Phonological Abilities and their Roles in Reading and Spelling – Differences between Boys and Girls: a Longitudinal Study of Beginning Readers

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ABSTRACT

Differences between boys and girls in the development of phonological abilities and in the roles played by rhyme awareness and phonemic awareness in reading and spelling acquisition were examined in this longitudinal study of beginning readers. Participants were 153 children (81 boys and 72 girls, mean age 5 years, 10 months at the commencement of the study) from a cross section of socio-economic areas in Southern Tasmania. The children were assessed within three months of starting their first year at school on a number of pre-literacy and cognitive measures, and again at the end of their first (N = 140) and second (N = 127) years of school on tasks measuring phonological abilities, reading, spelling, and attention. Rhyme detection and rhyme production tasks were used to measure rhyme awareness (the ability to isolate rhymes within words). Phoneme deletion tasks were used to measure phonemic awareness (the ability to isolate individual phonemes within words).

Recent findings across Australia indicate that girls are outperforming boys in reading, achieving up to five percentage points higher than boys in the Year 3 and Year 5 Literacy Benchmark Tests (House of Representatives Standing Committee on Education and Training, 2000) however Alexander and Martin (2000) proposed that such differences are restricted to those boys who are average to below average readers. Neuroimaging and lesion studies (e.g., Pugh et al., 1997; Frith & Vargha-Khadem, 2001) indicate that girls are more likely to engage the right hemisphere whereas boys predominantly engage the left hemisphere of the brain in undertaking phonological operations. Although the role played by the right hemisphere is controversial Pugh et al. (1997) proposed that the right hemisphere processes sounds at a fine-grained level whereas the left hemisphere engages in phonological processing using larger units of sound. This suggests that developing an awareness of

phonemes may be a more difficult task for boys and rhyme awareness may play a more important role in boys' early reading and spelling acquisition.

Results provided evidence that boys do not develop letter knowledge or phonemic awareness as readily as girls who demonstrated significantly better letter knowledge, phoneme deletion ability, and faster rapid automatised naming of letters than boys. Differences in distributions for graphemic and phonemic awareness factor scores (defined by high loadings from letter-name and letter-sound knowledge, phoneme deletion and RAN of letters) across the three phases of the study indicated a significant male disadvantage.

Concurrent and longitudinal hierarchical regression analyses indicated that rhyme awareness played a direct role in reading and spelling acquisition for boys but not girls. By the end of the second year there was a significantly greater proportion of boys than girls in the bottom quartile of the score distributions for all the reading measures with no differences in the top quartile. Boys were significantly poorer spellers than girls at the end of both the first and second years of school, and also showed significantly poorer ability to focus mental attention on a task.

These findings provide evidence of significant differences between boys and girls in the development of letter knowledge and phonemic awareness, and in the direct role of rhyme awareness in their reading and spelling acquisition. They also highlight important differences in the learning styles of the boys and girls in the study. The results have important practical implications for providing the best learning environments for boys and girls to develop reliable phonological skills. Theoretical implications lie in extending understanding of the direct role of rhyme awareness in beginning reading and spelling.

CHAPTER 1

Overview of the Thesis

Frith (1999) proposes a simple framework from which to view different theories of developmental disorders. The framework consists of three levels - biological, cognitive, and behavioural - any of which can be influenced by extensive contributions from environmental and social factors. Biological factors encompass genetic and specific brain characteristics, cognitive factors focus on information processing and the component processes involved in activities such as reading, whereas behavioural factors include the way an individual performs in measures of achievement, for example, in reading, and spelling. Whereas Frith presents her model as a way of understanding dyslexia, the model provides an appropriate framework from which to investigate sex differences in the normal development of reading and spelling. As Morton and Frith (1995) point out "what applies to deficits also applies to development" (p. 380). While both the terms "sex differences" and "gender differences" have been used by researchers to describe differences between males and females, the generic term *sex* rather than *gender* will be used throughout this thesis, following Halpern (1997).

The thesis aims to investigate the development of phonological awareness as determined by behavioural measures and it is not within the scope of the research to investigate biological or environmental causes of any sex differences. Biological differences are considered within the framework of investigation as underpinning the development of a functional phonological cognitive system.

The thesis reviews the literature on sex differences in reading related processes and considers research across several areas. Both theoretical and computational models of word recognition explain the cognitive processes engaged when we read words, focusing on the manner in which the phonological (or sub-lexical) and orthographic (or lexical) processes, which enable visual word recognition, operate, and an overview of these models will be presented in Chapter 2. Models of reading and spelling acquisition explain how children learn to read and to spell words, and in particular the manner in which the phonological and orthographic processes develop in successful reading and spelling acquisition and these will also be discussed in Chapter 2.

Chapter 3 focuses on phonological awareness given that one of the essential cognitive capacities for successful reading acquisition is a normally developing phonological system (Morton & Frith, 1995). The specific focus in this research is on the development of phonological abilities and their relation to reading and spelling measures. Chapter 4 presents an overview of what is known about biological and cognitive sex differences and how they relate to the development of phonological awareness and to reading and spelling acquisition in young readers. Chapter 5 presents the rationale for the empirical study.

Although there are many developmental studies which have investigated how phonological awareness develops in young readers, this research aims to investigate whether there are differences in the way that phonological abilities and phonological awareness develop in boys and girls in the first two years of reading and spelling acquisition. The study uses a longitudinal design and utilizes a number of pre-literacy measures, focusing on phonological and cognitive abilities in the initial phase. The second and third phases assess phonological abilities, phonological processing, reading, and spelling acquisition, and attention (in Phase 3).

Following the literature review and rationale, the experimental chapters, Chapters 6, 7, and 8, outline the methodology, results, and conclusions from each of the three phases of the study. The final experimental chapter, Chapter 9, presents the longitudinal analyses which focus on the relationship over the two years of the research between phonological awareness and reading and spelling acquisition for boys and girls. The final chapter (Chapter 10) presents the overall findings and conclusions from the research.

CHAPTER 2

Models of Word Recognition and Reading Acquisition

Models of Word Recognition

This literature review does not aim to assess which model gives the best account of word recognition but aims rather to theoretically underpin the research on sex differences in the cognitive processes of word recognition with an account of current theories. Models of word recognition seek to explain the cognitive processes engaged when we read words. The main theoretical positions fall into two broad classifications, dual-route models and single-route models, which offer differing explanations of the processes involved in word recognition.

Dual-route models

The dual-route theory of word recognition described by Coltheart (1978) and the dual-route cascaded model (Coltheart, Curtis, Atkins, & Haller, 1993) proposed two basic processing procedures operating as parallel routes to the lexicon (a mental dictionary which stores learned words in long-term memory). The first of these two routes is described as an indirect sub-lexical route (or phonological processing route), which uses a letter-to-sound rule procedure. The second route is described as a direct visual or lexical route (referred to also as the orthographic processing route), which uses a dictionary look-up procedure, and is faster because it addresses the whole word rather than assembling the word from its constituent parts. If the word is recognized as a whole in the reader's lexicon then processing occurs via the direct lexical route, whereas, if the word is not recognized, processing must occur via the slower phonological route using a letter-to-sound rule procedure. When the word is not recognized as a whole (if the word is unfamiliar or a nonword), as there is no accurate representation stored in the reader's lexicon (mental dictionary), the phonological processing route is engaged. To process the word phonologically the reader must assemble the separate phonemes in the word and sound them out to obtain a pronunciation. There are three steps involved in this process: parsing (or breaking down) the letter string into a series of letters (graphemes); using grapheme-phoneme conversion rules (GPCs) to assign the appropriate phoneme to each grapheme; and finally blending the phonemes to pronounce the word.

Dual route theorists argue that as normal readers are able to read both irregular words such as *yacht* and *pint* (which cannot be pronounced correctly by assembling the word using GPCs) as well as nonwords (which are made-up words that have not been seen before and therefore must be assembled using GPC rules) the reading system involves two separate mechanisms. Coltheart (1985) proposed that evidence from patients exhibiting different patterns of acquired dyslexia further supports the dual-route position. Dissociations between the ability to read irregular words (the orthographic component) and the ability to read nonwords (the phonological component) seen in these patients suggested that these two components of word recognition involve independent neural pathways and distinctly different mechanisms.

The Dual-Route Cascaded (DRC) model (Coltheart et al., 1993) provided a computational version of the basic dual-route model. The model takes letters as input and generates a phonemic representation as output. An important feature of the DRC model was its ability to learn the GPCs of English, which it was then able to apply to new letter strings it had not seen before and it was therefore able to demonstrate accuracy in nonword reading (Coltheart et al., 1993). Coltheart et al. used their model's ability to accurately read nonwords to challenge an alternative computational model developed by Seidenberg and McClelland (1989) which was unable to read nonwords as well as humans.

Computational learning is no longer a feature of the current version of the DRC model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), which has refined the way in which the two processing routes operate. The model proposes that the two routes share the same initial processing stages (the letter identification stage, which then proceeds to either the orthographic input lexicon or the GPC rule system), and final stage (both processing routes deliver a pronunciation of the word) (Coltheart et al., 2001).

Single-route theories

Single route theories of word recognition (e.g., Seidenberg & McClelland, 1989) challenge the ideas of separate and parallel neural pathways and the view that regularities can only be represented in terms of rules (Seidenberg, Plaut, Peterson, McClelland, & McRae, 1994) arguing that the orthographic (lexical), and phonological (sub-lexical) mechanisms (as well as the semantic processing mechanism) involved in word recognition are interconnected rather than separate as proposed in dual-route models. Seidenberg and McClelland's (1989) parallel distributed processing model of visual word recognition and pronunciation proposed a single, uniform procedure for computing a phonological representation from an orthographic representation that applied to all words and nonwords. In contrast to dual-route models, Seidenberg and McClelland's model does not contain a lexicon in which there are representations of known words. Rather than being represented in the reader's lexicon, as proposed by dual-route models, knowledge of words is encoded in weighted connections in the neural network. High frequency words are recognized more quickly than low frequency words because items that have been encountered more frequently have a larger impact on connection weights (Seidenberg & McClelland).

Seidenberg and McClelland's (1989) model proposed that its single mechanism learnt to process all word types and letter strings through experience with the spelling-to-sound correspondences, which are implicit in the set of words from which it learns. Processing is mediated by connections among units, through a system of hidden units, and is interactive across phonological, orthographic and semantic levels, with activation at one level influencing activation at the other levels. Although acknowledging that Seidenberg and McClelland's model was able to read irregular words at a level consistent with human participants, Coltheart et al. (1993) claimed that the model was unable to read nonwords as well as people do, and that this was a defect not in the database of training words, as suggested by Seidenberg and McClelland in defence of their model, but rather was a defect in the model itself.

Seidenberg and McClelland's model was influenced by the interactive activation model of word perception (McClelland & Rumelhart, 1981) and several earlier word recognition models including Morton's (1969) logogen model Coltheart's (1978) dual-route model, and Glushko's (1979) word analogy model. Seidenberg and McClelland's model incorporated Glushko's (1979) proposal that the pronunciation of both words and nonwords is influenced by knowledge of the pronunciations of known words. Thus in Glushko's model both words (regular and irregular) and nonwords share a common knowledge base operating in a unitary manner, rather than existing as separate mechanisms. Seidenberg and McClelland proposed that words with similar spellings and pronunciations produce overlapping, mutually beneficial changes in connection weights.

Ehri (1998) following the connectionists' view that sight word learning evolves from a connectionist forming process, proposed that readers learn sight words (and recognize them as whole words) by forming connections between graphemes in the spellings and phonemes underlying pronunciation of individual words. Ehri criticized the dual-route view for its failure to explain why it is necessary for beginning readers to have phonological awareness and phonological recoding skill in order to learn to read words. According to Ehri, this process of establishing systematic visual-phonological connections between spellings and pronunciations, rather than arbitrary connections between spellings and meanings (as proposed by the dual-route view) allows readers to remember how to read not only regular words (with conventional GPCs) such as "stop", but also irregular words (containing unconventional GPCs) such as "island" in which all but the "s" conform to GPCs.

Another recent model which supports the view that word recognition depends on two successive procedures, has been proposed by Ans, Carbonnel, and Valdois (1998). This connectionist model developed in the French language, defines the two mechanisms in its structure as a global mechanism, which uses knowledge about whole word correspondences and an analytic mechanism based on the activation of word syllabic segments. Ans et al. describe these two mechanisms as functions of the system's ability to recognize input as either familiar or unfamiliar. In accordance with dual-route conceptions the model accounts for the basic features of both normal and pathological reading performance, however, in accordance with the connectionist approach, pronunciation of the word or nonword is always developed from knowledge from previously experienced letter strings.

In summary, this discussion of models of word recognition has highlighted theoretical differences between dual-route and single route models, however both explanations highlight and recognize the two essential component processes involved in word recognition, i.e., phonological processing and orthographic processing.

Models of Reading Acquisition

Early theories of how children learn to read (e.g., Frith, 1985) proposed that development occurs in a series of stages, and that all children move through the same stages. The first stage is described as an early logographic stage (in which young children learn to recognize familiar words based on the physical appearance of the word) followed by an alphabetic stage (when the child begins to learn GPC rules and uses them in reading) and a final orthographic stage (in which words are quickly processed into orthographic units without using phonological decoding).

Stuart and Coltheart (1988) challenged the invariant stages outlined in Frith's model, proposing that a child might completely bypass the logographic stage and begin with the alphabetic stage. Following Stuart and Coltheart, Byrne (1992) proposed the notion of a default option whereby the acquisition procedure outlined in Frith's (1985) model applied unless the child had access to certain initial representations of phonemic structure, that is, phonemic awareness. Phonemic awareness is an essential requirement for progress to the alphabetic stage, a child without phonemic awareness will read logographically at first (the default option). The shift to the alphabetic stage depends on achieving phonemic awareness and independently provided information about phonemic structure is necessary for the shift to occur (Byrne, 1992; Ehri, 1991).

Ehri (1998) proposed that reading acquisition can best be explained as emerging stages, each distinguished by the kind of word-specific connection that is established. Ehri's first stage is similar to Frith's logographic stage, which Ehri called a visual-cue reading or pre-alphabetic stage in which readers read words by rote memorization of connections between visual cues and meanings of words. Ehri called the next stage a phonetic-cue reading or partial alphabetic stage in which readers use their elementary knowledge of letter names and sounds to form partial connections between spellings and pronunciations. During the third full alphabetic stage readers use their phonemic segmentation and phonological recoding skill to form complete connections that secure the entire spelling of the word in memory as a visual symbol for phonemic units in pronunciation. The fourth stage is called the consolidated alphabetic stage in which the reader learns about the structure of larger units in words consisting of letter sequences that recur across several words, and the final stage is referred to as the automatic alphabetic stage in which the reading process has become automatic.

In contrast to stage-based theories Share (1995) proposed an item-based theory in which reading development can be best understood as a progression from heavy dependence on sub-lexical (or phonological) processing in the early stages of learning to read, to greater dependence on lexical (or orthographic) processing skills as the reader develops competency and fluency. Phonological recoding, according to Share, operates as a self-teaching mechanism, allowing the beginning reader to independently acquire an autonomous lexicon of known words.

Share outlined three key features of the self-teaching function of phonological recoding. Firstly the developmental role of phonological recoding is item-based rather than stage-based, which implies that the process of word recognition depends on the frequency with which a child has been exposed to a specific word. Secondly, the process of phonological recoding gradually expands the growing store of orthographic representations in the child's lexicon, implying that the development of proficient orthographic processing is dependent on the successful functioning of the phonological component of word recognition. Hence (and thirdly) the self-teaching mechanism encompasses both component processes required for fluent word recognition, that is, phonological and orthographic processing, and both make independent contributions to the acquisition of fluent word recognition skills, however the phonological component is primary and the orthographic component is secondary. "Although individual differences in orthographic processing appear to make an independent contribution to word recognition skill, this contribution must necessarily be secondary to the role of phonological factors because orthographic factors, in and of themselves, have little self-teaching potential" (Share, p.169).

Repeated successful phonological recoding attempts enable connections between letters and sounds to be strengthened until the whole word is recognized. Research indicates that relatively few such attempts will result in the word being successfully stored in the lexicon (Manis, 1985; Share 1999). Consequently in a child with normally developing phonological recoding skills, high frequency words may be recognized visually (orthographically) from the earliest stages of reading development. Share proposed that phonological recoding also plays a role in reading irregular words. "Most irregular words when encountered in natural text, have sufficient letter-sounding regularity (primarily relating to consonants) to permit selection of the correct target among a set of candidate pronunciations" (Share, p. 166). The irregularity of the English language is frequently overestimated and once a child understands that letters represent sounds then known words can be used as the basis for reading new words (Bowey, 1996; Ehri, 1998).

There is increasing empirical support for the critical role that phonological recoding (print-to-sound translation) plays in developing fluent reading skills. Phonological recoding (often referred to as decoding) requires knowledge of at least a basic set of letter-sound correspondences, the ability to blend sound segments, as well as insight into the alphabetic principle, or understanding that printed letters represent sounds (Bowey, 1996). In Ehri's (1992) view phonological recoding is central not only to decoding unfamiliar words but also for reading sight words, as it is recoding knowledge that allows the reader to establish the network of connections leading from a word's spelling to its pronunciation in memory when the word is established as a sight word.

Models of Spelling Acquisition

Whereas there is a large literature base investigating how we read words and how reading acquisition occurs, there has been considerably less experimental investigation of how we spell words and how spelling develops. In a recent paper Houghton and Zorzi (2003) presented the first model of spelling, a dual-route connectionist model. The model proposes two routes which operate in parallel with one route mapping directly from phonemes to graphemes, and a second route operating as a frequency-sensitive lexical pathway with the final spelling resulting from the combined outcome of both routes.

There is considerable empirical evidence to support a strong relationship between reading and spelling (e.g., Caravolas, Hulme, & Snowling, 2001: Ehri & Wilce, 1987). Whereas grapheme-phoneme correspondence rules are used for reading, phoneme-grapheme correspondence rules are used for spelling, and beginners utilize both graphemes and phonemes to read and spell (Ehri, 1997). Ehri highlighted similarities and differences between reading and spelling with the aim of providing a clearer understanding of how the two concepts are linked during their development.

As with reading acquisition, various models have been proposed to illustrate how spelling processes change as children develop spelling skills. Early descriptions of spelling development (e.g., Gentry, 1982) presented spelling as developing in a series of qualitatively different stages which depicted beginning spellers as focused on representing speech sounds in their spelling, with spellings guided by common phoneme-grapheme mappings and letter-name knowledge. These models proposed that the knowledge about the variety of letter-sequences that are possible in English and about where each letter-sequence should be used developed only after children had developed a collection of sight words. Treiman and Cassar (1997) argued that such theories were too simple and underestimated young children's abilities, and although phonology and letter-name knowledge play important roles in early spelling, young children also possess some potential knowledge about the orthographic regularities of written language.

Ehri (1997) referred to the earliest stage of spelling acquisition as the pre-alphabetic stage (also referred to as the logographic or pre-communicative stage by some researchers), which occurs before children have developed knowledge about the alphabet and how it represents speech. The next stage in Ehri's model is referred to as the partial alphabetic (or semiphonetic) stage, in which some sounds are known but alphabetic knowledge is incomplete. Once children know the conventional grapheme-phoneme units, particularly how vowels are symbolized with letters, they pass into the full alphabet stage, in which their invented spellings are more complete than those generated in the previous stage. The final stage is referred to as the consolidated alphabetic stage, in which children become aware of the structure of larger units in words consisting of letter sequences that recur across several words. Ehri proposes that these developmental stages reflect increasing understanding of the alphabetic system and that the differences between the stages are reflected in both the reading and spelling performances of children

Ehri (1997) claims that "reading words and spelling words are one and the same, almost" (p.264). Ehri proposes that the difference between the two processes relates to the different responses required to read and spell words, with the act of reading involving a single response, that of pronouncing a word, whereas the act of spelling involves multiple responses, that of writing several letters in the correct sequence. Consequently, more information is needed in memory to spell words accurately than to read words. According to Ehri's (1997) theory, "the underlying knowledge sources may fully support both reading and spelling responses for many words that conform to students' knowledge of the system, providing students have read those words enough times in a way that activates connection-forming processes to secure letters in memory" (p.264). With words that are not as well known and include letters that are outside the student's knowledge of the system connections are less stable. Consistent with Ehri's theory Bosman and Van Orden (1997) proposed that spelling and reading are interdependent and that both are mediated by phonology.

In a recent investigation of the developmental relationship between spelling and reading ability which supports Ehri's (1997) proposal of the critical role played by phoneme-grapheme connections in memory, Caravolas et al. (2001) provided evidence that skilled spelling requires a foundation in phonological transcoding ability which in turn enables the formation of orthographic representations. They concluded that spelling ability in English depends critically on phoneme awareness and letter-sound knowledge arguing that "primitive phoneme-grapheme mappings provide children with a "phonemic scaffold" onto which they can map increasingly complex and word-specific grapheme patterns" (p.771).

Conclusions

Models of word recognition and of reading and spelling acquisition highlight the critical role of the phonological component process and of phonological awareness. Gaining the knowledge that words consist of a sequence of phonemes and learning how these phonemes are symbolized with letters is critical for the development of word reading and spelling (Ehri, 1989). Furthermore the internalization of the spelling system as part of phonological knowledge enables the development of both reading and spelling skill, and this can only develop with adequate instruction. Although it is acknowledged that the orthographic process also makes an independent contribution to word recognition skill its role, according to Share (1995) is secondary to the role of phonological factors. The focus of this paper will be on the phonological component process, and the way the development of phonological awareness impacts on children's beginning reading and spelling.

CHAPTER 3

Phonological Awareness

There is substantial evidence to support the critical role that phonological abilities play in the development of word recognition and successful reading acquisition (e.g., Goswami & Bryant, 1990; Hatcher & Hulme, 1999; Share, 1995; Wagner & Torgesen, 1987). The general term ''phonological abilities' covers a wide range of skills of which phonological awareness, "the ability to reflect on and manipulate the phonemic segments of speech" (Tunmer, 1991, p.105) plays a critical, and causal role (Adams, 1990; Share, 1995; Wagner & Torgesen, 1987; Yopp, 1988) in reading acquisition. There is also considerable support for the proposal that it is the process of learning to read that promotes the development phonological and phonemic awareness (Morais, Alegria & Content, 1987; Ehri, 1989). Stanovich (1992) proposes that the relationship between phonological awareness and reading is one of reciprocal causation which can have important bootstrapping effects on reading achievement.

Children with poor phonological awareness are likely to become poor readers (Bradley & Bryant, 1983) and instruction that focuses on phonological awareness has been shown to facilitate beginning reading and spelling acquisition, particularly if it is linked to specific instruction in letter knowledge (Bradley & Bryant, 1983; Byrne & Fielding-Barnsley, 1991). These studies suggest that letter-sound knowledge and phonemic awareness are "critical co-requisites in reading acquisition" (Share, 1995, p.161). While there is wide acceptance of the pivotal role played by phonological awareness, the theoretical issue of just what constitutes the specific components of phonological awareness is still the subject of considerable debate.

Terminology

The terms *phonological awareness* and *phonological sensitivity* have been used synonymously throughout much of the literature. Stanovich (1992) recommends that the generic term *phonological sensitivity* be used to cover the set of processing constructs being tapped by various phonological tasks. Perfetti, Beck, Bell, and Hughes (1987) highlight a difference between phonological sensitivity, involving recognition of the phonological aspects of oral language such as rhyme and alliteration, and phonological awareness, requiring an awareness of individual phonemes. For the purpose of this literature review and empirical study, the term *phonological awareness* will be used throughout as a broad term to encompass those phonological skills associated with both rhyme awareness and awareness of phonemes. The term *rhyme awareness* will be used to refer specifically to the ability to isolate rhyming sounds within words (e.g., the "at" within the words "cat", "mat" and "sat"). The term *phonemic awareness* will be used to refer specifically to the ability to isolate individual phonemes within words (e.g., the "k", "a" and "t" sounds within the word "cat').

Following Liberman (1991) the term *phoneme* will be used rather than *sound.* The correspondences between graphemes (letters) and phonemes are not really correspondences with sounds but with the phonology of the language, a distinction, according to Liberman that has practical importance in that it emphasises the point that the problem is more than one of simply getting the child to learn to associate visual symbols with sounds.

Operationalising phonological awareness

A wide range of tasks has been used by researchers to measure phonological awareness. Performance on phonological awareness tasks may vary with the cognitive demands of the tasks, with tasks that require attention to syllables being easier than those requiring attention to onsets and rimes which in turn are easier than those tasks requiring attention to phonemes (Treiman & Zukowski, 1996). Yopp (1988) evaluated the reliability, validity and relative difficulty of 10 tests that have been used to operationalise the concept of phonemic awareness. Yopp's findings confirmed those of Stanovich, Cunningham, and Cramer (1984) that for kindergarten children rhyme tasks are the easiest of the phonemic awareness tasks to perform and phoneme deletion tasks are the most difficult. Yopp's study also revealed two highly related factors underlying phonemic awareness, simple phonemic awareness (segmentation, blending, sound isolation, and phoneme counting), and compound phonemic awareness (tasks that required a number of steps to complete, e.g., phoneme deletion).

Yopp (1988) outlined the cognitive requirements of various phonemic awareness tasks, indicating that a complex task such as phoneme deletion (introduced by Bruce, 1964) requires considerably more cognitive steps to complete when compared with a simple phonological awareness task such as a rhyme judgement task. Phoneme deletion requires the child to perform an operation (isolate a given sound) and then hold the resulting sound in memory while performing another task (recall the remaining sounds and then blend these to yield the new word or nonword). Yopp thus referred to phoneme deletion as a compound awareness task.

Phonological awareness as a metalinguistic skill

Phonological awareness requires the ability to bring knowledge of spoken language into conscious awareness (Tunmer & Hoover, 1992). According to Mattingly (1972) reading is a deliberately acquired, language-based skill, dependent on an individual's linguistic awareness. Knowledge of spoken language is well developed in most beginning readers, however intuitive oral language knowledge is not sufficient for the acquisition of fluent reading skills (Tunmer & Hoover). Tunmer and Hoover proposed that learning to read requires that knowledge of spoken language be applied to written language, which involves the metalinguistic ability to reflect on the structural features of spoken language. Liberman (1991) proposed that this contact between spoken and written language requires special skills, involving awareness of phonemes, which enable acquisition of reading. Many five and six year old children with normal language skills are unable to perform simple metalinguistic operations such as segmenting familiar spoken words into their constituent phonemes (Tunmer & Hoover). Gombert (1992) proposed that the transition from unconscious implicit metalinguistic awareness to an explicit, consciously controlled metalinguistic awareness is developmental.

Bentin (1992) made a distinction between early phonological awareness (sensitivity to onset and rime), and phonemic awareness (the ability to isolate segments and manipulate single phonemes requiring explicit knowledge about phonemic segments), suggesting the possibility that these skills are separable and qualitatively different forms of phonological awareness. Goswami and Bryant (1990) proposed that phonological awareness is a gradually developing ability, and so these two forms of phonological awareness (early phonological sensitivity, and phonemic awareness) represent two levels along a continuum of a single ability. Although awareness of rime develops early, without explicit knowledge of the written language that represents the spoken language, young children experience difficulty when asked to subdivide a rime into phonemes (Treiman & Zukowski, 1991). The shift to phonemic awareness requires explicit and conscious awareness of the phonological structure of words (Liberman, 1991), a skill that is dependent on appropriate learning experiences (Duncan, Seymour, & Hill, 1997; Share, 1995). Goswami and East

(2000) proposed that the difference between implicit and explicit awareness of rime should also be considered in relation to a child's early phonological awareness.

The pivotal role of the alphabetic principle in the development of phonological awareness

Reading acquisition is dependent on the discovery of the alphabetic principle (Alegria & Morais, 1991). Once the alphabetic principle that letters represent sounds is understood, then the child can focus on letter-sound relationships and learn to work out unfamiliar items independently (Bowey, 1996; Share, 1995, 1999). Two important precursors of learning the alphabetic principle are phonological awareness and knowledge about letter-names and letter-sounds, which provide a good foundation for the development of reading skills (Frost, 2001; Muter, Hulme, Snowling, & Taylor, 1998; Share, 1995; Treiman, 2000). Ehri (1992) suggests that once beginning readers acquire a basic knowledge of letter-names or phonemes they begin to refine the visual cues used to recognize familiar words by establishing visual-phonological connections, through association of one or more printed letters with sounds in the word's pronunciation. The connections that link the letters to the pronunciation are formed out of the reader's knowledge of GPCs.

Knowledge of GPC rules provides a powerful mnemonic system that links the written forms of specific words to their pronunciation in memory (Ehri, 1998). This partial decoding strategy however requires more than just letter-sound knowledge; it is dependent also on phonemic awareness, the specific ability to recognize identity between learned letter-names and sublexical segments in spoken words (Share, 1995). Bowey (1996) suggested that for children who find it difficult to focus on the sound structure of spoken words, the phonological recoding process may remain a mystery whereas "children who can make phonological judgements effortlessly are more likely to notice phonological similarities in a wide range of contexts and thus be able to spontaneously detect print-sound correspondences at a variety of levels, thereby increasing phonological recoding skills" (p.117).

Bowey (1994) found that both novice and nonreaders with high letter knowledge were sensitive to the phonemic structure of spoken words, which is consistent with accounts that distinguish between explicit (metalinguistic) and implicit phonemic analysis. Foy and Mann (2001) similarly found that the older children in their study of four-to-six year old children who had undoubtedly been exposed to more vocabulary and letter instruction than the younger children, possessed better phonological awareness abilities.

Bradley (1988) found that beginning readers who were taught the connection between early phonological awareness (rhyming words) and memory for letter strings (using plastic letters) made early gains in reading text. Muter et al. (1998) found that the combination of letter knowledge and phoneme segmentation ability reflected the extent to which their participants (four to six year olds) were able to achieve phonological linkage (Hatcher, Hulme, & Ellis, 1994). For prereaders to shift attention from environmental cues to the print itself, they need to learn the alphabet. Due to the number of letter shapes, and because the sounds are folded into adjacent sounds and are difficult to distinguish as units, children need instruction and practice in these prerequisites before they can begin reading words and text independently (Ehri, 1991).

Many researchers argue that children's knowledge about letters is one of the best longitudinal predictors of reading success in young children (e.g., Adams, 1990; Muter et al., 1998; Stuart & Coltheart, 1988). Studies show that children usually learn the names of letters well before they learn their sounds (McBride-Chang, 1999;

Treiman, 2000). McBride-Chang concluded that letter-naming and letter-sound knowledge are different but overlapping abilities, each contributing unique variance to reading related skills. Frost (2001) identified two types of letter knowledge, which he referred to as formal and functional letter knowledge. Whereas formal letter knowledge enables the child to identify letter-names and their sounds, functional letter knowledge enables the child to convert formal letter knowledge into word processing strategies and to activate phonological representations to a higher level of attention. Frost contends that the development of functional letter-knowledge ability is an important basis for further reading development.

There is considerable support for the proposal that phoneme awareness skills are strongly associated with cognitive abilities that are relatively dependent on formal instruction (Foy & Mann, 2001). Children who possess more developed emergent literacy skills such as phonological processing abilities, print knowledge and oral language appear to benefit more from reading instruction and hence learn to read sooner (Anthony, Lonigan, Burgess, Driscoll, Phillips, & Cantor, 2002). Learning to read appears to be a major factor affecting the development of phonological awareness.

The role of large (rhyme awareness) versus small (phoneme awareness) phonological units as predictors of children's reading skills

The theoretical issue of the roles played by early phonological awareness (rhyme awareness) and phonemic awareness in reading acquisition is controversial, and has been the focus of considerable empirical study over recent years. Large-unit theories propose that children naturally make use of their pre-reading rhyming skills in order to structure their early attempts to read, whereas small-unit theories propose that it is the actual experience of learning to read, especially learning letter-phoneme-correspondences, that directs phonological awareness towards an awareness of phonemes (Duncan et al., 1997).

Large-unit theories

Goswami and Bryant's (1990) theoretical position focuses on the role of large phonological units (syllable onset and rhyme awareness), which they propose act as a developmental precurser to a focus on smaller units of sound at the level of the phoneme, that is., phonemic awareness. Goswami and Bryant (1990) furthermore contended that rhyme awareness makes a direct and specific contribution to word reading that is independent of phonemic awareness and manipulation ability. Inherent in the large-unit theoretical position is the idea that phonological awareness develops progressively (Trieman, 1992) from initial focus on larger units, which children find easier and more natural, before progression to instruction focusing on phonemes. According to Goswami and East (2000) the most plausible developmental models of reading are those that give both rhymes and phonemes a role to play from the beginning of reading.

There is considerable empirical support for Goswami and Bryant's theory (Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Foy & Mann, 2001; Hoien, Lundberg, Stanovich, & Bjaalid, 1995). Bradley and Bryant (1983) demonstrated that four to five year olds' performance on phonological oddity tasks (measuring rhyme awareness) predicted performance on standardized reading and spelling tests over three years later. Using path analyses Bryant et al. 's (1990) longitudinal results led them to propose that rhyme and alliteration affect reading in two ways. Firstly there is a developmental path from rhyme sensitivity to phoneme sensitivity a year or more later, which is strongly related to reading (an indirect route via phoneme detection skills). Secondly their results showed a direct connection between rhyme sensitivity and reading that was independent of phoneme detection ability (a direct route).

A later study (Hoien et al., 1995) using group administered tests, isolated three separate phonological awareness factors – a phoneme factor, a syllable factor, and a rhyme factor, which corresponded to the different levels of language required by the tasks, with each operating as separate predictors of early word decoding ability. Hoien et al. found that phonemic awareness was a strong predictor of early reading acquisition, and rhyme was demonstrated to be a factor separable from phonemic awareness, which made an independent, although small, contribution to explaining the variance in reading. Foy and Mann (2001) in their study of a small number (N =40) of four to six year olds, concluded that their results were consistent with those of Hoien et al.'s determining that phoneme and rhyme awareness skills represented separable components of phonological awareness.

The findings of Anthony et al., (2002), based on confirmatory factor analysis, revealed that a one-factor model best explained their results of a study of two groups of younger (N = 109) and older (N = 149) preschool children, and similarly supported a developmental conceptualization of phonological awareness, but did not support the position that rhyme awareness and phoneme awareness were separable factors, each making an independent contribution to reading. Although both early phonological development and phonemic awareness were measured in this study, the children's explicit phonological awareness was obviously at a very early stage of development. In their deletion task (elision phonemes) both the younger and older groups scored barely above chance indicating that few of these children had begun to develop an explicit awareness of phonemes.

Small-unit theories

Small unit theorists propose that phonemic awareness, rather than developing progressively from early phonological awareness (as posited by large-unit theorists), develops in response to the actual experience of learning to read, and more specifically from learning grapheme-to-phoneme correspondences (Duncan et al., 1997). Several studies provide empirical support for the small-unit theoretical position (Duncan et al., 1997; Hatcher & Hulme, 1999; Hulme, Hatcher, Nation, Brown, Adams, & Stuart, 2002; Muter et al., 1998; Muter & Snowling, 1998; Seymour & Duncan, 1997; Stanovich et al., 1984).

A study of 49 kindergarten children by Stanovich et al. (1984) found little relation between a rhyme test and reading in their five-year old participants, and little relation either between rhyme and phoneme detection measures, although ceiling effects were evident on the rhyming tasks used, and possibly compromised the rhyming results. Stanovich et al. found that their phoneme detection tasks were related to and were good predictors of reading ability one year later, proposing that their data supported viewing the concept of phonological awareness as a single factor.

Seymour and colleagues (Duncan et al., 1997; Seymour & Duncan, 1997) contend that large-unit theory does not give a valid account of the initial stages of learning to read. Although the children in Seymour and Duncan's longitudinal study of beginning readers entered Year 1 from nursery school with well-established rhyming skills they did not use this knowledge in their initial attempts at reading, but rather as their knowledge of letters increased they tended increasingly to follow a small unit approach. Their data did suggest that although the children's reading of both words and nonwords remained predominantly a small unit process, there were signs of an emerging sensitivity to rhyme segments. Seymour and Duncan suggest that in the pre-school stage children may develop implicit awareness of rhyme, but that this does not have immediate effects on reading where instruction in letters and the alphabetic principle emphasizes small units and results in an emergence of an explicit (metalinguistic) awareness of phonemes which then preceeds an explicit awareness of rhymes. In accordance with these findings Duncan and Johnston (1999) found dissociations in phonological skills in a group of poor Grade 6 readers with indications that intact awareness of rhyme may not be a prerequisite for the development of phoneme awareness as proposed by Goswami and Bryant (1990). However the role of rhyme in older readers may be quite different to that found in beginning readers.

Muter et al. (1998) found measures of children's phonemic awareness of small phonological units, particularly phonemes, to be better predictors of individual differences in learning to read than tasks based on large units (rhyme). Muter et al. identified rhyming and segmentation as two distinct and relatively independent factors in their longitudinal study of beginning readers (N =38). Rhyming was defined by measures of rhyme detection and rhyme production, whereas segmentation was defined by measures of phoneme identification and phoneme deletion. Segmentation was strongly related to reading and spelling. Contrary to Goswami and Bryant's (1990) theoretical position, early rhyming skills were not a determinant of early reading skills. However by the end of the second year of school, rhyming had begun to exert a predictive effect on spelling, but not on reading. These findings should be viewed in light of several limitations including the small sample of children, their middle class bias, and the above average IQ of the children. The average IQ of the 38 children was in the High Average range with a restricted Standard Deviation of 10.7

indicating a sample of children with higher than average IQs spread across a more narrow range than would be expected in a normal distribution of IQ scores.

A follow-up study of 34 nine-year-old children, originally participants in the Muter et al. (1998) longitudinal study as four to six year olds, also established rhyme and phoneme awareness as independent skills (Muter & Snowling, 1998). Whereas tests of rhyme detection given at ages four to six proved to be poor long-term predictors of reading accuracy, phoneme awareness was found to be a very powerful predictor of reading accuracy, both in the short and long term.

In a longitudinal training study of seven-year old children experiencing significant reading difficulties, Hatcher and Hulme (1999) determined that phoneme deletion skills were a significant predictor of responsiveness to reading remediation whereas rhyme skills were not. The authors suggest that phoneme manipulation skills may be important as a measure of the extent to which a child possesses well-specified, segmentally structured phonological representations. Hatcher and Hulme hypothesised that the possession of well-specified representations is crucial to the process of creating direct mappings between orthographic and phonological representations when learning to read.

Supporting their earlier studies Hulme et al. (2002) similarly found that measures of phoneme awareness were the best concurrent and longitudinal predictors of reading skill, with onset-rime skills making no additional predictive contribution once phonemic skills were accounted for. Although the authors suggest that assessments of children's phonological skills should pay particular attention to phonemic level skills, they do propose, in support of Bryant et al. (1990), that there is good evidence that the development of phonological skills proceeds from an awareness of large units to later awareness of small units (phonemes). The children in their study clearly found identification of phonemes more difficult than onset-rime units. Importantly this study used onset-rime awareness and phoneme awareness tasks that were directly comparable and from which floor and ceiling effects were absent (Bowey, 2002).

Attempts to resolve the contention surrounding large versus small unit theories

The Hulme et al. (2002) study prompted considerable debate. Bryant (2002) contended that Hulme et al. (2002) misinterpreted Bryant et al.'s (1990) ideas about the indirect route between early phonological awareness and reading. An essential component of the indirect route is a strong connection between phoneme awareness, reading, and spelling, which Bryant refers to as a proposal "about the intricate mechanisms of development, not about the relative strength of predictions" (p.44). Bryant suggested that it is in relation to the direct route proposed by Goswami and Bryant's (1990) model, that Hulme et al.'s finding that children's rime scores no longer predicted their reading scores when differences in phoneme awareness were controlled (which is in conflict with Bryant et al., 1990) could suggest that the direct route in fact may not exist. It may be that the influence of rhyme awareness on reading is simply via the indirect route proposed in Goswami and Bryant's (1990) model. Hulme et al.'s (2002) failure to measure the children's IQ and hence their inability to control for differences in IQ, is an important limitation.

Bowey (2002) also criticized both the Bryant et al. (1990), and Hulme et al. (2002) studies for their failure to control for the autoregressive effects of earlier reading ability. Wagner et al. (1994) proposed that the failure to include the autoregressive effect of a variable measured at a prior time on the same variable at a later time is a frequently omitted possible cause of differences when looking at causal factors in reading. Similarly Tunmer (1991) proposed that the process of learning to read itself may produce skills that greatly facilitate children's performance on phonological awareness tasks. If there is a reciprocal relationship between phonological awareness and reading, children who possess some preschool reading ability may perform better on measures of phonological awareness.

Bowey (2002) proposed that Hulme et al.'s (2002) finding that phoneme awareness is a better predictor of word reading than rhyme awareness, may simply indicate that, at this developmental level, phoneme awareness is a better measure of the construct of phonological awareness than rhyme awareness. Bowey suggested that for children at risk of later reading difficulties the most appropriate training programmes should prepare them to understand reading instruction by focusing on developmentally appropriate levels of phonological awareness and that complex phonological awareness tasks may be beyond some beginning readers. Similarly Anthony et al. (2002) highlighted the importance of assessment tools being developmentally appropriate for any given child.

Goswami (2002) proposed that the logical conclusion to be drawn from Hulme et al.'s (2002) study is that large units play a developmentally complementary role in reading acquisition to that played by small units. The key to resolving this issue may lie in "adopting a developmental view of the nature of the phonological representations that underlie the development of literacy" (Goswami, 2002, p.54). Goswami proposes that once instruction in reading commences, phonological representations, which prior to instruction code relatively large units such as syllables and onsets and rime, are rapidly restructured to represent phoneme-level information.

Evidence from Phonological Awareness Intervention Studies

Although the development of phonological awareness is strongly linked to the process of learning to read itself phonemic awareness does not develop efficiently without explicit and conscious instruction (Duncan et al., 1997, Share, 1995). Phonological awareness intervention studies have been conducted in recent years to evaluate the effectiveness of phonological training programs in improving children's phonological awareness skills and hence their reading and spelling performance. The early intervention study conducted by Bradley and Bryant (1988), introduced earlier in this chapter, showed that explicit instruction in phonological awareness and training with plastic letters led to an improved understanding of the connection between sounds and print and hence to early gains in reading text. More recently the National Reading Panel conducted two quantitative meta-analyses to evaluate firstly the effects of phonemic awareness instruction (Ehri, Nunes, Willows, Schuster et al., 2001), and secondly the effects of systematic phonics instruction (Ehri, Nunes, Stahl, & Willows, 2001) on learning to read and spell. These studies showed a large and statistically significant impact of phonemic awareness instruction, particularly at the pre-school level and systematic phonics instruction was proved to be more effective in helping children learn to read than all other forms of instruction including whole language. The effects of phonics instruction were also found to be larger when phonics instruction was begun early (d = 0.55 rather than after 1st Grade (d = 0.27).

