2	.22	.19	.13	.26	.09	.13
3	.24	.25	.05	.15	.14	.21
4	.14	.04	.06	.01	.10	.13
5	.33*	.26	.30	.18	.23	.14
6	.32*	.19	.31	.15	.23	.18
7	.42*	.39*	.43*	.26		
8	.49**	.44*	.46**	.27		
9	.77***	.74***	.76***	.68***		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 7

Concurrent Correlations Between Tapping and Burt Read Phonemes: Unadjusted and Adjusted for Key Variables

	Correlation Between Tapping and Burt Read Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
1						
2	.18	.16	.09	.22	.06	.09
3	.15	.14		.07	.03	.10
4	.12	.03	.04	-.02	.08	.11
5	.33*	.28	.30	.18	.27	.18
6	.32*	.19	.29	.14	.29	.21
7	.37*	.34*	.38*	.20		
8	.49**	.42*	.43*	.21		
9	.56**	.51**	.54**	.40*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 8

Concurrent Correlations Between Tapping and Burt Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Correlation Between Tapping and Burt Spell Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
1						
2	.53**					
3	.47**	.48**		.35*		
4	.41*	.38*	.33*	.20	.44**	.39*
5	.37*	.36*	.33*	.22	.32*	.24
6	.39*	.27	.30	.21	.35*	.29
7	.57**	.52**	.54**	.47**		
8	.59**	.52**	.50**	.36*		
9	.61***	.55**	.59**	.47**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 9

Concurrent Correlations Between Tapping and Pseudoword Read Phonemes: Unadjusted and Adjusted for Key Variables

	Correlation Between Tapping and Pseudoword Read Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
1						
2	.71***	.72***	.66**	.61***	.70***	.67***
3	.43*	.43*	.39*	.28	.38*	.41*
4	.08	.10	.03	-.15	.05	.06
5	.21	.24	.18	-.01	.26	.00
6	.24	.21	.27	.02	.16	.04
7	.23	.18	.31	-.03		
8	.46**	.40*	.45**	.22		
9	.67***	.63***	.66***	.54**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 10

Concurrent Correlations Between Tapping and Pseudoword Spell Phonemes: Unadjusted and Adjusted for Key Variables

	Correlation Between Tapping and Pseudoword Spell Phonemes: Adjusted for -					
Time	Unadj	PPVT-R[a]	Digit Span	Letter Sound	Rhyme	Allit-eration
1						
2	.58***	.64***	.47**	.42*	.54**	.51**
3	.39*	.40*	.22	.22	.36*	.38*
4	.44**	.43*	.37*	.17	.44**	.43*
5	.45**	.48**	.41*	.34	.42*	.33*
6	.37*	.31	.26	.21	.34*	.29
7	.67***	.64***	.64***	.63***		
8	.60***	.55**	.55**	.42*		
9	.65***	.60**	.65***	.50**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1, 6, and 9.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 11

Multiple Regression Analyses of TAAS-Phonemes, Letter Knowledge and TAAS-Phonemes x Letter Knowledge with Burt Reading as Criterion Variable

Time 4

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.545	.297	.297**
2. Letter Name	.707	.500	.203**
3. TAAS-Phonemes x Letter Name	.714	.509	.009

Time 5

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.448	.201	.201*
2. Letter Name	.698	.488	.287**
3. TAAS-Phonemes x Letter Name	.698	.488	.000

Time 6

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.282	.080	.080
2. Letter Name	.723	.522	.442**
3. TAAS-Phonemes x Letter Name	.749	.562	.040

Time 7

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.466	.217	.217*
2. Letter Sound	.653	.427	.210*
3. TAAS-Phonemes x Letter Sound	.657	.432	.005

Time 8

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.541	.293	.293**
2. Letter Sound	.675	.456	.163*
3. TAAS-Phonemes x Letter Sound	.676	.457	.001

Time 9

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.509	.259	.259*
2. Letter Sound	.656	.430	.171*
3. TAAS-Phonemes x Letter Sound	.658	.433	.003

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.
*$p < .05$. **$p < .001$. (two tailed tests)

Table 12

Multiple Regression Analyses of TAAS-Phonemes, Letter Knowledge and TAAS-Phonemes x Letter Knowledge with Burt Spell Phonemes as Criterion Variable

Time 4

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.637	.405	.405**
2. Letter Name	.756	.571	.166**
3. TAAS-Phonemes x Letter Name	.769	.592	.021