Conclusions

Early phonological awareness (the ability to detect and produce rhymes and the sensitivity to subsyllabic segments) develops differently from phonemic awareness (the ability to isolate and manipulate individual phonemes in speech (Bentin, 1992). Early phonological awareness appears to emerge naturally in most children who have been exposed to nursery rhymes or other sound games, and develops implicitly and independently of reading instruction. The shift to phonemic awareness occurs in most children when they come to understand the alphabetic principle through explicit instruction. From a developmental perspective early phonological awareness appears to exert an indirect effect on reading through the development of phonemic awareness, which once developed is the most powerful predictor of concurrent and longitudinal reading ability. The direct role of rhyme awareness in reading acquisition, both in the short-term and long-term remains unclear.

CHAPTER 4

Cognitive and Biological Sex Differences

Cognitive Sex Differences

The question of sex differences, whether they exist, and in what form they exist if in fact they do exist, is an area of research that is contentious. Conclusions about differences in the area of reading and spelling do not mean there is a better or smarter sex (Halpern, 1997) but rather may imply that boys and girls develop and use reading strategies differently. Nationally in Australia girls as a group are outperforming their male peers in literacy achieving up to five percentage points higher than boys in the year 3 and year 5 Literacy Benchmark Test (House of Representatives Standing Committee on Education and Training, 2002). The issue of why such differences are occurring needs to be addressed. Are such differences the outcome of non-cognitive differences such as those associated with SES, cultural or socialization, concentration or interest differences, or can an explanation be found in cognitive differences in the way boys and girls develop and utilize specific component skills which are critical to successful reading and spelling acquisition? The issue of differences between boys and girls in phonological awareness, a foundation skill in beginning reading and spelling acquisition is of theoretical importance in extending our understanding of the way reading processes develop in children, and of practical importance to educators in training teachers and in guiding instruction programs in beginning reading.

Standardised tests of intelligence have been constructed so that there are no reliable differences between males and females and while some tasks show no sex differences there are others which show small differences and a few tasks where differences are large and consistent (Neisser, 1996). Many studies suggest that females, on average score higher than their male peers on tasks demanding rapid access to and the use of phonological and semantic information in long-term memory, comprehension of complex prose, fine-motor skills and perceptual speed (Halpern, 1997). In contrast, males on average, have been found to score higher than their female peers on tasks requiring visual-spatial transformations in working memory, motor skills involved in aiming, spatio-temporal responses, and mathematical and scientific reasoning (Halpern).

One of the earliest reviews of the literature on sex differences was conducted by Macoby and Jacklin (1974), who established a criterion that sex differences existed only where a large number of studies found sex differences in the same direction for a given variable, however their methodology has been criticized as "vote counting" (Halpern, 2000). Macoby and Jacklin concluded that there were small differences in verbal ability between the sexes with the magnitude of the female advantage varying, but being most usually about one quarter of a standard deviation. Following this review, Hyde and Linn (1988) investigated the nature of sex differences in verbal ability through a meta-analysis of existing research, concluding that there were no sex differences in verbal ability, at least in the standard ways that verbal ability has been measured. They divided the studies used in their analysis into two groups, prior to 1973 (roughly corresponding to the sample used by Macoby & Jacklin) and those published in 1974 or later. The effect size of the female advantage was significantly larger for the pre 1973 studies ($d=0.23$) than for the post 1973 studies ($d=0.10$).

Wallschlaeger and Hendricks (1997) point out deficiencies in the literature on dyslexia for failing to give sufficient attention to sex differences and the failure of some studies to even identify the sex of their participants, and of others for not using appropriately balanced samples, particularly in studies of dyslexia in which the control group often contains fewer boys, and the dyslexic group a greater number of boys. Wallshlaeger and Hendricks found that academic skills in a nondyslexic sample of participants had an impact especially for females, with females with low academic skills clearly performing below males in a phoneme reversal task and a sentence completion task.

A review of a large number of phonological awareness studies reveals that although many have used balanced numbers of boy and girl participants many fail to give a break-down of the numbers of male and female participants (e.g. Bradley, 1988 Duncan & Johnson, 1999; Foy & Mann, 2001; Goswami & East, 2000; Kirby & Parrila, 1999; Seymour & Evans, 1994; Seymour & Duncan, 1997). Studies which have subdivided participants into groups based on letter knowledge and/or phonemic awareness often report more boys than girls in groups with lower ability in these areas (e.g. Bowey, 1994; Frost, 2001).

Sex differences in symbol matching tasks

At a more specific level of investigation, Majeres (1997, 1999) using young adult participants, examined sex differences in phonological processing using symbol matching tasks. Majeres (1999) concluded that the sex differences found in symbol matching resulted from a difference in speech-based processes, which may be the result of a sex difference in phonological representation. Majeres contended that symbol matching tasks probably share the same phonological processes that are important in learning to read. Furthermore, sex differences in phonological processing may have a direct bearing on the acquisition of early reading skills, on the methods used in teaching those skills, and especially on the early reading problems frequently found in boys (Majeres, 1999).

Sex differences in children diagnosed with reading disability

The issue of sex differences in the occurrence of dyslexia has been widely debated (Lambe, 1999) however there is now strong evidence that dyslexia is far more prevalent in boys than in girls (Backes, Vuurman, Wennekes, Spronk Wuisman, Engelshoven, & Jolles, 2002). Hyde and Linn (1988) raised the possibility that samples drawn from normal classrooms may not include many low scoring boys, as more boys than girls are removed from regular classrooms for placement in special classes such as remedial reading classes. Girls learn to read sooner and there are more boys than girls who require special training in remedial reading programs (Hyde & Linn). Boys are over represented at the low-ability end of many distributions, including attention deficit disorders, delayed speech, dyslexia (even allowing for possible referral bias), stuttering, learning disabilities, and speech and language disorders (Flannery, Liederman, Daly, & Schultz, 2000; Halpern, 1997). Data from Flannery et al. (2000) strongly suggests that there is a significant substantial prevalence of boys with reading disability, irrespective of economic and racial differences.

The ratio of boys to girls diagnosed with reading disability varies with the population used, the definition of dyslexia employed, and other biological and cultural factors but is consistently between 2: 1 and 5: 1 (Wallschlaeger & Hendricks, 1997), however the excess of males appears to be a robust finding (Stevenson, 1992). School-based referrals show a higher proportion of males to females than research-identified populations and may be linked to boy's behaviour as teachers rated both reading disabled and normal boys in school settings as significantly more active, more inattentive, and as having more behavioural problems than girls (Shaywitz, Shaywitz, Fletcher, & Escobar, 1990). The discrepancy may also be explained by the criteria used for diagnosis, which fluctuates between 2 and 1.5 standard deviations in degree of underachievement in reading (Flannery et al., 2000). Nass (1993) suggested that maturation differences, with girls maturing faster, could hypothetically alter interhemispheric connections exaggerating learning disabilities in males. Boys are more likely to be incorrectly diagnosed as learning disabled in the early grades because of their slower rate of maturation in childhood (Halpern, 1997).

Ellis (1989) argued that "studies of individual differences in reading development where intelligence is controlled generate patterns of associations which are essentially similar to those that arise from studies of developmental dyslexia" (p. 551).

Sex differences in normal readers

There is considerable evidence indicating that boys as a group are underachieving in literacy when compared with girls both Australia and worldwide (Alexander & Martin, 2000; Education Review Office, New Zealand, 1998; Gambell & Hunter, 1999; House of Representatives Standing Committee on Education and Training, 2002; Office for Educational Review, Tasmania, 1998) There is evidence that boys are more variable in performance on tests than girls, particularly in some tests of general knowledge, quantitative ability, and spelling (Sattler, 2001), and that the distributions of boys' scores over the entire range of scores may differ from girls (Feingold, 1992).

Effect sizes in research on sex differences

Effect size (also known as strength of association) shows the size of any difference between means. An effect size assesses "the amount of total variance in the dependant variable that is predictable from knowledge of the levels of the independent variable" (Tabachnick & Fidell, 1996, p. 53). A number of effect size statistics are used and in examining sex differences (*d*) is often used to index the size of an effect by measuring how much the male and female means differ in standard deviation units. An effect size of 1.0 indicates that the difference between the groups is one standard deviation whereas an effect size of 0 indicates that the male and female means are the same. Using *d* an effect size of 0.2 is considered small, an effect size of 0.5 is moderate, and an effect size of 0.80 is considered large (Cohen, 1988). Cohen (1992) describes a medium effect size as representing "an effect likely to be visible to the naked eye of a careful observer" (p. 156) and a small effect size as "noticeably smaller than medium but not so small as to be trivial" (p.156). One of the most common effect size statistics is eta squared (actually partial eta squared but labeled eta squared) which is calculated by SPSS as part of the ANOVA output. Values of eta squared can range from 0 to 1 and Pallant (2001) suggests the following guidelines (from Cohen, 1988) in the interpretation of the size of an effect based on eta squared - 0.01 represents a small effect, 0.06 represents a moderate effect and 0.14 represents a large effect.

According to Feingold, (1992) findings based on *d* as the sole effect size consider only sex differences in means and Feingold asserts that the possibility that the sexes may differ in variability has been almost completely ignored by researchers using meta-analysis or test norms. If sexes differ in both means and variability, the sex differences would be different at the tails of the distribution. If the more variable sex has a higher mean, that sex's overrepresentation in the right tail (high scores) would exceed that which would be expected from *d,* whereas if the sex with the higher mean score is lower in variability, the sex difference would be larger in the left tail (low scores) and smaller in the right tail (high scorers) than would be expected from *d* (Feingold). Feingold proposes that "it is preferable to consider the means and standard deviations for both sexes as parameters (instead of statistics) and to examine only the magnitude of sex differences (via effect sizes) in central tendency and variability" (p.68).

Biological sex differences

Evidence from functional neuroimaging studies

Studies using functional neuroimaging technology have attempted to link cognitive processing functions to brain structures to allow a clearer understanding of the cognitive structure of the brain (Halpern, 2000). Functional Magnetic Resonance Imaging (fMRI) allows the noninvasive mapping of brain areas involved in the component processing operations of complex cognitive tasks such as reading words and nonwords, providing researchers with pictures showing which parts of the brain are activated during the performance of a particular task.

There is growing evidence from this research to support the suggestion that the areas of the brain responsible for language functions may be organized differently in males and females. Whereas there is strong support for the proposal that the left cerebral hemisphere is specialized for the processing of natural language, the extent of right hemisphere involvement in language processing such as in word recognition tasks is controversial (Weekes, Capetillo-Cunliffe, Rayman, Iacoboni, & Zaidel, 1999). There is also growing evidence to support the proposal that there are differences between boys and girls in the involvement of the right hemisphere in such tasks (Backes et al., 2002). Shaywitz et al. (1995), and Pugh et al. (1997) suggested that language functions are more likely to be more highly left lateralized in males whereas the pattern is different in females who engage more diffuse neural systems involving both cerebral hemispheres, although Pugh et al. acknowledged that there was substantial variation among the women in their study. Pugh et al. proposed that both hemispheres play a role in phonological processing, with the differences between hemispheres being the grain size of the mapping engaged in by each hemisphere, with more fine-grained mapping occurring in the right hemisphere. Pugh et al. suggested that those without right hemisphere involvement in phonological processing still engage in phonological processing but this may be at a grain size larger than the phoneme.

In a study using 12 males and 12 females, all right-handed, and word recognition tasks which isolated phonological and orthographic processing, Weekes et al. (1999) also observed that the right hemisphere has access to a phonological processing route in addition to that provided by the left hemisphere. They found that the skill level of the participant also influenced hemispheric specialization for phonological and orthographic processing variables with lower performing participants showing selective deficits in the right hemisphere.

The sex differences found in the Pugh et al. study were differences in the mode of word recognition, not in word recognition skill. However Pugh et al. propose that "it is conceivable that earlier phonological awareness may lead to a focus on smaller grain-sized units, at least in the beginning stages of learning to read, although this hypothesis is clearly in need of testing" (p. 314). Given the considerable evidence that the brains of boys and girls mature differently (e.g., De Bellis et al., 2001; Lambe, 1999) it is not unreasonable to suggest that girls may develop earlier phonemic awareness making reading and spelling acquisition a smoother process for them as a group than is the case for boys.

A recent fMRI study (Rossell, Bullmore, Williams, & David, 2002) has confirmed Pugh et al.'s, and Shaywitz et al.'s findings. Males in this study showed activation that was more lateralized to the left hemisphere, whereas females showed activation in a greater number of brain regions during the task per se and also showed greater right-sided activation. Rossell et al. also found behavioural evidence to support the imaging findings - males showed marginally faster reaction times when words were presented to the right-visual field whereas females showed a left visual-field advantage.

The substantial variation in hemispheric dominance found in women by Pugh et al. (1997) may relate to Weekes et al.'s (1999) finding that the skill level of the participant also influenced hemispheric specialization with lower performing participants showing selective deficits in the right hemisphere. Vikingstad, George, Johnson, and Cao (2000) also contended that Shaywitz et al's conclusion that women predominantly engage both hemispheres when processing phonologically simplifies the complexity of the cortical language distribution finding in their fMRI study that whereas the males were also generally left-lateralised, the females formed two subgroups, one with left-lateralisation, and the other with bilateral representation. However the participants with bilateral representation were primarily female, which is consistent with Pugh et al.'s finding of substantial variation among their female participants. Vikingstad et al. concluded that women have a higher incidence of bilateral language representation than men with degree of laterality varying as a function of task demand. Although it may be that the neural representation of specific language functions differs between the sexes, another explanation may be found in the underlying strategy or cognitive processing route used (phonological or orthographic as posited by dual-route models), which may differ between men and women (Vikingstad et al.). Weekes et al. also suggest that the presence of phonological processing in the right hemisphere may depend on available resources and the strategies used, which are subject to individual differences.

Evidence from Positron Emission Tomography (PET)

Consistent with the findings of Shaywitz et al.(1995) and Pugh et al. (1997) Rumsey, Horwitz, Donohue, Nace, Maisong, and Andreason (1997) in a PET study of adults (age range 18 – 40) found that the phonological processing tasks (reading pseudowords, and a pseudoword decision-making task) activated the left-hemisphere in their male participants. However whereas Shaywitz et al. and Pugh et al. found that their orthographic task activated the extrastriate region, in contrast to their phonological processing task which activated the inferior frontal gyrus, Rumsey et al. found that the same region was also activated in the orthographic tasks (irregular word reading and a lexical decision task using real words), although to a lesser extent. In explaining these conflicting findings Rumsey et al. proposed that the orthographic task used by Shaywitz et al. was primarily a task involving visual feature detection (judging whether two consonant strings contain the same pattern of upper and lower case alternation) in contrast to the linguistically based design used in their study. Rumsey et al. propose that their results are consistent with single route connectionist models of reading, with both phonological and orthographic processing being subserved by a common neural network. Shaywitz et al.'s and Pugh et al.'s results are more consistent with dual-route models as their results suggest that the two component processes of word recognition activate two different regions of the brain.

Jaeger, Lockwood, Van Valin, Kemmerer, Murphy, and Wack's (1998) PET data also suggested stronger left-lateralisation for men than for women, and suggest that these findings could be compatible with those of Shaywitz et al. (1995) and Pugh et al. (1997). The task used by Jaeger et al., computing past tense forms from stems, would have involved more phonological processing than would have been required to simply read those stems aloud as required by Shaywitz et al. and Pugh et al. which did not reveal any sex differences. This finding of greater differences during the more complicated past tense tasks is consistent with the hypothesis that sex differences are more likely to occur as the complexity of the task increases, and the authors suggest that this may also explain why some neuroimaging studies (e.g., Price, Moore, & Friston, 1996) failed to find sex differences with very simple tasks.

Lesion studies

Lesion studies provide further evidence of sex differences in hemispheric involvement in verbal abilities (e.g., Lambe, 1999; Frith & Vargha-Khadem, 2001). Lambe contends that sex "appears to be a critical variable for research into language and reading skills in general and dyslexia in particular" (p. 530). McGlone (1977) reported that males with left hemisphere lesions showed specific verbal deficits and concluded that her findings suggested a greater degree of functional brain asymmetry in right handed men than women. Right-sided lesions appear more likely to impact on some types of verbal ability in females than in males (Lambe; Kimura, 1987). Lambe proposed furthermore that there may be sex differences in the timing of cortical maturation with the human temporal cortex maturing faster in girls than in boys.

Frith and Vargha-Khadem (2001) analysed reading and spelling performance in a sample of 45 children (mean age 10-11 years) with one-sided brain damage. There were no differences between the four groups (male, female for each experimental and control condition) in IQ or age. Results showed a significant sex by 'side of lesion' interaction, for both familiar and unfamiliar words, with left-side damage producing greater impairment in boys' reading and spelling performance than in girls' for whom right-sided damage produced a greater impairment. Boys with left hemisphere lesions performed significantly less well than controls, however there was no significant difference between performance for girls with right-sided lesions and controls. Whereas hemispheric side of damage made little difference for girls, left-hemispheric damage adversely affected boys' performance.

These results are consistent with Shaywitz et al.'s (1995) and Pugh et al.'s (1997) findings that phonological processes tend to be more strongly left-lateralised in males. Importantly whereas Shaywitz et al.'s and Pugh et al.'s studies used adult participants, Frith and Vargha-Khadem's study extends their findings to children, suggesting that sex differences in hemispheric specialization emerge in young children. As there is a wealth of research indicating that early phonological skills predict later reading success (e.g., Share, 1995; Wagner & Torgesen, 1987), Frith and Vargha-Khadem propose that a consequence of stronger lateralization of phonological processing functions in boys than in girls may be a disruption of the smooth acquisition of literacy skills specifically in boys.

Conclusion

The evidence of biological differences between males and females in the phonological component processing subsystem based on these brain imaging studies suggests that sex differences related to reading should be directed at this more specific area of investigation.

CHAPTER 5

Rationale for the Empirical Study

In Australian schools girls are outperforming boys in literacy, according to the results of the Year 3 and Year 5 Literacy Benchmark Tests (House of Representatives Standing Committee on Education and Training, 2002). Standardized tests of intelligence (Neisser, 1996) show that there are no differences between males and females in general intelligence however reliable differences have been found in some tests of cognitive abilities (Halpern & LaMay, 2000). Investigation into cognitive sex differences has concentrated largely on broad domains of difference, such as verbal ability, and the findings are equivocal. Investigations into biological sex differences, on the other hand, reveal that there are specific differences between males and females in the brain areas engaged in phonological processing tasks. Given the critical and causal role of phonological abilities in the development of word recognition and successful reading and spelling acquisition (e.g., Adams, 1990; Share, 1995; Wagner & Torgesen, 1987; Yopp, 1988) an investigation into sex differences in phonological abilities and the role of phonological awareness in predicting concurrent and longitudinal reading and spelling ability for girls and boys is of both theoretical and practical importance.

The focus of this investigation is on the development in boys and girls of the cognitive processes associated with reading and spelling, concentrating on the phonological component. Biological differences are considered within the framework of the investigation as they underpin the development of an efficient cognitive system, which enables a child to read, as outlined in Frith's (1999) three-level framework.

Biologically there is growing evidence from fMRI studies (Pugh et al., 1997; Rosell et al., 2002; Shaywitz et al., 1995; Vikingstad et al., 2000), from PET (Positron Emission Tomography) studies (Rumsey et al., 1997), and from lesion studies (Frith & Vargha-Khadem, 2001; Lambe, 1999) that females predominately use both hemispheres of the brain in tasks requiring phonological analysis whereas males predominantly use the left hemisphere. Frith and Vargha-Khadem's (2001) study extended earlier findings in young adults (e.g., Pugh et al.) to children and indicated that lack of access to right hemispheric phonological processing may disrupt the smooth acquisition of literacy skills in boys. It is possible that phonemic awareness (the ability to isolate individual phonemes within words) may be an earlier developing skill in girls than in boys who may not have access to the finer-grained phonological analysis (the ability to use small units of sound) which Pugh et al. suggest occurs in the right hemisphere. This earlier development of phonemic awareness may benefit girls in their reading and spelling acquisition.

Rhyming tasks require the identification of larger units of sounds in words (rhymes) which, according to Pugh et al., occurs in the left hemisphere which is used in phonological processing tasks by both girls and boys. However if boys are slower to develop phonemic awareness it is likely that larger-unit phonological analysis may play a more salient role in their reading and spelling acquisition.

Although the overall means for girls on various measures of reading are often higher than those for boys (e.g., Alexander & Martin, 2000; House of representatives Standing Committee on Education and Training, 2002; Tasmanian Office for Educational Review, 1998; Temple & Cornish, 1993), Alexander and Martin found that the disadvantage for boys in reading was restricted to those boys who were average or below-average readers.

Two main research questions will be addressed. The first research question will focus firstly on girls' and boys' performance on tasks measuring letter knowledge, phonemic awareness and rhyme awareness, and on whether girls do develop earlier phonemic awareness than boys, secondly on whether this contributes to earlier reading and spelling acquisition, and thirdly on the extent of any disadvantage for boys if efficient phonemic awareness is delayed. It is predicted that girls will achieve significantly higher scores than boys on those tasks requiring knowledge and analysis of phonemes (phoneme deletion, letter-name knowledge, and letter-sound knowledge), thus demonstrating earlier development of letter knowledge and phonemic awareness. It is also predicted that there will be no difference between boys and girls on the rhyme awareness tasks. It is hypothesized that earlier development of letter knowledge and phonemic awareness will lead to earlier reading and spelling acquisition.

It is predicted that any disadvantage for boys in word recognition and reading, will be for those boys who are in the lower scoring end of the distribution. Alexander and Martin (2000) reported in their study that, in their sample of over 800 Tasmanian girls and boys aged from six to 16, who were assessed on word recognition tests, that boys were "disproportionately frequent in the lower ranges of these reading tests but not necessarily less frequent in higher ranges" (p.144). As spelling is a more complex task than reading and is critically dependent on phonemic awareness and letter-sound knowledge (Caravolas et al., 2001) it is predicted that boys at the lower end of the distribution will also be disadvantaged in spelling.

The second research question will address the direct role played by phonemic awareness and rhyme awareness in reading and spelling acquisition of boys and girls. Although there is considerable evidence supporting the direct role of phonemic awareness in reading (e.g., Adams, 1990; Muter et al., 1998, Muter & Snowling, 1998; Hulme et al., 2002) and spelling (e.g., Caravolas et al., 2001; Ehri, 1997), the direct role of rhyme awareness in reading and spelling acquisition has not been clearly determined. Whereas large-unit theorists claim that rhyme awareness makes a direct and specific contribution to word reading that is independent of phonemic awareness (e.g., Foy & Mann, 2001, Goswami & Bryant; Hoien et al., 1995), small-unit theorists propose that rhyme awareness does not make a direct contribution (e.g., Duncan et al., 1997; Hulme et al., 2002; Muter et al., 1998). Based on the fMRI and lesion studies reviewed it is possible that the direct role of rhyme awareness may not be uniform across boys and girls. It is expected in the current study that phonemic awareness will be a significant predictor of reading and spelling acquisition for both girls and boys. Based on the fMRI and lesion study findings discussed it is predicted that rhyme awareness may be of greater significance as a concurrent and longitudinal predictor of reading and spelling for boys than for girls.

The longitudinal design of the study consisting of three phases will provide an opportunity to identify patterns of development in phonological abilities, reading, and spelling in boys and girls from the beginning of their formal schooling through to the end of their second year of school. Furthermore it will enable an examination of the predictive roles played by letter knowledge, phonemic awareness and rhyme awareness in the reading and spelling acquisition of boys and girls across this time frame. The children participating in the study will be assessed within the first three months of starting school (Phase 1) and again at the end of both their first (Phase 2) and second (Phase 3) years of formal schooling.

Phase 1 will assess a range of phonological, cognitive, and speech-based skills, and readiness for reading. Phases 2 and 3 will reassess the children's phonemic awareness, rhyme awareness, letter-name and letter-sound knowledge. Rapid Automatised Naming of letters ability (Denckla & Rudel, 1976) will be assessed in Phases 2 and 3, and attention will be assessed in Phase 3. Reading accuracy, irregular word, reading, nonword reading, and spelling ability will be assessed in both Phases 2 and 3. Differences between boys and girls will also be investigated on a mixed-case symbol matching task in Phases 1 and 2, following Majeres' (1999) proposal that symbol matching tasks probably share the same phonological processes that are important in learning to read.

CHAPTER 6

The Empirical Study – Phase 1

Method

Participants

Participants were 153 Preparatory (Prep) children (mean age = 5 years, 10 months) from five different Southern Tasmanian schools (see Table 1). Tasmanian children spend a part-time year in Kindergarten, before full-time attendance in Prep. Information letters and consent forms were sent to parents of all Prep children in the targeted schools. Signed informed consent forms were returned for all 153 participating children. The targeted schools included city schools from both upper and lower socioeconomic suburbs and a rural school. The total sample of children included 81 boys and 72 girls.

Table 1

Demographics and Ages of Participants

School	Total *N*	SES	Boys Mean Age (*SD*)	Boys (*n*)	Girls Mean Age (*SD*)	Girls (*n*)
1	18	Urban (H)	5.63 (.25)	11	5.81 (.29)	7
2	50	Urban (L)	5.77 (.31)	23	5.83 (.26)	27
3	42	Urban (H)	5.98 (.31)	22	5.76 (.33)	20
4	30	Rural	5.76 (.24)	16	5.98 (.26)	14
5	13	Urban (L)	5.91 (.26)	9	5.40 (.19)	4
Total	153		5.81 (.30)	81	5.81 (.30)	72

Note. Values in parentheses indicate standard deviations (H) = High, (L) = Low
Mean ages in decimals

Tests and Materials

In the design of this initial phase of the study a decision was made to assess a broad range of pre-literacy skills.

Each child completed the following tests:

IQ. Following Mann (1991) children were tested on the Block Design and Vocabulary subtests from the Wechsler (1989) Preschool and Primary Scale of Intelligence (WPPSI-R), to provide a short form IQ measure (Sattler, 1992).

Vocabulary development. The Peabody Picture Vocabulary Test (Form 111A) (Dunn & Dunn, 1997) was administered to provide a measure of receptive vocabulary. A measure of expressive vocabulary was provided by the WPPSI Vocabulary subtest.

Phonological processing. Two nonword repetition tasks based on stimuli used by Gathercole and Baddeley (1990) were used (see Appendix 1). Administration followed that of Gallagher, Frith, and Snowling (2000). The children were told that they were going to look at some pictures of Australian animals and that these animals had unusual names, just as some people have unusual names. Children were presented with 20 individual pictures of Australian animals and were asked to repeat the animal's name (a nonword) after the experimenter (immediate repetition), and then to repeat the name after a delay of six seconds (delayed repetition). A score of two was obtained for a correct repetition, a score of one if a single error was made (either reduced or created clusters, or substitutions). If the child repeated the nonword with two or more errors, a score of zero was given. A maximum raw score of 40 was possible for each condition, i.e., for immediate repetition, and for delayed repetition.

Memory. A wordspan task (see Appendix 2) was given in two conditions, words forward and words backward, to assess short-term memory and working memory (Rohl & Pratt, 1995). Children were given two trials each of two, three, four, and five words. The test was discontinued after two failed trials at a particular level. A maximum raw score of 10 was possible for each condition.

Symbol matching test. A computerised symbol-matching test (see Appendix 3) was used to further measure phonological processing based on that used by Majeres (1999). Children completed three conditions, each of 10 trials. Three practice items preceded each test with corrective feedback to ensure that the task was understood. The three conditions were matching symbols, matching uppercase letters, and matching mixed-case letters, presented in two rows, one upper and the other lower case. Two rows in horizontal layout were used, with the second row directly under the first, each consisting of four symbols (selected from $, +, &, #, =, @, %) or letters (selected from F, G, H, J, K, M, N, P, Y presented in either upper or lower case) according to the condition and presented on a PC. Instructions were read to the children by the experimenter. For each trial a computerised score out of 10 and a reaction time for each condition was produced.

Phonological abilities. The following subtests from the Phonological Abilities Test –PAT (Muter, Hulme, & Snowling, 1997) were administered according to administration instructions except for some additional instructions as indicated:

1. *Rhyme detection* This subtest, presented in picture format, required the child to select the word, which rhymed with the stimulus word from an array of three choices. Following criticism of this task used by Muter, Hulme, Snowling, and Taylor (1998) by Bryant (1998), the experimenter introduced the test by explaining the term rhyme and providing examples from Nursery

Rhymes of rhyming words (e.g., *wall* and *fall* from the children's nursery rhyme, "Humpty Dumpty").

2. *Phoneme deletion.* In this test the child was asked to remove either the first or the final phoneme from a single syllable word
3. *Speech rate.* This test required the child to repeat the word "buttercup" 10 times as quickly as possible while the experimenter recorded the time taken. Three trials were given following a practice trial in which the child repeated his/her own name 10 times.
4. *Letter-name and letter-sound knowledge.* The administration instructions of the PAT were altered to test both letter-name, and letter-sound knowledge. The 26 letters were presented in random order.

Word identification. The only reading measure, measuring word identification and the children's readiness for reading was List A from the Ready to Read Word Test (Clay, 1979). One change was made to the original version with the word *mum* substituted for the word *mother.* Children were asked to say any words that they could recognize from the list, presented in 24 point Arial font and lower case letters on a single A4 laminated sheet.

Procedure

All children were tested individually in quiet rooms at their schools, in a series of four sessions, each lasting approximately 20 minutes during an eight-week period between March and May, 2001. The study had ethical approval from the University of Tasmania Human Ethics Committee and permission was granted by the Education Department of Tasmania to approach School Principals to seek the involvement of the teachers and children in the study.

Design and Data Analysis

Between-sex means, standard deviations, effect sizes, variance ratios and boy/girls ratios of standard deviations were calculated for raw scores. Correlation matrices for all participants were conducted to analyse the relationships between all variables. Principal Components Analysis was used to investigate the underlying processes creating the relationships between the pre-literacy measures. Differences between boys and girls on the Factor scores were investigated using histograms, scatterplots, and ANOVA.

ANCOVAs with Age, and WPPSI IQ scores entered as covariates, to control for any differences in age and IQ, were used to investigate sex differences on the phonological awareness measures outlined in the hypotheses. An alpha level of .05 was used for all analyses except for significance testing between correlations where an alpha level of .01 was used. Stepwise Regression Analyses were used to determine the best predictors of phonological awareness measures. One-way ANOVAs and paired samples *t* tests were conducted post hoc to test for significant differences between individual means where appropriate.

Results and Discussion

Raw data were analysed to produce means and standard deviations for all the children's performance measures. These are shown in see Table 2. The IQ estimates were calculated from the Vocabulary and Block Design subtests of the Wechsler Preschool and Primary Scale of Intelligence – Revised (WPPSI-R) (Sattler, 1992).

Following Hyde and Linn (1988) effect sizes are shown by *d,* which is defined as the female mean minus the male mean, divided by the pooled within-sex standard deviation. Positive values of *d* represent superior female performance and negative values represent superior male performance. As can be seen in Table 2, girls performed better than boys on most of the phonological awareness measures, particularly on the more difficult tasks. The largest effect size can be seen for phoneme deletion (final phoneme) (d = .30). Other notable, although smaller, effect sizes can be seen for phoneme deletion (total score) (d =.26), letter-name knowledge (d =.25), letter-sound knowledge (d =.21), nonword repetition in the delayed condition (d =.26), the upper-case symbol matching (d =.26), and the mixed-case symbol matching tasks (d =.22). ANOVAs indicated there were no significant differences between the raw scores for boys and girls on any of the measures, although there was a trend for girls to perform at a higher level than boys for phoneme deletion (final sound), $F(1, 151) = 3.51$, $MSE = 8.17$, $p = .06$.

Following Alexander and Martin (2000) the square root of the variance ratio (as used by Feingold, 1992) provided a male/female ratio of standard deviations. A ratio >1 indicates greater variance in boy's scores, while a variance ratio < 1 indicates greater variance in girl's scores. The combination of greater variability and a higher mean indicates differences between boys and girls in the right tail (high scores) whereas greater variability combined with a lower mean indicates that the difference would be larger in the left tail (low scores) than would be expected solely from d (Feingold). Greater variability can be seen in boy's scores particularly for the Ready to Read test (1.32) with sex differences in both right and left tails, letter-names (1.16) with differences in the left tail, nonword repetition (immediate) (1.12) with small differences in the left tail, and the upper-case symbol matching task (1.11) once again with small differences in the left tail. There was greater variability in girl's symbol-matching scores (.91) and word span backwards scores (.93), but these differences were small.

Table 2

Children's Raw Means (Standard Deviations in Parentheses), Effect sizes and Ratios of Standard Deviations for Boys (n =81) and Girls (n =72)

	Boys	Girls	Total	*d*	*Boy/girl ratio of SDs*
WPPSI BD	24.51 (6.39)	24.22 (5.99)	24.37 (6.19)	-0.05	1.07
WPPSI Voc	25.26 (6.86)	24.50 (6.58)	24.90 (6.72)	-0.06	1.04
Short-form WPPSI IQ	107.8 (14.79)	106.40(14.35)	107.10(14.55)	-0.09	1.03
PPVT	84.78 (16.1)	82.01 (15.83)	83.48 (15.98)	-.17	1.02
Rhyme detection	6.20 (3.40)	6.08 (3.18)	6.13 (3.30)	-0.04	1.07
Phoneme Deletion	5.59 (5.37)	7.01 (5.41)	6.30 (5.41)	0.26	.99
Phoneme Deletion (Begin)	2.48 (3.02)	3.08 (3.20)	2.76 (3.11)	0.19	.94
Phoneme Deletion (End)	3.05 (2.87)	3.92 (2.85)	3.46 (2.88)	0.30	1.01
Speech rate	1.09 (.22)	1.09 (.21)	1.09 (.21)	0.00	1.05
Letter-names	15.46 (8.30)	17.36 (7.13)	16.45 (7.74)	0.25	1.16
Letter-sounds	12.68 (7.76)	14.43 (7.83)	13.57 (7.80)	0.21	.99
NW Repetition (Immediate)	31.20 (6.73)	31.90 (5.96)	31.53 (6.37)	0.11	1.12
NW Repetition (Delay)	21.44 (8.47)	23.65 (8.21)	22.48 (8.39)	0.26	1.03
Word Span (FWD)	4.68 (1.24)	4.88 (1.16)	4.77 (1.21)	0.17	1.06
Word Span (BWD)	2.04 (1.25)	2.26 (1.34)	2.14 (1.29)	0.17	.93
Symbol match	8.24 (1.59)	8.32 (1.73)	8.28 (1.65)	0.05	.91
Upper-case symbol match	8.36 (1.58)	8.75 (1.42)	8.55 (1.51)	0.26	1.11
Mixed-case Symbol Match	6.86 (2.15)	7.32 (2.06)	7.08 (2.11)	0.22	1.04
Ready to Read	2.23 (3.32)	2.33 (2.52)	2.28 (2.96)	0.03	1.32

Note. Pooled within-group standard deviations are shown in the total column for each variable

Positive (+) *d* indicates superior girls' performance, negative (-) *d* indicates superior boys' performance

Boy/Girl ratio of standard deviations shows variability in scores with >1 indicating greater variance in boys' scores and <1 indicating greater variance in girls' scores

Relationships between Children's Performance Variables

To explore the relationships between all Phase 1 measures, correlations were run, on the full sample of children (N=153) and are shown in Table 3. Because of the increased likelihood of Type 1 errors, separate correlations for boys and girls were not conducted.

Most of the pre-literacy measures were well correlated with Ready to Read scores. The pre-literacy variables that related most strongly to the Ready to Read test were letter-sound knowledge (.62), letter-name knowledge (.58), phoneme deletion total score (.59), and phoneme deletion beginning sound (the deletion task that the children founder harder) (.58). There were moderate relationships with the mixed case symbol matching task (.48), rhyme detection (.40), speech rate (.41), and word span backwards (.42). The relationship between cognitive ability (verbal and non verbal) and Ready to Read was significant, but weaker, in the 0.3 range. The difference between the correlations for rhyme detection (.40) and phoneme deletion (.59) with Ready to Read was significant (ps < .05).

Phoneme deletion related significantly to both letter-name and letter-sound knowledge. Letter-name knowledge correlated significantly more strongly with phoneme deletion ability (.60) than with rhyme detection ability (.38). Letter-sound knowledge also correlated more strongly with phoneme deletion (.69) than with rhyme detection (.40) and this difference was significant (p < .001). The difference between phoneme deletion (beginning sound) and letter-sound knowledge (.68) was stronger than that between phoneme deletion (beginning sound) and letter-name knowledge (.57) indicating the increased requirement for awareness of individual sounds in this task. In summary both letter-sound and letter-name knowledge correlated more strongly with phoneme deletion ability than with rhyme detection ability, reflecting the greater need for awareness of individual sounds for success on the phoneme deletion tasks, but not on the rhyme detection task.

Non word repetition (delay) was more strongly correlated with phoneme deletion total score (.57) than was nonword repetition (immediate) (.49) reflecting the greater load placed on phonological processing by the requirement to maintain the nonword in the phonological loop during the delay, and by the manipulation of phonemes in the phoneme deletion task. Both nonword repetition tasks were less well correlated with the rhyme detection task (in the lower end of the .4 range). Both nonword repetition tasks were well correlated with both receptive vocabulary (PPVT) (.51) and expressive vocabulary (WPPSI Vocabulary) (.52), indicating a strong relationship between the ability to hold novel phonetic forms in memory with the growth of vocabulary (Gathercole & Baddeley, 1993). Similar correlations can be seen between the two Nonword repetition tasks and word span forwards (.51, .53). Non word repetition, described by Gallagher et al. (2000) as a phonological processing task appears to be more strongly related to phonemic awareness, as measured by phoneme deletion, than to early phonological awareness, as measured by rhyme detection.

The mixed case symbol matching task was strongly correlated with both letter-names and letter-sounds. It was also significantly well correlated with many of the phonological measures in the .4 range, including phoneme deletion, rhyme detection, and both nonword repetition tasks. It was well correlated with WPPSI Vocabulary (.52). These correlations lend support to Majeres' (1999) suggestion that such tasks do have much in common with the speech-based information stored and rehearsed in the phonological loop.

Table 3

Intercorrelations of all variables for all participants (N =153)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.Rhyme detection	1.0	.36**	.33**	.37**	.33**	.38**	.40**	.29**	.48**	.36**	.44**	.42**	.27**	.33**	.11	.14	.30**	.40**
2.PD (Begin)		1.0	.63**	.91**	.38**	.57**	.68**	.34**	.37**	.32**	.49**	.53**	.34**	.47**	.06	.29**	.39**	.58**
3.PD (End)			1.0	.89**	.32**	.51**	.57**	.38**	.36**	.34**	.41**	.50**	.39**	.38**	.21*	.27**	.41**	.48**
4. PD total				1.0	.39**	.60*	.69**	.39**	.40**	.36**	.49**	.57**	.40**	.48**	.14	.31**	.44**	.59**
5.Speech rate					1.0	.40**	.43*	.37**	.38**	.42**	.40**	.44**	.28**	.38**	.29**	.25**	.24**	.41**
6.Letter-names						1.0	.85**	.42**	.57**	.45**	.52**	.51**	.34**	.57**	.29**	.25**	.58**	.58**
7.Letter-sounds							1.0	.44**	.58**	.46**	.54**	.57**	.35**	.53**	.27**	.27**	.53**	.62**
8.WPPSI BD								1.0	.48**	.51**	.32**	.36**	.29**	.35**	.32**	.32**	.32**	.36**
9.WPPSI Voc									1.0	.70**	.52**	.52**	.35**	.51**	.27**	.19*	.40**	.37**
10.PPVT										1.0	.51**	.51**	.38**	.48**	.36**	.18*	.33**	.33**
11.NW rep I											1.0	.74**	.51**	.48**	.29**	.14	.28**	.34**
12.NW Rep D												1.0	.53**	.44**	.33**	.32**	.32**	.41**
13.Word Span Fwd													1.0	.41**	.27**	.26**	.18*	.24**
14.Word Span Bwd														1.0	.27**	.25**	.40**	.42**
15.Sym Match															1.0	.47**	.21*	.14
16.UC Match																1.0	.29**	.17*
17.MC Match																	1.0	.48**
18.Ready to Read																		1.0

Note. PD = Phoneme Deletion, BD = Block Design, Voc = Vocabulary, NW rep I Nonword repetition Immediate, Nonword repetition Delay, Fwd= forward, BWD = Backwards, Sym Match =Symbol match, UC Match= Upper case symbol match, MC match = mixed case symbol match. ** p<.01 * p<.05

An examination of the Processes Creating the Relationships between Children's Pre-literacy Variables through Factor Analysis

To investigate the underlying processes creating the relationships between the 13 pre-literacy variables, the raw data for all participants for those variables were entered into a Principal Component analysis using SPSS. Using Kaiser's criterion of extracting only factors with an eigenvalue ≥ 1 the analysis yielded two factors which together accounted for 57.44% of the variance. Investigation of the screeplot showed a very clear first factor followed by two smaller factors before leveling out. Furthermore investigation of the eigenvalues showed that a third factor had a value of .94 so an analysis was conducted extracting the three factors which now accounted for 64.69% of the variance. This model also resulted in fewer residuals with absolute values >.05 (25%) compared with the two factor model (52%) as a further indication that the 3 Factor model was a better fit to the data. The Kaiser-Meyer-Olkin measure of sampling adequacy (.907) was very acceptable and reflects the strong positive correlations in the data. Varimax rotation was performed to aid in the interpretation of the factors identified in the three-factor solution, and the rotated factors are shown in Table 4.

Table 4

Raw Score Loadings on Rotated Factors from the Principal Component Analysis with Varimax Rotation

	Factor		
Variable	Graphemic and Phonemic Awareness	Phonological Processing	Cognitive Ability
Rhyme Detection		.36	.41
Phoneme Deletion	.66	.48	
Letter-Names	.81		
Letter-Sounds	.79	.34	
Mixed-Case Symbol Matching	.77		
WPPSI Block Design			.73
WPPSI Vocabulary	.32		.74
PPVT			.81
Nonword Rep Immediate		.76	
Nonword Rep Delay		.76	
Word Span Forward		.78	
Word Span Backwards	.47	.37	.38
Speech Rate		.35	.49
Variance			
% Variance	22.78%	21%	20.91%

Note. Only loadings above .3 are shown

The rotated factors are relatively clear with many of the variables loading on only one factor, although there were some complex variables, which loaded onto more than one factor (rhyme detection, the "buttercup" speech rate test, and word span backwards). Factor 1, accounting for 22.78% of the variance has been interpreted as a graphemic and phonemic awareness factor to reflect both awareness of graphemes (letter-name and letter-sounds) as well as phonemic awareness (the ability to hear the individual sounds in spoken words and delete either the beginning or end sound and say how the new word would sound). This factor is defined by high loadings from, letter-name knowledge, letter-sound knowledge, scores on the mixed-case symbol matching test, and from phoneme deletion. Factor 2, accounting for 21% of the variance, is interpreted as a phonological processing factor, which could also be seen as a verbal working memory factor, with high loadings from the two nonword repetition tasks (Gallagher et al., 2000), and word span forward. Phoneme deletion (defined in the first factor) also loaded onto this factor (.48) but not as strongly as onto the first factor, reflecting the processing load in the phoneme deletion task as children manipulate the constituent sounds to produce the word or nonword resulting from the deletion. Factor 3, accounting for 20.91% of the variance, and interpreted as a cognitive ability factor, is defined by high loadings from PPVT, and WPPSI Vocabulary, and WPPSI Block. Design. As there were only 81 boys and 72 girls it was considered unwise to conduct separate Factor Analyses for boys and girls (Tabachnick & Fidell, 1996).

Rhyme failed to load highly on any of these factors. Yopp (1988) also found that rhyming did not load highly onto either of the two factors revealed in her principal factor analysis and suggested that rhyming may be measuring a different phonological ability than most other phonological awareness tests.

The Effect of Sex on Factor scores

Distributions on the three factor scores were examined through analysis of separate histograms for boys and girls as shown in Figures 1, 2, and 3.

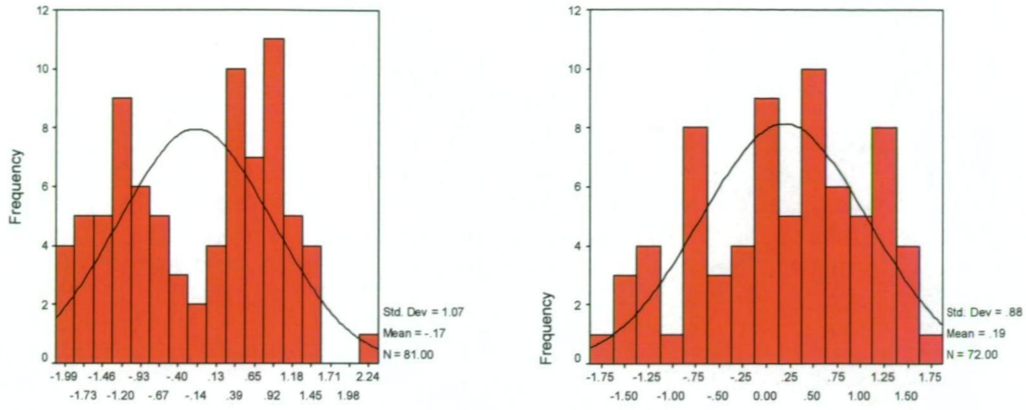

Figure 1. Distribution of graphemic and phonemic awareness factor scores for boys (left) and girls (right).

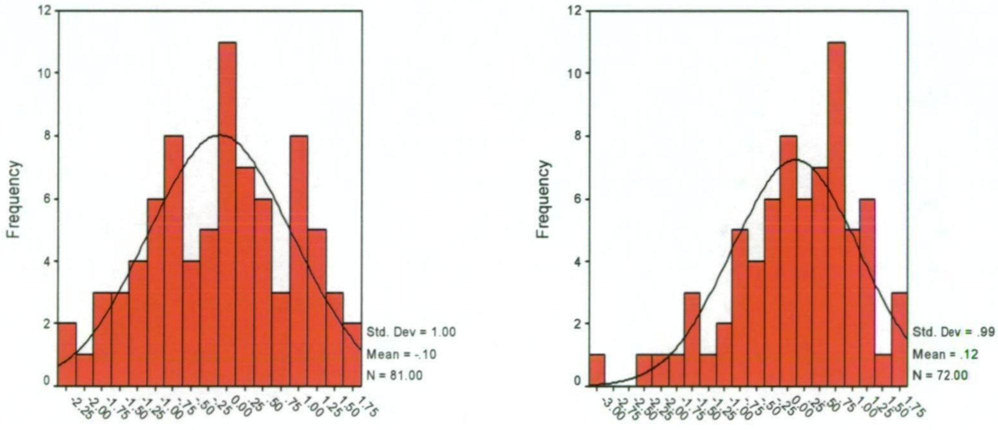

Figure 2. Distribution of phonological processing factor scores for boys (left) and girls (right).

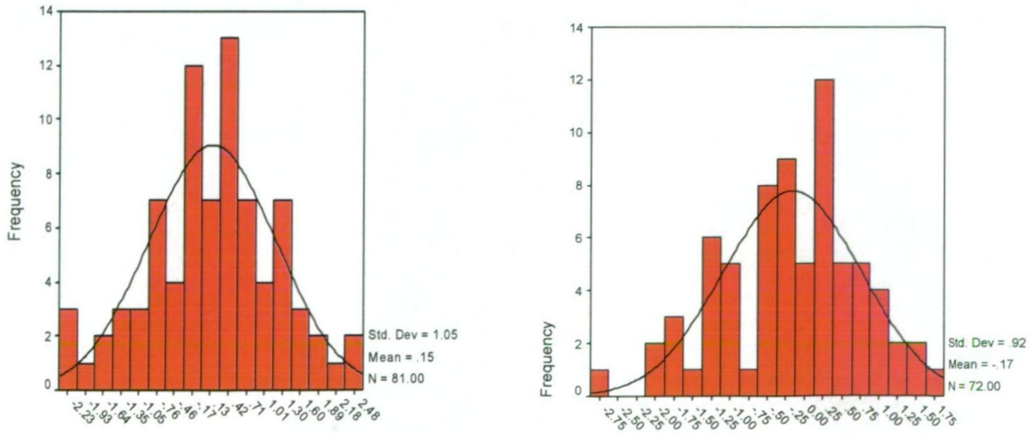

Figure 3. Distribution of cognitive ability factor scores for boys (left) and girls (right).

Descriptive information relating to the three factor scores is displayed in Table 5. The Kolmogorov-Smirnov one-sample test of Normality showed that all separate distributions for boys and girls were consistent with the normal distribution except for the boys' scores on the graphemic and phonemic awareness factor.

Table 5

Means (SDs) and distribution normality for boys and girls on the three factor scores as shown by one-sample Kolmogorov-Smirnov Tests

	Boys		Girls	
Factor	Mean (SD)	Normality *p* value	Mean (SD)	Normality *p* value
Graphemic and Phonemic Awareness	-.167 (1.07)	.004	.188 (.88)	.20
Phonological Processing	-.10 (1.0)	.20	.12 (.99)	.20
Cognitive Ability	.15 (1.01)	.20	-.17 (.92)	.20

Examination of the distributions of scores reveals varying patterns for boys and girls. As can be seen in Figure 1, there was a greater proportion of girls ($M = .19$) (58%) above the within-sex mean ($M = .03$) than below (42%) for graphemic and phonemic awareness while boys ($M = -.17$) were fairly evenly distributed above and below. The Kolmogorov-Smirnov two-sample test was used to assess the normality of the separate distributions for boys and girls. This showed that all distributions of scores were normal with the exception of the boy's scores on the graphemic and phoneme awareness factor which as can be seen in the Histogram displayed in Figure

1 shows a greater number of scores than would be expected in the left tail of the distribution. A comparison of the separate distributions show a bimodal distribution for boys with many fewer boys than girls in the right tail while girls' scores were more heavily weighted at the upper end of the distribution. There appear to be more boys than girls with poorly developed graphemic and phonemic awareness skills.

As shown in Figure 2 for the phonological processing factor there was a greater proportion of girls (*M* = .12) above the within-sex mean (*M* = -.01) (60%) than below (40%) whereas the distribution in boys' scores (*M* = -.10) revealed approximately 54% below and 46% above. This distribution was similar to that on the graphemic and phonemic awareness factor for girls however there were more boys above the mean on the phonological processing factor scores than there were for the phonemic awareness factor.

As shown in Figure 3 for the cognitive ability factor there was a greater proportion of boys (*M* = .15) above (58%) the combined boys and girls' mean (*M* = -.02) and a greater proportion of girls (*M* = -.17) below the mean (approximately 54%). The means for girls on both the phoneme awareness and phonological processing factor predictor scores (*M* = .19, .12 respectively) were higher than those of the boys (*M* = -.17, -.10 respectively), while the boy's cognitive ability mean (*M* = .15) was higher than that for girls (*M* = -.17).

To examine more closely the emerging picture of varying distributions of scores across the three factors, scatterplots were produced. The relationship between graphemic and phonemic awareness and cognitive ability is shown in Figure 4, between phonological processing and cognitive ability in Figure 5, and between graphemic and phonemic awareness and phonological processing in Figure 6.

Figure 4 shows that there are a number of boys with above average cognitive ability who have below average graphemic and phonemic awareness skills at this stage of their reading development. Noticeably fewer girls fall into this category. There are a reasonably equal number of boys and girls who are below average on both and also who are above average on both. There are many more girls than boys who show above average graphemic and phonemic awareness skills with below average cognitive ability.

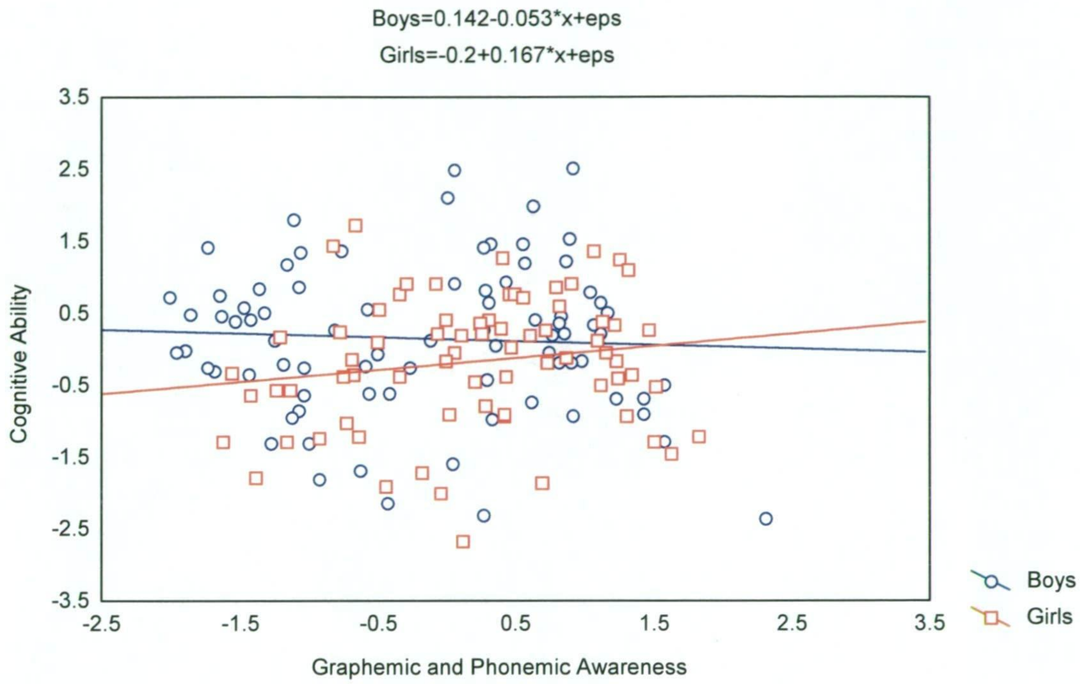

Figure 4. The relationship between graphemic and phonemic awareness and cognitive ability for boys (n = 81) and girls (n =72).

Figure 5 shows a similar picture with a number of boys with above average cognitive ability who display poorly developed phonological processing skills, however there are also a small number of girls who also fall into this category. Figure 6 shows that there are noticeably a greater number of boys than girls with a combination of below average graphemic and phonemic awareness and phonological processing abilities.

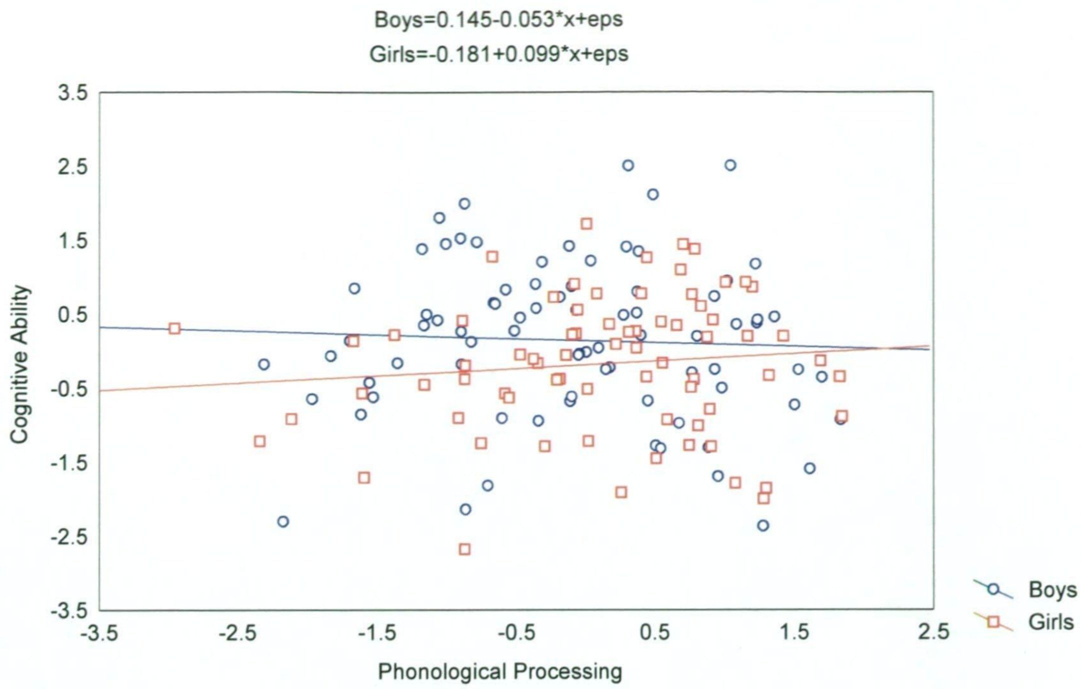

Figure 5. The relationship between phonological processing and cognitive ability and for boys (n =81) and girls (n = 72).

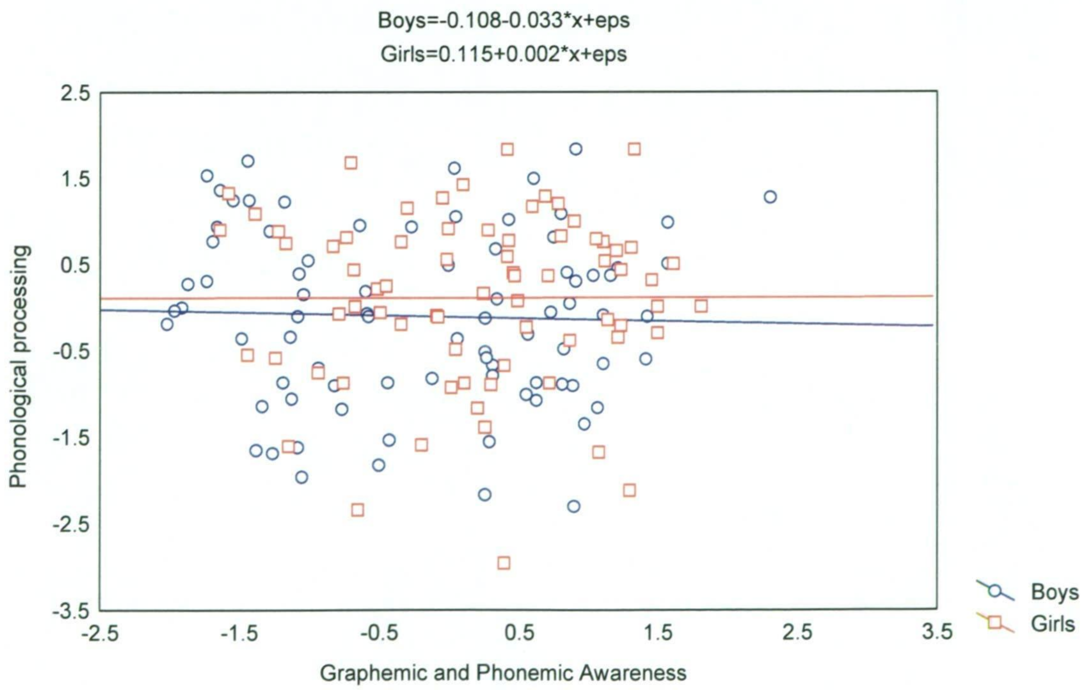

Figure 6. The relationship between graphemic and phonemic awareness and phonological processing for boys (n =81) and girls (n = 72).

There were more boys than girls with poorly developed graphemic and phonemic awareness in spite of their generally higher cognitive abilities in this sample. While there were a number of boys with above average cognitive ability who have below average graphemic and phonemic awareness skills at this stage of their reading development, there were considerably fewer girls in this category. Gallagher et al. (2000) tentatively suggested that the higher IQ characteristics of the at-risk "literacy normal" group in their investigation of the precursors of literacy delay in children at genetic risk of dyslexia, may act as a protective factor against early reading difficulties. Furthermore, Stuart and Coltheart (1988) concluded from their longitudinal investigation of reading acquisition that "a more intelligent child, even if not capable of phonological analysis when confronted with the task of learning to read, will have more strategies available to memorise the printed words to which he or she is exposed than will a less intelligent child" (p. 163).

Huba and Ramisetti-Mikler (1995) suggested that some early readers may acquire their reading facility by relying on strategies other than the alphabetic principle and the present results suggest that this may be particularly so for boys. Therefore, although speculative, perhaps for those boys with higher cognitive ability and poor graphemic and phonemic awareness skills, their higher cognitive ability is acting as a protective factor against reading difficulties at this early stage of their reading development.

The Effect of Sex on Factor Scores

A 2[Sex: boys, girls] x 3 (Factor score: graphemic and phonemic awareness, phonological processing, cognitive ability) repeated measures ANOVA was performed to examine the effect of sex on the children's performance on the factor scores based on the Factor Analysis. There was a significant interaction, as shown in

Figure 7, between Sex and Factor score, F (2,302) = 4.96, MSE = .97, p <.01. The effect size of this interaction was small to moderate (n^2 =0.03).

One-way ANOVAs showed girls' graphemic and phonemic factor scores (M =.19) were significantly higher than boys' graphemic and phonemic awareness factor scores (M = -.17), F (1,151) = 4.91, p<.05 (n^2 =0.03). Boy's cognitive ability factor scores (M = .15) were significantly higher than girl's cognitive ability factor scores (M = -.17), F (1,151) = 3.97, p=.048 (n^2 =0.03). There was no significant difference between phonological processing factor scores for boys and girls, F (1,151) = 1.82, *n.s.*

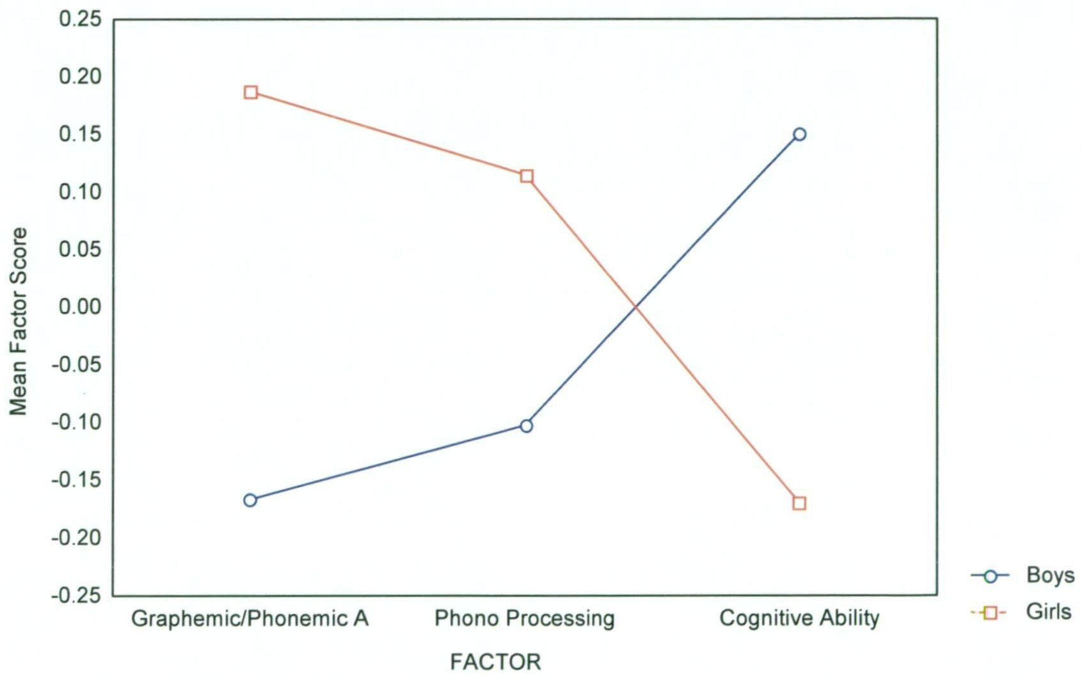

Figure 7. The effect of sex on graphemic and phonemic awareness, phonological processing and cognitive ability factor scores.

Testing the Specific Hypotheses Exploring Differences in Phonological Awareness

To examine the sex differences within those phonological awareness and processing variables of specific interest (phoneme deletion, rhyme detection, letter-name, and letter-sound knowledge), analyses of covariance were conducted controlling for differences in age and IQ. Given the evidence that there are no reliable differences between males and females in overall IQ in the general population (Neisser, 1996) it would be expected that there would be no difference between the IQs of the boys and girls in this study. The cognitive ability factor indicates that the present sample of children is not quite representative of the children in the general population which strengthens the need to control for any differences in IQ before exploring differences in the children's phonological abilities. A WPPSI IQ composite score was computed based on the two WPPSI IQ measures, that is., WPPSI Vocabulary, and WPPSI Block Design. Raw scores were converted to Standardized Deviation scores (z scores) before the conversion to the composite score. The correlation between Factor 3 (cognitive ability) and the WPPSI IQ measure was strong (.85, p <01).

The Effect of Sex on Pre-literacy Measures of Phonological Awareness Controlling for Differences on WPPSI IQ and Age

To test the hypothesis that girls would show higher phoneme deletion ability than boys, due to their awareness of smaller units of sound, but that there would be no difference on rhyme detection because of the focus on larger units of sound, separate Analyses of Covariance were run with sex as the between subjects factor firstly with phoneme deletion total score as the dependent variable, and secondly with rhyme detection as the dependent variable. To control for differences in IQ, which have been noted in the analysis of the effect of boy/girl differences in the factor scores, before comparing differences in phonological skills, WPPSI IQ, and also age, were entered as covariates in each analysis.

There was no significant difference between boys and girls on the rhyme detection task, $F(1,149) = .01$, $MSE = 8.65$, *n.s.,* however girls performance on the phoneme deletion task (adjusted M) = 7.15) was significantly higher than that of boys (adjusted $M = 5.48$), $F(1,149) = 4.67$, $MSE = 22.75$, $p < .05$. The effect size of this difference was small to moderate ($n^2 = 0.03$).

The Effect of Sex on Letter-name and Letter-sound Knowledge

To test the hypothesis that girls would show better knowledge of letter-names and letter-sounds, also due to the need for awareness of small units of sound or individual phonemes, one-way ANCOVAs were run with age, and WPPSI IQ entered as covariates. For letter-names there was a significant effect of Sex, $F(1,149) = 5.39$, $MSE = 40.31$, $p < .05$. The adjusted mean for girls, after taking into account differences on age, and WPPSI IQ ($M = 17.57$) was significantly higher than for boys ($M = 15.12$). The effect size of the difference between means was again small to moderate ($d = 0.35$, $n^2 = 0.04$)

For letter-sounds there was also a significant effect of sex, $F(1,149) = 5.11$, $MSE = 38.87$, $p < .05$. The adjusted mean for girls, after taking into account differences on age, and WPPSI IQ, ($M = 14.75$) was significantly higher than for boys ($M = 12.46$). The effect size of this difference was similar to that for letter-name knowledge ($n^2 = 0.03$).

The effect of sex on Ready to Read scores

There was no effect of sex on Ready to Read scores after controlling for differences in age, and WPPSI IQ, $F(1,149) = .24$, $MSE = 7.35$, *n.s.*.

The effect of sex on mixed-case symbol matching

There was a trend for girls ($M = 7.36$) to be more accurate than boys ($M = 6.88$) on the mixed-case condition of the symbol matching task, $F(1,149) = 2.81$, $MSE = 3.69$, $p < .1$ ($n^2 = 0.02$). While girls achieved greater accuracy on the mixed-case symbol matching task the difference was not significant. Majeres (1999) found that young women were significantly more accurate and faster in mixed-case symbol matching which involves name-mediated matching. At this young age the children found it difficult to complete this task as quickly as possible and this may explain the failure to find a significant difference between boys and girls.

The effect of sex on nonword repetition scores

Separate Analyses of Covariance were conducted with sex as the between subjects factor firstly with nonword repetition in the immediate recall condition and secondly with nonword repetition in the delayed recall condition, as the dependent variables. Age and WPPSI IQ were entered as covariates to control for differences in these variables. There was no significant difference between boys and girls in the immediate recall condition, $F\ (1,149) = 1.24$, $MSE = 31.17$, *n.s.*, however girls scored significantly higher in the delayed condition ($M = 23.88$) than boys ($M = 21.25$), $F\ (1,149) = 5.17$, $MSE = 50.99$, $p < .05$, and the effect size of this difference was small to moderate ($d = 0.34$, $n^2 = 0.03$).

Whereas there were no significant differences on the nonword repetition task in the immediate condition, girls were significantly more accurate on the more difficult nonword repetition task in the delay condition. Perhaps boys in general found it difficult to focus attention on maintaining the nonword in memory for the delay period. Gallagher et al. (2000) describe the nonword repetition task in the immediate condition as a test of implicit phonological processing, however the delayed condition requires explicit attention.

Further Examination of the Sex Differences found in Phoneme Deletion Ability

When differences on letter-sound knowledge were also controlled, along with differences in age, and WPPSI IQ, in the univariate ANOVA with phoneme deletion as the dependent variable and Sex as the between subjects factor, the sex difference was no longer significant, $F\ (1,148) = .623$, $MSE = 14.85$, *n.s*. Similarly when differences in nonword repetition delay were also controlled together with differences in age, and WPPSI IQ in the univariate ANOVA, with phoneme deletion as the dependent variable and sex as the between subjects factor, the sex difference was no longer significant, $F(1,148) = 1.72$, $MSE = 18.95$, *n.s.* This suggests that the sex differences found on phoneme deletion may be accounted for by differences in both letter-sound awareness and nonword repetition delay.

Conclusions

The primary focus of this phase of the research was to investigate differences between boys and girls in phonological abilities in the beginning phase of reading acquisition firstly through an investigation of differences between boys and girls in underlying processes, as determined by factor analysis, and secondly through the testing of hypotheses relating to predicted differences between boys and girls in the development of phonemic awareness.

There are several possibilities which may explain the trend for girls to have better graphemic and phonemic awareness at this preliminary stage in their formal schooling. They may provide behavioural support for Frith and Vargha-Khadem's (2001) conclusion that if language functions are more highly left-lateralised in boys and bilateral in girls, this may inhibit the smooth acquisition of literacy skills in boys.. The results are in the expected direction to also support Pugh et al.'s suggestion that earlier phonological awareness may result in a focus on smaller grain-sized units, at least in the beginning stages of learning to read, in girls. The better letter knowledge displayed by the girls in the study is most likely fostering the development of earlier phonemic awareness in girls. The effect sizes of the differences are small and will need to be larger to provide stronger support for the hypotheses. It is always possible that the observed differences could be the result of greater interest in bookish activities in girls, or because of the home literacy environment which may foster greater interest in literacy based activities in girls than in boys.

The superior performance of girls in both letter-name and letter-sound knowledge, and on the phoneme deletion task suggests that for many boys the acquisition of reading skills may not be as smooth as might be expected, as proposed by Frith and Vargha-Khadem (2001), although the differences are only evident in the development of letter and phonemic awareness skills and were not evident in reading readiness. Given that letter knowledge provides children with a means to decode new words, the reading development of children with poor letter knowledge skills will be delayed (Gallagher et al., 2000).

The finding of significant differences between boys and girls in the phoneme deletion task, but not in the rhyme detection task, and in nonword repetition in the delayed recall condition, but not in the immediate recall condition, is consistent with Jaeger et al.'s, (1998) proposal that sex differences are more likely to be found on more complex phonological tasks.

The issue of differences in development of phonological abilities between boys and girls has important practical importance in helping to explain why many more boys than girls experience reading problems and why boys' performance is generally below girls'. Given the critical importance of phonological abilities in reading acquisition, it is possible that those children, many of whom are boys, who are slow to develop phonemic awareness, may find reading too demanding a task and as a consequence, lose interest, motivation, and confidence in their ability to learn to read.

Based on the "Matthew effect" (Stanovich, 1986) which proposes "a rich-get-richer and poor-get-poorer" (p.360) pattern in reading achievement, it could be anticipated that those children with poorer phonemic awareness, even at this early stage of their reading development, will experience a delay in reading acquisition compared with their peers who have already developed some phonemic awareness and are beginning to read. Given the reciprocal relationship between phonemic awareness and reading and the self-teaching role of phonemic awareness (Share, 1995) those children with better phonological skills are off to a good start and most will find learning to read a rewarding and enjoyable experience, whereas those who are struggling to make the connection between written and spoken language may well continue to struggle.

In conclusion, the preliminary findings from this initial phase of the research of differences between boys and girls in the development of phonological awareness in beginning readers indicate that there are a greater number of boys, compared with their female peers, who have poorly developed letter-name and letter-sound knowledge and below average phonemic awareness ability. Although there were a number of boys with above average cognitive ability who had poorly developed phonological abilities at this early stage of their reading development, there were fewer girls who fell into this category.

CHAPTER 7

The Empirical Study – Phase 2

Method

Participants

Phase 2 data were collected approximately seven months after the completion of Phase 1, that is, at the end of the children's first year of formal schooling. Participants in Phase 2 of the study were 140 of the original sample of children. The 13 children who were not available for retesting in this phase of the study had either left the district or were on an extended absence from school because of illness. Phase 2 included 72 boys and 68 girls. Comparisons between the children who remained in the study and those who dropped out showed no significant difference between the groups indicating that attrition did not result in a biased sample in Phase 2. The demographics and ages of Phase 2 participants are shown in Table 6.

Table 6

Demographics and Ages of Participants in Phase 2

School	Total *N*	SES	Boys Mean Age (*SD*)	Boys (*n*)	Girls Mean age (*SD*)	Girls (*n*)
1	15	Urban (H)	6.18 (.26)	9	6.37 (.29)	6
2	47	Urban (L)	6.36 (.26)	23	6.39 (.26)	24
3	39	Urban (H)	6.41 (.28)	19	6.34 (.32)	20
4	28	Rural	6.31 (.26)	14	6.51 (.28)	14
5	11	Urban (L)	6.43 (.26)	7	5.89 (.18)	4
Total	140		6.39 (.27)	72	6.37 (.30)	68

Note. Values in parentheses indicate standard deviations
(H) = High, (L) = Low

Mean ages in decimals

Tests and Materials

All of the following tests were administered individually to each child, in two fixed order sessions.

Symbol matching test. The computerised symbol-matching test, as outlined in Phase 1, was administered again in Phase 2. The instruction "make a decision as quickly as possible" was stressed to ensure that the children did in fact make a quick decision about the two rows of symbols or letters.

Phonological abilities. The Rhyme Detection, Phoneme Deletion and Letter knowledge (both name and sound) subtests were administered from the Phonological abilities Test – PAT (Muter, et al., 1997) as outlined in Phase 1.

Rapid Automatised Naming (RAN). The Denckla and Rudel (1976) RAN of letters was used to assess speed of processing. This assessment was not administered in Phase 1 as the children's letter knowledge was judged to be insufficiently developed to allow a valid assessment of speed of processing.

Reading ability measures.

Neale Analysis of Reading Ability (3rd Ed.), Form 1 (Neale, 1999). This test requires the children to read short stories of increasing difficulty until a ceiling of errors is reached, and provides standardised percentile scores for reading accuracy (the ability to accurately read aloud words in context), comprehension (the ability to answer questions about the passage just read), and rate (time taken to read each passage).

Word Identification from the Woodcock Reading Mastery Tests – Revised (Woodcock, 1987). This subtest was administered to assess basic word identification skills.

Irregular word reading test (see Appendix 4): This test assessed orthographic processing skills. A raw score of 68 was possible.

The Martin & Pratt Nonword Reading test (Martin & Pratt, 2001): This test assessed decoding skills. A maximum raw score of 54 was possible.

Spelling ability measures. The following tests were administered in a single group session to assess spelling skills:

South Australian Spelling Test (SAST) (DECS, 1997). The first 30 words were administered to class groups of children from the participating schools.

A Nonword spelling test consisting of 10 words from the Martin and Pratt (2001) Nonword Reading Test (see Appendix 5) was given to class groups from participating schools, following administration of the SAST. Children were instructed to watch the experimenter's lips as each nonword was enunciated and to write each funny made-up word from the sounds in the word. Any valid phonological spelling was marked correct, e.g., either *guf* or *juf* was accepted for "juf".

Design and data Analysis

Between-sex means, standard deviations, effect sizes, variance ratios, and boy/girl ratios of standard deviations were calculated for all Phase 2 raw scores. The basic design for Phase 2 was a one-way ANCOVA with sex as the between-subjects factor and the Phase 2 measures as the Dependent measures. The covariates in each analysis were age, and WPPSI IQ z scores from Phase 1. Correlation matrices were used to examine the underlying processes creating the relationships between Phase 2 measures.

Factor analysis, was conducted as outlined in Phase 1 and Factor scores were investigated using histograms, scatterplots and ANOVA. Hierarchical regression analyses were conducted to determine the significant concurrent predictors of reading ability and spelling. An alpha level of .05 was used for all analyses except for significance testing between correlations where an alpha level of .01 was used. One-way ANOVAs and paired samples *t* tests were conducted post hoc to test for significant differences between individual means where appropriate.

Results and Discussion

Raw data were analysed to produce means and standard deviations for all the children's performance measures, as shown in Table 7. ANCOVAs were run with age, and WPPSI IQ, (measured in Phase 1) as the covariates in each analysis, to measure significance levels of any differences between boys and girls. Effect sizes are shown by partial eta squared (as calculated by SPSS) to describe the proportion of total variance in each dependent variable explained by the difference between boys and girls as shown in Table 8.

Table 7

Raw Means and Standard Deviations (SD) for Boys (n =72) and Girls (n = 68) and all Children

	Mean (SD)			
	Boys (SD)	Girls (SD)	Overall (SD)	Boy/girl ratio of SDs
Rhyme Detection	8.35 (2.44)	7.83 (3.13)	8.10 (2.80)	0.78
Phoneme Deletion	9.88 (6.57)	11.06 (6.12)	10.45 (6.36)	1.07
Phoneme Deletion (Begin)	4.94 (3.50)	5.51 (3.25)	5.22 (3.38)	1.07
Phoneme Deletion (End)	4.96 (3.35)	5.54 (3.20)	5.25 (3.28)	1.09
Letter-Names	21.16 (6.75)	22.85 (4.85)	21.97 (5.95)	1.39
Letter-Sounds	21.21 (4.70)	22.27 (5.02)	21.72 (4.87)	0.93
RAN	58.22 (37.21)	46.91 (18.92)	52.77 (30.26)	1.97
Neale Accuracy	15.69 (17.42)	14.88 (10.44)	15.30 (14.41)	1.67
Neale Comprehension	5.39 (5.26)	5.75 (3.90)	5.56 (4.63)	1.35
Neale Rate	20.12 (13.96)	19.43 (9.93)	19.78 (12.13)	1.41
Irregular word reading	10.44 (9.09)	10.15 (6.14)	10.30 (7.77)	1.48
Nonword Reading	11.06 (11.59)	10.23 (8.31)	10.66 (10.10)	1.39
Woodcock Word Identification	23.40 (18.17)	24.84 (13.97)	24.10 (16.22)	1.30
SAST	12.18 (7.82)	14.71 (6.59)	13.41 (7.34)	1.19
Nonword Spelling	3.75 (2.91)	4.28 (2.67)	4.01 (2.80)	1.09
Symbol match	8.35 (1.56)	8.79 (1.19)	8.56 (1.41)	1.31
Upper-case symbol match	8.54 (1.43)	9.00 (1.21)	8.76 (1.34)	1.18
Mixed-case Symbol Match	7.10 (2.08)	7.99 (2.13)	7.53 (2.14)	0.98

Note. Values in parentheses represent standard deviations

Boy/Girl ratio of standard deviations shows variability in scores with >1 indicating greater variance in boys' scores and <1 indicating greater variance in girls' scores

Table 8

Analysis of Covariance with Sex as the between subjects factor for all Children's Phase 2 Raw Scores, with Age and WPPSI IQ as the covariates in each analysis

	df	*F*	*Effect Size* (n^2)	*p*
Rhyme detection	1	.51 (5.81)	.00	.48
Phoneme Deletion	1	3.34 (28.01)	.02	.07
Phoneme Deletion (Begin)	1	2.54 (8.50)	.02	.11
Phoneme Deletion (End)	1	3.12 (7.54)	.02	.078
Letter-names	1	4.77 (28.38)	.03	.034*
Letter-sounds	1	3.03(18.56)	.02	.084
RAN	1	7.32 (.84)	.05	.008**
Neale Accuracy	1	.00 (172.24)	.00	1.0
Neale Comprehension	1	1.05 (15.00)	.01	.31
Neale Rate	1	.012 (132.48)	.00	.91
Irregular word reading	1	.016(49.75)	.00	.90
Nonword Reading	1	.028 (86.24)	.00	.87
Woodcock Word Identification	1	1.01 (203.35)	.01	.32
SAST	1	7.49(40.76)	.05	.007*
Nonword Spelling	1	2.80 (6.15)	.02	.097
Symbol Match	1	4.50(1.84)	.03	.04*
Upper-case symbol match	1	5.06 (1.64)	.04	.03*
Mixed-case Symbol Match	1	9.44 (3.63)	.07	.003*
error	139			

Note. Values in parentheses represent mean square errors
Error df was 138 for Letter-Names and Letter-Sounds

Following Alexander and Martin (2000) the square root of the variance ratio provided a more conservative measure of the variance between boy and girl means. A variance ratio >1 indicates greater variance in boys' scores, while a variance ratio < 1 indicates greater variance in girls' scores. Greater variability can be seen in boys' scores particularly for RAN, Neale accuracy, comprehension and rate, Irregular word reading, Nonword reading and Woodcock Word Identification, letter-names, and the symbol-matching task. Greater variability in girls' scores can be seen only for letter-sound knowledge.

Girls (adjusted $M = 23.00$) knew significantly more letter-names than boys (adjusted $M = 21.01$), $F\ (1,135) = 4.77$, $MSE = 28.38$, $p<.05$, and achieved significantly faster RAN z scores (adjusted $M = .22$) than boys (adjusted $M = -.20$), $F\ (1,136) = 7.32$, $MSE = .84$, $p<.01$. Girls (adjusted $M = 14.93$) achieved significantly higher SAST scores than boys (adjusted $M = 11.97$), $F\ (1,136) = 7.49$, $MSE = 40.76$, $p<.01$. Girls (adjusted $M = 8.82$, 9.02, and 8.04) also achieved significantly higher scores on each of the symbol-matching tasks (symbols, upper case letters, and mixed-case letters) than boys (adjusted $M = 8.32$, 8.53, and 7.05), $F\ (1,136) = 4.50$, $MSE = 1.83$, $p<.05$, $F\ (1,136) = 5.06$, $MSE = 1.64$, $p<.05$, and $F\ (1,136) = 9.44$, $MSE = 3.63$, $p<.01$ respectively.

Many of the children had reached ceiling on both the rhyme detection and phoneme deletion tasks as shown in Figure 8 (z scores were used in these histograms). Just 1.4% of the children failed to score on the rhyme detection task, while 16% failed to score on the phoneme deletion task. The scores on the rhyme detection task were negatively skewed (-1.38) and as can be seen in Figure 8 there is a pile up of perfect scores (54%). The scores on the phoneme deletion task were also negatively skewed (-.68) but not as dramatically as in the rhyme detection task with 39% achieving a perfect score. Results particularly in relation to the children's rhyme awareness should be interpreted in view of the strong ceiling effect.

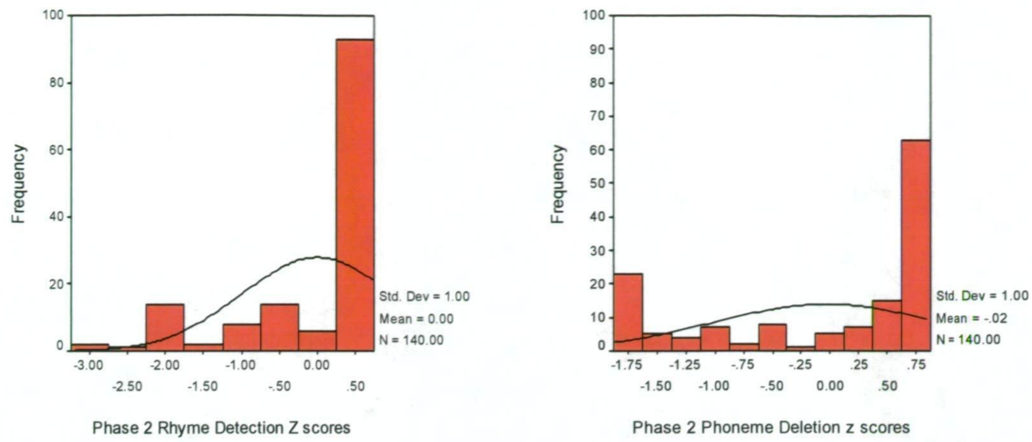

Figure 8. Distribution of children's scores on the rhyme detection (left) and phoneme deletion (right) tasks.