Time 5

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.580	.336	.336**
2. Letter Name	.749	.561	.225**
3. TAAS-Phonemes x Letter Name	.762	.580	.019

Time 6

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.504	.254	.254*
2. Letter Name	.687	.472	.218**
3. TAAS-Phonemes x Letter Name	.696	.485	.013

Time 7

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.579	.335	.335**
2. Letter Sound	.792	.627	.292**
3. TAAS-Phonemes x Letter Sound	.792	.628	.001

Time 8

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.538	.289	.289**
2. Letter Sound	.818	.669	.38**
3. TAAS-Phonemes x Letter Sound	.830	.689	.020

Time 9

	R	R^2	Increase in R^2
1. TAAS-Phonemes	.509	.259	.259*
2. Letter Sound	.656	.430	.171*
3. TAAS-Phonemes x Letter Sound	.658	.433	.003

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

*$p < .05$. **$p < .001$. (two tailed tests)

Table 13

Multiple Regression Analyses of Tapping, Letter Knowledge and Tapping x Letter Knowledge with Burt Reading as Criterion Variable

Time 2

	R	R^2	Increase in R^2
1. Tapping	.218	.048	.048
2. Letter Name	.546	.298	.250*
3. Tapping x Letter Name	.549	.301	.003

Time 3

	R	R^2	Increase in R^2
1. Tapping	.240	.058	.058
2. Letter Name	.592	.350	.292**
3. Tapping x Letter Name	.613	.376	.026

Time 4

	R	R^2	Increase in R^2
1. Tapping	.138	.019	.019
2. Letter Name	.591	.350	.331**
3. Tapping x Letter Name	.593	.351	.001

Time 5

	R	R^2	Increase in R^2
1. Tapping	.331	.109	.109
2. Letter Name	.640	.410	.301**
3. Tapping x Letter Name	.649	.421	.011

Time 6

	R	R^2	Increase in R^2
1. Tapping	.321	.103	.103
2. Letter Name	.708	.502	.399**
3. Tapping x Letter Name	.709	.503	.001

Time 7

	R	R^2	Increase in R^2
1. Tapping	.415	.173	.173*
2. Letter Sound	.644	.415	.242*
3. Tapping x Letter Sound	.653	.426	.011

Time 8

	R	R^2	Increase in R^2
1. Tapping	.487	.237	.237*
2. Letter Sound	.630	.396	.159*
3. Tapping x Letter Sound	.637	.406	.010

Time 9

	R	R^2	Increase in R^2
1. Tapping	.770	.592	.592**
2. Letter Sound	.816	.665	.073*
3. Tapping x Letter Sound	.817	.667	.002

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

*$p < .05$. **$p < .001$. (two tailed tests)

Table 14

Multiple Regression Analyses of Tapping, Letter Knowledge and Tapping x Letter Knowledge with Burt Spell Phonemes as Criterion Variable

Time 2

	R	R^2	Increase in R^2
1. Tapping	.533	.284	.284**
2. Letter Name	.671	.450	.166*
3. Tapping x Letter Name	.715	.511	.061

Time 3

	R	R^2	Increase in R^2
1. Tapping	.470	.221	.221*
2. Letter Name	.714	.510	.289**
3. Tapping x Letter Name	.751	.565	.055

Time 4

	R	R^2	Increase in R^2
1. Tapping	.409	.167	.167*
2. Letter Name	.646	.418	.251**
3. Tapping x Letter Name	.647	.418	.000

Time 5

	R	R^2	Increase in R^2
1. Tapping	.369	.136	.136
2. Letter Name	.625	.391	.255**
3. Tapping x Letter Name	.632	.399	.009

Time 6

	R	R^2	Increase in R^2
1. Tapping	.387	.150	.150**
2. Letter Name	.586	.343	.193*
3. Tapping x Letter Name	.592	.350	.007

Time 7

	R	R^2	Increase in R^2
1. Tapping	.566	.320	.320**
2. Letter Sound	.799	.638	.318**
3. Tapping x Letter Sound	.808	.653	.015

Time 8

	R	R^2	Increase in R^2
1. Tapping	.586	.343	.343**
2. Letter Sound	.813	.661	.318**
3. Tapping x Letter Sound	.816	.665	.004

Time 9

	R	R^2	Increase in R^2
1. Tapping	.607	.369	.369**
2. Letter Sound	.677	.458	.089
3. Tapping x Letter Sound	.681	.464	.006