As can be seen in Table 8 there was a moderate effect size (shown by partial eta squared, (n^2)) in differences between boys and girls for mixed-case symbol matching (7% of the variance explained), SAST (5%), rapid automatised naming (5%),with small effect sizes for the other two symbol matching conditions, symbols (3%) and upper-case (4%), for letter-names (3%). Smaller effect sizes can be seen for letter-sounds (2%) and phoneme deletion (2%).

The general trend was for girls to have lower standard deviations with boys having generally lower means and higher standard deviations. Boys are disproportionately frequent in the lower ranges of many of the tests but not uniformly represented in the higher ranges. Looking at those tests where girls achieved significantly higher (or faster) results, for letter-name knowledge there are disproportionately more boys in the lower end of the distribution but not in the top end where boys and girls are equally represented indicating that the male disadvantage is restricted to those boys who are below average. For spelling (SAST) and RAN a different pattern can be seen with disproportionately more boys than girls in the lower end and fewer boys than girls in the top end of the distribution, indicating that the male disadvantage is a general disadvantage which affects the full range of abilities. Table 9 shows the percentages of boys and girls in the bottom and top ends of the distributions on these variables. There was a significantly greater number of boys than girls in the bottom quartile of the RAN distribution ($p < .05$) and a somewhat greater number of boys than girls in the bottom quartile of the SAST distribution ($p = .07$). There were more girls than boys in the top quartiles of both the RAN and SAST distributions, indicating a general male disadvantage. There were no differences in the percentages of boys and girls in the bottom and top ends of the distributions for the Phase 2 reading measures.

Whereas there were no differences between the means for the various reading measures (Neale Accuracy, Comprehension, and Rate, irregular word reading, nonword reading and the Woodcock Word Identification test) girls' standard deviations were consistently much lower than boys' standard deviations on all these measures. As Table 7 shows the boy/girl ratio of standard deviations ranged from 1.3 to 1.7 for these reading measures which is higher than the 1.13 to 1.2 reported by Alexander and Martin (2000). The boy/girl ratio of standard deviations also indicated greater variability in boys' scores for RAN (1.97), letter-names (1.39), and for spelling (SAST) (1.19).

Table 9

Percentage of Boys and Girls in the Upper and Lower Ranges of the Distribution of Scores for Variables in which Girls Achieved Significantly Higher (or faster) Results than Boys

	Letter-name knowledge		RAN		SAST	
	Boys	Girls	Boys	Girls	Boys	Girls
Bottom 25%	11.1%	4.5%	29.2%	15%	29.2%	16.2%
Top 25%	33.6%	32.8%	19.4%	32.8%	19.4%	32.4%

Note. RAN = Rapid Automatised Naming of Letters: SAST = South Australian Spelling Test

Relationships between Children's Performance Variables

To explore the relationships between all Phase 2 measures correlations were conducted on the full sample of children (N=140) as shown in Tables 10. As in Phase 1 separate correlations for boys and girls were not conducted because of the increased likelihood of type 1 errors. All reading measures were very highly related. Neale Accuracy, Comprehension, and Rate were highly correlated (in the .86 range). Both the Woodcock Word Identification Test and the Irregular Word Reading Test related very strongly to Neale accuracy scores (in the .9 range), as did the Martin and Pratt Nonword Reading Test (.86). Neale Accuracy also related strongly to the SAST (.73).

Phoneme deletion related significantly to both letter-name and letter-sound knowledge. Letter-name knowledge correlated significantly more strongly with phoneme deletion ability (.66) than with rhyme detection ability (.28), $p < .001$. Letter-sound knowledge also correlated more strongly with phoneme deletion (.58) than with rhyme detection (.32) and this difference was also significant ($p < .001$). In summary both letter-sound and letter-name knowledge related more strongly to phoneme deletion ability than to rhyme detection ability, reflecting the greater need for awareness of individual sounds for success on the phoneme deletion tasks, but not on the rhyme detection task.

As shown in Table 11 phoneme deletion was strongly correlated with all the reading measures (in the high .5 to .6 range) whereas rhyme detection related significantly but more weakly to the reading measures (in the high .3 to low .4 range) and these differences in correlations (between rhyme detection and phoneme deletion with each reading measure) were all significant (*ps*<.01). Reading was more strongly related to phoneme awareness (as measured by the total phoneme deletion score) than to rhyme awareness (as measured by rhyme detection), *p*<.01 for irregular word reading, Nonword reading, and Woodcock word identification. A similar pattern can be seen in the relationship between the two spelling measures, SAST and nonword spelling, with both relating significantly more strongly to phoneme deletion ability (.74, .67) than to rhyme detection ability (.39, .38 respectively, *ps*< .001).

Rapid automatised naming (RAN) was negatively well correlated (in the .4 to .5 range) with the reading measures. A very strong negative relationship can be seen between RAN and knowledge of letter-names (-.77) indicating that those children with good letter knowledge, and hence greater fluency with letters, were able to process the letters on the RAN more rapidly and hence achieve faster times.

Table 10

Intercorrelations of all Phase 2 Measures for all Children (N =140)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.Neale Accuracy	1.0	.86**	.87**	.94**	.37**	.57**	.58**	.58**	.49**	.46**	.93**	-.48**	.26**	.21**	.39**	.86**	.73**	.64**
2.Neale Comprehension		1.0	.75**	.81**	.37**	.59**	.55**	.57**	.47**	.46**	.81**	-.45**	.26**	.18**	.37**	.72**	.65**	.58**
3.Neale Rate			1.0	.84**	.30**	.49**	.53**	.51**	.49**	.45**	.84**	-.49**	.20*	.19*	.33**	.70**	.65**	.48**
4.Irregular words				1.0	.38**	.59**	.63**	.62**	.53**	.50**	.94**	-.51**	.27**	.24**	.36**	.84**	.75**	.65**
5.Rhyme Detection					1.0	.47**	.44**	.45**	.28**	.32**	.43**	-.31**	.17	.22*	.29**	.39**	.43**	.38**
6.Phoneme Deletion (begin)						1.0	.82**	.92**	.58**	.54**	.69**	-.53**	.31**	.29**	.36**	.64**	.73**	.67**
7.Phoneme Deletion (end)							1.0	.91 **	. 68**	.62**	.71**	-.58**	.30**	.34**	.39**	.63**	.70**	.62**
8.Phoneme Deletion total								1.0	.66**	.58**	.69**	-.58**	.27**	.28**	.36**	.64**	.74**	.67**
9.Letter-Names									1.0	.60**	.63**	-.77**	.20*	.23**	.32**	.50**	.62**	.53**
10.Letter-Sounds										1.0	.60**	-.53**	.20*	.26**	.43**	.52**	.62**	.56**
11.Woodcock Word Identification											1.0	-.58**	.29**	.26**	.42**	.88**	.82**	.71**
12.RAN												1.0	-.25**	-.29**	-.33**	-.47**	-.60**	-.49**
13.Symbol matching													1.0	.52**	.39**	.30**	.28**	.23**
14.Upper-case Symbol matching														1.0	.37**	.24**	.29**	.26**
15.Mixed-case Symbol Matching															1.0	.35**	.36**	.27**
16.Nonword reading																1.0	.79**	.74**
17.SAST																	1.0	.83**
18.Nonword spelling																		1.0

Note. RAN = Rapid Automatised Naming (letters), SAST = South Australian Spelling Test.

,* p<.05, ** p<.01

Table 11

Significance level for Differences between Correlations for all Children (N = 140)

Correlation Pair 1	Correlation Pair 2	Significance Level Of Difference (*P*)
Irregular Words / Rhyme Detection (.38**)	Irregular Words / Phoneme Deletion (.62**)	.008**
Woodcock Word Identification / Rhyme Detection (.43**)	Woodcock Word Identification / Phoneme Deletion (.69**)	.002**
Nonword Reading / Rhyme Detection (.39**)	Nonword Reading / Phoneme Deletion (.64**)	. 005**
SAST / Rhyme Detection (..43**)	SAST / Phoneme Deletion (.74**)	.0001***
Nonword Spelling / Rhyme Detection (.38**)	Nonword Spelling / Phoneme Deletion (..67**)	.0008***
Letter-Names / Rhyme Detection (.28**)	Letter-Names / Phoneme Deletion (.66**)	.0000***
Letter-Sounds / Rhyme Detection (.32**)	Letter-Sounds / Phoneme Deletion (.58**)	.007**

Note. $*p < .05$ $**p < .01$ $***p < .001$

The Processes Underlying the Relationships Between Phase 2 Variables

To investigate the underlying processes that have created the relationships between the Phase 2 variables, the raw data for all reading and processing variables measured in Phase 2 were entered into a Principal Components analysis with varimax rotation. RAN scores were converted to z scores and the positive and negative signs reversed to overcome the problem of smaller scores representing better scores. The analysis included all Phase 2 variables without the symbol matching measures. Inclusion of the three symbol-matching conditions created a separate third factor with loadings only from the symbol-matching variables (this analysis can be seen in Appendix 10). Using Kaiser's criterion of extracting only factors with an eigenvalue ≥ 1 the analysis yielded two factors which together accounted for 74.83% of the variance. The Kaiser-Meyer-Olkin measure of sampling adequacy (.926) was very good for the analysis and reflects the strong positive correlations in the data.

The factors identified in the two-factor solution, shown in Table 12, are clearly defined, although rhyme detection was again a complex variable, as in Phase 1, loading weakly onto both factors. The two spelling measures loaded moderately onto both factors, although more strongly onto the second factor and will therefore be determined as forming part of the second factor. Factor 1, accounting for 42.32% of the variance has been interpreted as a reading ability factor, defined by high loadings (in the .8 to .9 range) from the three Neale measures (Accuracy, Comprehension, and Rate) and the word identification measures (the Woodcock Word Identification Test, and irregular word reading) and also the Martin and Pratt Nonword Reading Test. Factor 2, accounting for 32.50% of the variance, has been interpreted as a graphemic and phonemic awareness factor because of the high loadings from phoneme deletion (.74), letter-name knowledge (.84), letter-sound knowledge (.74), RAN letters (.79) and the two spelling measures (in the .6 range).

Table 12

Raw Score Loadings on Rotated Factors from the Principal Components Analysis with Varimax Rotation

	Component	
Variable	Reading	Graphemic and Phonemic Awareness
Neale Accuracy	.94	
Neale Comprehension	.83	
Neale Rate	.84	
Irregular Word Reading	.89	.36
Nonword Reading	.80	.42
Woodcock Word Identification	.84	.49
Rhyme Detection	.30	.42
Phoneme Deletion	.44	.74
Letter-Names		.84
Letter-Sounds		.74
RAN Letters		.80
SAST	.60	.67
Nonword Spelling	.52	.62
Variance		
% Variance	42.32%	32.50%

Note. Only loadings above .3 are shown

The Effect of Sex on Factor Scores

Distributions on the two factor predictor scores were examined through analysis of Histograms displaying boy/girl distributions, as shown in Figures 9

(Reading Ability) and 10 (Graphemic and Phonemic Awareness). Examination of the distributions of scores for the each of the two factors reveals varying patterns for boys and girls on these two scores.

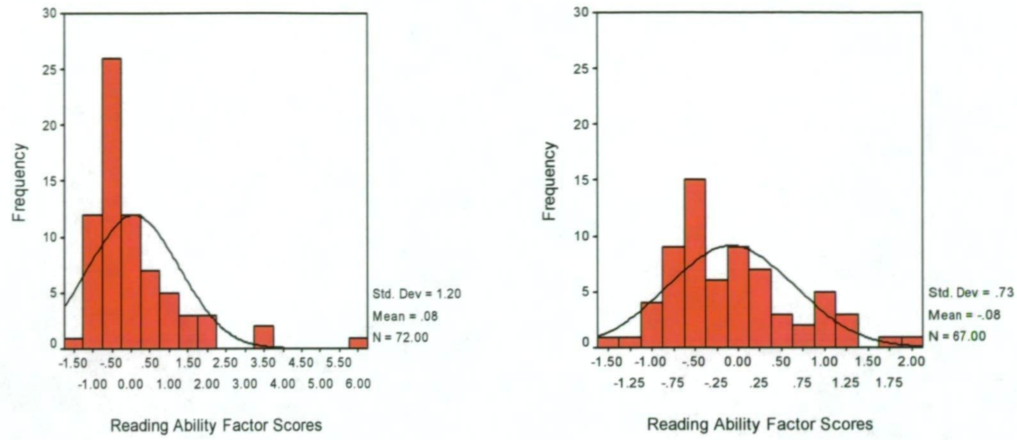

Figure 9. Distribution of reading ability scores for boys (left) and girls (right).

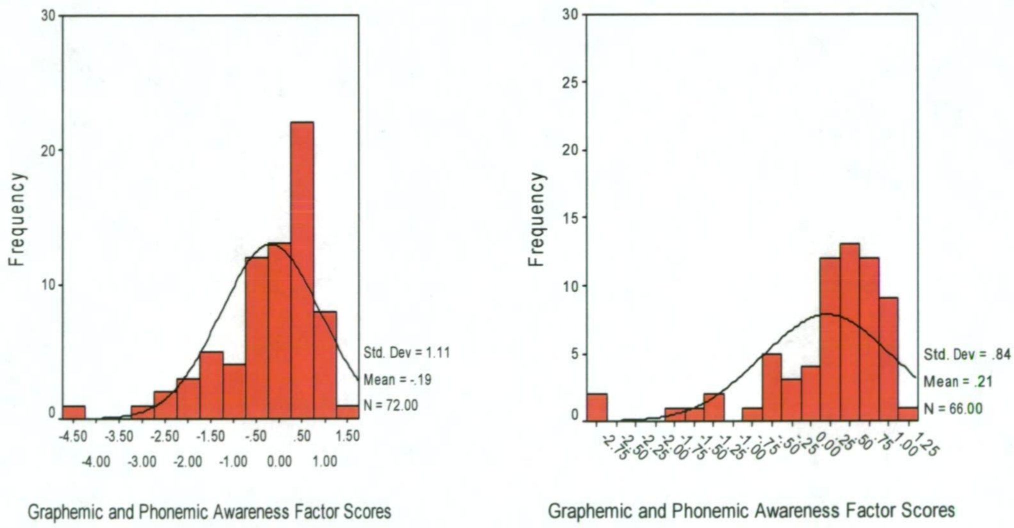

Figure 10. Distribution of graphemic and phonemic awareness scores for boys (left) and girls (right).

The distribution of reading factor scores showed a positive skewness in both boys' and girls' distributions. A greater proportion of both boys (64%) (range = -1.38 to 5.8, M = 0.07) and girls (63%),(range = -1.41 to 2.10, M = -.08). were below the within-sex mean. The Kolmogorov-Smirnov one-sample test was used to assess the normality of the separate distributions for boys and girls. This revealed that both boys' and girls' distributions deviated from normality. However, the Smogorov-Smirnov two-sample test showed that the boys' and girls' distributions did not differ significantly from each other (p>.05). While the positive skewness of the boys' distribution (2.42) indicates a significant deviation from normality with three boys more than 3 standard deviations above the overall mean of 0, all the girls fall within 2 standard deviations of the mean also with a positive skewness (.81) but within the limits of a normal distribution.

For the graphemic and phonemic awareness factor there was a greater proportion of girls (range = -2.84 to 1.24, M = 21) above the within-sex mean of 0 (76%) than below (24%) while just 36% of boys (range = -4.27 to 1.43, M = -.19) were above and 64% below. Both boys' (-1.38) and girls' (-1.88) distributions were negatively skewed. The two-sample Kolmogorov-Smirnov nonparametric test showed that boys' and girls' distributions of scores did differ significantly from each other (p<.05) as they did on the graphemic and phonemic awareness factor in Phase 1. The distribution of girls' scores is clearly weighted towards the upper end.

To examine the relationship between the two factors for boys and girls a scatterplot was produced and this is shown in Figure 11, which shows an interesting picture at both tails of the distribution. Boys clearly dominate the right tail, with three boys who have outstanding reading ability with average graphemic and phonemic awareness. There are noticeably many more boys than girls with below average reading ability and graphemic and phonemic awareness.

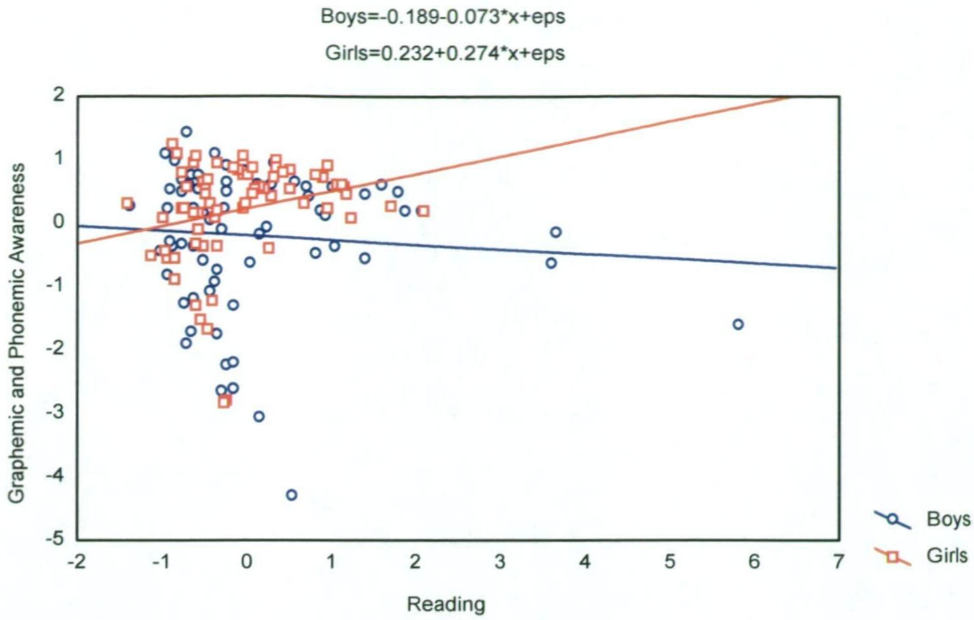

Figure 11. Scatterplot showing the relationship between reading ability and graphemic and phonemic awareness ability for boys and girls.

The Effect of Sex on Factor Scores

A 2[Sex: boys, girls] x 2 (Factor score: reading ability, graphemic and phonemic awareness) ANOVA was used to analyse the effect of sex on the children's performance on the factor scores. There was no significant main effect of sex, F (1,137) = 1.03, MSE = .1.03, n.s., or of factor score, F (1,137) =.01, MSE = .97, n.s.

The interaction between sex and factor score, shown in Figure 12, was significant F (1,137) = 5.69, MSE = .97, p <.05. Separate paired samples t tests for boys and girls revealed that there was no difference between factor scores for boys, t(71) =1.36, *n.s.,* whereas girls' scores were significantly higher for graphemic and phonemic awareness (.21) than for reading ability (-.19), t (66) = -2.48, p<.05. One-way Sex ANOVAs on the factor scores showed that girls' graphemic and phonemic awareness factor scores (M =.21) were significantly higher than boys' graphemic and phonemic awareness factor scores (M =-.19), F (1, 137) = 5.85, MSE = .97, p<.05.

There was no significant difference between girls' and boys' reading factor scores, F (1, 137) = .88, MSE = .97, *n.s.*

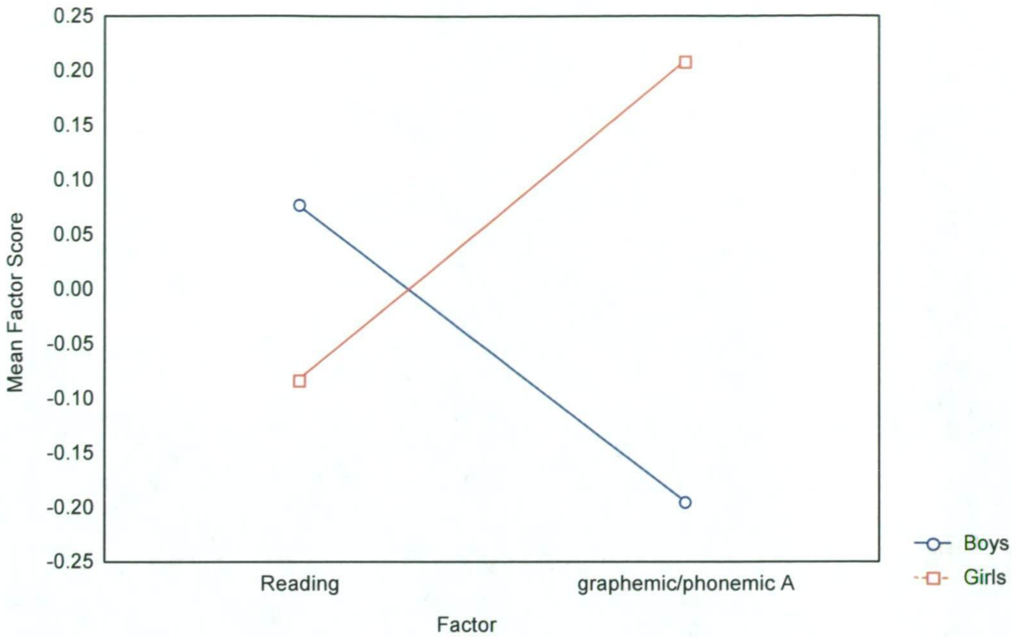

Figure 12. The effect of sex on reading ability, and graphemic and phonemic awareness factor scores.

The Effect of Sex on Reading and Spelling

A 2[Sex: boy, girl] x 2 (Ability: reading, spelling) ANCOVA was conducted to analyse the effect of sex on the children's performance on reading and spelling. Differences in age and WPPSI IQ were controlled by entering these as covariates in the analysis. Z scores were used for Neale Accuracy and SAST scores. There was no significant effect of sex, F (1,136) = 2.14, MSE = 2.84, n.s., or of ability score, F (1,136) =.01, MSE = .16, *n.s.*

The interaction between sex and ability score, shown in Figure 13, was significant F (1,137) = 10.856, MSE = 2.81, p <.01, (n^2=.07). An inspection of Figures 12 and 13 shows a very similar interaction between the sex x factor score illustrated in Figure 11 and the sex x reading ability interaction illustrated in Figure

13, with girls achieving significantly better scores than boys on both the graphemic and phonemic awareness factor scores and on the SAST measure of spelling with no significant difference on the reading factor and Neale accuracy scores. Separate paired samples *t* tests for boys and girls revealed that boys' reading accuracy scores (.03) trended towards being significantly higher than their spelling score (-.17), t (71) =1.91, p =.06, whereas girls' scores spelling scores (.18) were significantly higher than their reading ability scores (-.02, t (67) = -3.23, p<.05. One-way Sex ANOVAs for each ability showed that girls' spelling scores (M =.18) were significantly higher than boys' spelling scores (M =-.17), F (1, 138) = 4.13, MSE = .98, p<.05. There was no significant difference between girls' and boys' reading accuracy scores, F (1, 138) = .11, MSE = 1.01, *n.s.*

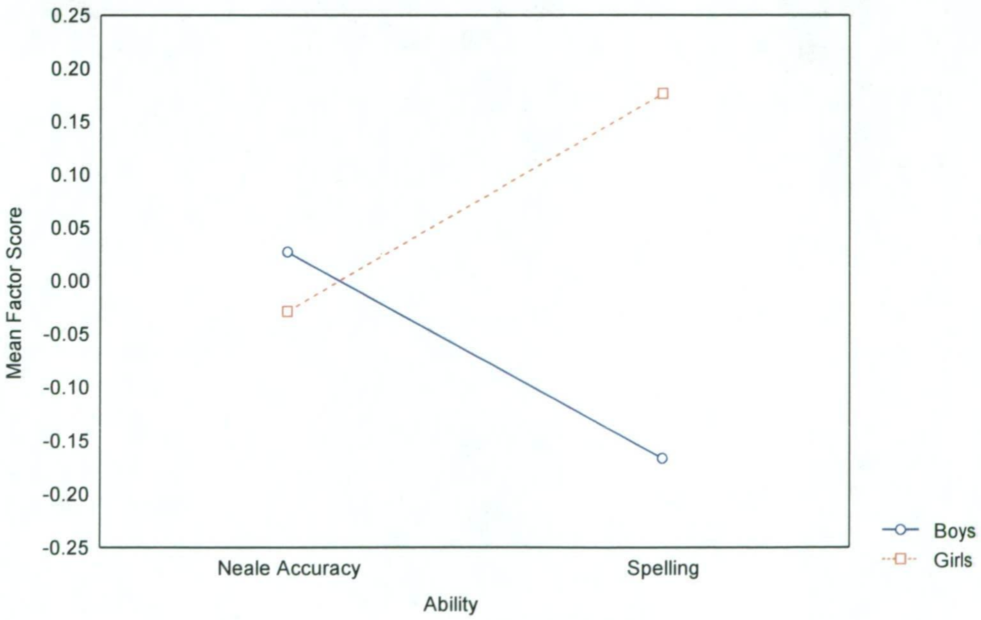

Figure 13. The effect of sex on reading and spelling ability.

The Effect of Sex on Phonological Awareness

Because of the strong ceiling effect (shown in Figure 8) in the rhyme detection and to a lesser extent on the phoneme deletion task it was considered unwise to conduct an analysis of the effect of sex on phonological awareness however these two scores will be used as predictors in the following regression analyses.

The relationship between reading and spelling ability at the end of the first year of school with concurrent phonological awareness predictors (rhyme detection and graphemic and phonemic awareness)

The relationship between the Phase 2 phonological awareness variables which defined the graphemic and phonemic awareness factor, rhyme detection, and reading (reading accuracy, nonword reading, and irregular word reading), and spelling ability in Phase 2 were investigated firstly through correlations and secondly in a series of hierarchical multiple regression analyses, firstly for all participants ($N = 139$), and then separately for boys ($n = 72$) and girls ($n = 67$). One girl was not tested on letter-name or letter-sound knowledge and so is not included in these analyses. Rhyme detection, which failed to load onto the graphemic and phonemic awareness factor, but which is an integral part of this research was included in the predictor set to determine its relationship with reading and spelling.

Ready to Read scores (the only reading measure used in Phase 1) were also included in the Regression analyses to control for the autoregressive effects of earlier reading ability. Bowey (2002) proposed that it is essential to control for the autoregressive effects of earlier reading skill in hierarchical multiple regression analyses and criticises the longitudinal studies of Bryant et al. (1990) and Muter et al. (1998) for failing to do so. Similarly Wagner et al. (1994) proposed that failure to include the autoregressive effect of a variable measured at an earlier time on the same variable at a later time is a frequently omitted possible cause when looking at causal factors. "The best predictor of future behaviour is often past behaviour" (p.74).

Similarly Tunmer (1991) proposed that the process of learning to read itself may produce skills that greatly facilitate children's performance on phonological awareness tasks and children who possess some preschool reading ability may perform better on tests of phonological awareness.

The correlations between the predictor set to be used in the regression analyses and Phase 2 Reading accuracy, nonword reading, irregular word reading, and spelling are shown in for all participants in Table 13 and for boys and girls separately in Table 14. Table 13 shows that of the phonological awareness variables the predictor with the strongest relationship with reading and spelling was phoneme deletion, with correlations of .74 with Neale Accuracy, .66 with nonword reading, .73 with irregular word reading, and .75 with spelling (SAST). Rhyme detection also correlated moderately with reading and spelling (in the .3 to .4 range). The difference between these two correlations (i.e., between phoneme deletion and rhyme detection) with all the reading measures and spelling was significant ($p<.01$). Phase 1 Ready to Read scores correlated strongly with the Phase 2 irregular word reading and Neale Accuracy (.71), and nonword reading (.61) and moderately with spelling (.53) suggesting that the Ready to Read Test given very early in a child's schooling provides a very good indication of reading ability by the end of the child's first year of formal schooling, at least for this sample of children.

Table 13

Correlations of Phase 1-2 Predictor Measures with Phase 2 Reading and Spelling Outcome Measures for all Children

	§ Neale Accuracy	Nonword Reading	§ Irregular Word Reading	Spelling (SAST)
Phase 1	*N*=153	*N*=153	*N*=153	*N*=153
WPPSI IQ	.50**	.41**	.50**	.47**
Ready to Read	.71**	.61**	.71**	.53**
Phase 2	*N*=140	*N*=140	*N*=140	*N*=140
Rhyming	.43**	.39**	.40**	.43**
Phoneme Deletion	.74**	.66**	.73**	.75**
Letter-names	.68**	.51**	.69**	.62**
Letter-sounds	.62**	.52**	.65**	.62**
RAN	.65**	.47**	.66**	.60**

Note. §= transformed scores

** $p < .01$.

Table 14

Correlations of Phase 1-2 Predictor Measures with Phase 2 Reading and Spelling Outcome Measures for Boys and Girls

	§Neale Accuracy		Nonword Reading		§Irregular Word Reading		Spelling (SAST)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Phase 1	*n*=81	*n*=72	*n*=81	*n*=72	*n*=81	*n*=72	*n*=81	*n*=72
WPPSI IQ	.48**	.56**	.44**	.39**	.46**	.56**	.45**	.54**
Ready to Read	.75**	.63**	.71**	.42**	.75**	.63**	.49**	.60**
Phase 2	*n*=72	*n*=68	*n*=72	*n*=68	*n*=72	*n*=68	*n*=72	*n*=68
Rhyming	.45**	.47**	.40**	.42**	.37**	.47**	.48**	.46**
Phoneme deletion	.73**	.77**	.68**	.67**	.73**	.75**	.73**	.78**
Letter-names	70**	.63**	.54**	.45**	.72**	.62**	.65**	.55**
Letter-sounds	60**	.68**	.57**	.50**	.61**	.73**	.59**	.65**
RAN	61**	.79**	.46**	.57**	.62**	.80**	.57**	.67**

Note. § transformed scores

** $p < .01$

In order to determine the relative strength of the Phase 2 rhyme detection and the graphemic and phonemic awareness measures as predictors of concurrent reading and spelling ability, a series of hierarchical multiple regressions were conducted with Neale Accuracy, nonword reading, irregular word reading, and SAST spelling scores as dependent variables. The graphemic and phonemic variables used were those which loaded on to the graphemic and phonemic awareness factor in Phase 2 (phoneme deletion, letter-name knowledge, letter-sound knowledge, and RAN). Rhyme detection which did not load onto either factor in the Principal Components

Analysis, shown in Table 12, but which is an integral part of this research was also used in all this analysis, although the presence of a strong ceiling effect in the Phase 2 rhyme detection is expected to compromise its impact. That rhyming failed to load onto the graphemic and phonemic awareness factor in this phase, or onto any factor in Phase 1, strongly suggests that the rhyming tasks were measuring a different phonological ability to the phonemic awareness tasks such as phoneme deletion.

The raw scores for all the variables to be used in these regression analyses were converted into Z scores, based on the full sample of children, to ensure comparability of measurement scales across all the variables. Scores were checked for outliers. There were a number of outliers on the Ready to Read Test (Phase 1) who were all the children who were able to score above 4 out of the possible 15 (n = 22) on this reading readiness test. As the outliers were due to the nature of the test and similar outliers would be expected if a comparable group of beginning readers was tested it was decided to leave them in the analysis as at the beginning of any first year at school it would be expected that there would be a few children operating at this level.

To meet the distributional assumption of normality between predicted DV scores and error of prediction (Tabachnick & Fidell, 1996) histograms and descriptive statistics for the four reading and spelling measures to be used as dependent variables in the hierarchical regression analyses as well as the residuals scatterplots produced by SPPS as part of the regression analysis output were examined The distributions of the Phase 2 Neale Accuracy and irregular word reading scores showed a positive skew. The skew of 2.12 for the Phase 2 Neale Accuracy scores and 1.59 for irregular word reading scores were considered large enough to warrant transformation. The distribution of scores for both nonword reading and the South Australian Spelling Test scores met the criteria for normality.

A square root transformation of the Phase 2 Neale Accuracy scores was carried out according to the procedure outlined in Tabachnick and Fidell (1996). Inspection of the histogram based on the transformed scores indicated a normal distribution with a skew of 0.19. Inspection of the normal probability plots of residuals for the regression equations using the raw and transformed scores showed that the linear relationship was improved using the transformed Neale Accuracy scores with the points lying in an almost straight diagonal line suggesting no deviations from normality. Inspection of the scatterplot of standardised residuals also showed an improvement using the transformed scores with one outlier at 3.1 SDs. As this score exceeded the 3SD marker by just 0.1 a decision was made to leave it in the analysis. Based on this examination the transformed Neale reading accuracy scores were used as the DV to analyse the concurrent predictors of reading accuracy at the end of the first year of school (Phase 2).

A square root transformation was also conducted on the irregular word reading scores, which also produced a normal distribution of -.09. The linear relationship was improved and inspection of the scatterplot of standardised residuals showed that there were no outliers in excess of 3 SDs.

According to Tabachnick & Fidell (1996) "there are no distributional assumptions about the IVs, other than their relationship with the DV". Tabachnick & Fidell point out that a prediction equation may be enhanced if IVs are normally distributed, and while the predictive effect of those IVs which trended toward ceiling may have been enhanced if they had been normally distributed the distributions on these variables reflect an ordinary sample of children of that age many of whom would be expected to have an excellent grasp of the concept of rhyme detection and to know all their letter names and letter sounds. Of the IVs to be used in the regression analyses Phase 2 rhyme, letter-names, letter-sounds and RAN showed departures from normality. Logarithmic transformation of these variables improved their distributions but did not substantially change their correlations with the reading and spelling measures to be used as dependent variables in the regressions analyses. Consequently all the regression analyses were conducted using raw scores, converted to z scores, for all the independent variables.

The important examination under review was the relative contributions of rhyming and graphemic and phonemic awareness abilities to reading and spelling for boys and girls at the end of their first year at school, so these two variables were entered as the final two steps in each analysis. Chronological age was always entered at step 1, and WPPSI IQ (measured in Phase 1) at step 2, to control for any differences in age and IQ, before entering the remainder of the variables. Phase 1 Ready to Read was always entered at step 3 to control for the autoregressive effects of earlier reading ability (Bowey, 2002; Wagner et al., 1994). Of the phonological awareness variables, rhyme detection, as representative of early phonological awareness ability was always entered at step 4. The graphemic and phonemic awareness variables (determined by the Factor Analyses) were always entered as a block at the final step.

Concurrent Predictors of Reading Accuracy

The first series of hierarchical regression analyses shown in Table 15, assessed the predictive relationship between Phase 2 age, WPPSI IQ, (measured in Phase 1), Phase 1 Ready to Read scores, Phase 2 rhyme detection, and the Phase 2 graphemic and phonemic awareness variables (phoneme deletion, letter-name and letter-sound knowledge, and RAN) with Phase 2 Neale Accuracy (transformed scores).

For the combined sample of boys and girls all the variables entered made significant additional contributions at the stage at which they are entered, except for age which was a preliminary control. The model accounted for 80.5% of the total variance in Neale accuracy scores. In the final equation Phase 1 Ready to Read scores were the most powerful predictor of Phase 2 Neale accuracy ($\beta = .45, p < .001$). Of the block of graphemic and phonemic awareness variables, entered at the final step, both phoneme deletion ($\beta = .25, p < .001$) and RAN of letters ($\beta = .22, p < .001$) made significant incremental improvement in prediction additional to Phase 1 Ready to Read.

Regression analyses run separately for boys, shown in Table 15, revealed that WPPSI IQ, Ready to Read, rhyme detection, and the graphemic and phoneme deletion variables all made significant contributions at the stage that they were entered, with the model accounting for 82.5% of the total variance in Phase 2 reading accuracy. The analysis for girls, shown in Table 15, also showed that WPPSI IQ, Ready to Read, rhyme detection and the phonemic awareness variables all added significant variance on entry, with the model accounting for 83.2% of the total variance.

Table 15

Summary of Hierarchical Regression Analyses for Concurrent Rhyme detection and the Graphemic and phonemic awareness Variables Predicting Reading Accuracy Ability at the end of the First Year of Formal Schooling

	All Children (N = 139)			Boys (n = 72)			Girls (n = 67)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.003			.000			.013
Age	.34(.55)	.05		.00(.93)	.00		.56(.61)	.12	
Step 2			.251***			.236***			.298***
Age	-.12(.48)	-.02		-.40(.83)	-.05		.07(.52)	.01	
WPPSI IQ[a]	1.10 (.16)	.51***		1.12(.26)	.49***		1.01(.20)	.56***	
Step 3			.308***			.394***			.157***
Age	.20 (.37)	.03		.38(.59)	.05		.12(.46)	.03	
WPPSI IQ[a]	.57(.14)	.26***		.68(.19)	.28**		.55(.20)	.30	
P 1 R to Read	.38(.04)	.61***		.43(.05)	.67***		.28(.06)	.47***	
Step 4			.032**			.037**			.044*
Age	.44(.37)	.07		.62(.57)	.08		.40(.46)	.08	
WPPSI IQ[a]	.35(.15)	.16*		.47(.20)	.19*		.27(.23)	.15	
P 1 R to Read	.37(.04)	.59***		.41(.05)	.64***		.28(.06)	.47***	
Rhyme Det	.39(.12)	.21**		.52(.19)	.22**		.35(.15)	.26*	
Step 5			.212***			.158***			.320***
Age	.10(.26)	.02		.25(.43)	.03		-.09(.29)	-.02	
WPPSI IQ[a]	-.10(.11)	-.05		-.07(.17)	-.03		-.13(.15)	-.07	
P 1 R to Read	.28(.03)	.45***		.32(.04)	.50***		.19(.04)	.32***	
Rhyme Det	.15(.08)	.08		.20(.15)	.08		.15(.10)	.11	
Phoneme D.	.46(.11)	.25***		.41(.17)	.20*		.43(.14)	.28**	
Letter-names	.11(.13)	.06		.22(.20)	.12		-.06(.15)	.03	
Letter-sounds	.32(.10)	.17		.38(.15)	.17*		.18(.12)	.13	
RAN	.40(.11)	.22***		.27(.15)	.16		1.04(.21)	.44***	
Total variance explained			80.5%			82.5%			83.2%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Det = Rhyme Detection, Phoneme D = Phoneme Deletion. [a]measured in Phase 1. Dependent variable is Phase 2 Neale Accuracy (transformed scores) *p<.05, **p<.01, ***p<.001.

In the final equations Phase 1 Ready to Read scores were the most powerful predictor for boys (β =.50, $p < .001$) but not girls (β =.32, $p < .001$) for whom RAN of letters was the most powerful predictor of their reading accuracy scores (β =.44, $p < .001$). The amount of variance accounted for by the Phase 1 Ready to Read scores and by phonemic awareness differed significantly between boys and girls. For boys, Phase 1 Ready to Read scores at step 3 accounted for a large 39.4% of the total variance in Phase 2 Neale Accuracy scores while for girls Phase 1 Ready to Read scores at step 3 accounted for 15.7% of the total variance in Phase 2 Neale Accuracy scores and the difference between these two percentages was significant, ($p < .001$). For both boys (β =.22, $p < .01$) and girls (β =.26, $p < .05$). Phase 2 rhyme detection made a significant incremental improvement in prediction additional to Phase 1 Ready to Read at step 4, but the effect was reduced below the significance level following the inclusion of the graphemic and phonemic awareness variables at step 5.

For boys the graphemic and phonemic awareness variables, of which both phoneme deletion (β =.20, $p < .05$) and letter-sounds (β =.17, $p < .05$) made a significant incremental improvement in prediction additional to Ready to Read, accounted for an additional 15.8% of the total variance in reading accuracy scores For girls the graphemic and phonemic awareness variables, of which both phoneme deletion (β =.28, $p < .01$) and RAN of letters (β =.44, $p < .001$) made a significant incremental improvement in prediction additional to Ready to Read accounted for an additional 32% of the total variance in girls Phase 2 reading accuracy scores. The difference between these two percentages was also significant ($p < .05$).

Considerable evidence exists in the literature that phonemic awareness develops as a consequence of exposure to letter knowledge and alphabetic print.

Alegria and Morais (1991) argued that instruction in learning to read an alphabetic writing system is typically a prerequisite for the ability to represent explicitly spoken words as sequences of phonemes as young children are unable to spontaneously isolate the segmental units of speech. Wagner and Torgesen (1987) proposed that phonological awareness develops at about the age children are taught to read and children show a dramatic change in their competency for tasks that require isolating and manipulating phonemes once reading instruction begins (Wagner et al., 1993). It could be concluded on this basis that girls have benefited from reading instruction during their first year of formal schooling to a greater extent than boys and hence are able to draw on their developing phonemic awareness to a greater extent than boys at this stage of their literacy development.

The Relationship between Irregular Word Reading and Nonword Reading in the First Two Years of School with Concurrent Phonological Awareness Predictors – Early Phonological Awareness, and Graphemic andPhonemic Awareness

Regression analyses were run for the full sample of children and for boys and girls separately to investigate the role of different concurrent phonological abilities as predictors of irregular word and nonword reading at the end of the first year of schooling. Transformed scores were used for irregular word reading, and the raw nonword reading scores were converted into z scores for these analyses. As with the series of analyses for reading accuracy, age was entered at step 1, and WPPSI IQ (measured in Phase 1) was entered at step 2, as preliminary controls. Phase 1 Ready to Read was entered at step 3 to control for the autoregressive effects of previous reading ability. The Phase 2 phonological variables were entered last, rhyme detection at step 4, and the block of graphemic and phonemic awareness variables at step 5.

Table 16

Summary of Hierarchical Regression Analysis for Concurrent Rhyme Detection and the Graphemic and Phonemic Awareness Variables Predicting Irregular Word Reading Ability at the end of the First Year of Formal Schooling

	All Children (N = 140)			Boys (n = 72)			Girls (n = 68)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.003			.000			.018
Age	.25(.38)	.06		-.04(.64)	-.01		.47(.43)	.13	
Step 2			.242***			.219***			.295***
Age	.-.07(.34)	-.02		-.33(.57)	-.06		.12(.37)	.03	
WPPSI IQ[a]	.75(.11)	.50***		.79(.18)	.47***		.72(.14)	.55***	
Step 3			.310***			.404***			.149***
Age	15(.26)	.03		.21(.41)	.04		.15(.33)	.04	
WPPSI IQ[a]	.38(.10)	.25***		.43(.13)	.26*		.40(.15)	.30**	
P 1 R to R	.26(.03)	.61***		.30(.04)	.68***		.19(.05)	.46***	
Step 4			.021*			.013			.046*
Age	.29(.26)	.07		.31(.41)	.06		.36(.33)	.10	
WPPSI IQ[a]	.26(.11)	.17		.35(.14)	.21		.19(.16)	.15	
P 1 R to Read	.26(.03)	.60***		.29(.04)	.66***		.19(.05)	.46***	
Rhyme Det	.22(.08)	.17*		.21(.14)	.13		.26.(11)	.27*	
Step 5			.240***			.206***			.340***
Age	.03(.18)	.01		.04(.28)	.01		-.02(.20)	-.01	
WPPSI IQ[a]	-.08(.08)	-.05		-.08(.11)	-.05		-.11(.10)	-.09	
P 1 R to Read	.19(.02)	.45***		.22(.03)	.50***-		.13(.03)	.32***	
Rhyme Det	.04(.06)	.03		-.04(.10)	-.03		.11(.07)	.12	
Phoneme D	.29(.07)	.23***		.28(.11)	.20*		.23(.10)	.20*	
Letter –names	.07(.08)	.06		.23(.13)	.18		-.11(.10)	-.08	
Letter-sounds	.30(.07)	.23***		.29(.10)	.20**		.25(.08)	.24**	
RAN	.29(.08)	.23***		.18(.10)	.16		.77(.14)	.45***	
Total variance explained			81.6%			82.2%			84.9%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Det = Rhyme Detection, Phoneme D = Phoneme Deletion. [a]measured in Phase 1. The dependent variable is Phase 2 irregular word reading (transformed scores). *p<.05, **p<.01, ***p<.001.

Concurrent Predictors of Irregular Word Reading at the end of the First Year of School

The analysis for all children, shown in Table 16, showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 81.6% of the total variance in irregular word reading at the end of the first year of school.

For the full sample of children Phase 1 Ready to Read (β =.61, $p < .001$) was the most powerful of Phase 2 irregular word reading, accounting for 31% of the total variance at step 3 and maintaining its effect through steps 4 & 5. Of the block of graphemic and phonemic awareness variables entered at the final step, phoneme deletion (β =.23, $p < .001$) letter-sound knowledge (β =.23, $p < .001$), and RAN (β =.29, $p < .001$) all made an incremental improvement in prediction additional to Phase 1 Ready to Read as concurrent predictors of irregular word reading at the end of the first year of school.

The analysis for boys, (see Table 16) showed that WPPSI IQ, Ready to Read scores and the phonemic awareness variables all accounted for additional significant variance in Phase 2 irregular word reading scores at the stage at which they were added into the equation with the model accounting for 82.2% of the total variance. For boys at step 3 Ready to Read scores (β =.68, $p < .001$), accounted for a large 40.4% of the total variance in Phase 2 irregular word reading and maintained its effect through steps 4 and 5 with the addition of the phonological variables. Of the graphemic and phonemic awareness variables entered at the final step letter-sound knowledge (β =.20, $p < .01$) was the only variable to make a significant incremental improvement in prediction additional to Phase 1 Ready to Read.

The analysis for girls, (also see Table 16) showed that WPPSI IQ, Ready to read scores and both rhyme detection and the graphemic and phonemic awareness variables all accounted for additional significant variance in Phase 2 irregular word reading scores when added into the equation with the model accounting for 84.9% of the total variance. For girls at step 3 Ready to Read scores (β =.46, $p < .001$) accounted for a significant 14.9% of the total variance and maintained its significant effect through steps 4 and 5. Of the graphemic and phonemic awareness variables entered at step 5 both phoneme deletion (β =.20, $p < .05$) and RAN (β =.45, $p < .001$) made a significant improvement in prediction additional to Phase 1 Ready to Read.

As was the case with reading accuracy, Ready to Read scores accounted for a large portion (40.4%) of the total variance in Phase 2 irregular word reading for boys, whereas for girls it accounted for 14.9% of the total variance in irregular word reading scores at the end of the first year of school, and this difference in percentages was significant ($p<.01$). Also consistent with the finding for reading accuracy the graphemic and phonemic awareness variables accounted for a larger proportion of the total variance for girls (34%) than for boys (20.6%), however this difference did not reach significance for irregular word reading.

Concurrent Predictors of Nonword Reading at the end of the First Year of School

This series of regression analyses, shown in Table 17, assessed the predictive relationships between Phase 2 age, WPPSI IQ (measured in phase 1), Ready to Read (also measured in Phase 1) Phase 2 rhyme detection, and the Phase 2 phonemic awareness variables (phoneme deletion, letter-name and letter-sound knowledge and RAN) with Phase 2 nonword reading at the end of the children's first year of formal schooling. The analysis for all children showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 59.1% of the total variance in nonword reading at the end of the first year of school. For the full sample of children Phase 1 Ready to Read (β =.38, p < .001) accounted for 23% of the total variance. Of the block of graphemic and phonemic awareness variables (step 5) phoneme deletion (β =.38, p < .001) and letter-sound knowledge (β =.17, p < .05), made a significant incremental improvement in prediction additional to Phase 1 Ready to Read.

Table 17

Summary of Hierarchical Regression Analysis for Concurrent Rhyme Detection and the Graphemic and Phonemic Awareness Variables Predicting Nonword Reading Ability at the end of the First Year of Formal Schooling

	All Children (*N* = 140)			Boys (*n* = 72)			Girls (*n* = 68)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.000			.003			.017
Age	.08(.30)	.02		-.25(.51)	-.06		.35(.33)	.13	
Step 2			.169***			.198***			.131**
Age	-.16(.28)	-.04		. .46(.47)	-.11		.14(.32)	.05	
WPPSI IQ[a]	.49(.09)	.42***		.33(.12)	.45***		.35(.11)	.37**	
Step 3			.230***			.354***			.062*
Age	-.01(.24)	.00		-.06(.35)	-.01		.16(.31)	.06	
WPPSI IQ[a]	.24((.09)	.20**		.33(.12)	.25**		.20(.13)	.21	
P 1 R to Read	.18(.03)	.53***		.22(.03)	.63***		.10(.04)	.30*	
Step 4			.036**			.023			.088**
Age	.14(.14)	.04		.04(.35)	.01		.38(.30)	.14	
WPPSI IQ[a]	.10(.10)	.09		.24(.12)	.18		-.03(.15)	-.03	
P 1 R to Read	.17(.02)	.51***		.22(.03)	.61***		.09(.04)	.30*	
Rhyme Det	.23(.08)	.23**		.22(.12)	.17		.27(.10)	.37**	
Step 5			.156***			.135***			.238***
Age	-.00(.210	.00		-.25(.31)	-.06		.26(.26)	.10	
WPPSI IQ[a]	-.11(.09)	-.09		-.02(.12)	-.02		-.20(.13)	-.21	
P 1 R to Read	.13(.02)	.38***		.17(.03)	.48***		.05(.04)	.17	
Rhyme Det	.09(.07)	.10		.08(.11)	.07		.13(.09)	.18	
Phoneme D	.38(.09)	.38***		.35(.12)	.32**		.43(.13)	.50**	
Letter –names	-.04(.10)	-.04		-.09(.14)	-.09		-.05(.14)	-.05	
Letter-sounds	.17(.08)	.17*		.32(.11)	.27**		.02(.11)	.03	
RAN	.08(.09)	.08		.07(.11)	.07		.29(.19)	.22	
Total variance explained			59.1%			71.3%			53.6%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Det = Rhyme Detection, Phoneme D = Phoneme Deletion. [a]measured in Phase 1
*p<.05, **p<.01, ***p<.001.

The separate analyses for boys and girls, shown in Table 17, revealed some important differences in the relative importance of early reading ability (Ready to Read) as a predictor of nonword reading, as was the case with reading accuracy, and irregular word reading, at the end of the first year of formal schooling. The separate boys' analysis also showed that WPPSI IQ, Ready to Read and the graphemic and phonemic awareness variables made significant additional contributions at the stage they were entered accounting for 71.3% of the total variance in nonword reading at the end of the first year of school. Neither age nor rhyme detection accounted for significant additional variance in the boys' analysis. In the final equation for boys Phase 1 Ready to Read scores (β =.48, $p < .001$) accounted for a significant 35.4% of the total variance. Of the phonemic awareness variables (step 5) phoneme deletion (β =.32, $p < .01$), and letter-sound knowledge (β =.27, $p < .01$), made an incremental improvement in prediction additional to Phase 1 Ready to Read for boys.

The analysis for girls showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 53.65% of the total variance in nonword reading at the end of the first year of school, considerably less variance than was accounted for by the model in the boys' analysis. For girls the graphemic and phonemic awareness variables , entered at the final step, accounted for 23.8% of the total variance in their Phase 2 nonword reading scores with phoneme deletion (β =.50, $p < .01$) the only significant predictor.

Phase 1 Ready to Read scores accounted for just 6.2% of the total variance in Phase 2 nonword reading for girls and its contribution was non-significant. For boys, however, Ready to Read scores accounted for a much larger and significant proportion of the total variance in Phase 2 nonword reading scores (35.4%) and the difference between these two percentages was significant ($p<.001$).

In summary, earlier reading ability (measured by the Ready to Read test in the children's first three months of schooling) was the most powerful predictor of reading (Neale Accuracy, irregular word and nonword reading) for boys. Boys' Ready to Read scores accounted for a significantly greater proportion of the total variance in all three reading measures than they did for girls. In contrast, for girls the graphemic and phonemic awareness variables accounted for a significantly greater proportion of the total variance in reading accuracy and irregular word reading than they did for boys. They also accounted for a larger proportion of the total variance in girls' nonword reading scores than they did for boys, however this difference was not significant.

Concurrent Predictors of Spelling at the end of the First Year of School

The first in this series of regression analyses, shown in Table 18, assessed the predictive relationships between Phase 2 age (step 1), WPPSI IQ (step 2), Ready to Read (step 3) rhyme detection (step 4), and the graphemic and phonemic awareness variables (phoneme deletion, letter-name, letter-sound knowledge, and RAN) (entered as a block at step 5), with Phase 2 spelling ability (SAST) measured at the end of the children's first year of formal schooling. For the combined sample of boys and girls all the variables entered, except for age, made significant additional contributions at the stage when they were entered and the model accounted for 67.6% of the total variance in spelling scores at the end of the first year of formal schooling. For the full sample of children at step 3 Phase 1 Ready to Read scores ($\beta = .41, p < .001$) was a significant predictor accounting for 13.9% of the total variance in Phase 2 spelling scores. Of the graphemic and phonemic awareness variables entered at step 5 phoneme deletion ($\beta = .42, p < .001$) letter-sound knowledge ($\beta = .20, p < .01$) and RAN ($\beta = .17, p < .05$) all made a significant incremental improvement in prediction additional to Phase 1 Ready to Read of Spelling performance at the end of the first year of schooling.

Separate regression analyses, shown in Table 18, were run for boys and for girls using the same predictors, as outlined above. Differences between boys and girls in the importance of early phonological awareness (rhyme detection) and graphemic and phonemic awareness were highlighted in these analyses. For boys all the variables entered, except for age, made significant additional contributions to Phase 2 spelling at the stage at which they were entered, with the model accounting for 64.2% of the total variance in Phase 2 spelling scores. For boys the graphemic and phonemic awareness variables accounted for 23.2% of the total variance with phoneme deletion (β =.40, $p < .01$) and letter-sound knowledge (β =.22, $p < .05$) making a significant incremental improvement in prediction additional to Phase 1 Ready to Read.

For girls all the variables, except for age, made significant additional contributions to Phase 2 spelling at the stage at which they were entered and the model accounted for 74.9% of the total variance. For girls Ready to Read scores accounted for a significant proportion (12.9%) of the total variance in spelling scores. Of the graphemic and phonemic awareness variables, entered at the final step, phoneme deletion (β =.50, $p < .001$) made a significant incremental improvement in prediction additional to Phase 1 Ready to Read.

Table 18

Summary of Hierarchical Regression Analysis for Concurrent Rhyme Detection and the Graphemic and Phonemic Awareness Variables Predicting Spelling Ability at the end of the First Year of Formal Schooling

	All Children (N = 140)			Boys (n = 72)			Girls (n = 68)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.006			.000			.025
Age	.27(.30)	.08		-.02(.48)	-.01		.47(.36)Z	.16	
Step 2			.211***			.204***			.261***
Age	.01(.27)	.00		-.23(.43)	-.06		.15(.32)	.05	
WPPSI IQ[a]	.54(.09)	.47***		.57(.14)	.46***		.55(.11)	.52***	
			.139***			.133***			.129***
Age	.13(.25)	.04		.00(.40)	.00		.18(.29)	.062	
WPPSI IQ[a]	.35(.09)	.30***		.41(.13)	.33**		.30(.12)	.29*	
P 1 R to Read	.14(.03)	.41***		.13(.03)	.39***		.15(.04)	.43***	
Step 4			.046**			.073**			.049*
Age	.30(.24)	.08		.17(.39)	.04		.36(.29)Z	.12	
WPPSI IQ[a]	.20(.10)	.17*		.27(.13)	.21		.12(.14)	.11	
P 1 R to Read	.13(.03)	.39***		.11(.03)	.35**		.15(.04)	.43***	
Rhyme Det	.25(.08)	.25**		.37(.13)	.30**		.23(.09)	.28*	
Step 5			.274***			.232***			.285***
Age	.10(.18)	.03		-.11(.32)	-.03		.24(.21)	.08	
WPPSI IQ[a]	-.08(.08)	-.06		-.09(.12)	-.07		-.11(.10)	-.10	
P 1 R to Read	.07(.02)	.22***		.05(.03)	.16		.11(.03)	.30***	
Rhyme Det	.09(.06)	.09		.18(.11)	.15		.05(.07)	.06	
Phoneme D	.42(.08)	.42***		.41(.12)	.40**		.47(.11)	.50***	
Letter-names	.02(.09)	.02		.08(.14)	.09		-.10(.11)	-.09	
Letter-sounds	.20(.07)	.20**		.24(.11)	.22*		.17(.09)	.20	
RAN	.17(.08)	.17		.08(.11)	.09		.24(.15)	.16	
Total variance explained			67.6%			64.2%			74.9%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Det = Rhyme Detection, Phoneme D = Phoneme Deletion. [a]measured in Phase 1
*p<.05, **p<.01, ***p<.001.

Awareness of letter-sounds and phoneme deletion ability (or the ability to manipulate and blend phonemes) were the most important predictors of spelling development for both boys and girls. This is consistent with Ehri's (1997) proposal that it is knowledge of the alphabetic system (the ability to manipulate and blend phonemes together with knowledge of the letters (names and sounds and the correspondences between them) that is the critical determinant of spelling ability. Ehri's proposal is further supported by a later study by Caravolas et al., (2001) which demonstrated that phoneme awareness and letter-sound knowledge were the two fundamental precursor skills necessary for spelling development.

Boys' spelling ability appears to be compromised by their poorer ability to manipulate and blend phonemes and by their weaker letter name and sound knowledge compared with the girls in the study. Spelling which requires multiple responses (writing several letters in the correct sequence).according to Ehri (1997) is a more cognitively demanding task than reading which requires a single response (pronouncing a word). Jaeger et al.'s (1998) finding of sex differences in tasks with a greater phonological processing load suggests that differences between boys and girls are more likely to be found as the complexity of the task increases and this may explain why there were no significant differences between boys and girls in reading measures but girls were significantly more accurate spellers than boys.

CHAPTER 8

The Empirical Study – Phase 3

Method

Participants

Phase 3 data were collected 12 months after Phase 2, that is, at the end of the children's second year of formal schooling. Participants in Phase 3 of the study were 127 of the original sample of 153 children who participated in Phase 1. The children who dropped out of the study from Phase 2 to Phase 3 had all left the district and were unavailable to be participants in Phase 3. Three boys who were unavailable for testing in Phase 2, because of extended absences from school, were available for Phase 3 testing and are included in the Phase 3 results. Phase 3 included 68 boys and 59 girls. Comparisons between the children who remained in the study and those who dropped out showed no significant difference between the groups indicating that attrition did not result in a biased sample in Phase 3. The demographics and ages of Phase 3 participants are displayed in Table 19.

Table 19
Demographics and Ages of Phase 3 Boy and Girl Participants

School	Total (*N*)	SES	Boys' Mean Age (*SD*)	Boys (*n*)	Girls' Mean Age (*SD*)	Girls (*n*)
1	12	Urban (H)	7.15 (.28)	8	7.23 (.23)	4
2	40	Urban (L)	7.25 (.30)	19	7.34 (.27)	21
3	35	Urban (H)	7.33 (.29)	18	7.20 (.33)	17
4	28	Rural	7.21 (.24)	15	7.48 (.26)	13
5	12	Urban (L)	7.33 (.24)	8	6.72 (.14)	4
Total	127		7.26 (.28)	68	7.29 (.32)	59

Note. Values in parentheses indicate standard deviations, (H) = High, (L) = Low
Mean ages in decimals

Tests and Materials

The children were tested on the following instruments:

Letter-name and letter-sound knowledge. Administered from the Phonological Abilities Test – PAT (Muter, et al., 1997) as outlined in Phase 1.

Rhyme production. Following Stanovich, Nathan, and Vala-Rossi (1986), the children were asked to provide a word, which rhymed with each of ten test words spoken by the experimenter (see Appendix 6). Two practice items were given, during which corrective feedback was provided. A raw score of 10 was possible.

Rhyme categorisation. The children were asked to listen carefully while the experimenter said four words one after the other and to say which word did not rhyme with the other three (see Appendix 7). Care was taken to ensure that the four words were uttered at an even pace and with the same emphasis on each word. Two practice items preceded the test with feedback provided on these two items. A raw score of 10 was possible.

Alliteration categorisation. Following the procedure used for the rhyme categorisation task children were asked to identify the word that began with a different sound from the other three words (see Appendix 7). A raw score out of 10 was possible .

Grapheme-phoneme deletion task. This forced choice grapheme-phoneme deletion task was used by Martin, Pratt, and Fraser (2000), Kirby (2002), and Martin, Pratt, Claydon, Morton, and Binns (2003) in recent studies. There were four conditions – auditory orthographic, visual phonological, auditory phonological, and visual orthographic. The task order was counterbalanced across all participants. The children were instructed to take away a grapheme (letter/orthographic) or a phoneme (sound/phonological) from the word and were either shown the word (visual)or asked to listen to the word (auditory). If an orthographic strategy was required the children were instructed to delete a grapheme and pronounce the new word based on its spelling or orthography. If a phonological strategy was required the children were instructed to delete a phoneme and pronounce the word based on what it would sound like or its phonology. Appendix 8 shows the full instructions for this task. Two practice items with corrective feedback preceded each condition. No corrective feedback was given during the test items. A score of eight was possible for each of the four conditions.

Rapid automatised naming (RAN). The Denckla and Rudel (1976) RAN letters was used to assess speed of processing. The time taken to name all letters was taken using a stopwatch and recorded in seconds.

Reading ability measures. The following instruments were administered to assess the children's reading skills at the end of Grade 1.

1. Neale Analysis of Reading Ability (3rd Ed.) (Neale, 1999), Form 2
2. An Irregular word reading test (see Appendix 4) to assess orthographic processing skills. A raw score of 68 was possible.
3. The Martin & Pratt (2000) Nonword Reading test, form A, was administered to assess decoding skills. A maximum raw score of 54 was possible.

All of the above tests were administered individually to each child in a quiet room, in two fixed order sessions, with the exception of the grapheme-phoneme deletion task, for which the task order was counterbalanced across all participants.

Spelling ability measures. The following tests were administered in a single group session to assess spelling skills:

1. South Australian Spelling Test (SAST). The first 40 words were administered to class groups of children from the participating schools.

2. A Nonword spelling test consisting of 10 words from the Martin and Pratt (2000) Nonword Reading Test (see Appendix 9) were given to the class groups from the participating schools, following administration of the SAST. Children were instructed to watch the experimenter's lips as each nonword was enunciated and to write each funny made-up word from the sounds in the word.

The d2 test of attention. Administration of the d2 Test of Attention (Brickenkamp & Zillmer, 1998) was according to the instructions for child participants set out in the manual. Group administration was used in a different session from the spelling tests. Inclusion of the attention measure was based on research evidence of an association between attentional problems and reading difficulties (e.g. Rabiner, Coie, the Conduct Problems Prevention Research Group, 2000; Rowe & Rowe, 1992)

Design and Data Analysis

The basic design for Phase 3 was a mixed design ANCOVA with sex as the between subjects variable with chronological age, and WPPSI IQ (measured in Phase 1) entered as covariates to control for any differences in age and IQ, and the Phase 3 measures as the dependent variables. An alpha level of .05 was used for all analyses except for significance testing between correlations where an alpha level of .01 was used. Greenhouse-Geisser adjustment was used in all repeated measures analyses. Correlations for the entire sample were used to investigate the relationships between all the variables measured in Phase 3. Factor analysis was used to examine the underlying processes creating the relationships between the variables and Factor scores were investigated using histograms, scatterplots and ANOVA. In order to test for significant differences between individual means, t tests and one-way ANOVAs were used post hoc. Hierarchical regression analyses were conducted to determine the significant concurrent predictors of reading and spelling ability.

Results and Discussion

Raw data (shown in Table 20) were analysed to produce means and standard deviations for all the children's performance measures. ANCOVAs (shown in Table 21) were run with age, and WPPSI IQ (measured in Phase 1) as the covariates in each analysis, to measure significance levels of any differences between boys and girls, as well as effect sizes measured by eta squared (n^2) to show the percentage of the variance in each dependent variable accounted for by the difference between boys and girls and also by d' (female mean-male mean divided by the within-sex standard deviation).

Girls scored significantly higher than boys on several of the phonological awareness and processing measures. Girls ($M = 6.10$) scored significantly higher than boys ($M = 4.78$) on alliteration categorisation, $p<.01$, $n^2 = 0.07$ indicating a moderate effect size. The alliteration categorisation task required the child to isolate the initial sounds in a series of four words and say which word began with a different sound and so can be considered a task requiring explicit phonemic awareness. Girls also achieved significantly higher scores on three of the grapheme-phoneme deletion conditions (visual phonological, $M = 2.54$, auditory phonological, $M = 5.20$, and visual orthographic, $M = 3.95$) than boys ($M = 1.78$, 3.78, and 3.19 respectively). For the visual phonological condition $p<.01$ and the effect size was moderate ($n^2 = 0.06$). For the auditory phonological condition $p<.001$ and the effect size was moderate to large ($n^2 = 0.12$). For the visual phonological condition $p<.01$ and the effect size was moderate (n^2 =0. 05). The strength of the difference between boys and girls on these three conditions of the grapheme-phoneme deletion task was moderate to fairly large with from 5% to 12% of the variance in these variables explained by the difference between boys and girls.

Table 20

Raw Means and Standard Deviations (SD) for Boys (n =68) and Girls (n = 59) and all Children (N = 127) Values in Parentheses Represent Standard Deviations

	Mean (SD)			
	Boys (SD)	Girls (SD)	Overall (SD)	Boy/girl ratio of SDs
Rhyme Production	6.60(3.02)	6.85 (2.82)	6.72 (2.92)	1.07
Rhyme Categorisation	6.47 (2.27)	6.90 (2.10)	6.67 (2.19)	1.08
Alliteration Categorisation	4.78 (3.03)	6.10 (2.84)	5.39 (3.00)	1.06
Grapheme-Phoneme deletion Auditory Orthographic	0.69 (1.31)	0.97 (1.45)	0.825 (1.38)	0.90
Grapheme-Phoneme deletion Visual Phonological	1.78 (1.84)	2.54(1.73)	2.13(1.82)	1.06
Grapheme-Phoneme deletion Auditory Phonological	3.78(2.37)	5.20(2.23)	4.44(2.40)	1.06
Grapheme-Phoneme deletion Visual Orthographic	3.19(1.90)	3.95(1.70)	3.54(1.84)	1.12
Letter-Names	23.99 (3.47)	24.88 (3.28)	24.40 (3.40)	1.06
Letter-Sounds	22.62 (3.56)	24.32 (2.13)	23.41 (3.09)	1.67
RAN (secs)	40.93 (17.40)	34.61 (13.75)	37.99 (16.06)	1.27
Neale Accuracy	30.97 (21.81)	34.51 (18.27)	32.61 (20.24)	1.19
Neale Comprehension	10.74 (7.28)	12.12 (6.27)	11.38 (6.84)	1.16
Neale Rate	38.81 (22.10)	41.63 (18.09)	40.12 (20.30)	1.22
Irregular word Reading	21.72 (13.17)	24.75 (10.39)	23.13 (12.01)	1.27
Nonword Reading	20.12 (13.05)	22.53 (10.93)	21.24 (12.13)	1.19
SAST	21.63 (10.31)	25.31 (8.35)	23.34 (9.59)	1.23
Nonword Spelling	4.82 (3.39)	5.85 (3.06)	5.30 (3.27)	1.11
D2 Concentration perf.	61.5 (25.02)	68.91 (23.07)	64.91 (24.32)	1.08
D2 % errors	12.97 (10.35)	9.43 (8.59)	11.33 (9.70)	1.20

Note. Boy/Girl ratio of standard deviations shows variability in scores with >1 indicating greater variance in boys' scores and <1 indicating greater variance in girls' scores

Table 21

Analysis of Covariance with Sex as the Between Subjects factor for all Children's Phase 2 Raw Scores, with Age, and WPPSI IQ, as the Covariates in each Analysis

	N	*F*	*Effect size* n^2	*p*
Rhyme Production	127	.91 (5.99)	0.01	.34
Rhyme Categorisation	127	2.82 (3.34)	0.02	.08
Alliteration Categorisation	127	9.47 (6.76)	0.07	.003**
G-P deletion Auditory Orthographic	127	1.69(1.69)	0.01	.195
G-P deletion Visual Phonological	127	7.96 (2.62)	0.06	.006**
G-P deletion Auditory Phonological	127	16.17(4.32)	0.12	.000***
G-P deletion Visual Orthographic	127	6.58 (2.91)	0.05	.012*
Letter-names	127	3.11 (9.71)	0.03	.08
Letter-sounds	127	12.82 (7.95)	0.09	.000***
RAN (secs)	127	6.26 (214.32)	0.05	.014*
Neale Accuracy	127	1.83 (311.54)	0.02	.179
Neale Comprehension	127	3.15 (28.23)	0.03	.078
Neale Rate	127	1.03 (353.15)	0.01	.312
Irregular word reading	127	3.51 (107.19)	0.03	.06
Nonword Reading	127	.2.16 (115.07)	0.02	.14
SAST	127	7.38(66.62)	0.06	.008**
Nonword Spelling	127	5.36 (8.12)	0.04	.022*
d2 Concentration Performance	127	4.43 (420.80)	0.04	.037*
d2 % errors	127	5.94 (74.97)	0.05	.016*
error	123			

Note. Values in parentheses represent mean square errors. G-P = Grapheme Phoneme Deletion task, RAN = Rapid Automatised Naming (letters), SAST = South Australian Spelling Test

$^*p < .05$ $\quad$ $^{**}p < .01$ $\quad$ $^{***}p < .001$

Girls (M = 24.32) demonstrated significantly better letter-sound knowledge than boys (M = 22.62), $p < .001$, $n^2 = 0.09$), indicating a moderate to large effect size, and significantly faster processing speed in the RAN task (M = 34.61 s) than boys (M = 40.93 s) $p<.05$, $n^2 = 0.05$, indicating a moderate effect size.

There were no differences between boys and girls in Neale Accuracy, Neale Rate, irregular word reading or nonword reading scores. Girls' Neale Comprehension scores were higher (M = 12.12) than boys' (M = 10.74), and this difference tended towards significance, p= .08, however the effect size of this difference was small (n^2=0.03). Girls (M = 25.31, 5.85) scored significantly higher than boys (M = 21.63, 4.82) on both spelling measures (SAST, and Nonword spelling), $p<.01$ (n^2=0.06), .$p<.05$ ($n^2 = 0.04$).

Girls showed significantly better concentration performance in the d2 Test of Attention (M = 68.91) than boys (M = 61.5), $p<.05$, $n^2 = 0.04$) and made significantly less errors on the d2 Test of Attention (M = 9.43%) than boys (M = 12.97%), $p<.05$, ($n^2 = 0.05$).

Boy/girl ratios of standard deviation were also calculated for each performance measure as outlined in Chapter 6 (Phase 1). As Table 20 shows, greater variability can be seen in boys' scores particularly for Letter-sounds (1.67), RAN (1.27), Neale accuracy (1.19), comprehension (1.16) and rate (1.22), irregular word reading (1.27), Nonword reading (1.11), spelling (SAST (1.23) and Nonword spelling (1.11)), and the d2 Test of Attention % of errors (1.20).

Boys are disproportionately represented in the lower ends of many of the Phase 3 measures. Table 22 shows the percentages of boys and girls in the bottom and top ends of the distributions for the measures in which girls were significantly better (or faster) than boys. In all these measures, except for spelling (SAST), there were more boys than girls in the bottom 25%, and fewer boys than girls in the top 25% of the distribution. For spelling there were more boys than girls in the bottom 25% but equal numbers of boys and girls in the top 25%. The difference between the proportion of boys and girls in both the bottom and top 25% of the distribution for letter-sound knowledge was significant (p <.001).

Table 22

Percentage of Boys and Girls in the Upper and Lower Ranges of the Distribution of Scores for Variables in which Girls achieved Significantly Higher (or faster) Results than Boys

	Alliteration categorisation		Phoneme Deletion Auditory/Phonological		Grapheme Deletion Visual/Orthographic	
	Boys	Girls	Boys	Girls	Boys	Girls
Bottom 25%	31%	11.9%*	33.8%	13.6%*	22.1%	8.5%*
Top 25%	13.2%	23.7%	17.6%	33.9%*	10.3%	22.3%
	Letter-sounds knowledge		**RAN**		**SAST**	
	Boys	Girls	Boys	Girls	Boys	Girls
Bottom 25%	39.7%	11.9%***	36.8%	11.9%**	30.9%	13.6%*
Top 25%	19.1%	62.7%***	17.6%	30.5%	22.1%	23.7%
	Nonword spelling		**D2 Concentration performance**			
	Boys	Girls	Boys	Girls		
Bottom 25%	30.9%	16.9%	29.4%	15.3%*		
Top 25%	16.2%	22%	19.1%	30.5%		

Note. RAN = Rapid Automatised Naming; SAST = South Australian Spelling Test
Significance level of the difference between distributions * p<.05, **p<.01, ***p <.001

Table 23 shows the percentages of boys and girls in the bottom and top quartiles of the score distributions for the reading measures. There were significantly greater proportions of boys than girls in the bottom quartiles of the distributions for reading accuracy, comprehension, and for irregular word reading and there was a trend for this also in nonword reading, however there were no significant differences in the top quartiles of any of the reading measures. Interestingly this was not so in Phase 2 where there were no differences between boys and girls in either the bottom or top quartiles. This indicates that the male disadvantage is restricted to those boys who are average to below average readers and perhaps an explanation for the greater number of boys in the bottom quartile of the reading distributions can be found in the greater need for phonemic awareness at this stage whereas at the end of the first year of school the use of other strategies may have been acting as a protective factor against reading failure.

Table 23

Percentage of Boys and Girls in the Upper and Lower Ranges of the Distribution of Scores for Scores for Phase 3 Reading and Spelling Outcome Measures

	Neale Accuracy		Neale comprehension		Irregular word Reading	
	Boys	Girls	Boys	Girls	Boys	Girls
Bottom 25%	32.4%	15.3%*	30.9%	15.3%*	32.4%	15.3%*
Top 25%	27.9%	23.7%	25%	28.8%	27.9%	22%

	Nonword Reading	
	Boys	Girls
Bottom 25%	29.4%	16.9%
Top 25%	25%	28.8%

Note. Significance level of the difference between distributions *p<.05,

Relationships between Children's Performance Variables

To explore the relationships between all Phase 3 measures correlations were run, on the full sample of children (N=127) and these are shown in Table 24. All reading measures were very highly correlated. Neale Accuracy, comprehension, and rate were highly correlated (in the .80 range). Irregular word reading related very strongly to Neale accuracy (.94), as did the Martin and Pratt Nonword Reading Test (.89). SAST related strongly to irregular word reading (.91), nonword reading (.86), Neale Accuracy (.87) and to the nonword spelling (.82).

Table 24

Intercorrelations between all Phase 3 Measures for all Participants (*N* =127)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.Neale Accuracy	1.0	.86**	.80**	.94**	.89**	.63**	.65**	.58**	.63**	.61**	.61**	.65**	.52**	.50**	-.61**	.87**	.76**	.45**
2.Neale Comprehension		1.0	.69**	.81**	.73**	.58**	.61**	.61**	.55**	.62**	.54**	.57**	.48**	.42**	-.52**	.76**	.66*	.55**
3.Neale rate			1.0	.77**	.70**	.49**	.53**	.41**	.41**	.49**	.45**	.51**	.47**	.41*	-61*	.71**	.64**	.41**
4.Irregular words				1.0	.88**	.63**	.68**	.59**	.55**	.66**	.67**	.62**	.58**	.54**	-.64**	.91**	.75**	.45**
5. Nonword reading					1.0	.62**	.69**	.56**	.57**	.61**	.66**	.67**	.53**	.56*	-.59**	.86**	.80**	.41**
6.Rhyme production						1.0	.57**	.49**	.40**	.44**	.48**	.43**	.44**	.34**	-.49**	.61**	.64**	.24**
7.Rhyme Categorisation							1.0	.60 **	. 39**	.53**	.53**	.49**	.43**	.52**	-.47**	.65**	.64**	.41**
8Alliteration Categorisation								1.0	.39**	.57**	.51**	.41**	.41**	.46**	-.45**	.55**	.55**	.41**
9.G-P Deletion aud/ ortho									1.0	.36**	.32**	.45**	.25**	.31**	-.26**	.52**	.48**	.36**
10. G-P Deletion vis/phono										1.0	.54**	.40**	.42**	.40**	-.49**	.64**	.57**	.41**
11G-P Deletion aud/phono											1.0	.47**	.52**	.53**	-.54**	.70**	.60**	35**
12. G-P Deletion vis/ortho												1.0	.47**	.52*	-.47**	.67**	.59**	.38**
13.letter-Names													1.0	.60**	-.75*	.61**	.52**	.38**
14.letter-Sounds														1.0	-.51*	.57**	.49**	.28**
15.RAN															1.0	-.68**	-.55**	-.49**
16. SAST																.1.0	.82**	.49**
17.Nonword Spelling																	.1.0	.50**
18.D2 Attention test																		.1.0

Note. G-P Deletion = Grapheme- Phoneme Deletion task, aud = auditory, vis= visual, ortho = orthographic, phono = phonological

** $p<.01$ * $p<.05$

Rhyme production, rhyme categorisation and phoneme deletion (in the auditory phonological condition) and grapheme deletion (in the visual orthographic condition) were well related to Neale Accuracy, irregular word reading and nonword reading and both SAST and nonword spelling (in the .6 range), indicating that both rhyme awareness and phoneme/grapheme awareness had a similar relationship with reading and spelling.

Letter-name and letter-sound knowledge were more strongly related to phoneme deletion (auditory phonological condition) (in the .5 range) than to rhyme production (.44, and .34 respectively). The relationship between letter-sounds and rhyme categorisation (.52) was stronger than between letter-names and rhyme categorisation (.43) indicating the importance of letter-sound knowledge in the identification of the final sound in a set of words to determine which word did not rhyme with the other three words in the set.

Rapid automatised naming (RAN) was negatively well correlated (in the .5 to .6 range) with the reading measures indicating that those children who were able to rapidly name letters were also better readers. A very strong negative relationship can be seen between RAN and knowledge of letter-names (-.75) indicating that children with good letter knowledge, and hence greater fluency with letters, were able to process the letters on the RAN more rapidly and achieve faster times. The educational implications of the relationship between the RAN letter task (proposed by its authors Denckla and Rudel (1974) to be an excellent predictor of reading) letter-name knowledge, and reading was recently highlighted in a study by Neuhaus and Swank (2002). Neuhaus and Swank suggested that "teachers need to teach individual letters and to recognise that each letter counts in the march toward literacy" (p. 170). According to Neuhaus and Swank to read well requires that children are able to quickly, accurately, and consistently attach a label to a letter, and letter knowledge must become automatic.

The d2 Test of Attention was significantly correlated with all reading, spelling and phonological awareness and processing measures ($p < .001$). Correlations ranged from .55 for Neale Comprehension to .24 with rhyme production, highlighting the important and global role that concentration plays in reading and reading related

The Processes Underlying the Relationships between Phase 3 Variables

To investigate the underlying processes that have created the relationships between the Phase 3 variables, the raw data for all reading, processing, and concentration performance variables measured in Phase 3 were entered into a Principal Components analysis with varimax rotation. RAN scores were converted into z scores with the + and – signs reversed to provide a positive rather than negative relationship with the remaining variables in the analysis. Because of the large floor effect in both incongruent conditions of the grapheme-phoneme deletion task only the two congruent conditions were included in the factor analysis (i.e., the auditory phonological and visual orthographic conditions). The incongruent conditions were such difficult tasks for the children that their contribution in any discussion of the analysis is most probably not valid. Using Kaiser's criterion of extracting only factors with an eigenvalue ≥ 1 the analysis yielded two factors which together accounted for 67.68% of the variance. The Kaiser-Meyer-Olkin measure of sampling adequacy (.933) was very satisfactory for the analysis reflecting the strong positive correlations in the data. The rotated factor matrix is shown in Table 25.

Table 25

Raw Score Loadings on Rotated Factors from the Principal Components Analysis with Varimax Rotation

	Component	
Variable	Reading/Spelling	Graphemic and Phonemic awareness
Neale Accuracy	.89	.33
Neale Comprehension	.83	
Neale Rate	.74	.31
Irregular Word Reading	.85	.41
Nonword Reading	.83	.39
Rhyme Production	.70	
Rhyme Categorisaton	.69	.34
Alliteration Categorisation	.58	.36
G-P Deletion (Aud/Phonological)	.51	.55
G-P Deletion (Vis/ orthographic)	.57	.44
Letter-Names		.86
Letter-Sounds		.76
Ran Letters	.38	.76
SAST	.79	.49
Nonword Spelling	.78	.35
D2 Concentration	.40	.41
Variance		
% Variance	43.86%	23.82%

Note. Only loadings above 0.3 are shown

The factors identified in the two-factor solution are clearly defined, although concentration loaded weakly onto both factors. This is not unexpected given the broad impact of the ability to focus attention on all the performance measures tested. The auditory phonological condition of the grapheme-phoneme deletion task also loaded onto both factors although the loading was stronger on the 2nd factor.

Factor 1, accounting for 43.86% of the variance has been interpreted as a reading and spelling ability factor, defined by high loadings (in the .8 range) from Neale reading accuracy and comprehension, the word identification measures (irregular word reading, and the Martin and Pratt Nonword Reading Test – in the .8 range), the two spelling measures (SAST, and nonword spelling – in the .7 range) Neale reading rate (.74), the rhyming measures (rhyme production and rhyme categorisation (in the .6 range) and alliteration categorisation (.56), and the Grapheme-Phoneme deletion visual orthographic task (.57).

Factor 2, accounting for 23.82% of the variance, has been interpreted as a graphemic and phonemic awareness factor because of the high loadings from letter-name knowledge (.86), letter-sound knowledge (.76), RAN letters (.76).The grapheme-phoneme deletion auditory phonological task (.55) also loaded more strongly onto Factor 2. As with Phases 1 & 2, due to insufficient numbers, it was considered invalid to run separate factor Analyses for boys and girls.

Analysis of Factor scores

Distributions on the factor scores were examined through analysis of histograms displaying score distributions for boys and girls for each factor score as shown in Figures 14, and 15. Examination of the distributions of scores for each of the two factors reveals varying patterns for boys and girls on these two scores. The distribution of scores for the reading/spelling factor is much wider for boys, (ranging from -2.3 to 2.58, *M* = -.04) than girls (ranging from –1.55 to 2.32, *M* = .04). Skewness was greater in boys' scores (.26), than in girls' scores (.17) but neither differed significantly from normal. Overall 44.1% of boys and 64.9% of girls achieved reading/spelling scores greater than the within-sex mean of zero.

For the graphemic and phonemic awareness factor score there was a greater proportion of girls (range = -.4.57 to 1.73) above zero (81.4%) than below (18.6%) while boys' scores (range = -2.98 to 1.09) revealed an even distribution above (51.5%) and below (48.5%) the mean. Skewness was -.1.4 for boys and –3.57 for girls. The distribution of boys' scores clearly shows many boys with good graphemic and phonemic awareness but also a long tail of boys with poor graphemic and phonemic awareness (*M*= -.26). The distribution of girls' scores is clearly weighted towards the upper end (*M*= .30). With the exception of two girls with very low graphemic and phonemic awareness, girls demonstrated well developed or marginally below average graphemic and phonemic awareness.

The two-sample Kolmogorov-Smirnov nonparametric test showed that whereas boys' and girls' distributions of reading/spelling factor scores did not differ significantly from each other (p<.05), the distribution of boys' and girls' graphemic and phonemic awareness scores did differ significantly from each other (p<.05) as they did on the graphemic and phoneme awareness factor in both Phase 1, and Phase 2.

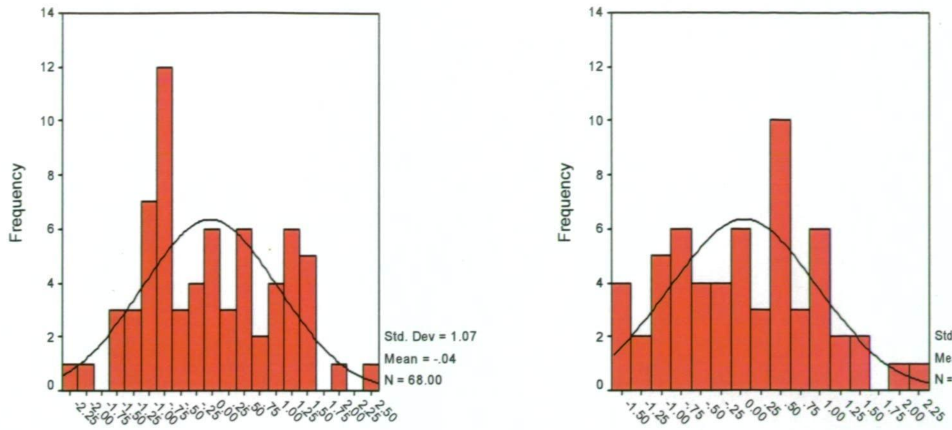

Figure 14. Distribution of reading/spelling ability scores for boys (left) and girls (right).