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

*$p < .05$. **$p < .001$. (two tailed tests)

Table 15

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Read at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Burt Read at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.59***	.61***	.43*	.54**	.59***
5	.43**	.45**	.27	.42*	.37*
6	.23	.25	.14	.21	.20
7	.46**	.49**	.26		
8	.53**	.48**	.39*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 16

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Read at end of Year One: Unadjusted and Adjusted for Key Variables

	Burt Read at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3	.16				
4	.58***	.60***	.38*	.54**	.59***
5	.43**	.45**	.27	.42*	.37*

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 17

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Read at end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Read at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.46**	.47**	.33*	.43*	.48**
5	.32*	.34*	.20	.32	.28
6	.24	.28	.16	.22	.19
7	.43*	.46**	.24		
8	.53**	.48**	.39*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 18

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Spell Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.55**	.55**	.27	.51**	.54**
5	.44**	.46**	.27	.43*	.39*
6	.27	.36*	.17	.23	.24
7	.37*	.47**	.12		
8	.52**	.44*	.37*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 19

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Spell Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.54**	.55**	.19	.50**	.53**
5	.44**	.46**	.27	.43*	.39*

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 20

Predictive Correlations from TAAS-Phonemes at Time (t) to Burt Spell Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at end of Year Two (Time 9): Adjusted for -				
Time	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.27	.28	.11	.23	.27
5	.14	.17	.02	.14	.15
6	.28	.37*	.20	.25	.25
7	.35*	.42*	.12		
8	.52**	.44*	.37*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 21

Predictive Correlations from TAAS-Phonemes at Time (t) to Pseudoword Read Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.60***	.60***	.30	.58**	.60***
5	.54**	.53**	.41*	.53**	.50**
6	.18	.20	.02	.18	.09
7	.64***	.68***	.54**		
8	.48**	.43*	.30		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 22

Predictive Correlations from TAAS-Phonemes at Time (t) to Pseudoword Read Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.63***	.64***	.40*	.60***	.63***
5	.54**	.53**	.41*	.53**	.50**

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 23

Predictive Correlations from TAAS-Phonemes at Time (t) to Pseudoword Read Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.38*	.38*	.13	.33*	.39*
5	.27	.28	.12	.27	.22
6	.40*	.45**	.33*	.38*	.35*
7	.55**	.58**	.40*		
8	.48**	.43*	.30		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 24

Predictive Correlations from TAAS-Phonemes at Time (t) to Pseudoword Spell Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.58***	.58**	.24	.54**	.57**
5	.44**	.44**	.28	.43*	.40*
6	.34*	.42*	.27	.31	.32*
7	.47**	.52**	.31		
8	.61***	.55**	.51**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 25

Predictive Correlations from TAAS-Phonemes at Time (t) to Pseudoword Spell Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.69***	.69***	.47**	.67***	.69***
5	.44**	.44**	.28	.43*	.40*

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1

$^*p < .05$. $^{**}p < .01$. $^{***}p < .0005$.

Table 26

Predictive Correlations from TAAS-Phonemes at Time (t) to Pseudoword Spell Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3					
4	.32*	.33*	.11	.25	.32
5	.33*	.36*	.24	.32	.31
6	.39*	.48**	.33*	.35*	.33*
7	.54**	.62***	.39*		
8	.61***	.55**	.51**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

$^*p < .05$. $^{**}p < .01$. $^{***}p < .0005$.

Table 27

Predictive Correlations from Tapping at Time (t) to Burt Read at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Burt Read at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.10	.04	.02[b]	.04	.07
2	.26	.17	.18	.06	.13
3	.26	.27	.14	.16	.23
4	.07	-.01	-.18	.03	.07
5	.34*	.28	.19	.30	.15
6	.17	.09	.05	.10	.11
7	.45**	.40**	.29		
8	.57**	.52**	.38*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 28

Predictive Correlations from Tapping at Time (t) to Burt Read at end of Year One: Unadjusted and Adjusted for Key Variables

	Burt Read at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.14	.10	.08[b]	.10	.12
2	.35*	.33*	.27	.28	.29
3	.22	.22	.05	.17	.22
4	.08	.01	-.23	.05	.08
5	.34*	.28	.19	.30	.15