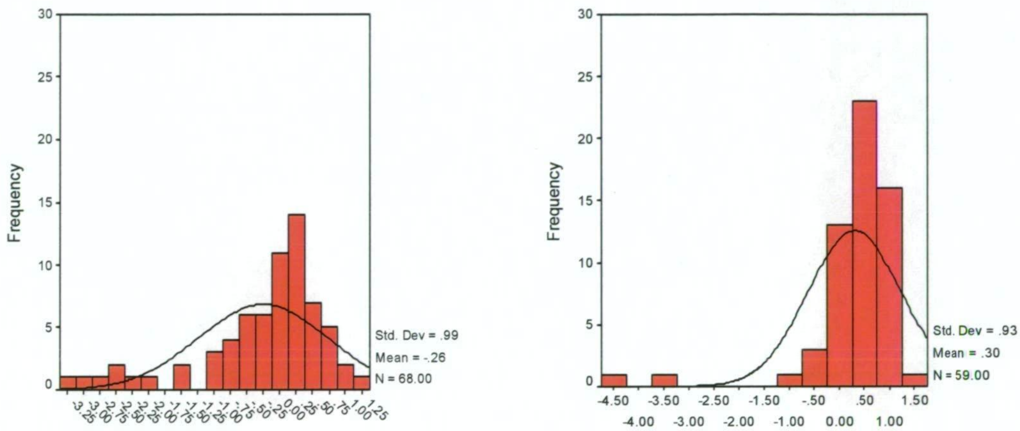

Figure 15. Distribution of graphemic and phonemic awareness scores for boys (left) and girls (right).

A scatterplot was produced to examine the relationship between the factor scores for boys and girls, as shown in Figure 16. There are clearly many more boys than girls with poorly developed reading/spelling and graphemic and phonemic awareness skills. As in Phase 2 there were two girls with very poor graphemic and phonemic awareness skills, however the majority of girls showed average to above average graphemic and phonemic awareness skills.

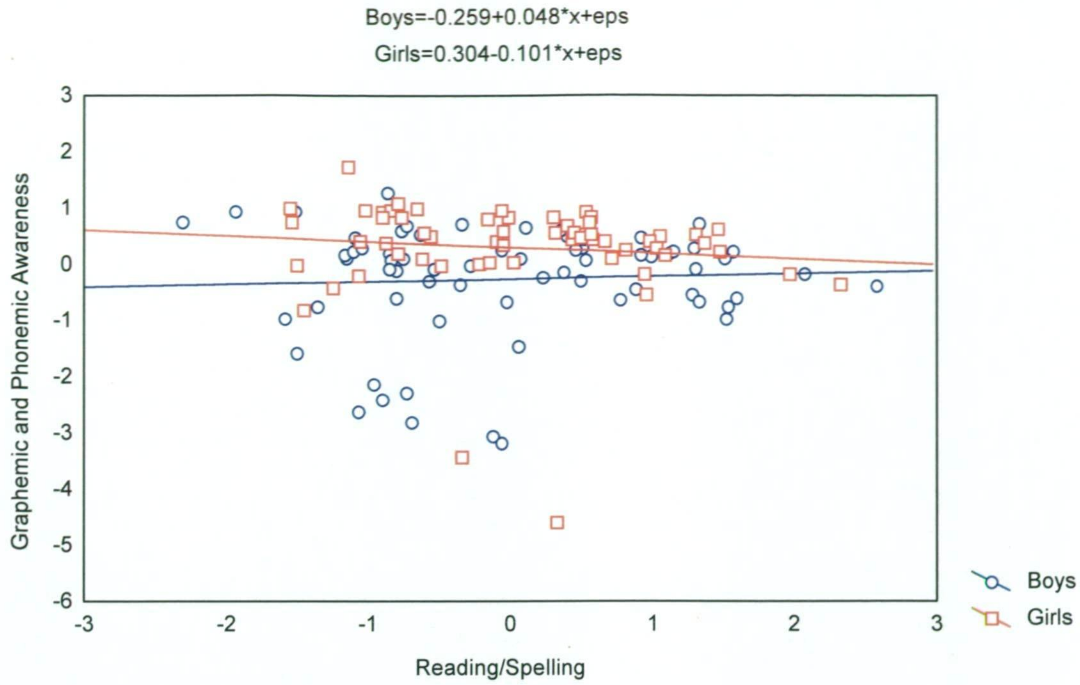

Figure 16. The relationship between reading/spelling ability and graphemic and phonemic awareness ability.

The Effect of Sex on Factor Scores

A 2[Sex: boy, girl] x 2 (Factor score: reading/spelling ability, graphemic and phonemic awareness) was used to analyse the effect of sex on the children's performance on the factor scores. Overall girls (M = .17) scored significantly higher scores than boys (M = -.15) and the effect size was moderate, F (1,125) = 6.72, MSE = .98, p<.05 (n^2=0.05).

The interaction, shown in Figure 17, between sex and factor score trended towards significance with a small to moderate effect size, F (1,125) = 3.70, MSE = .98, p = .05 (n^2=0.03). One way ANOVAs for Sex and Factor scores showed that the difference between boys' and girls' means for reading/spelling factor scores was not significant, F (1,125) = .19, MSE = 1.01, *n.s.* For graphemic and phonemic awareness, however, girls (M = .30) performed significantly more accurately than boys (M = -.26), F (1,125) = 10.70, MSE = .93, p <.01 (n^2=0.08).

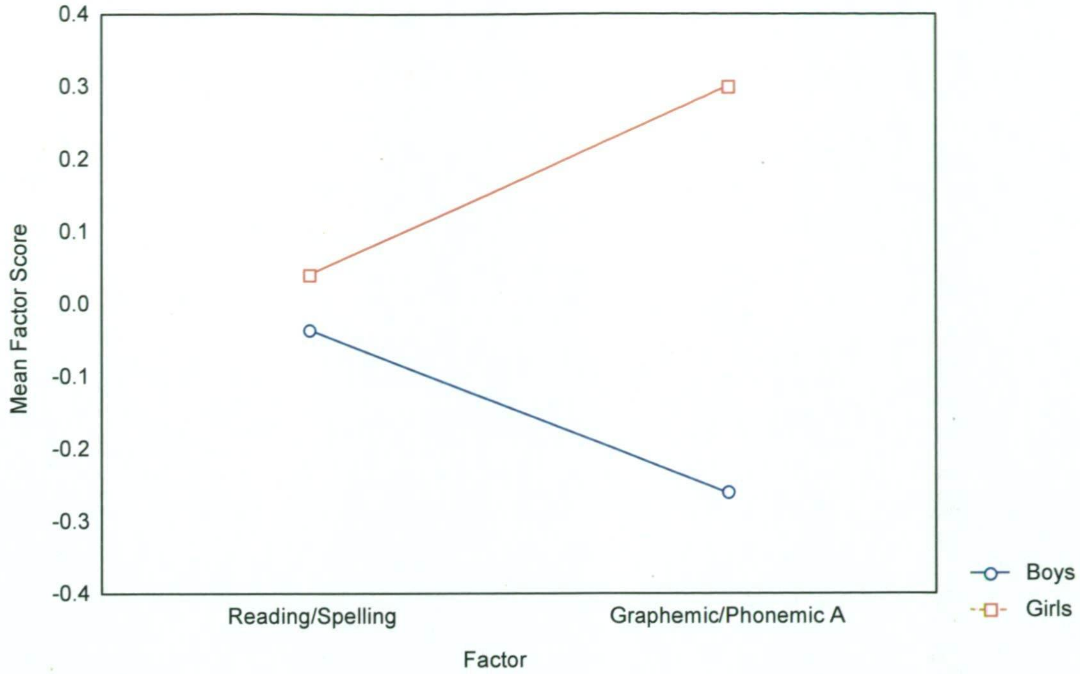

Figure 17. The effect of sex on reading/spelling ability, and graphemic and phonemic awareness factor scores.

The Effect of Sex on Phonological Awareness

A 2[Sex: boy, girl] x 2 (Phonological awareness: rhyme production, phoneme deletion) ANCOVA was used to analyse the effect of sex on the children's performance on the phonological awareness tasks, after controlling for any differences between boys and girls on age and WPPSI IQ. Z scores were used for rhyme production and phoneme deletion (auditory phonological condition) to achieve parity between the two phonological awareness scores. Overall girls' scores (M = .17) were significantly higher than boys' scores (M = -.15), F (1,123) = 9.39, MSE = 98, p <.05, (n^2 =0.07). There was a significant interaction between sex and phonological awareness task, F (1,123) = 7.56, MSE = .48, p <.01, (n^2 =0.06). This interaction is illustrated in Figure 18 and shows that while there was no significant difference between boys' and girls' scores in rhyme production, F (1,125) = .23, MSE = 1.01, p

>.05, (n^2 =0.00), girls (M = .32) achieved significantly higher phoneme deletion scores than boys and the effect size of this difference was moderate to large (M = -.28), F (1,125) = 12.07, MSE = .92, p >.01, (n^2 =0.09).

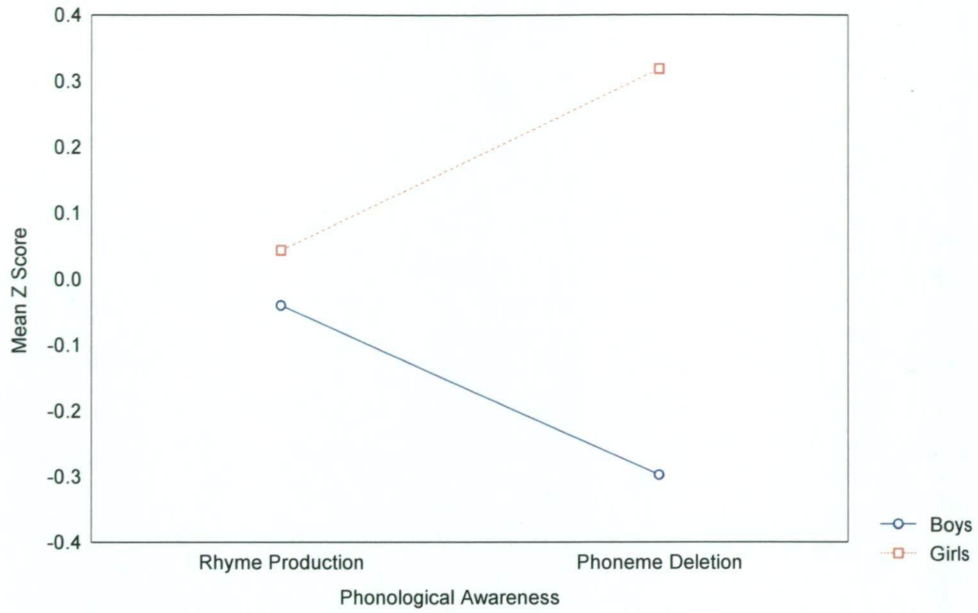

Figure 18. The effect of sex on mean phonological awareness as measured by rhyme awareness and phoneme deletion tasks.

Results of the Grapheme-Phoneme Deletion task

Many children found the two incongruent conditions of the grapheme-phoneme deletion task, i.e., the auditory orthographic (when instructed to delete a letter from a spoken word and say what the new word would spell) and the visual phonological (when instructed to delete a sound from a visually presented word and say how the new word would sound) conditions, very difficult. For each condition the maximum score possible was eight. The scores for the auditory orthographic condition ranged from 0 to 5 for boys and 0 to 6 for girls, however 50.6% children failed to score in this condition. The scores on the visual phonological condition ranged from 0 to 8 for boys and 0 to 7 for girls with 19.5% of children failing to score. In contrast, in the congruent auditory phonological condition only 5.8% of children failed to score with 6.5% achieving a maximum score of eight correct while in the congruent visual orthographic condition only 2.6% failed to scores with just one child achieving the maximum score of eight. It can be seen from Table 31 that girls were more accurate than boys on all four conditions and that the children were most accurate on the auditory phonological condition, that is, when asked to delete a sound from a spoken word.

Table 26

Mean number of Correct Responses for Boys and Girls across the Four Conditions in the Grapheme-Phoneme Deletion Task (maximum score = 8)

	Auditory presentation		Visual presentation	
	Phonological Instructions	Orthographic Instructions	Phonological Instructions	Orthographic Instructions
Boys (*n* = 68)	3.78 (2.37)	.69 (1.30)	1.78 (1.84)	3.19 (1.90)
Girls (*n* = 59)	5.20 (2.23)	.97 (1.45)	2.54 (1.73)	3.95 (1.70)
Total (*N* = 127)	4.44 (2.40)	.82 (1.34)	2.14 (1.82)	3.54 (1.84)

The distribution of scores for boys and girls in the two congruent conditions, i.e., auditory phonological and visual orthographic are shown in Figure 19, and Figure 20. In the auditory phonological condition, skewness was .02 for boys and -.85 for girls. As Figure 18 shows the distribution of girls' scores is more heavily weighted towards the upper end with only 18.6% of girls but 42.6% of boys, achieving less than four out of the possible eight in this condition. The two-sample Kolmogorov-Smirnov test showed that in fact the boys' and girls' distributions of scores for the auditory phonological condition differed significantly from each other (p<.05).

In the visual orthographic condition skewness was -.367 for boys and -.667 for girls. 58.8% of boys and 44.1 % of girls scored less than four out of the possible eight. The Kolmogorov-Smirnov two-sample test showed that there was no significant difference in the distributions of scores for boys and girls for the visual orthographic condition.

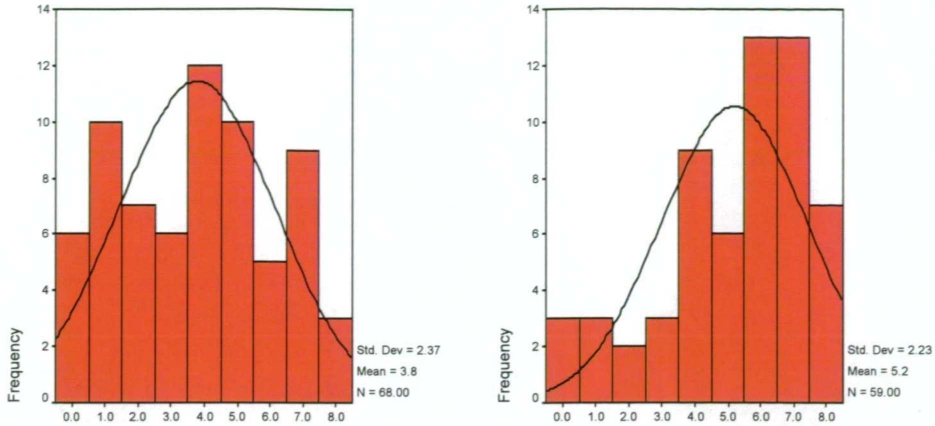

Figure 19. Distribution of scores on the auditory phonological grapheme-phoneme deletion task for boys (left) and girls (right).

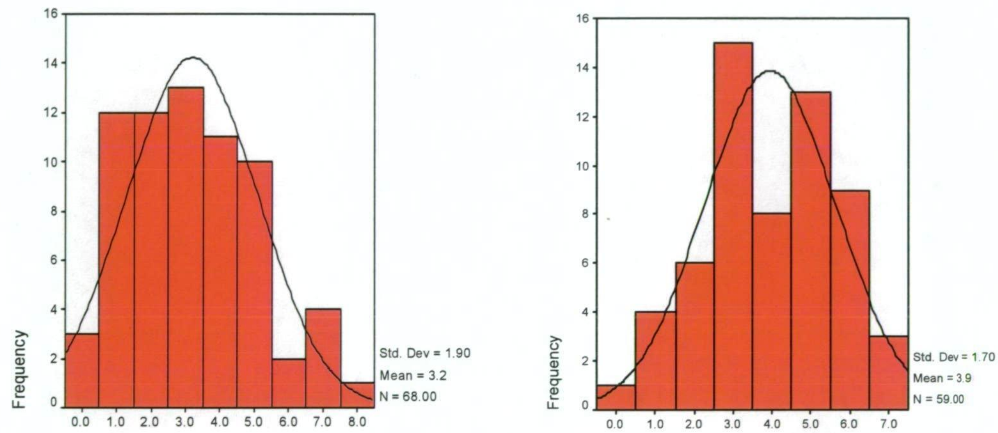

Figure 20. Distribution of scores on the visual orthographic grapheme-phoneme deletion task for boys (left) and girls (right).

The raw response data were analysed with a 2[Sex: boy, girl] x 2 (Presentation: auditory, visual) x 2 (Instructions: orthographic, phonological) repeated measures ANOVA. Overall girls (M = 3.16) performed significantly better than boys (M = 2.36), F (1,125) = 10.99, MSE = 7.45, p <.01.The children were significantly more accurate when phonological instructions were given (M = 3.33) than when orthographic instructions were given (M = 2.20), F (1,125) = 61.93, MSE = 2.09, p <.001.

As shown in Figure 21, the children were significantly more accurate when the instructions given were consistent with the modality of presentation, $F(1,125) = 389.77$, $MSE = 2.09$, $p <.001$. In the auditory presentation modality children scored significantly higher when phonological instructions were given, i.e. when asked to delete a sound from a spoken word ($M = 4.44$) than when inconsistent orthographic instructions were given, i.e., when asked to delete a letter from a spoken word and say what the remaining word spelt ($M = 0.82$), $t(126) = 17.295$, $p <.001$. Similarly in the visual presentation modality children were significantly more accurate with orthographic instructions, i.e. when asked to delete a letter and say what the new word spelt ($M = 3.54$) than with inconsistent phonological instructions, that is. when presented visually with a word being instructed to delete a sound and say how the remaining word would sound ($M = 2.13$).

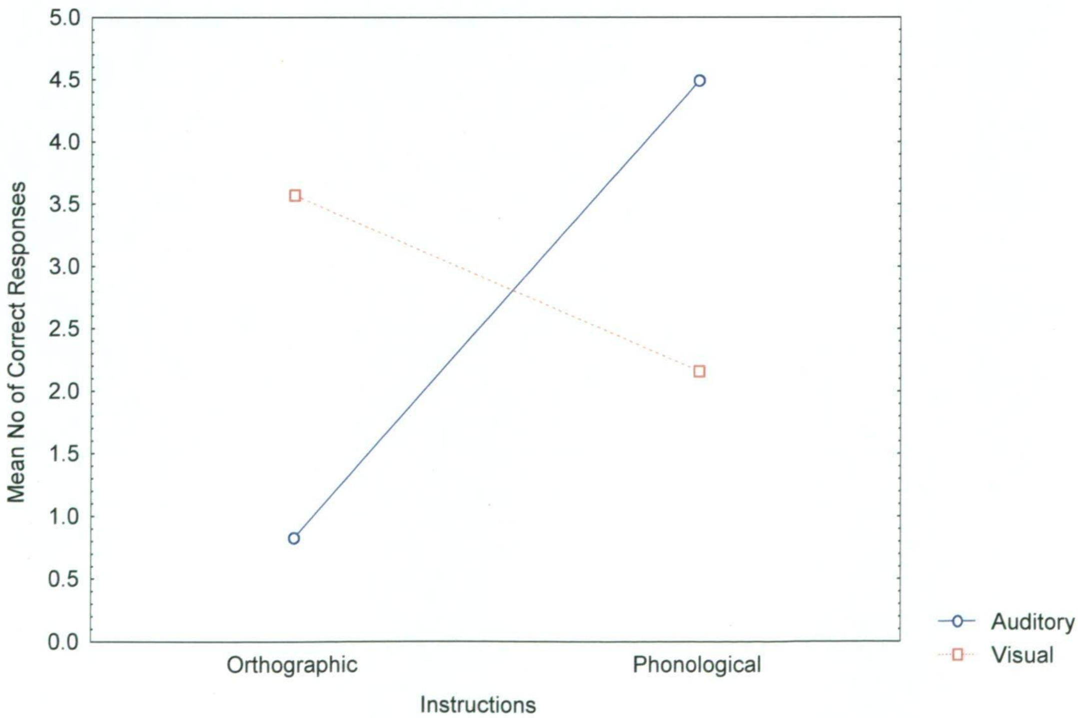

Figure 21. Differences in mean deletion task accuracy for orthographic and phonological instructions across auditory and visual presentation modalities.

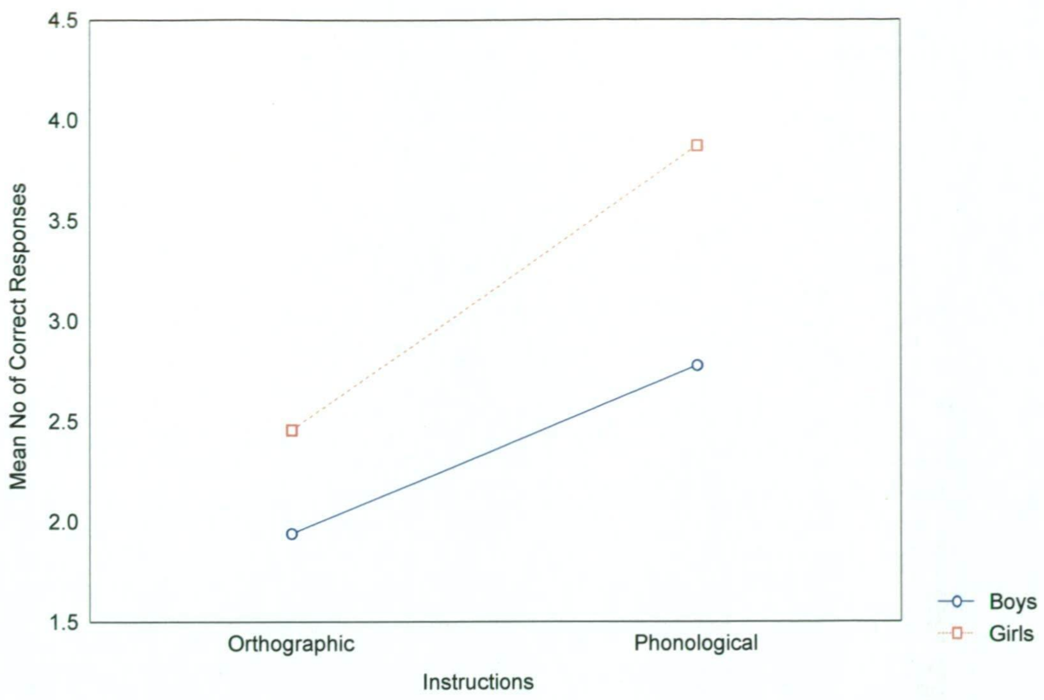

Figure 22. Differences between boys and girls in response to phonological and orthographic instructions

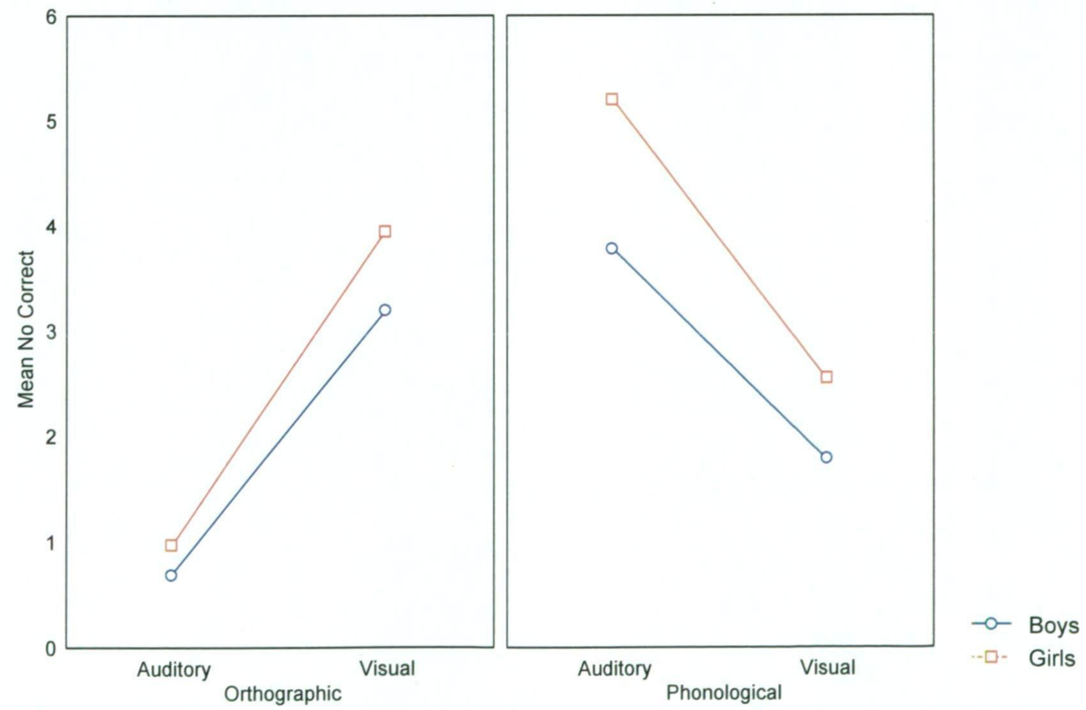

Figure 23. Mean number of correct responses for boys and girls for both orthographic and phonological instructions across auditory and visual presentation modalities.

The sex by instruction interaction was significant and is shown in Figure 22. One-way ANOVAs were used to test for significant differences between means. Girls were significantly more accurate than boys with both phonological and orthographic instructions. Girls (M = 7.74) were significantly more accurate with phonological instructions than boys (M = 5.56), F (1, 125) = - 11.87, $p < .01$ (n^2 =0.09). Girls (M = 4.92) were also significantly more accurate than boys (M = 3.88) with orthographic instructions, F (1, 125) = - 4.58, $p < .05$ (n^2 =0.04).

The sex by instruction by presentation modality interaction was significant, F (1,125) = 4.96, MSE = 2.11, p <.05, and is shown in Figure 22. One-way ANOVAs were used to test for significant differences between boys' and girls' mean scores for each condition. In the congruent conditions girls (M = 7.74) were significantly more accurate in the auditory phonological condition than boys (M = 5.20), F (1, 125) = - 12.07, $p < .01$ (n^2 =0.09), and were also significantly more accurate (M = 3.95) than boys (M = 3.19), F (1, 125) = - 5.54, $p < .05$ (n^2 =0.04) in the visual orthographic task. In the incongruent conditions, in the visual phonological condition girls (M = 2.54) were significantly more accurate than boys (M = 1.78), F (1, 125) = - 5.74, $p < .05$ (n^2 =0.04), however there was no significant difference between boys and girls and the most difficult auditory orthographic task, F (1, 125) = - 1.26, *n.s.*

The finding that children were more accurate in the congruent tasks, with the auditory phonological task (when instructed to delete a sound from a spoken word and say how the new word would sound) and the visual orthographic task (when instructed to delete a letter from a visually presented word and say what the new word would spell) is consistent with Martin, Pratt, Claydon, Morton, and Binns (2003) who proposed that the reduced level of accuracy on incongruent tasks reflects the additional phonological processing load in the incongruent conditions (Gathercole &

Baddeley, 1993). Martin et al. suggest that "the ability to supply accurate inconsistent responses appears to lag four years behind the ability to supply accurate consistent responses" (p.21). Both incongruent tasks were beyond many of the Grade 1 children in the present study, particularly the auditory orthographic task on which over 50% of the children failed to score. This finding is also consistent with Martin et al.'s results for Grade 1 children for whom the auditory orthographic condition was also the most difficult of the four conditions and in their study it remained the most difficult until Grade 5 where there was a shift to the visual phonological being the most difficult. For young children and certainly for the Grade 1 children in the present study it was easier for them to manipulate a visual letter string into an auditory code (the condition that is consistent with the reading process itself) than to manipulate an auditory code into a visual one. In the auditory orthographic incongruent condition the children were obviously handicapped by their lack of secure spelling connections and most were unable to visualise the spelling of the spoken words to enable a successful letter deletion.

That the children were significantly more accurate with phonological instructions than with orthographic instructions suggests that the children at this stage of their reading development rely heavily on phonological strategy use. The children as a group were able to manage to use orthographic instructions in the visual modality indicating that they had developed some level of orthographic strategy competency before the end of Grade 1, but only in the visual modality, not in the incongruent auditory presentation modality which imposed an additional processing load. Martin et al. also found that orthographic strategy use was evident in the children of this age group.

In viewing the differences between boys and girls reflected in these results it appears that boys are lagging behind girls in both the consolidation of phonological strategy use and, as a consequence, in their progression to orthographic strategy use, which can only develop when strong grapheme-phoneme connections are securely established in memory (Ehri, 1997). In viewing the results of the two congruent tasks, the auditory phonological task can be considered the best measure of the children's phonemic awareness, as it does not require the ability to read or spell the words for successful completion of the task, and is comparable with the phoneme deletion task used in the first two phases of this research. Correct performance in the other three conditions of the grapheme-phoneme deletion task is dependent on the child's ability to read and spell the words and their derivatives and children who were unable to read and spell the words were unable to successfully complete the deletions.

The relationship between reading and spelling ability at the end of the second year of school with concurrent phonological awareness predictors (rhyme production and phonemic awareness)

The relationship between the Phase 3 variables which defined the graphemic and phonemic awareness factor, rhyme production, and reading (reading accuracy, irregular word reading, and nonword reading) and spelling ability in Phase 3 were investigated firstly through correlations and secondly in a series of hierarchical multiple regression analysis, firstly for all participants (N = 127), and then separately for boys (n = 68) and girls (n= 59). Rhyme production (as a measure of rhyme awareness), which failed to load onto the graphemic and phonemic awareness factor, but which is an integral part of this research was included in the predictor set to determine its relationship with reading and spelling.

The correlations between the predictor set to be used in the regression analyses and the Phase 3 reading and spelling measures for all participants are shown in Table 27, and separately for boys and girls in Table 28. There were strong relationships between Phases 2 reading measures and the Phase 3 reading and spelling measures (range from .70 to .87). Both rhyme production (in the low .6 range) and phoneme deletion (.61 to .70) were strongly correlated with all the reading and spelling measures. This is in contrast with Phases 1 and 2 in which rhyme awareness (measured by a rhyme detection task) showed significantly weaker relationships with reading and spelling measures than phoneme deletion. The rhyme production task used in Phase 3 measured the children's explicit awareness of rhyme in contrast with the rhyme detection task used in Phases 1 and 2 which measured implicit awareness of rhyme. Explicit awareness of rhyme is strongly related to reading and spelling as is explicit awareness of phonemes.

The most notable difference between boys and girls correlations can be seen in the relationship between rhyme production with each of the reading and spelling measures which is stronger for boys.

Table 27

Correlations of Phase1 - 3 Predictor Measures with Phase 3 Reading and Spelling Outcome Measures for all Children

	Neale Accuracy	Irregular Word Reading	Nonword Reading	Spelling (SAST)
Phase 1	*N*=153	*N*=153	*N*=153	*N*=153
WPPSI IQ	.49**	50**	.46**	.48**
Phase 2	*N*=140	*N*=140	*N*=140	*N*=140
Neale accuracy	.85**	.77**	.77**	.70**
Irregular word Reading	.87**	.80**	.79**	.75**
Nonword Reading	.81**	.77**	.82**	.72**
Spelling (SAST)	.77**	.79**	.79**	.83**
Phase 3	*N*=124	*N*=124	*N*=124	*N*=124
Rhyming	.63**	.63**	.62**	.61**
Phoneme Deletion	.61**	.67**	.66**	.70**
Letter-names	.52**	.58**	.53**	.61**
Letter-sounds	.50**	.54**	.56**	.57**
RAN	.61**	.64**	.59**	.68**

Note. ** $p < .01$

Table 28

Correlations of Phase 1-3 Predictor Measures with Phase 3 Reading and Spelling Outcome Measures at the end of the second year of schooling for Boys and Girls

	Neale Accuracy		Irregular Word Reading		Nonword Reading		Spelling (SAST)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Phase 1	*n*=81	*n*=72	*n*=81	*n*=72	*n*=81	*n*=72	*n*=81	*n*=72
WPPSI IQ	.49**	.51**	.49**	.54**	.49**	.45**	.51**	.48**
Phase 2	*n*=72	*n*=68	*n*=72	*n*=68	*n*=72	*n*=68	*n*=72	*n*=68
Neale accuracy	.86**	.86**	.77**	.83**	.79**	.74**	.70**	.76**
Irregular word Reading	.88**	.86**	.81**	.80**	.81**	.77**	.75**	.78**
NW Reading	.84**	.78**	.78**	.79**	.86**	.77**	.75**	.73**
Spelling (SAST)	.76**	.78**	.76**	.83**	.82**	.76**	.81**	.84**
Phase 3	*n*=68	*n*=59	*n*=68	*n*=59	*n*=68	*n*=59	*n*=68	*n*=59
Rhyming	.70**	.53**	.71**	.51**	.71**	.49**	.71**	.48**
Phoneme deletion	.65**	.55**	.65**	.69**	.70**	.61**	.73**	.63**
Letter-names	.55**	.46**	.60**	.53**	.54**	.50**	.61**	.59**
Letter-sounds	.46**	.60**	.47**	.69**	.51**	.69**	.50**	.68**
RAN	.64**	.55**	.65**	.61**	.60**	.55**	.68**	.65**

Note. ** $p < .01$

As outlined in Chapter 7 the distributions of all reading and spelling measures to be used as dependent variables in the regression analyses were examined and all were normally distributed. The raw scores for all the variables to be used in these regression analyses were converted into Z scores, based on the full sample of children, to ensure comparability of measurement scales across all the variables. As discussed in Chapter 7 (Phase 2) following Bowey (2002) all the following Hierarchical Regression Analyses controlled for Phase 2 scores on each Dependent Variable (i.e., reading accuracy, irregular word reading, nonword reading, and spelling measured at Phase 2) before looking at the best Phase 3 predictors. In each of the following hierarchical regression analyses age was always entered at Step 1, and WPPSI IQ as Step 2, and Phase 2 scores on each Dependent Variable at step 3. The question under review is the relative contributions of concurrent rhyming and graphemic and phonemic awareness abilities to reading and spelling for boys and girls, so these two variables were always entered as the final two steps in each analysis – rhyme production at step 4 and the graphemic and phonemic awareness variables at step 5. The graphemic and phonemic awareness variables were those variables with the highest loadings on the graphemic and phonemic awareness factor, that is, phoneme deletion, letter-name knowledge, letter-sound knowledge, and RAN (see Table 30). Phoneme deletion in the auditory phonological condition, the condition comparable with the phoneme deletion tasks used in Phases 1 and 2, is used in these analyses and is referred to simply as phoneme deletion.

Concurrent Predictors of Reading Accuracy at the end of the Second Year of School

The first series of hierarchical regression analyses shown in Tables 29, assessed the predictive relationship between Phase 3 age, WPPSI IQ, (measured in Phase 1), Phase 2 reading accuracy, Phase 3 rhyme production, and the graphemic and phonemic awareness variables (phoneme deletion, letter-name and letter-sound knowledge, and RAN) with Phase 3 reading accuracy (Neale Analysis of Reading).

Table 29

Summary of Hierarchical Regression Analyses for Concurrent Rhyme Production and Graphemic and Phonemic awareness Variables Predicting Reading Accuracy Ability at the end of the Second Year of School

	All Children (N = 124)			Boys (n = 65)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.033*			.018			.054
Age	.61(.30)	.18*		.54(.49)	.14		.66(.36)	.23	
Step 2			.224***			.236***			.222***
Age	.31(.27)	.09		..22(.44)	.05		.37(.33)	.13	
WPPSI IQ[a]	.55(.09)	.48***		.61(.14)	.49***		.49(.12)	.48***	
Step 3			.492***			.517***			.499***
Age	.28(.16)	.08		.05(.25)	.01		.47(.18)	.17*	
WPPSI IQ[a]	.19(.06)	.17**		.23(.08)	.18**		.10(.08)	.10	
P2 R Acc	.75(.05)	.77***		.69(.06)	.79***		.99(.09)	.80***	
Step 4			.030***			.057***			.002
Age	.34(.15)	.10*		.12(.22)	.03		.49(.19)	.17*	
WPPSI IQ[a]	.08(.06)	.07		.06(.08)	.05		.08(.08)	.08	
P 2 R Acc	.67(.05)	.69***		.58(.06)	.67***		.96(.10)	.78***	
P3 Rhyme Pro	.23(.06)	.23***		.34(.08)	.32***		.05(.08)	.05	
Step 5			.052***			.043**			.031
Age	.17(.14)	.05		.00(.20)	.00		.32(.19)	.11	
WPPSI IQ[a]	.04(.06)	.04		.02(.08)	.02		.05(.09)	.05	
P 2 R Acc	.59(.05)	.61***		.52(.05)	.59***		.88(.11)	.71***	
Rhyme Pro	.04(.02)	.12*		.19(.08)	.18*		.00(.08)	.00	
Phoneme D	.16(.05)	.15**		.18(.07)	.16*		.10(.08)	.10	
Letter –names	-.01(.06)	-.01		.00(.09)	.00		-.06(.11)	-.06	
Letter-sounds	.04(.05)	.04		.03(.06)	.04		.07(.15)	.05	
RAN	.16(.06)	.16*		.16(.08)	.16*		.17(.12)	.16	
Total variance explained			83.1%			87.1%			80.8%

Note. P 2 R Acc = Phase 2 Reading accuracy, Rhyme Pro = Rhyme Production, Phoneme D = Phoneme Deletion [a] measured in Phase 1
*p<.05, **p<.01, ***p<.001

For the combined sample of boys and girls, shown in Table 29, all the variables entered made significant additional contributions at the stage at which they are entered and the model accounted for 83% of the total variance in Phase 3 reading accuracy scores. Phase 2 reading accuracy scores were the most powerful predictor of Phase 3 reading accuracy accounting for an additional 49.2% of the total variance at step 3 and retaining this significant effect as a predictor at step 5 (β =.61, $p < .001$). Rhyme production made a significant incremental improvement in prediction additional to Phase 2 reading accuracy at step 4 and the significant effect of rhyme production was retained after the inclusion of the graphemic and phonemic awareness variables (β =.12, p =.05). Of the block of graphemic and phonemic awareness variables at step 5, phoneme deletion ability (β =.20, $p < .01$), and RAN scores were significant predictors (β =.16, p =.05).

Regression analyses run separately for boys revealed that all the variables entered into the regression equation, except for age, made significant contributions at the stage that they were entered, with the model accounting for 87.2% of the total variance in Phase 3 reading accuracy. The analysis for girls showed that WPPSI IQ, and Phase 2 reading accuracy scores were the only variables to add significant variance on entry, with the model accounting for 80.8% of the total variance.

Phase 2 reading accuracy scores were the most powerful predictor for boys accounting for an additional 51.7% of the variance in Phase 3 reading accuracy scores at step 3 and retaining this significant effect at step 5 after the inclusion of rhyme production and the graphemic and phonemic awareness variables (β =.60, $p < .001$). Rhyme production made a significant incremental improvement in prediction additional to Phase 2 reading accuracy scores and retained its significant effect after inclusion of the graphemic and phonemic awareness variables (β =.18, $p < .05$). The graphemic and phonemic awareness variables accounted for an additional 4.3% of the total variance in boys' Phase 3 reading accuracy scores. Of the graphemic and phonemic awareness variables both phoneme deletion ($\beta = .16, p < .05$) and RAN ($\beta = .16, p < .05$) were significant predictors.

For girls the only significant predictor of reading accuracy at the end of their second year of schooling was their Phase 2 reading accuracy scores accounting for 49.9% of the total variance at step 3 and retaining its significant effect at step 5 ($\beta = .71, p < .001$). Neither rhyme production (which accounted for 0.2% of the total variance at step 4) nor the graphemic and phonemic awareness variables (which accounted for 3.1% of the total variance at step 5) accounted for further significant variance in girls' Phase 3 reading accuracy scores, suggesting that by the end of their second year of schooling girls as a group have developed beyond dependence on sublexical or phonological processing strategies.

Table 29 highlights differences between boys and girls with the graphemic and phonemic awareness and rhyme variables accounting for a greater % of the total variance in reading accuracy in boys (10%) than in girls (3.3%). For boys rhyme production, phoneme deletion, and RAN were all significant predictors of reading accuracy at the end of the second year of schooling whereas for girls none of the graphemic and phonemic awareness or rhyme production was a significant predictor. Although the coefficient of RAN was the same for girls as it was for boys, with the smaller number it fell below the level of significance.

The Relationship between Irregular Word Reading and Nonword Reading at the end of the Second Year of School with Concurrent Phonological Awareness Predictors – Early Phonological Awareness, and Graphemic and Phonemic Awareness

Regression analyses were run for the full sample of children and for boys and girls separately to investigate the role of different concurrent phonological abilities as predictors of irregular word and nonword reading at the end of the second year of schooling. As with the series of analyses for reading accuracy, Phase 3 chronological age was entered at step 1, and WPPSI IQ (measured in Phase 1) was entered at step 2, as preliminary controls. Phase 2 irregular or nonword reading was entered at step 3 to control for the autoregressive effects of previous irregular word or nonword reading ability. The Phase 3 phonological variables were entered last, rhyme production at step 4, and the block of graphemic and phonemic awareness variables at step 5.

Concurrent Predictors of Irregular Word Reading at the end of the Second Year of School

The analysis for all children, shown in Table 30, showed that all variables made significant additional contributions at the stage they were entered accounting for 80.2% of the total variance in irregular word reading at the end of the second year of school.