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 29

Predictive Correlations from Tapping at Time (t) to Burt Read at end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Read at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.20	.14	.17[b]	.20	.20
2	.14	.10	.11	.14	.16
3	.28	.27	.26	.29	.28
4	-.06	-.17	-.23	-.07	-.02
5	.17	.08	.03	.18	.06
6	.22	.07	.11	.14	.11
7	.47**	.42*	.33*		
8	.57**	.52**	.38*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 30

Predictive Correlations from Tapping at Time (t) to Burt Spell-Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.39*	.35	.34[b]	.36*	.36*
2	.44**	.43*	.31	.33*	.34*
3	.52**	.53**	.42*	.45**	.51**
4	.30	.28	.02	.29	.29
5	.34*	.30	.18	.32*	.18
6	.25	.01	.11	.10	.18
7	.55**	.50**	.44*		
8	.63***	.58**	.45**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 31

Predictive Correlations from Tapping at Time (t) to Burt Spell-Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.19	.16	.14[b]	.14	.15
2	.38*	.37*	.30	.30	.29
3	.49**	.49**	.38*	.44**	.49**
4	.25	.21	-.11	.23	.24
5	.34*	.30	.18	.32*	.18

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 32

Predictive Correlations from Tapping at Time (t) to Burt Spell-Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	Burt Spell Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.15	.06	.12[b]	.14	.14
2	.14	.06	.14	.13	.11
3	.44*	.45**	.43*	.45**	.45**
4	.09	-.06	-.03	.09	.10
5	.25	.11	.15	.25	.31
6	.20	-.10	.10	.12	.16
7	.54**	.48**	.42*		
8	.63***	.58**	.45**		

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 33

Predictive Correlations from Tapping at Time (t) to Pseudoword Read Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.35*	.35*	.32[b]*	.31	.32*
2	.75***	.75***	.67***	.75***	.75***
3	.44**	.44**	.34*	.40*	.42*
4	.26	.28	-.10	.25	.25
5	.27	.33*	.09	.21	.02
6	.20	.09	.02	.22	.02
7	.41*	.36*	.23		
8	.54**	.50**	.30		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 34

Predictive Correlations from Tapping at Time (t) to Pseudoword Read Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.04	.06	-.02[b]	-.03	.01
2	.62***	.63***	.53**	.60***	.57**
3	.27	.28	.06	.21	.27
4	.10	.13	-.28	.07	.09
5	.27	.33*	.09	.44**	.02

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 35

Predictive Correlations from Tapping at Time (t) to Pseudoword Read Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Read Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.02	-.02	.01[b]	.01	.00
2	.21	.19	.15	.18	.21
3	.49**	.49**	.51**	.49**	.50**
4	.13	.07	-.08	.13	.16
5	.41*	.38*	.31	.44*	.27
6	.36*	.25	.26	.31	.26
7	.49**	.45**	.36*		
8	.54**	.50**	.30		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 36

Predictive Correlations from Tapping at Time (t) to Pseudoword Spell Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.37*	.36*	.36[b]	.36*	.34*
2	.56**	.56**	.37*	.56**	.53**
3	.61***	.61***	.56**	.57**	.60***
4	.48**	.49**	.25	.47**	.47**
5	.37*	.41*	.23	.33*	.26
6	.34*	.16	.24	.23	.30
7	.57**	.53**	.47**		
8	.58**	.52**	.35*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 37

Predictive Correlations from Tapping at Time (t) to Pseudoword Spell Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.18	.19	.16[b]	.16	.16
2	.50**	.51**	.44**	.46**	.47**
3	.48**	.48**	.37*	.44**	.49**
4	.29	.31	-.03	.28	.29
5	.37*	.41*	.23	.33*	.26

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 38

Predictive Correlations from Tapping at Time (t) to Pseudoword Spell Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	Pseudoword Spell Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1	.01	-.07	-.04[b]	-.01	-.01
2	.20	.16	.16	.11	.19
3	.51**	.51**	.52**	.48**	.51**
4	.07	-.05	-.10	.07	.07
5	.29	.18	.19	.25	.26
6	.35*	.13	.27	.24	.20
7	.58**	.53**	.48**		
8	.58**	.52**	.35*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

[b] Correlations were adjusted for Letter Name rather than Letter Sound at Time 1 because 24 of the 29 children knew no letter sounds at Time 1

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 39

Predictive Correlations from Tapping at Time 1 to Literacy Measures at Times 3 - 5: Unadjusted and Adjusted for Key Variables

Literacy Measure	Unadjusted Correlation	Correlation adjusted for -			
		PPVT-R[a]	Letter Name	Rhyme	Alliteration
Burt Read: Time 3	.29	.24	.22	.25	.27
Burt Read: Time 4	.32*	.28	.27	.28	.30
Burt Read: Time 5	.27	.23	.20	.23	.25
Burt Spell Phonemes: Time 3	.33*	.29	.29	.28	.29
Burt Spell Phonemes: Time 4	.27	.24	.22	.21	.21
Burt Spell Phonemes: Time 5	.30	.29	.25	.26	.28
Pseudoword Read Phonemes: Time 3	.42*	.40*	.38*	.39*	.40*
Pseudoword Read Phonemes: Time 4	.29	.30	.25	.26	.28
Pseudoword Read Phonemes: Time 5	.14	.14	.09	.09	.13
Pseudoword Spell Phonemes Time 3	.24	.25	.21	.19	.21
Pseudoword Spell Phonemes Time 4	.28	.27	.26	.23	.23
Pseudoword Spell Phonemes Time 5	.18	.18	.11	.15	.15

Note. Times 1 - 6, $n = 29$

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 40

Predictive Correlations from Burt Reading at Time (t) to TAAS-Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3	.37*	.39*	.26	.30	.34*
4	.47**	.52**	.40*	.47**	.47**
5	.23	.28	.01	.18	.13
6	.51**	.54**	.31	.48**	.43*
7	.50**	.47**	.36*		
8	.45**	.39*	.21		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 41

Predictive Correlations from Burt Reading at Time (t) to TAAS-Phonemes at end of Year One: Unadjusted, Adjusted for Key Variables

	TAAS-Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.17	.24	.18	.09	.13
3	.23	.30	.18	.17	.26
4	.32*	.40*	.23	.22	.32*
5	.23	.28	.01	.18	.13

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 42

Predictive Correlations from Burt Reading at Time (t) to TAAS-Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.43*	.37*	.44*	.42*	.43*
3	.50**	.45**	.46**	.48**	.52**
4	.55**	.50**	.52**	.45**	.55**
5	.47**	.42*	.24	.42*	.44*
6	.45**	.38*	.34*	.38*	.36*
7	.43*	.40*	.18		
8	.46**	.39*	.21		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 43

Predictive Correlations from Burt Spell Phonemes at Time (t) to TAAS-Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3	.71***	.73***	.57**	.68***	.71***
4	.52**	.54**	.35*	.54**	.53**
5	.57**	.60**	.48**	.55**	.53**
6	.61***	.65***	.42*	.59**	.57**
7	.61***	.55**	.52**		
8	.53**	.40*	.19		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 44

Predictive Correlations from Burt Spell Phonemes at Time (t) to TAAS-Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.17	.25	.14	.07	.11
3	.36*	.41*	.30	.30	.39*
4	.48**	.51**	.29	.42*	.47**
5	.57**	.60***	.48**	.55**	.53**

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 45

Predictive Correlations from Burt Spell Phonemes at Time (t) to TAAS-Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Allit-eration
1					
2	.31*	.21	.29	.29	.31
3	.60***	.57**	.53**	.59**	.60**
4	.62***	.60**	.56**	.54**	.62***
5	.41*	.39*	.14	.41*	.38*
6	.43*	.35*	.30	.40*	.37*
7	.61***	.53**	.42*		
8	.53**	.40*	.19		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 46

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to TAAS-Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3	.56**	.57**	.33*	.53**	.55**
4	.58***	.57**	.47**	.56**	.58**
5	.39*	.39*	.20	.41*	.32*
6	.74***	.75***	.64***	.73***	.69***
7	.47**	.43*	.31		
8	.54**	.48**	.31		

Note. Times 1 - 6, n = 29; Times 7 - 9, n = 27.

[a] PPVT-R was administered at Times 1 and 6.

*p < .05. **p < .01. ***p < .0005.

Table 47

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to TAAS-Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.25	.25	.24	.21	.20
3	.25	.29	.16	.21	.27
4	.36*	.36*	.20	.30	.35*
5	.39*	.39*	.20	.41*	.32*

Note. Times 1 - 6, n = 29.

[a] PPVT-R was administered at Times 1 and 6.

*p < .05. **p < .01. ***p < .0005.