Table 30

Summary of Hierarchical Regression Analysis for Concurrent Rhyme Production and Graphemic and Phonemic Awareness Variables Predicting Irregular Word Reading Ability at the end of the Second Year of School

	All Children (*N* = 124)			Boys (*n* = 65)			Girls (*n* = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.033*			.012			.073*
1. Age	.62(.30)	.18*		.45(.51)	.11		.73(.34)	.27*	
Step 2			.225***			.229***			.248***
Age	.31(.27)	.09		.13(.45)	.03		.43(.30)	.16	
WPPSI IQ[a]	.56(.09)	.48***		.62(.14)	.49***		.50(.11)	.51***	
Step 3			.419***			.445***			.384***
Age	.25(.18)	.08		.01(.29)	.00		.42(.20)	.16*	
WPPSI IQ[a]	.22(.07)	.19**		.25(.10)	.20*		.18(.08)	.18*	
P2 Irregular	.70(.06)	.71***		.67(.07)	.73***		.77(.09)	.70***	
Step 4			.030**			.072***			.000
Age	.33(.17)	.10		.08(.26)	.02		.43(.21)	.16*	
WPPSI IQ[a]	.11(.07)	.10		.06(.10)	.05		.17(.09)	.18	
P 2 Irregular	.61(.06)	.62***		.54(.07)	.58***		.76(.10)	.69***	
Rhyme Pro	.24(.07)	.23**		.39(.09)	.36***		.02(.09)	.02	
Step 5			.095***			.054**			.124***
Age	.13(.15)	.04		-.03(.25)	-.01		.18(.18)	.07	
WPPSI IQ[a]	.04(.06)	.03		-.01(.09)	-.00		.11(.08)	.11	
P 2 Irreg	.50(.05)	.51***		.46(.07)	.50***		.59(.09)	.54***	
Rhyme Pro	.11(.06)	.11		.23(.10)	.21*		-.07(.08)	-.08	
Phoneme D	.25(.06)	.25***		.21(.09)	.19*		.29(.08)	.31***	
Letter –names	.03(.07)	.03		.08(.11)	.08		-.18(.10)	-.20	
Letter-sounds	.08(.06)	.08		.06(.07)	.07		.29(.14)	.23*	
RAN	.11(.07)	.11		.08(.10)	,08		.15(.11)	.15	
Total variance explained			80.2%			81.2%			82.9%

Note. P 2 Irregular = Phase 2 Irregular word reading, Rhyme Pro = Rhyme Production, Phoneme D = Phoneme Deletion [a]measured at Phase 1.
*p<.05, **p<.01, ***p<.001

As shown in Table 30 Phase 2 irregular word reading was the most powerful of Phase 2 irregular word reading, accounting for 41.9% of the total variance at step 3 and retaining this significant effect as a predictor at step 5 after the inclusion of rhyme production and the graphemic and phonemic awareness variables ($\beta = .51, p < .001$). Rhyme production at step 5 failed to make a significant incremental improvement in prediction additional to Phase 2 irregular word reading ($\beta = .11$, *n.s.*) The block of graphemic and phonemic awareness variables entered at step 5 accounted for an additional 9.5% of the total variance with phoneme deletion ($\beta = .22, p < .01$) the only significant concurrent graphemic and phonemic awareness predictor of irregular word reading at the end of the second year of school.

The analysis for boys, (see Table 30) showed that all variables, with the exception of age, accounted for additional significant variance in Phase 3 irregular word reading scores at the stage at which they were added into the equation with the model accounting for 81.2% of the total variance. For boys Phase 2 irregular word reading scores accounted for an additional 44.5% of the total variance at step 3 in Phase 3 irregular word reading and retained this significant effect as a predictor at step 5 ($\beta = .50, p < .001$). Rhyme production scores for boys made a significant incremental improvement in prediction additional to Phase 2 irregular word reading and retained this significant effect as a predictor following the inclusion of the graphemic and phonemic awareness variables at step 5 ($\beta = .51, p < .001$). The graphemic and phonemic awareness variables accounted for a further significant 5.4% of the total variance in boys' Phase 3 irregular word reading with phoneme deletion the only significant predictor ($\beta = .19, p < .05$).

The analysis for girls, (also see Table 30) showed that only WPPSI IQ, Phase 2 irregular word reading scores and the graphemic and phonemic awareness variables accounted for additional significant variance in Phase 3 irregular word reading scores when added into the equation with the model accounting for 82.9% of the total variance. For girls, as with the full sample and boys' analyses, Phase 2 irregular word reading scores accounted for a large additional percentage of the total variance (38.4%) at step 3 in Phase 3 irregular word reading and retained this significant effect as a predictor at step 5 (β =.54, $p < .001$) after inclusion of rhyme production and the graphemic and phonemic awareness variables. In contrast to the boys analysis rhyme production failed to make any significant incremental improvement additional to Phase 2 irregular word reading for girls. The graphemic and phonemic awareness variables accounted for a further 12.4% of the total variance in girls' Phase 3 irregular word reading scores with both phoneme deletion (β =.31, $p < .001$) and letter-sound knowledge (β =.23, $p < .05$) significant predictors.

The separate analyses for boys and girls highlight a greater importance of rhyming strategies in boys' irregular word reading. Rhyme production accounted for a significant additional 7% of the variance in boys' irregular word reading scores, whereas it's contribution was not significant for girls (0%) and the difference between the two percentages was significant, $p<.05$. Graphemic and phonemic awareness accounted for a greater proportion of the total variance in Phase 3 irregular word reading for girls (12.4%) than for boys (5.4%), *n.s.*, and this difference can be seen in the additional variance for boys accounted for by rhyme production.

Concurrent Predictors of Nonword Reading at the end of the Second Year of School

This series of regression analyses, shown in Table 31, assessed the predictive relationships between Phase 3 chronological age, WPPSI IQ (measured in Phase 1), Phase 2 nonword reading, Phase 3 rhyme production, and the Phase 3 graphemic and phonemic awareness variables (phoneme deletion, letter-name and letter-sound knowledge and RAN) with Phase 3 nonword reading at the end of the children's second year of formal schooling.

The analysis for all children, shown in Table 31 revealed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 78.6% of the total variance in nonword reading at the end of the second year of school. For the full sample of children Phase 2 nonword reading accounted for an additional 46.8% of the total variance at step 3 in Phase 3 nonword word reading and retained this significant effect as a predictor at step 5 (β =.55, $p <$ .001) following the inclusion of rhyme production and the graphemic and phonemic awareness variables. Of the block of graphemic and phonemic awareness variables phoneme deletion (β =.38, $p <$ .001) was the only significant predictor, although letter-sound knowledge was close to significance (β =.11, p =.05), as was RAN (β =.13, p = .07).

The separate boys' analysis also showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 83.2% of the total variance in nonword reading at the end of the second year of school. For boys Phase 2 nonword reading accounted for an additional 46.8% of the total variance at step 3 in Phase 3 nonword word reading and retained this significant effect as a predictor at step 5(β =.55, $p <$ .001). Of the phonological awareness variables under review only rhyme production made a significant incremental improvement in prediction additional to Phase 2 nonword reading at step 4 and its significance as a predictor was retained following the inclusion of the graphemic and phonemic awareness variables (β =.20, $p <$ .05). The block of graphemic and phonemic awareness variables failed to add any significant improvement in the prediction of boys Phase 3 nonword reading at step 5.

Table 31

Summary of Hierarchical Regression Analysis for Concurrent Rhyme Production and Graphemic and Phonemic awareness Variables Predicting Nonword Reading Ability at the end of the Second Year of School

	All Children (N = 124)			Boys (n = 65)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.031			.013			.061
1. Age	.60(.30)	.18		.45(.50)	.11		.70(.36)	.25	
Step 2			.204***			.247***			.165**
Age	.30(.28)	.09		.12(.44)	.03		.45(.34)	.16	
WPPSI IQ[a]	.53(.09)	.46***		.63(.14)	.50***		.42(.12)	.42**	
Step 3			.468***			.498***			425***
Age	.22(.17)	.06		-.04(.25)	-.01		.39(.23)	.14	
WPPSI IQ[a]	.20(.06)	.17**		.21(.09)	.17*		.19(.09)	.18*	
P 2 Non Word	.73(.05)	.74***		.72(.07)	.79***		.76(.09)	.69***	
Step 4			.020**			.043**			.002
Age	.28(.17)	.08		.02(.23)	.01		.42(.24)	.15	
WPPSI IQ[a]	.11(.07)	.09		.08(.09)	.06		.16(.10)	.16	
P 2 Non Word	.65(.06)	.66***		.60(.07)	.66***		.74(.10)	.67***	
Rhyme Pro	.20(.07))	.19**		.31(.09)	.29**		.05(.10)	.05	
Step 5			.063***			.031*			.10**
Age	.13(.16)	.04		-.03(.23)	-.01		.23(.22)	.08	
WPPSI IQ[a]	.05(.06)	.04		.04(.09)	.03		.13(.10)	.13	
P 2 Non Word	.53(.06)	.55***		.51(.07)	.55***		.56(.10)	.51***	
Rhyme Pro	.11(.06)	.11		.22(.09)	.20*		-.03(.09)	-.04	
Phoneme D	.16(.06)	.15*		.15(.09)	.14		.11(.10)	.11	
Letter –names	.00(.07)	.00		-.02(.10)	-.02		-.11(.130	-.12	
Letter-sounds	.11(.06)	.11		.07(.07)	.08		.47(.17)	.36**	
RAN	.13(.07	.13		.12(.09)	.13		.08(.13)	.08	
Total variance explained			78.6%			83.2%			75.3%

Note. P 2 Non Word = Phase 2 Nonword Reading, Rhyme Pro = Rhyme Production, Phoneme D = Phoneme Deletion [a] measured in Phase 1.
*p<.05, **p<.01, ***p<.001

The analysis for girls, also shown in Table 31, revealed that only WPPSI IQ, Phase 2 nonword reading and the graphemic and phonemic awareness variables made significant additional contributions at the stage they were entered accounting for 75.3% of the total variance in nonword reading at the end of the second year of school. For girls Phase 2 nonword reading accounted for an additional 42.5% of the total variance at step 3 in Phase 3 nonword reading and retained this significant effect as a predictor at step 5 (β =.51, $p < .001$). The graphemic and phonemic awareness variables accounted for an additional 10% of the total variance with letter-sound knowledge (β =.36, $p < .01$) the only significant predictor. Rhyme production failed to make any significant incremental improvement in prediction at step 4 for girls.

In summary, the most powerful predictor of reading (accuracy, irregular word and nonword reading) for boys and girls was their reading ability measured at the end of their first year of schooling. Of the phonological awareness variables under review some differences regarding use of phonological awareness strategies in reading have been uncovered by these analyses. For boys' their concurrent rhyme production scores accounted for a significant proportion of the total variance in all three reading measures additional to the effects of their reading ability at the end of their first year of school. In contrast, for girls, rhyme production accounted for no significant additional variance for any of the reading measures.

Concurrent Predictors of Spelling at the end of the First Year of School

This series of regression analyses, shown in Table 32, assessed the predictive relationships between Phase 3 age (step 1), WPPSI IQ (step 2), Phase 2 spelling as measured by the SAST (step 3) rhyme production (step 4), and the graphemic and phonemic awareness variables (phoneme deletion, letter-name, letter-sound knowledge, and RAN) (entered as a block at step 5), with Phase 3 spelling ability

(SAST) measured at the end of the children's second year of formal schooling. For the combined sample of boys and girls all the variables entered, made significant additional contributions at the stage when they were entered and the model accounted for 79.7% of the total variance in spelling scores at the end of the second year of formal schooling. Phase 2 SAST scores accounted for an additional 43.1 % of the total variance at step 3 in Phase 3 spelling and retained this significant effect as a predictor at step 5 (β =.47, $p < .001$). Rhyme production made a significant incremental improvement in prediction additional to Phase 2 SAST at step 4 and retained this significant effect as a predictor following the inclusion of the graphemic and phonemic awareness variables at step 5 (β =.19, $p < .05$). Of the graphemic and phonemic awareness variables both phoneme deletion (β =.18, $p < .01$) and RAN (β =.16, $p < .05$) were significant concurrent predictors of spelling performance at the end of the children's second year of schooling.

Table 32

Summary of Hierarchical Regression Analysis for Concurrent Rhyme Production and Graphemic and Phonemic awareness Variables Predicting Spelling Ability at the end of the Second Year of School

	All Children (N = 124)			Boys (n = 65)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.054*			.032			.089*
Age	.78(.30)	.23*		.70(.49)	.18		.81(.34)	.30	
Step 2			.225***			289***			.184***
Age	.48(.27)	.14		.35(.42)	.09		.56(.32)	.21	
WPPSI IQ[a]	.55(.09)	.48***		.68(.13)	.55***		.43(.12)	.44***	
Step 3			.431***			.378***			.469***
Age	.25(.17)	.07		-.02(.29)	-.00		.49(.19)	.18*	
WPPSI IQ	.19(.06)	.16**		.30(.10)	.24**		.06(.08)	.06	
P 2 SAST	.74(.06)	.74***		.70(.08)	.70***		.80(.08)	.78***	
Step 4			.021**			.058***			.000
Age	.33(.17)	.10		.10(.26)	.03		.50(.20)	.19*	
WPPSI IQ[a]	.10(.07)	.09		.14(.09)	.12		.05(.09)	.05	
P 2 SAST	.66(.06)	.66***		.55(.08)	.55***		.79(.09)	.78***	
Rhyme Pro	.20(.07)	.19**		.35(.09)	.33***		.02(.08)	.02	
Step 5			.066***			.065**			.043
Age	.20(.15)	.06		.07(.24)	.02		.33(.20)	.12	
WPPSI IQ[a]	.06(.06)	.05		.09(.09)	.08		.02(.09)	.02	
P 2 SAST	.47(.06)	.47***		.39(.08)	.40***		.65(.11)	.64***	
Rhyme Pro	.12(.06)	.12*		.22(.09)	.21*		-.09(.08)	-.01	
Phoneme D	.18(.06)	.18**		.23(.09)	.21*		.10(.09)	.10	
Letter –names	.00(.07)	.01		-.03(.10)	-.03		-.01(.11)	-.01	
Letter-sounds	.10(.06)	.10		.10(.07)	.11		.03(.16)	.02	
RAN	.16(.07)	.16*		.16(.09)	.17		.21(.12)	.21	
Total variance explained			79.7%			82.2%			78..5%

Note. P 1 R to R = Phase 1 Ready to Read, Rhyme Pro = Rhyme Production, Phoneme D = Phoneme Deletion [a]measured in Phase 1
*p<.05, **p<.01, ***p<.001

Separate regression analyses, shown in Table 32, were run for boys and for girls using the same predictors, as outlined above and these showed differences between boys and girls in the importance of rhyme awareness (rhyme production) and graphemic and phonemic awareness. For boys all the variables entered, except for age, made significant additional contributions to Phase 3 spelling at the stage at which they were entered, with the model accounting for 82.2% of the total variance in Phase 3 spelling scores. Phase 2 SAST scores accounted for an additional 37.8% of the total variance at step 3 in Phase 3 SAST and retained this high level of significance as a predictor at step 5 ($\beta = .40, p < .001$). For boys rhyme production made a significant incremental improvement in prediction additional to Phase 2 SAST at step 4 and retained this significance level following the inclusion of the graphemic and phonemic awareness variables at step 5 ($\beta = .21, p < .05$). Of the graphemic and phonemic awareness variables only phoneme deletion ($\beta = .21, p < .05$) was a significant concurrent predictors of boys' spelling performance at the end of the second year of schooling.

For girls all the variables, except for rhyme production, made significant additional contributions to Phase 3 spelling at the stage at which they were entered and the model accounted for 78.5% of the total variance. For girls only Phase 2 SAST scores accounted for an additional 46.9% of the total variance at step 3 in Phase 3 SAST and retained this high level of significance as a predictor at step 5 ($\beta = .64, p < .001$). Neither rhyme production ($\beta = -.01$, *n.s*) nor the graphemic and phonemic awareness variables, accounted for significant additional variance in girls' Phase 3 spelling scores additional to Phase 2 SAST scores.

In summary, as was the case with the Phase 2 measures of reading accuracy, irregular word and nonword reading for boys and girls, the most powerful predictor of spelling was the children's spelling ability measured at the end of their first year of schooling. Of the phonological awareness variables under review the differences regarding use of phonological awareness strategies in reading, have been replicated in these analyses of spelling. For boys concurrent rhyme production scores accounted for a significant proportion of the total variance in spelling scores at the end of their second year of schooling, additional to their spelling ability at the end of their first year of school, as was the case for all three reading measures additional to their reading ability at the end of their first year of school. In contrast, for girls, rhyme production accounted for no significant additional variance for any of the reading or spelling measures. As was the case with reading accuracy none of the phonological awareness variables accounted for any significant variance in girls' spelling ability at the end of their second year of schooling, reinforcing the conclusion drawn in relation to reading accuracy, that by the end of their second year of schooling girls as a group have developed beyond dependence on sublexical or phonological processing strategies, although they are still relying to some extent on graphemic and phonemic awareness strategies for both irregular word and nonword reading.

CHAPTER 9

The Empirical Study –Longitudinal Analysis

The aim of the longitudinal analysis was firstly to identify differences between boys and girls over the two years of the study in phonemic awareness, rhyme awareness, alphabet knowledge, reading, and spelling, and secondly to assess the relative importance for boys and girls of phonological abilities, measured in the first two phases, in predicting reading and spelling performance at the end of the children's first and second years of formal schooling.

The phonemic awareness variables used were those which loaded on to the graphemic and phoneme awareness factor in Phase 1 (letter-name knowledge, letter-sound knowledge, and phoneme deletion), in Phase 2 (letter-name knowledge, letter-sound knowledge, phoneme deletion, and RAN), and in Phase 3 (letter-name knowledge, letter-sound knowledge, RAN, and phoneme deletion). Although mixed-case symbol matching also loaded on to the phoneme awareness factor in Phase 1 it was not used in any of the longitudinal analyses.

The rhyme awareness variables, rhyme detection (measured in Phases 1 and 2) and rhyme production (measured in Phase 3), failed to load onto the graphemic and phonemic awareness factor in any phase, however, as rhyme awareness forms an integral part of this research they were also used in all the longitudinal analyses. The failure of rhyme awareness to load onto the graphemic and phonemic awareness factor in any phase strongly suggests that the rhyming tasks were measuring a different phonological ability to the phonemic awareness tasks such as phoneme deletion. It also highlights the important relationship between letter-name and letter-sound knowledge and phonemic awareness but not between letter-name and letter-sound knowledge and rhyme detection which can be a well-developed skill without letter-sound familiarity. Although phonological processing measures were also assessed in Phase 1 the focus of this analysis is on phonological awareness skills, that is, graphemic and phonemic awareness and rhyme awareness.

An overview of Phases 1, 2, and 3 in relation to the longitudinal analysis

The means and standard deviations for all measures from each phase of the empirical study are presented in Chapters 6 (Table 2), 7 (Table 7), and 8 (Table 20). Kolmogorov-Smirnov two-sample tests showed that there was no significant difference between boys' and girls' distributions of scores on any of the Phase 1 and 2 individual variables under review in this longitudinal analysis. However there were significant differences between boys' and girls' distributions of scores on some of the Phase 3 variables. These were letter-sound knowledge ($p<.05$), Neale Accuracy ($p<.05$), RAN ($p<.05$), and phoneme deletion ($p<.05$).

Examination of histograms for these four variables showed that for letter-sound knowledge, shown in Figure 24, both boys' and girls' distributions were clustered at the upper end, as would be expected by the end of Grade 1, however the boys' distribution also showed a longer tail. The Mann-Whitney U Test showed that girls' Phase 3 letter-sound scores were significantly higher than boys' Phase 3 Letter-sound scores, Z = -3.27, $p<.01$. For Neale Accuracy, shown in Figure 25, both distributions were positively skewed with the boys' distribution being relatively flat with a greater number of extreme cases (both upper and lower) than the girls' distribution which was more peaked with thinner tails, however the Mann-Whitney U Test showed that there was no significant difference between boys' and girls' Phase 3 Neale Accuracy scores, Z = -1.32, n.s. For RAN (z scores with sign reversed), shown in Figure 26, both boys' and girls' scores were skewed towards the upper end with long thin tails at the lower end, and the Mann-Whitney U Test showed that girls had significantly faster RAN letter scores than boys, Z = -2.86, $p<.01$. For phoneme deletion, shown in Figure 27, boys scores were clustered at the lower end of the distribution which was relatively flat, while girls' scores clustered at the upper end of the distribution and the Mann-Whitney U Test showed that girls' phoneme deletion scores were significantly higher than boys' phoneme deletion scores, Z = -3.37, $p<.01$. Such differences between boys and girls serve to highlight the differences which are the focus of this research.

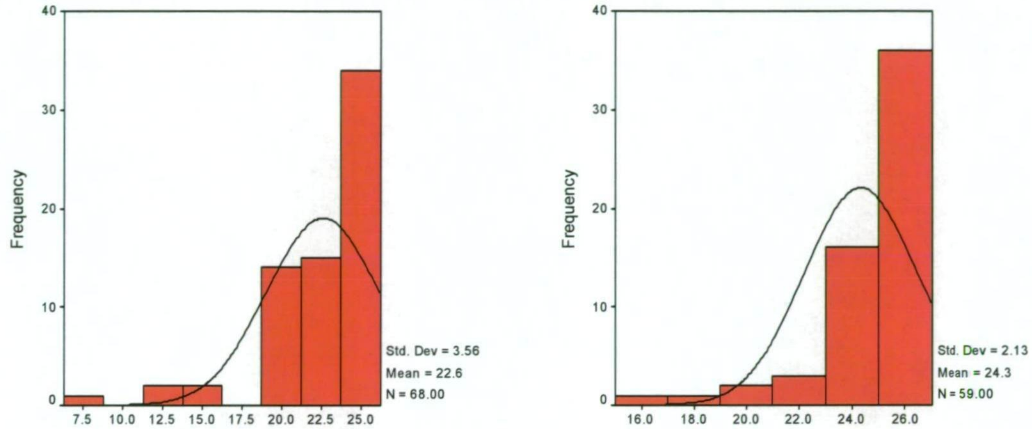

Figure 24. Distribution of Phase 3 letter-sound scores for boys (left) and girls (right).

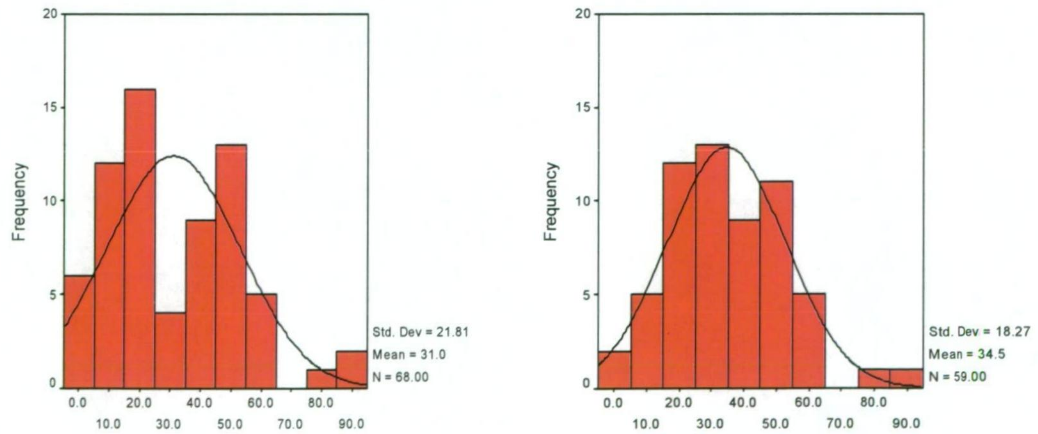

Figure 25. Distribution of Phase 3 Neale Accuracy scores for boys (left) and girls (right).

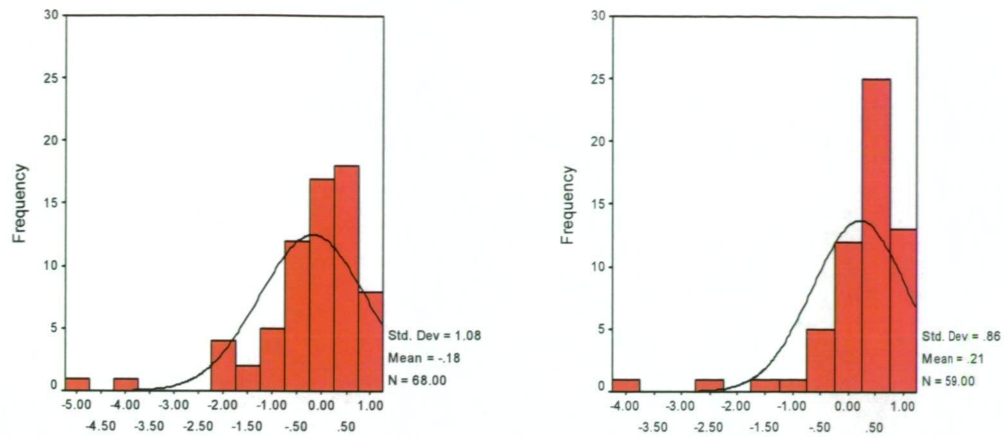

Figure 26. Distribution of Phase 3 RAN z (sign reversed) scores for boys (left) and girls (right).

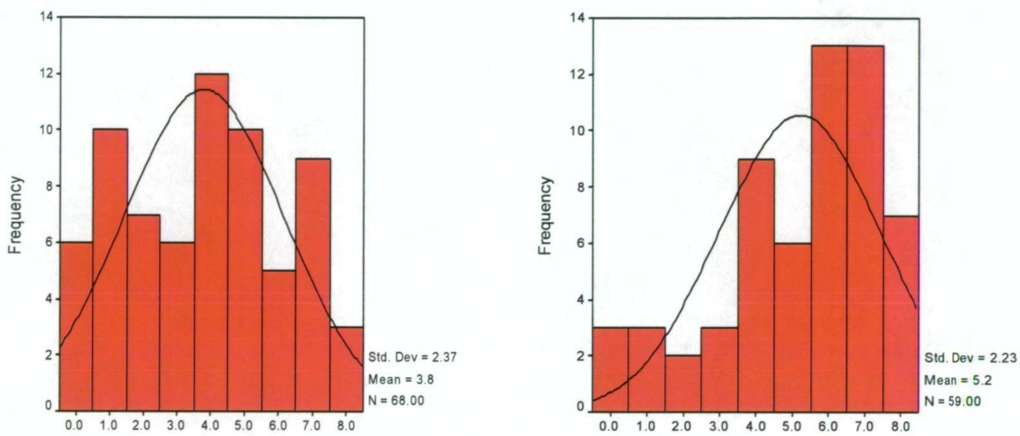

Figure 27. Distribution of Phase 3 phoneme deletion scores for boys (left) and girls (right).

In Phase 1 the children were in the very early stages of learning to read. Phase 1 testing, as outlined in Chapter 6, was conducted during the children's first three months of formal schooling. Overall the sample of children was of average cognitive ability as assessed by the WPPSI short-form IQ (M = 107.1, SD = 14.55). Approximately 36% of the children were nonreaders (39.5% of the boys and 32% of the girls). Only one child (a boy) was unable to score on the rhyme detection test while 24.5% (25.9% of the boys and 26.4% of the girls) were at ceiling. Approximately 22% of the children (25.9% of the boys and 18% of the girls) were unable to score on the phoneme deletion test in Phase 1 while 6.1% (6.2% of the boys and 6.9% of the girls) were at ceiling. The children knew on average 16 letter-names and 13 letter-sounds.

By Phase 2, approximately eight months later, at the end of their first year of formal reading instruction, the children had made substantial gains in their reading and phonological abilities. The children on average were able to read 24 words from the Woodcock Word Identification Test, read 10 irregular words, decode 10 nonwords, and spell 13 words from the SAST. At Phase 2, on the Neale Analysis of Reading ability test of reading accuracy, 28% of the boys and 22% of the girls were at or above the 75th percentile, while 32% of the boys and 22% of the girls were at or below the 25th percentile. The children were able to identify correctly, on average, 22 letter-names, and 22 letter-sounds. While just 1.4% of children failed to score on the rhyme detection test at Phase 2, 54% of children had reached ceiling (51% of the boys and 55.9% of the girls). On the phoneme deletion test 16% of the children failed to score (22% of the boys and 10% of the girls) with 39% of the children reaching ceiling (35% of the boys and 44% of the girls).

As many of the children had reached ceiling on the rhyme detection and phoneme deletion tests in Phase 2, these tests were replaced in Phase 3 with a more difficult rhyme production test and a more demanding phoneme deletion test which required the children to delete beginning, end, and internal sounds from the target words. Both the Phase 3 rhyme production and phoneme deletion tests provided a much better differentiation of abilities with a normal distribution of scores. In the Phase 3 rhyme production test 4.7% (4.4% of the boys and 5.1% of the girls) were at floor while 17.3% (17.6% of the boys and 16.1% of the girls) were at ceiling. In the phoneme deletion test 7.1% of all the children (8.8% of the boys and 5.1% of the girls) were at floor and 7.9% (4.4% of the boys and 17.3% of the girls) were at ceiling.

By Phase 3, at the end of Grade 1, and 12 months after Phase 2, the children could read an average of 23 irregular words, decode an average of 21 nonwords, and spell an average of 23 words from the SAST, and the children knew, on average, 24.4 letter-names and 23.4 letter-sounds.

In Phase 3, on the Neale Analysis of Reading Test of reading accuracy, 32.6% of the boys but just 12% of the girls were at or below the 25th percentile based on the test norms and this difference between percentages was significant, $p<.05$, while 41% of the boys and 42% of the girls were at or above the 75th percentile indicating no difference between boys and girls in the higher achieving range of scores but a significantly greater proportion of boys in the lower achieving range. When compared with the percentages of boys and girls in the bottom 25% of the distribution of Neale accuracy scores in Phase 2 there are now a similar proportion of boys but fewer girls who are underachieving in reading. 10% of the girls who were in the bottom 25% in Phase 2 were now achieving at a level above the 25th percentile.

Differences between boys and girls over time on phonological awareness, knowledge of alphabet names and sounds, reading and spelling

Differences between boys and girls over time on phonological skills

Differences between boys and girls over the first two years of formal schooling in the development of rhyme awareness and phonemic awareness were analysed with a 2[Sex: boys, girls] x 3[Time: Phase 1, Phase 2, Phase 3] x 2(Phonological Awareness: rhyme ability, phoneme deletion ability) mixed design Analysis of Variance. Z scores were used for this analysis to ensure comparability of measurement scales across the two phonological awareness variables. Z scores were calculated separately for each phase. The sex by phonological awareness interaction, shown in Figure 28, was significant, $F(1,122) = 7.57$, $p < .01$, and Tukey HSD post hoc tests indicated that over the three phases of the study girls ($M = .21$) were significantly more accurate on the phoneme deletion task than boys ($M = -.16$). There was no difference over the three phases of the study between boys' and girls' rhyme detection (Phases 1 and 2) and rhyme production (Phase 3) ability.

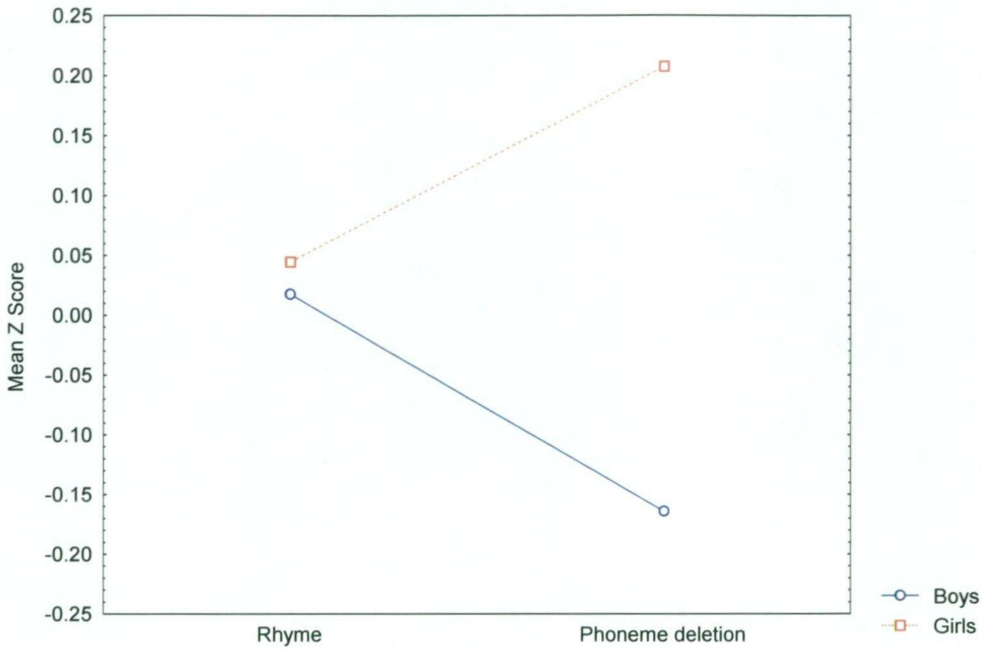

Figure 28. The effect of sex on rhyme ability and phoneme deletion ability over time.

As discussed in Chapters 6, 7, and 8, girls were significantly more accurate than boys on the phoneme deletion task in Phase 1, and the difference in Phase 3 (using a more difficult task) was significant. Girls were also more accurate than boys in Phase 2 but the difference did not reach significance which may be explained by the ceiling effect on the phoneme deletion task in Phase 2 (shown in Figure 8).

The hypothesis that due to a greater awareness of small units of sound (individual phonemes) girls would achieve higher scores than boys on the phoneme deletion task but there would be no such difference on the rhyme awareness tasks (rhyme detection in Phases 1 and 2, and rhyme production in Phase 3) was supported by these longitudinal results. There was no significant difference in any Phase or longitudinally between boys' and girls' performance on the rhyme awareness tasks which required an awareness of larger units of sound.

Differences between boys and girls over time on letter-names and letter-sounds

Differences between boys and girls over the first two years of formal schooling in the development of letter-name and letter-sound knowledge was analysed with a 2[Sex: boys, girls] x 3[Time: Phase 1, Phase 2, Phase 3] x 2(Letter Awareness: names, sounds) mixed design Analysis of Variance. As both letter-names and letter-sounds were measured on the same scale, raw scores were used for this analysis. Over the three phases of the study there was a significant effect of sex, $F\,(1,121) = 4.77$, $MSE = 124.64, p < .05$, with girls ($M = 21.36$) demonstrating significantly more accurate letter knowledge than boys ($M = 19.56$). The effect size of this difference was moderately small ($n^2 = 0.04$). Overall the children's letter-name knowledge ($M = 21.09$) was significantly more accurate than their letter-sound knowledge ($M = 19.84$), $F\,(1,121) = 25.72$, $MSE = 11.08, p < .001$. The effect size of this difference was large ($n^2 = 0.17$). There was also a significant main effect of time, $F\,(2, 242) = 195.20$, $MSE = 24.30, p < .001$, and Tukey HSD post hoc tests showed that the children's alphabet knowledge improved significantly at each phase of the study, $p < .001$ ($n^2 = 0.62$).

There was a significant time by letters interaction (shown in Figure 29), $F\,(2,242) = 13.76$, $MSE = 8.19, p < .001$ ($n^2 = 0.10$). and it was confirmed by Tukey HSD post hoc tests, that there was a significant improvement in both the children's letter-name and letter-sound knowledge at each phase of the study, $p < 001$. Tukey

HSD post hoc tests showed that although the children knew significantly more letters than sounds in Phase 1, $p < .001$, there was no significant difference between letter-name and letter-sound knowledge at either Phase 2 or Phase 3.

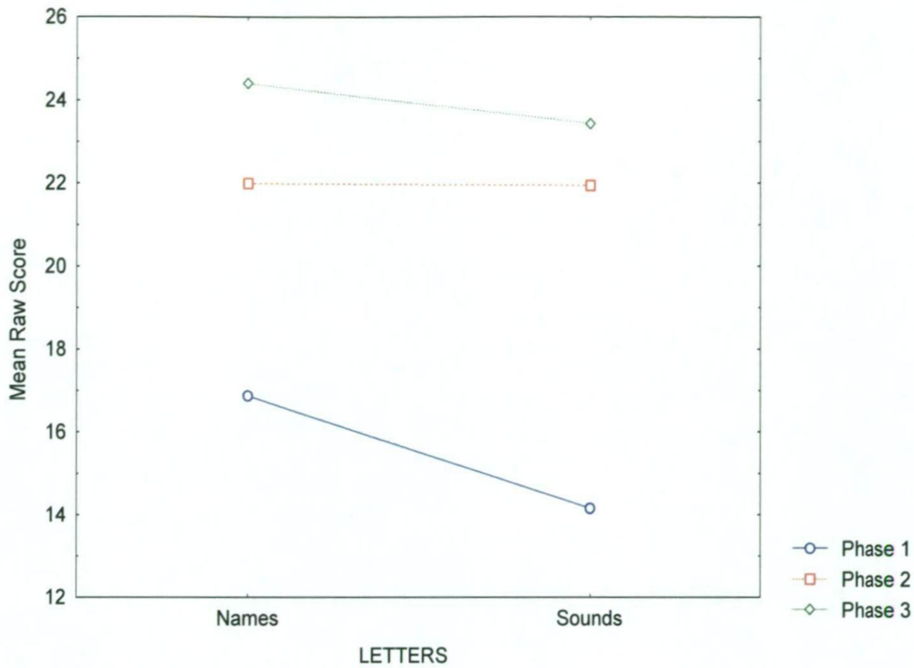

Figure 29. The effect of time on children's letter-name and letter-sound knowledge.

Taken together these findings provide longitudinal evidence that boys in general do not develop graphemic or phonemic awareness as readily as girls and, given the important role played by both graphemic and phonemic awareness in predicting future reading and spelling outcome, support Frith and Vargha-Khadem's (2001) suggestion that the acquisition of literacy skills may not be as smooth in boys. The results are also consistent with Pugh et al.'s (1997) suggestion that girls may develop an earlier focus on individual units of sound as a result of the greater likelihood of language functions being bilateral in girls. Males have been shown in neuroimaging (e.g., Pugh et al., 1997; Shaywitz et al, 1995) and lesion studies (Frith & Vargha-Khadem, 2001; Lambe, 1999) to demonstrate predominantly left-lateralised language functions. Pugh et al. proposed that individuals without right hemisphere involvement still use phonological processing but this may be at a grain size larger than the phoneme. The possible implication of this is that boys may find it a more demanding task to develop an awareness of smaller units of sound such as individual phonemes and so may rely to a greater extent on their awareness of larger units of sound in their early reading and spelling acquisition.

The next question to be considered is whether these differences impact on the children's reading and spelling acquisition over time.

Differences between boys' and girls' reading and spelling ability over time

As reading measures, except for the Ready to Read test, were not taken in Phase 1, differences between boys and girls from the end of their first year to the end of their second year of formal schooling in the development of reading and spelling ability was analysed with a 2[Sex: boys, girls] x 2[Time: Phase 2, Phase 3] x 2(Ability: reading accuracy, spelling) mixed design Analysis of Variance. Z scores were used for this analysis to ensure comparability of measurement scales across the reading accuracy (Neale Analysis of Reading) and spelling (SAST) measures.

There was a significant ability by sex interaction, $F(1, 122) = 10.52$, $MSE = .29$, $p < .01$, which is shown in Figure 30. The effect size of this interaction was moderately large ($n^2 = 0.08$). Tukey HSD post hoc tests showed that although there was no significant difference across the two phases between boys' and girls' reading accuracy ability, girls' spelling ability ($M = .18$) was significantly higher than boys' spelling ability ($M = -.15$) overall, $p < .001$.

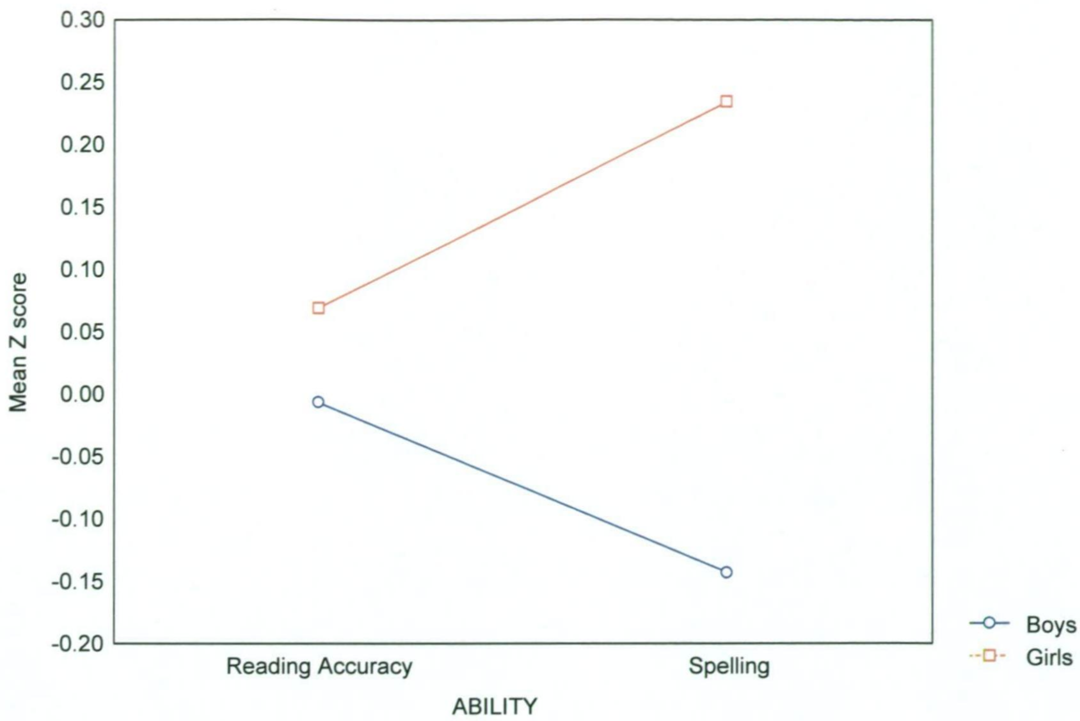

Figure 30. The effect of sex on reading accuracy and spelling over time from the end of the first year to the end of the second year of school.

This two way interaction was modified by a significant sex by time by ability interaction, F (1, 122) = 4.40, MSE = .10, p<.05, which is shown in Figure 31 which represents a moderately small effect size (n^2 = 0.04). To investigate this interaction sex by ability ANOVAs were run separately for Phase 2 and for Phase 3.

Phase 2

There was a significant sex by ability interaction, F (1, 138) = 10.84, MSE = .26, p<.01, and one-way ANOVAs showed that whereas there was no significant difference between boys' and girls' reading accuracy scores at Phase 2, girls' Phase 2 spelling scores (M = .18) were significantly higher than boys' (M = -.17) spelling scores, F (1,138) = 4.23, p <.05.