Table 48

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to TAAS-Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.16	.16	.09	.16	.15
3	.33*	.28	.19	.31	.33*
4	.39*	.42*	.32	.32	.40*
5	.33*	.34*	-.01	.43*	.29
6	.50**	.51**	.40*	.46**	.39*
7	.47**	.42*	.20		
8	.54**	.48**	.31		

Note. Times 1 - 6, n = 29.

[a] PPVT-R was administered at Times 1 and 6.

*p < .05. **p < .01. ***p < .0005.

Table 49

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to TAAS-Phonemes at next Time (t+1): Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2					
3	.61***	.61***	.36*	.59***	.60***
4	.51**	.52**	.28	.49**	.52**
5	.69***	.70***	.63***	.68***	.66***
6	.46**	.47**	.25	.44*	.42*
7	.63***	.58**	.56**		
8	.62***	.55**	.42*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 50

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to TAAS-Phonemes at end of Year One: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.35*	.36*	.37*	.31	.31
3	.21	.21	.09	.18	.22
4	.54**	.56**	.32*	.49**	.53**
5	.69***	.70***	.63***	.68***	.66***

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 51

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to TAAS-Phonemes at end of Year Two: Unadjusted and Adjusted for Key Variables

	TAAS-Phonemes at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.40*	.38*	.38*	.39*	.40*
3	.34*	.36*	.17	.34*	.34*
4	.58**	.57**	.54**	.53**	.61***
5	.45**	.45**	.23	.45**	.42*
6	.37*	.33*	.24	.34*	.32
7	.61***	.53**	.42*		
8	.62***	.55**	.42*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 52

Predictive Correlations from Burt Reading at Time (t) to Tapping at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Tapping at next Time (t+1) - Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.15	.15	.16	.05	.12
3	.05	-.05	-.04	.06	.01
4	.44**	.35*	.39*	.16	.43**
5	.25	.14	.10	.15	.09
6	.48**	.44*	.43*	.41*	.46**
7	.40*	.37*	.22		
8	.74***	.72***	.67***		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 53

Predictive Correlations from Burt Reading at Time (t) to Tapping at end of Year One: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.33*	.19	.35*	.18	.27
3	.27	.13	.19	.21	.21
4	.39*	.26	.33*	.12	.39*
5	.25	.14	.10	.15	.09

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Time 1.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 54

Predictive Correlations from Burt Reading at Time (t) to Tapping at end of Year Two: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.65***	.66***	.65***	.62***	.64***
3	.62***	.62***	.60***	.60***	.60**
4	.71***	.73***	.71***	.67***	.71***
5	.62***	.62***	.64***	.61***	.57**
6	.70***	.68***	.72***	.67***	.66***
7	.64***	.63***	.49**		
8	.74***	.72***	.67***		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 55

Predictive Correlations from Burt Spell Phonemes at Time (t) to Tapping at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Tapping at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.37*	.40*	.33*	.29	.35*
3	.23	.18	.08	.27	.20
4	.44**	.42*	.38*	.15	.42*
5	.29	.27	.14	.24	.18
6	.50**	.46**	.49**	.48**	.48**
7	.55**	.48**	.40*		
8	.58**	.56**	.44*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 56

Predictive Correlations from Burt Spell Phonemes at Time (t) to Tapping at end of Year One: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.34*	.17	.26	.15	.26
3	.26	.17	-.06	.18	.18
4	.37*	.34*	.25	.08	.35*
5	.29	.27	.14	.24	.18

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 57

Predictive Correlations from Burt Spell Phonemes at Time (t) to Tapping at end of Year Two (Time 9): Unadjusted and Adjusted for Key Variables

	Tapping at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.40*	.41*	.43*	.34*	.38*
3	.44*	.43*	.41*	.40*	.42*
4	.42*	.41*	.42*	.29	.47**
5	.39*	.38*	.36*	.38*	.33*
6	.59**	.56**	.62***	.57**	.55**
7	.62***	.60**	.44*		
8	.58**	.56**	.44*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 58

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to Tapping at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Tapping at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.39*	.39*	.35*	.36*	.37*
3	.29	.26	.15	.31	.27
4	.06	.09	-.06	-.18	.04
5	.19	.22	-.01	.22	.03
6	.27	.25	.16	.19	.23
7	.30	.25	.04		
8	.65***	.63***	.54**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 59

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to Tapping at end of Year One: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.26	.29	.10	.19	.18
3	.36*	.32*	.20	.32*	.32*
4	-.05	-.03	-.21	-.30	-.06
5	.19	.22	-.01	.22	.03

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 60

Predictive Correlations from Pseudoword Read Phonemes at Time (t) to Tapping at end of Year Two: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.17	.16	.27	.15	.13
3	.27	.25	.20	.25	.26
4	.42*	.42*	.40*	.35*	.43*
5	.29	.29	.23	.33*	.20
6	.45**	.44*	.40*	.41*	.37*
7	.46**	.44*	.20		
8	.65***	.63***	.54**		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 61

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to Tapping at next Time (t+1): Unadjusted and Adjusted for Key Variables

	Tapping at next Time (t+1): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.59***	.58**	.60***	.55**	.58**
3	.31*	.34*	.16	.33*	.30
4	.40*	.39*	.34*	.24	.38*
5	.43**	.49**	.35*	.40*	.34*
6	.61***	.62***	.59**	.62***	.60***
7	.62***	.59**	.51**		
8	.50**	.47**	.33*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 62

Predictive Correlations from Pseudoword Spell Phonemes at Time (t) to Tapping at end of Year One: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year One (Time 6): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.27	.29	.13	.16	.18
3	.12	.16	-.20	.08	.09
4	.34*	.33*	.18	.18	.32*
5	.43**	.49**	.35*	.40*	.34*

Note. Times 1 - 6, $n = 29$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 63

Predictive Correlations from Pseudoword Spell Phonemes at Time (t)to Tapping at end of Year Two: Unadjusted and Adjusted for Key Variables

	Tapping at end of Year Two (Time 9): Adjusted for -				
Time (t)	Unadj	PPVT-R[a]	Letter Sound	Rhyme	Alliteration
1					
2	.32*	.31	.45**	.30	.29
3	.05	.05	-.10	.03	.05
4	.35*	.34*	.39*	.27	.39*
5	.41*	.40*	.37*	.40*	.34*
6	.54**	.53**	.52**	.53**	.52**
7	.57**	.55**	.36*		
8	.50**	.47**	.33*		

Note. Times 1 - 6, $n = 29$; Times 7 - 9, $n = 27$.

[a] PPVT-R was administered at Times 1 and 6.

*$p < .05$. **$p < .01$. ***$p < .0005$.

Table 64

Factor Loadings and Proportionate Variance Contributions - Time 1

	Factor 1	Factor 2	Factor 3
Proportionate Variance Contributions (Total % of original variance = 78%)	.52	.27	.21
Letter Name	.74	.06	.16
Digit Span	.48	-.06	.5
Rhyme	.19	.84	.00
Alliteration	-.13	.93	.03
Tapping	-.11	.05	.90
TAAS-Syllables	.84	.00	-.19

Table 65

Factor Loadings and Proportionate Variance Contributions - Time 2

	Factor 1	Factor 2	Factor 3
Proportionate Variance Contributions (Total % of original variance = 73%)	.53	.23	.24
Letter Name	.47	.51	-.1
Letter Sound	.8	-.06	.01
Digit Span	.34	.15	.36
Rhyme	-.05	-.03	.79
Alliteration	.11	-.26	.81
Tapping	.62	.13	.11
TAAS-Syllables	.16	.65	-.2
Burt Read	-.15	.79	.03
Burt Spell Phonemes	.39	.54	.07
Pseudoword Read Phonemes	.91	.00	-.06
Pseudoword Spell Phonemes	.84	-.02	.04

Table 66
Factor Loadings and Proportionate Variance Contributions - Time 3

	Factor 1	Factor 2	Factor 3	Factor 4
Proportionate Variance Contributions (Total % of original variance = 83%)	.34	.16	.31	.19
Letter Name	.4	-.01	-.16	.52
Letter Sound	.74	-.06	-.04	.04
Digit Span	.00	.03	.73	-.08
Rhyme	.12	.86	-.09	.05
Alliteration	-.02	.87	-.01	-.02
Tapping	.13	.03	.66	-.16
TAAS-Syllables	-.19	-.21	.8	.16
Burt Read	-.13	.06	.03	.82
Burt Spell Phonemes	.4	.18	.02	.4
Pseudoword Read Phonemes	.58	.04	.16	.02
Pseudoword Spell Phonemes	.84	.1	-.01	-.16

Table 67
Factor Loadings and Proportionate Variance Contributions - Time 4

	Factor 1	Factor 2	Factor 3
Proportionate Variance Contributions (Total % of original variance = 70%)	.5	.25	.24
Letter Name	.66	.00	.13
Letter Sound	.27	.75	.22
Digit Span	.09	.15	.68
Rhyme	.7	-.45	.40
Alliteration	-.02	.00	.59
Tapping	-.08	.54	.58
TAAS-Phonemes	.54	.52	-.16
Burt Read	.88	-.08	.04
Burt Spell Phonemes	.77	.26	.28
Pseudoword Read Phonemes	.79	.26	-.15
Pseudoword Spell Phonemes	.59	.55	.23

Table 68
Factor Loadings and Proportionate Variance Contributions - Time 5

	Factor 1	Factor 2	Factor 3	Factor 4
Proportionate Variance Contributions (Total % of original variance = 79%)	.29	.24	.24	.24
Letter Name	.02	-.02	.03	.81
Letter Sound	.30	-.05	.27	.52
Digit Span	.02	.01	.92	.04
Rhyme	.00	.84	.12	-.33
Alliteration	-.02	.59	-.33	.38
Tapping	-.04	.69	.11	.16
TAAS-Phonemes	.86	-.05	-.13	-.15
Burt Read	.39	.13	-.01	.46
Burt Spell Phonemes	.62	.00	.09	.34
Pseudoword Read Phonemes	.65	-.21	-.07	.40
Pseudoword Spell Phonemes	.60	.08	.26	.16

Table 69
Factor Loadings and Proportionate Variance Contributions - Time 6

	Factor 1	Factor 2	Factor 3	Factor 4
Proportionate Variance Contributions (Total % of original variance = 80%)	.65	.17	.16	.02
Letter Name	.66	.14	.05	-.43
Letter Sound	.71	-.21	-.04	.04
Digit Span	.03	.16	.88	.00
Rhyme	-.32	.83	.30	.00
Alliteration	-.13	.71	-.24	.17
Tapping	.00	.57	.46	-.02
TAAS-Phonemes	.00	.02	.02	.76
Burt Read	.71	.08	-.18	-.13
Burt Spell Phonemes	.65	-.06	.01	.16
Pseudoword Read Phonemes	.56	.07	-.36	.13
Pseudoword Spell Phonemes	.47	-.1	.09	.38

Table 70
Factor Loadings and Proportionate Variance Contributions - Time 7

	Factor 1	Factor 2	Factor 3	Factor 4
Proportionate Variance Contributions (Total % of original variance = 90%)	.54	.14	.15	.16
Letter Sound	.71	.21	-.19	.06
Digit Span	.03	.89	.00	.08
Tapping	.00	-.07	.80	-.01
TAAS-Phonemes	.00	-.1	.06	.72
Burt Read	.75	-.18	.13	-.22
Burt Spell Phonemes	.62	.06	.15	.03
Pseudoword Read Phonemes	.64	-.23	-.18	.15
Pseudoword Spell Phonemes	.49	.15	.26	.09

Table 71
Factor Loadings and Proportionate Variance Contributions - Time 8

	Factor 1	Factor 2	Factor 3	Factor 4
Proportionate Variance Contributions (Total % of original variance = 90%)	.23	.22	.35	.20
Letter Sound	.25	.35	-.19	.50
Digit Span	-.07	.87	.05	.00
Tapping	-.08	.02	.63	.15
TAAS-Phonemes	.16	.02	.71	-.16
Burt Read	.76	.00	.07	-.02
Burt Spell Phonemes	.26	.15	.00	.48
Pseudoword Read Phonemes	.72	-.08	.04	.08
Pseudoword Spell Phonemes	-.05	-.12	.15	.68

Table 72
Factor Loadings and Proportionate Variance Contributions - Time 9

	Factor 1	Factor 2	Factor 3	Factor 4
Proportionate Variance Contributions (Total % of original variance = 90%)	.82	.10	.05	.04
Letter Sound	.80	.23	-.26	-.45
Digit Span	.49	.79	-.15	.32
Tapping	.76	-.4	-.17	.24
TAAS-Phonemes	.72	.12	.65	-.08
Burt Read	.89	-.29	-.13	.13
Burt Spell Phonemes	.87	-.07	.1	.23
Pseudoword Read Phonemes	.92	-.07	-.09	-.20
Pseudoword Spell Phonemes	.93	.04	.05	-.06

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