Phase 3

Similarly in Phase 3 the sex by ability interaction was again significant, $F\,(1, 125) = 5.55$, $MSE = .12$, $p<.05$, and one-way ANOVAs showed that as in Phase 2 whereas there was no significant difference between boys' and girls' reading accuracy scores at Phase 3, *girls'* Phase 3 spelling scores ($M = .18$) were significantly more accurate than boys' ($M = -.17$), $F\,(1, 125) = 4.76$, $p<.05$.

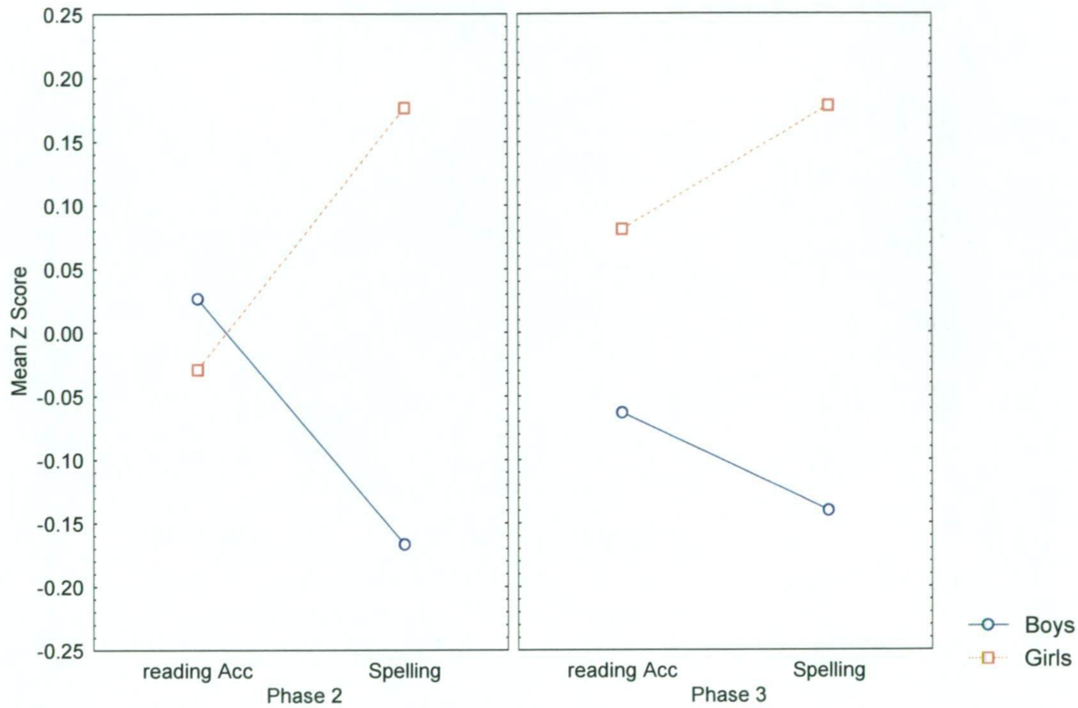

Figure 31. The effect of sex on reading accuracy and spelling ability at the end of the first (Phase 2) and second years (Phase 3) of formal schooling.

Figure 31 shows that boys have been unable to maintain their achievement level in reading when compared with the girls, although the difference between them is not significant. When viewed concurrently with the evidence that girls demonstrated significantly more accurate phonemic awareness skills than boys, this does suggest (albeit speculatively) that boys were able to use strategies other than phonemic awareness strategies to sustain their reading accuracy in the first year of school, however by the end of the second year the use of other strategies was unable to sustain their progress and this was impacting on the lower achieving boys.

In spelling, which is critically dependent on phonemic awareness skills (Ehri, 1997), other strategies cannot be used to compensate for deficits in phonemic awareness and boys were achieving at a significantly lower level than their female peers both at the end of their first school year and also at the end of their second school year.

Differences between boys' and girls' Irregular word and Nonword reading over time

Differences between boys and girls from the end of their first year to the end of their second year of formal schooling in the development of irregular and nonword reading ability were analysed with a 2[Sex: boys, girls] x 2[Time: Phase 2, Phase 3] x 2(Ability: irregular words, nonword reading) mixed design Analysis of Variance. Z scores were used for this analysis to ensure comparability of measurement scales across the measures again calculated separately for each phase.

There were no significant main effects revealed in the analysis, however there was a significant sex by time interaction, $F\,(1, 122) = 6.60$, $MSE = .27$, $p<.05$, shown in Figure 32. Tukey HSD post hoc tests indicated that over time there was no significant difference between boys' and girls' combined irregular and nonword reading scores at Phase 2, however girls' Phase 3 combined irregular and nonword reading scores ($M = .12$) were significantly higher than boys' ($M = -.10$) Phase 3 combined irregular and nonword reading scores, $p<.01$.

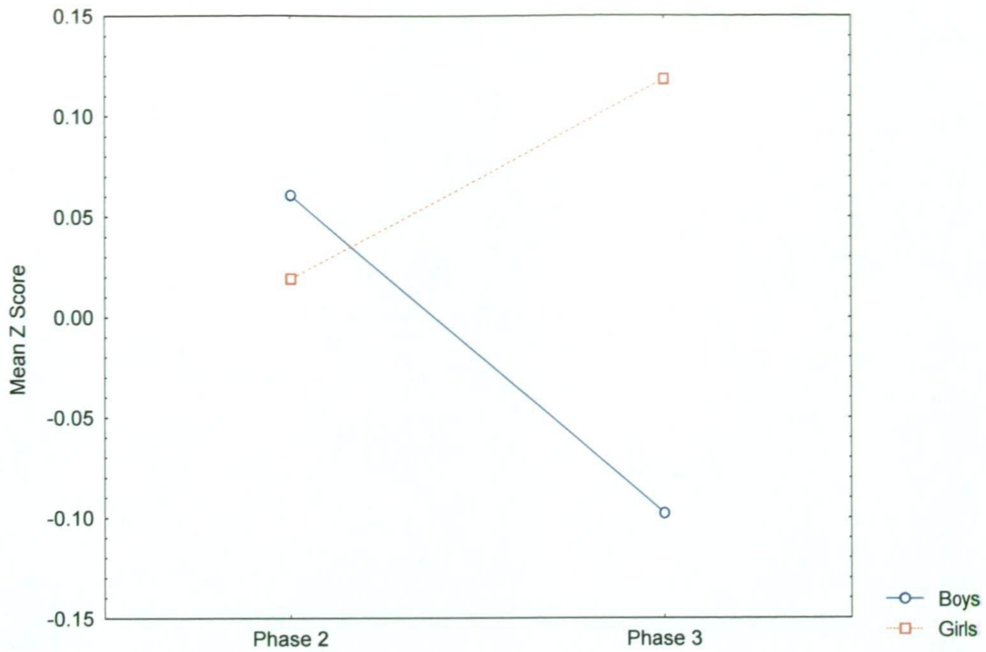

Figure 32. The effect of sex on combined irregular word and nonword reading from the end of the first year of school to the end of the second year of school.

Relationships between Phonemic Awareness Variables and Rhyming with Reading and Spelling measures over time

Correlations between phonological measures at Phases 1-3 with reading and spelling outcome measures at Phase 2 and 3 are shown in Table 33 for all participants and in Table 34 separately for boys and girls.

Table 33

Correlations of Phase 1-3 Predictor Measures with Phase 2 and 3 Reading and Spelling Outcome Measures for all Children.

	Neale Accuracy	Nonword Reading	Irregular Word Reading	Spelling (SAST)
Correlation of Phases 1 and 2 predictor measures with Phase 2 outcome measures				
Phase 1	*N*=153	*N*=153	*N*=153	*N*=153
WPPSI IQ	.51**	.41**	.50**	.45**
Rhyme detection	.46**	.47**	.41**	.42**
Phoneme deletion	.67**	.66**	.63**	.63**
Letter-names	.77**	.61**	.75**	.64**
Letter-sounds	.77**	.66**	.76**	.73**
Ready to Read	.71**	.61**	.71**	.53**
Phase 2	*N*=140	*N*=140	*N*=140	*N*=140
Rhyme detection	.37**	.39**	.38**	.43**
Phoneme Deletion	.60**	.66**	.64**	.75**
Letter-names	.49**	.51**	.53**	.62**
Letter-sounds	.46**	.52**	.50**	.62**
RAN	.47**	.47**	.51**	.60**
Correlation of Phases 1, 2, and 3 predictor measures with Phase 3 outcome measures				
Phase 1	*N*=127	*N*=127	*N*=127	*N*=127
WPPSI IQ	.49**	.46**	.50**	.49**
Rhyme detection	.48**	.44**	.46**	.41**
Phoneme deletion	.62**	.66**	.63**	.61**
Letter-names	.72**	.76**	.66**	.71**
Letter-sounds	.66**	.63**	.70**	.71**
Ready to Read	.68**	.61**	.56**	.53**
Phase 2	*N*=124	*N*=124	*N*=124	*N*=124
Rhyme detection	.41**	.41**	.41**	.40**
Phoneme Deletion	.71**	.75**	.74**	.80**
Letter-names	.64**	.59**	.68**	.71**
Letter-sounds	.52**	.55**	.56**	.61**
RAN	.59**	.57**	.62**	.66**
Phase 3	*N*=127	*N*=127	*N*=127	*N*=127
Rhyme production	.63**	.62**	.63**	.61**
Phoneme Deletion	.61**	.66**	.67**	.70**
Letter-names	.52**	.53**	.58**	.61**
Letter-sounds	.50**	.56**	.54**	.57**
RAN	.61**	.59**	.64**	.68**

Note. RAN = Rapid Automatised Naming (letters). *$p<.05$, **$p<.01$, ***$p<.001$.
Phase 2 Neale accuracy and irregular word reading scores transformed

Table 34

Correlations of Phase 1-3 Predictor Measures with Phase 2 and 3 Reading and Spelling Outcome Measures for boys and girls.

	Neale Accuracy		Nonword Reading		Irreg Word Reading		Spelling (SAST)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Correlation of Phases 1 and 2 predictor measures with Phase 2 outcome measures								
Phase 1	*n*=81	*n*=72	*n*=81	*n*=72	*n*=81	*n*=72	*n*=81	*n*=72
WPPSI IQ	.48**	.57**	.44**	.39**	.46**	.56**	.45**	.54**
Rhyme detection	.49**	.43**	.51**	.43**	.40**	.43**	.42**	.43**
Phoneme deletion	.66**	.71**	.72**	.62**	.61**	.69**	.58**	.68**
Letter-names	.80**	.73**	.70**	.50**	.79**	.71**	.68**	.59**
Letter-sounds	.77**	.79**	.72**	.64**	.79**	.75**	.75**	.70**
Ready to Read	.75**	.67**	.71**	.42**	.75**	.63**	.49**	.60**
Phase 2	*n*=72	*n*=68	*n*=72	*n*=68	*n*=72	*n*=68	*n*=72	*n*=68
Rhyme detection	.35**	.46**	.40**	.42**	.34**	.47**	.48**	.46**
Phoneme deletion	.59**	.69**	.68**	.67**	.63**	.69**	.73**	.78**
Letter-names	.49**	.52**	.54**	.45**	.56**	.50**	.65**	.55**
Letter-sounds	.47**	.52**	.57**	.50**	.49**	.55**	.59**	.65**
RAN	.44**	.67**	.46**	.57**	.48**	.68**	.57**	.67**
Correlation of Phases 1, 2, and 3 predictor measures with Phase 3 outcome measures								
Phase 1	*n*=68	*n*=59	*n*=68	*n*=59	*n*=68	*n*=59	*n*=68	*n*=59
WPPSI IQ	.49**	.51**	.49**	.45**	.49**	.54**	.51**	.48**
Rhyme detection	.53**	.40**	.53**	.29*	.52**	.37**	.46**	.33**
Phoneme deletion	.64**	.59**	.69**	.62**	.62**	.63**	.62**	.58**
Letter-names	.80**	.57**	.74**	.51**	.84**	.62**	.79**	.55**
Letter-sounds	.67**	.64**	.69**	.55**	.72**	.68**	.75**	.63**
Ready to Read	.72**	.60**	.62**	.45**	.64**	.55**	.55**	.49**
Phase 2	*n*=65	*n*=59	*n*=65	*n*=59	*n*=65	*n*=59	*n*=65	*n*=59
Rhyme Detection	.46**	.37**	.48**	.38**	.45**	.40**	.47**	.36**
Phoneme deletion	.73**	.69**	.81**	.65**	.75**	.73**	.81*	.77**
Letter-names	.68**	.55**	.64**	.49**	.71**	.58**	.75**	.59**
Letter-sounds	.54**	.48**	.55**	.53**	.55**	.55**	.61**	.59**
RAN	.59**	.65**	.58**	.62**	.61**	.67**	.64**	.72**
Phase 3	*n*=68	*n*=59	*n*=68	*n*=59	*n*=68	*n*=59	*n*=68	*n*=59
Rhyme production	.70**	.53**	.71**	.49**	.71**	.51**	.71**	.48**
Phoneme deletion	.65**	.55**	.70**	.61**	.65**	.70**	.73**	.63**
Letter-names	.55**	.46**	.54**	.50**	.60**	.53**	.61**	.59**
Letter-sounds	.46**	.60**	.51**	.69**	.47**	.69**	.50**	.58**
RAN	.64**	.55**	.60**	.55**	.65**	.61**	.68**	.65**

Note. RAN = Rapid Automatised Naming (letters). * $p<.05$, ** $p<.01$, *** $p<.001$. Phase 2 Neale Accuracy and irregular word reading scores transformed

Table 33, shows a much stronger relationship, for both Phases 1 and 2, between phoneme deletion and each of the reading and spelling measures assessed in Phase 2, than between rhyme detection and the Phase 2 reading and spelling measures. The difference between the Phases 1 and 2 rhyme detection and phoneme deletion correlations with the Phase 2 reading measures (Neale Accuracy, Irregular words, and Nonwords) and spelling (SAST) were all significant (*p*s$<$ .05). Examining the relationships between Phases 1 and 2 rhyme detection and phoneme deletion and the Phase 3 outcome measures a similar picture can be seen with Phase 3 nonword reading and spelling (*p*s$<$ .05). The differences between Phase 1 rhyme detection and phoneme deletion correlations with Phase 3 Neale Accuracy and irregular word reading showed a trend in this direction but were not significant. The difference between the Phase 2 rhyme detection and phoneme deletion correlations with the Phase 3 reading and spelling measures were all significant (*p*s$<$.01).

A different picture can be seen when examining the correlations between Phase 3 rhyme production and phoneme deletion scores with the Phase 3 reading and spelling measures. Both rhyme production and phoneme deletion correlated highly with all the Phase 3 reading and spelling measures (in the .6 range). Rhyme production required an explicit awareness of rhyme and was a much more difficult task for the children and showed a much closer relationship with the phoneme deletion task than the rhyme detection task administered in Phases 1 and 2., which required implicit awareness of rhyme.

In summary, in Phases 1 and 2, in which rhyming ability was measured with a simple rhyme detection test, the relationship between phoneme deletion and reading and spelling was significantly stronger than between rhyme detection (rhyme awareness) and reading and spelling, highlighting the importance of phonemic awareness in the beginning Phases of reading and spelling. By the end of the second year of formal reading instruction, in Phase 3, rhyming ability, as measured by rhyme production, showed a similar relationship to reading and spelling as phonemic awareness. WPPSI IQ showed a moderate relationship (.41 to .51) with all Phase 2 and 3 reading and spelling measures.

The separate correlations for boys and girls shown in Table 34 reveal some differences between boys' and girls' correlations in a number of areas. The relationship between Phase 1 Ready to Read and Phase 2 nonword reading was significantly higher for boys (.71) than for girls (.42), $p < .05$.

Significant differences can also be seen in the relationship between Phase 1 letter-name knowledge and Phase 3 Neale Accuracy, nonword reading, irregular word reading, and spelling (SAST). This relationship was significantly stronger for boys (.80, .74, .84, and .79 respectively) than for girls (.57, .51, .62, and .55 respectively), *p*s<.05. Rhyme production had a stronger relationship with Phase 3 Neale accuracy, Nonword reading, Irregular word reading, and SAST for boys (.70, .71, .71 and .71 respectively) than for girls (.53, .49, .51, and .48 respectively) and the difference for SAST was significant, $p<.05$.

In summary there were important differences in the relationships between variables for boys and girls. The relationship between reading ability measured in the first three months of full-time schooling and nonword reading t the end of the first year of schooling was significantly stronger for boys suggesting that boys' progress in reading nonwords in the first year of school is more closely related to their reading ability in the early months of school than is the case for girls. Phase 1 letter-name knowledge was significantly more strongly correlated with Phase 3 reading accuracy, nonword reading, irregular word reading, and spelling for boys than for girls.

Phase 3 rhyme production had a significantly stronger relationship with Phase 3 nonword reading and irregular word reading for boys than for girls and a significantly stronger relationship with spelling for boys than for girls. This suggests that boys use rhyming strategies to a greater extent than girls, particularly for spelling, but also when reading unfamiliar words, such as nonwords, and for reading irregular words.

The relationship between Reading and Spelling in the First Two Years of School and Phase 1 and 2 Phonological Awareness Predictors - Rhyme Awareness (rhyme detection), and Phonemic Awareness (Variables Determined by Factor Analysis in Phases 1 and 2).

Regression analyses were run for the full sample of children and separately for boys and girls to investigate the roles of phonemic awareness and rhyme awareness (measured in Phases 1, and 2) as predictors of reading and spelling performance at the end of the first and second years of formal schooling (measured in Phases 2 and 3). The resulting estimate weights were used in a series of path diagrams.

The raw scores for all the variables to be used in these regression analyses were converted into Z scores, based on the full sample of children, to ensure comparability of measurement scales across all the variables, and were calculated separately for each phase. Distributional assumptions of normality between predicted dependent variable scores and error of prediction (Tabachnick & Fidell, 1996) were checked and as outlined in Chapter 7 (ps. 100-102) transformed scores were used for both Phase 2 Neale Accuracy and Phase 2 Irregular word reading. All other dependent variables to be used in these analyses showed no deviation from normality or contained outliers in excess of 3 SDs.

The important question under review was the relative contributions of rhyming and graphemic and phonemic awareness abilities to reading and spelling for boys and girls in Phases 2 and 3, so these two variables were always entered as the final two steps in each analysis. In all these analyses chronological age was always entered at step 1, and WPPSI IQ (measured in Phase 1) at step 2 to control for any differences in age and IQ before entering the remainder of the variables. The reading (or spelling) measure from that phase (if applicable) was always entered at step 3 to control for the autoregressive effects of earlier reading (or spelling) ability (Bowey, 2002; Wagner et al., 1994). Rhyme detection, as representative of rhyme awareness ability was always entered at step 4. The graphemic and phonemic awareness variables (determined by the Factor Analyses at each Phase, and explained in Chapters 6, 7, and 8) were always entered as a block at the final step.

Longitudinal Predictors of Reading Accuracy at the end of the First and Second Years of School

Phase 1 Predictors

The first series of Regression analyses, shown in Table 35, assessed the predictive relationships between Phase 1 age, WPPSI IQ, Ready to Read, rhyme detection, phoneme deletion, and letter-name and letter-sound knowledge with Phase 2 Neale Accuracy scores (transformed), measured at the end of the children's first year of formal schooling.

For the combined sample of boys and girls all the variables entered made significant additional contributions at the stage at which they are entered, except for age which was a preliminary control. In the final equation neither age (β =.09, *n.s.*). nor WPPSI IQ (β =.-.01, *n.s.*) was a significant predictor. Phase 1 rhyme detection scores made a significant incremental improvement in prediction additional to Phase 1

Ready to Read at step 4, but the effect was diminished below the significance level following the inclusion of the graphemic and phonemic variables at step 5 (β =.09, p =.09). At step 5 Phase 1 Ready to Read scores were the most powerful predictor of Phase 2 Neale accuracy (β =.28, $p < .001$) while letter-names (β =..30, $p < .01$), phoneme deletion ability (β =.15, $p < .05$), and letter-sounds (β =.19, $p < .05$), all accounted for additional significant variance.

Regression analyses run separately for boys and girls, are also shown in Table 35. In the final equation age was a significant predictor of Phase 2 Neale Accuracy for boys (β =.19, $p < .05$), accounting for 6% of the total variance, but not for girls (β =-.00, *n.s.*

For boys Phase 1 rhyme detection made a significant incremental improvement in prediction additional to Phase 1 Ready to Read at step 4 (β =.20, $p < .05$) and maintained its significance following the inclusion of the graphemic and phonemic awareness variables at step 5. Of these variables, added at step 5, letter-name knowledge (β =.27, $p < .05$), made a significant incremental improvement in addition to age. Ready to Read (β =.33, $p < .001$) and rhyme detection (β =.15, $p < .05$).

For boys Phase 1 Ready to Read scores accounted for a substantial 40.5% of the total variance in Phase 2 Neale Accuracy scores at step 3, after the effect of age and WPPSI IQ, (β =.67, $p < .001$) whereas for girls Phase 1 Ready to Read scores accounted for 14.9% of the total variance in Phase 2 Neale Accuracy scores at step 3, after accounting for the effects of age and WPPSI IQ (β =.46, $p < .001$). The difference between these two percentages was significant, ($p < .01$).

In contrast to the regression equation for boys, for girls at step 4 rhyme detection failed to account for any additional significant variance in addition to Ready to Read scores in their Phase 2 Reading Accuracy scores. At step 5 the effect of Ready to Read scores on Phase 2 reading accuracy diminished below significance level following the inclusion of the letter familiarity and phonemic awareness variables. At step 5 for girls the only variable to account for significant variance was phoneme deletion (β =.25, $p < .05$).

Table 35

Summary of Hierarchical Regression Analyses for Phase 1 Variables Predicting Reading Accuracy Ability at the end of the First Year of Formal Schooling (Phase 2)

	All Children (N = 140)			Boys (n = 72)			Girls (n = 68)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.036			.060*			.014
Age	1.18 (.52)	.19*		1.78(.84)	.25		.58 (.61)	.12	
Step 2			.231***			.195***			.312***
Age	.56 (.46)	.09		1.08(.77)	.15		.01 (.52)	.01	
WPPSI IQ	1.07 (.16)	.49***		1.10(.26)	.45***		1.05 (.19)	.57***	
Step 3			.305***			.405***			.149***
Age	.65 (.36)	.10		1.34(.53)	.18*		-.00 (.46)	.00	
WPPSI IQ	.55 (.14)	.25***		.59 (.19)	.24**		.60 (.20)	.32	
P 1 R to Read	.38 (.04)	.60***		.43 (.05)	.67***		.28 (.06)	.46***	
Step 4			.014*			.026*			.007
Age	.80 (.36)	.13		1.71(.53)	.24**		.00 (.47)	.01	
WPPSI IQ	.44 (.15)	.20**		.42 (.19)	.17*		.52 (.22)	.28*	
P 1 R to Read	.35 (.04)	.56***		.38 (.05)	.60***		.26 (.07)	.44***	
Rhyme Detect	.26 (.12)	.14*		.39 (.17)	.20*		.16 (.18)	.10	
Step 5			.147***			.125***			.198***
Age	.57 (.30)	.09		1.38(.44)	.19**		-.00 (.38)	-.00	
WPPSI IQ	-.02 (.13)	-.01		-.02(.17)	-.01		-.02 (.20)	-.01	
P 1 R to Read	.17 (.04)	.28***		.21 (.05)	.33***		.08 (.06)	.13	
Rhyme Detect	.17 (.10)	.09		.29 (.14)	.15*		.05 (.14)	.03	
Phoneme D	.27 (.12)	.15*		.29 (.16)	.14		.38 (.17)	.25*	
Letter–names	.56 (.16)	.30**		.53 (.22)	.27*		.33 (.24)	.20	
Letter-sounds	.36 (.17)	.19		.42 (.23)	.20		.50 (.27)	.34	
Total variance explained			73.3%			79.1%			64.1%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB) *p<.05, **p<.01, ***p<.001. DV = Phase 2 Neale Accuracy (transformed scores)

The second series of Regression analyses, shown in Table 36, assessed the predictive relationships between Phase 1 age, WPPSI IQ, Ready to Read, rhyme detection, phoneme deletion, letter-name and letter-sound knowledge with Phase 3 Neale Accuracy scores, measured at the end of the children's second year of formal schooling. For the combined sample of boys and girls all the variables entered made significant additional contributions at the stage where they were entered, with the model accounting for 68.4% of the total variance. In the final equation for all children chronological age was a significant predictor of Phase 3 Neale Accuracy scores ($\beta = .13, p < .05$), accounting for 4.2% of the total variance. At step 3 Phase 1 Ready to Read made a significant incremental improvement after age and WPPSI IQ and at step 5 remained a powerful predictor of reading accuracy at the end of the second year of formal schooling ($\beta = .31, p < .001$). Phase 1 rhyme detection also made a significant incremental improvement in prediction additional to Ready to Read at step 4, and retained its significance as a predictor following the inclusion of the phonemic awareness variables ($\beta = .16, p < .05$). Of the graphemic and phonemic awareness variables, entered at the final step, phoneme deletion ($\beta = .18, p < .05$), and letter-name knowledge ($\beta = .41, p < .001$) were both significant predictors of Phase 3 reading accuracy for the full sample of children.

Table 36

Summary of Hierarchical Regression Analyses for Phase 1 Variables Predicting Reading Accuracy Ability at the end of the Second year of Formal Schooling (Phase 3)

	All Children (N = 127)			Boys (n = 68)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.042*			.023			.073*
Age	.68 (.29)	.21		.57 (.45)	.15		.78 (.37)	.27*	
Step 2			.208***			.217***			.214***
Age	.36 (.27)	.11		.20 (.41)	.05		.48 (.33)	.17	
WPPSI IQ	.53 (.09)	.47***		.58 (.13)	.48***		.48 (.12)	.47***	
Step 3			280***			.365***			.143***
Age	.45 (.21)	.13*	.	.39 (.30)	.11		.49 (.30)	.17	
WPPSI IQ	.25 (.08)	.22**		.31 (.10)	.26**		.22 (.13)	.22	
P 1 R to Read	.19 (.02)	.58***		.21 (.03)	.64***		.16 (.04)	.46***	
Step 4			.028**			.029*			.019
Age	.56 (.210	.17**		.54 (.30)	.15		.56 (.30)	.19	
WPPSI IQ	.17 (.08)	.15*		.22 (.11)	.18*		.15 (.14)	.15	
P 1 R to Read	.17 (.02)	.52***		.18 (.03)	.57***		.15 (.04)	.43**	
Rhyme Detect	.20 (.07)	.20**		.09 (.21)	.21*		.16 (.12)	.16	
Step 5			.097***			.134***			.062
Age	.43 (.19)	.13*		.25 (.26)	.07		.53 (.29)	.18	
WPPSI IQ	.00 (.08)	.00		.01 (.10)	.01		-.00(.15)	-.00	
P 1 R to Read	.10 (.03)	.31***		.10 (.03)	.33***		.08 (.05)	.24	
Rhyme Detect	.16 (.07)	.16*		.15 (.08)	.15		.12 (.12)	.12	
Phoneme D	.18 (.08)	.18*		.18 (.10)	.17		.15 (.14)	.16	
Letter-names	.41 (.10)	.41***		.59 (.13)	.58***		.11 (.19)	.11	
Letter-sounds	-.09 (.12)	-.10		-.22 (.14)	-.20		.16 (.22)	.18	
Total variance explained			65.5%			76.8%			51.1%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB). Dependent variable is Phase 2
*p<.05, **p<.01, ***p<.001.

The separate regression analyses for boys and girls, shown in Table 36, varied remarkably from the analysis of the entire sample. For boys all the variables, except for age, made significant additional contributions at the stage when they were entered, with the model accounting for 76.8% of the total variance. Ready to Read at step 3, after the effect of age and WPPSI IQ, accounted for 36.5% of the total variance in reading accuracy at the end of the second year of formal schooling and remained a powerful predictor at step 5 (β =.33, $p < .001$). For boys rhyme detection made a significant incremental improvement at step 4 additional to Phase 1 Ready to Read scores but the effect diminished to just below significance following the inclusion of the graphemic and phonemic awareness variables (β =.15, p =.06). At the final step the graphemic and phonemic awareness variables accounted for an additional 13.4% of the total variance with letter-name knowledge (β =.58, $p < .001$) a significant predictor of Phase 3 reading accuracy additional to Ready to Read..

In the girls' analysis age, WPPSI IQ and Ready to Read scores made a significant contribution at the stage when they were entered however neither rhyme nor the graphemic and phonemic awareness variables made a significant contribution to the analysis. For girls the model accounted for 51.1% of the total variance in their Phase 3 reading accuracy scores. In the final equation for girls none of the Phase 1 predictors was a significant predictor of Phase 3 Reading accuracy. As with Phase 2 reading accuracy, Ready to Read at step 3 accounted for a significantly larger percentage of the total variance for boys (36.5%) than it did for girls (14.3%), ($p <$ .01). The Phase 1 graphemic and phonemic awareness variables also accounted for a considerably larger percentage of the total variance in Phase 3 reading accuracy for boys (13.4%) than for girls (6.2%) however this difference was not significant. This is in contrast with the size of the role played by the Phase 1 graphemic and phonemic awareness variables in predicting Phase 2 reading accuracy where they accounted for a significantly greater proportion of the variance for girls than for boys, suggesting that use of graphemic and phonemic awareness as a reading strategy may be slower to develop in boys.

These analyses of the longitudinal Phase 1 predictors of reading accuracy measured at the end of the first and second years' of schooling point to important differences between boys and girls over the first two years of formal reading instruction. The significantly greater proportion of the total variance in both Phase 2 and 3 reading accuracy accounted for by boys' Phase 1 Ready to Read scores suggests that boys' reading ability at the end of the first year of school is strongly dependent on their very early reading ability, as measured by the Ready to Read test in Phase 1. Although this effect has lessened by the end of the second year, Ready to Read scores still accounted for a large and significant proportion of the total variance in boys' reading accuracy ability. Phase 1 Ready to Read scores, was not a significant predictor of girls' Reading Accuracy scores, neither at the end of their first (Phase 2) or second years of schooling (Phase 3).

For boys rhyme detection rather than phoneme deletion (phonemic awareness) accounted for significant variance in their reading accuracy and spelling at the end of the first year of school whereas for girls phoneme deletion (phonemic awareness) but not rhyme detection accounted for significant variance in their reading accuracy and spelling. Boys appear to be relying to a greater extent on strategies other than graphemic and phonemic awareness in the first year of formal reading instruction as there was no significant difference in boys' and girls' Neale Accuracy scores at the end of the first year, or at the end of the second year. For boys (but not girls) rhyme was a significant predictor of their Phase 2 reading accuracy scores, additional to

Ready to Read and letter-name knowledge. By the end of their second year of schooling a greater proportion of variance in Neale Accuracy scores (Phase 3) was accounted for by boys' Phase 1 graphemic and phonemic awareness, whereas for girls their Phase 1 graphemic and phonemic awareness now accounted for considerably less of the total variance and was not a significant predictor of their Neale Accuracy scores, suggesting that by the end of their second year of schooling girls have developed beyond dependence on those early graphemic and phonemic awareness abilities.

Phase 2 Predictors of Phase 3 Reading Accuracy

The final series of Regression analyses for reading accuracy, shown in Table 37, examined the predictive relationship between Phase 2 age (entered at step 1), WPPSI IQ (measured in Phase 1) at step 2, Phase 2 reading accuracy at step 3, Phase 2 rhyme detection at step 4 and Phase 2 graphemic and phonemic awareness variables (determined by factor analysis and outlined in Chapter 7) entered at the final step. In the final equation the most powerful Phase 2 predictor of Phase 3 Neale accuracy scores was the children's Phase 2 Neale accuracy scores, for all children (β =.62, $p <$ .001), for boys (β =.63, $p < .001$), and for girls (β =.69, $p < .001$). Once Phase 2 Neale Accuracy had been entered into the equation, Phase 2 phonemic awareness accounted for additional significant variance in Phase 3 reading accuracy for the full sample of children (β =.18, $p < .05$) but because of the smaller numbers in the separate boys' and girls' analyses did not retain its significance for either boys (β =.17, p =.065) or girls (β =.18, *n.s.*) in the separate Regression analyses.

Table 37

Summary of Hierarchical Regression Analyses for Phase 2 Variables and WPPSI IQ (measured in Phase 1) Predicting Reading Accuracy Ability at the end of the Second year of Formal Schooling (Phase 3)

	All Children (N = 124)			Boys (n = 65)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.010			.001			.063
Age	.34 (.32)	.10		-.15(.52)	-.04		.72 (.37)	.25	
Step 1			.240***			.257***			.22***
Age	.08 (.28)	.02		-.35(.46)	-.09		.44 (.34)	.15	
WPPSI IQ[a]	.57 (.16)	.50***		.63 (.14)	.51***		.49 (.12)	.48***	
Step 2			.500***			.52***			.50***
Age	.21 (.16)	.06		-.12(.26)	-.03		.42 (.19)	.15*	
WPPSI IQ[a]	.20 (.06)	.18**		.23 (.08)	.19**		.12 (.07)	.12	
P2 Read Ac	.76(.05)	.78***		.68 (.06)	.79***		..10 (.09)	.80***	
Step 3			.001			.006			.001
Age	.23 (.17)	.07		-.07(.26)	-.02		.40 (.19)	.14*	
WPPSI IQ[a]	.18 (.07)	.16**		.19 (.09)	.15*		.14 (.09)	.14	
P2 Read Ac	.75 (.05)	.77***		.67 (.06)	.76***		1.01 (.09)	.81***	
Rhyme Detect	.04 (.06)	.04		.12 (.09)	.10		-.04 (.07)	-.04	
Step 5			.057***			.060**			.02
Age	.20 (.15)	.06		-.11(.23)	-.03		.39 (.20)	.14	
WPPSI IQ[a]	.08 (.06)	.07		.03 (.09)	.03		.11 (.09)	.10	
P2 Read Ac	.60 (.05)	.62***		.55 (.06)	.63***		.86 (.12)	.69***	
Rhyme Det	-.06(.05)	-.01		.02 (.08)	.02		-.06 (.07)	-.07	
Phoneme D	.18 (.07)	.18*		.17 (.09)	.19		.17 (.11)	.18	
Letter–names	.12 (.07)	.12		.17 (.10)	.19		.06 (.11)	.05	
Letter-sounds	-.02(.06)	-.02		-.00(.08)	.00		-.03 (.09)	-.03	
RAN	.08 (.06)	.09		04 (.08)	.05		.04 (.16)	.03	
Total variance			80.8%			83.8%			80.5%

Note. P 2 Read Ac = Phase 2 Reading Accuracy, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB) *p<.05, **p<.01, ***p<.001

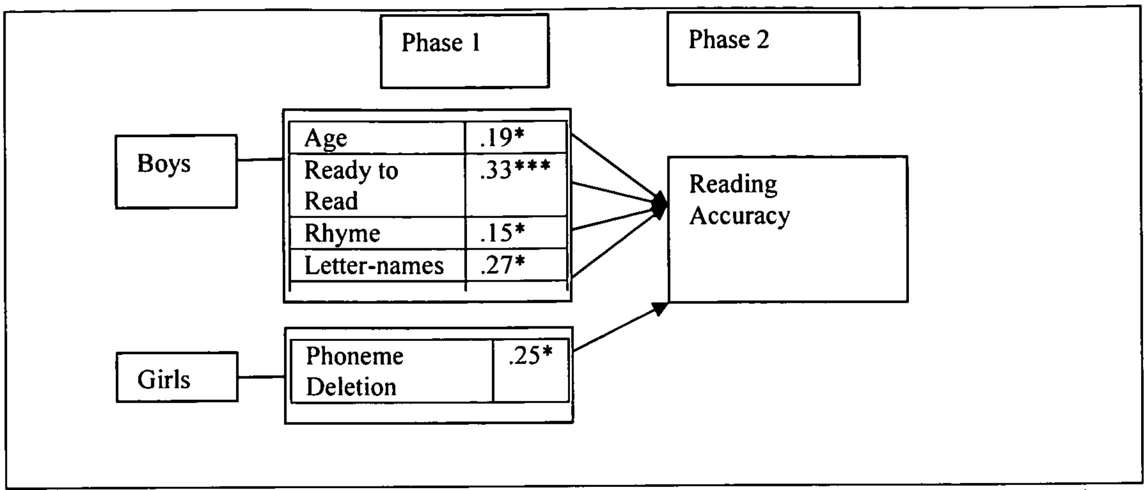

Figure 33. Path diagram showing the predictive relationship between Phase 1 rhyme awareness, and graphemic and phonemic awareness variables with Phase 2 reading accuracy for boys and girls. Only the significant predictors are shown.*p<.05, **p<.01, ***p<.001

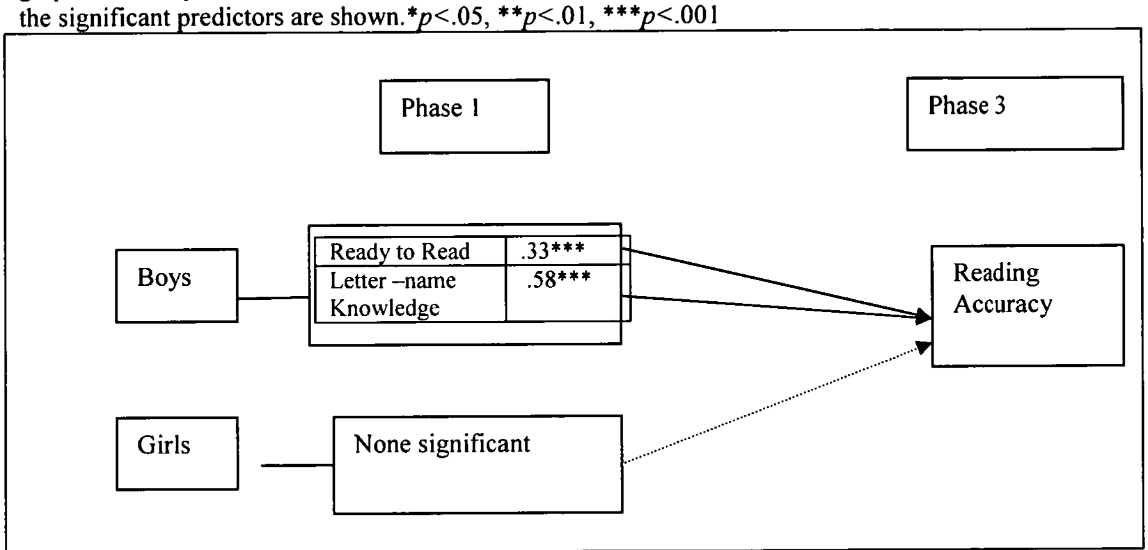

Figure 34. Path diagram showing the predictive relationship between rhyme awareness, and the graphemic and phonemic awareness variables measured in Phases 1 with Phase 3 reading accuracy for boys and girls. Only the significant predictors are shown.*p<.05, **p<.01, ***p<.001.

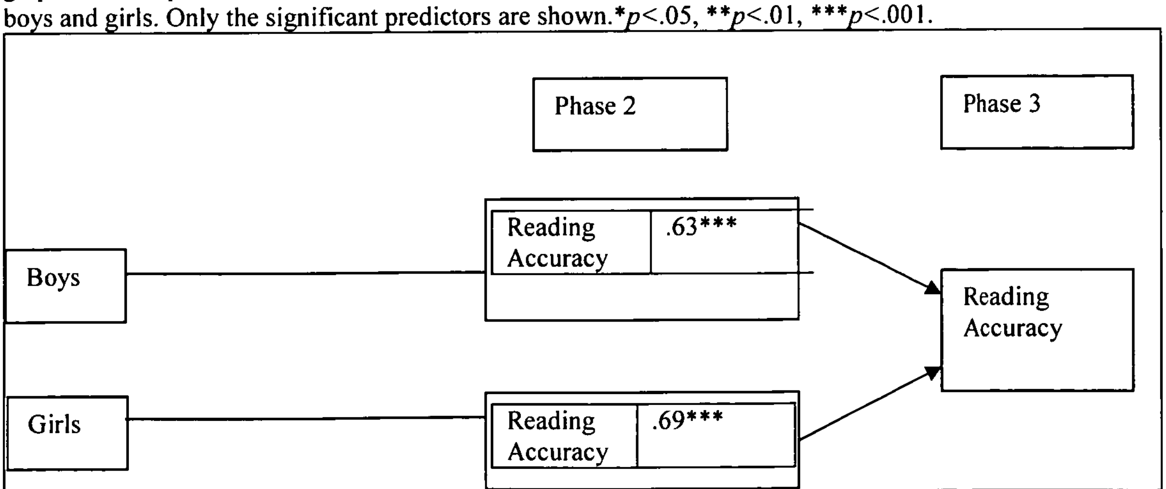

Figure 35. Path diagram showing the predictive relationship between rhyme awareness, and the graphemic and phonemic awareness variables measured in Phase 2 with Phase 3 reading accuracy for boys and girls. Only the significant predictors are shown.*p<.05, **p<.01, ***p<.001.

The path diagrams in Figures 33, 34 and 35 show the pattern of predictive relationships between Phases 1 and 2 early phonological awareness (rhyme detection), the graphemic and phonemic awareness variables and the Ready to Read test with both Phase 2 and 3 Neale Accuracy scores for boys and girls. The finding that Phase 2 rhyme detection was not a significant predictor of Phase 3 reading accuracy could well be accounted for by the ceiling effect in Phase 2 rhyme detection.

Longitudinal predictors of Spelling ability at the end of the First and Second years of School

Phase 1 Predictors

The first in this series of regression analyses, shown in Table 38, assessed the predictive relationships between Phase 1 age (step 1), WPPSI IQ (step 2), Ready to Read (step 3) rhyme (step 4), phoneme deletion, letter-name and letter-sound knowledge (entered as a block at step 5), with Phase 2 spelling ability (SAST) measured at the end of the children's first year of formal schooling. For the combined sample of boys and girls all the variables entered made significant additional contributions at the stage when they were entered and the model accounted for 59.4% of the total variance in spelling scores at the end of the first year of formal schooling. Age (β =.22, $p < .01$) was a significant predictor accounting for 4.9% of the total variance in Phase 2 spelling scores. After accounting for the effect of age, WPPSI IQ, and Phase 1 Ready to Read at step 4 rhyme detection made an significant improvement in prediction (β =.18, $p < .05$) but the effect was diminished below significance level following the inclusion of the graphemic and phonemic awareness variables which accounted for a further 19.8% of the total variance, with letter-sound knowledge (β =.48, $p < .001$) and phoneme deletion (β =.22, $p < .01$) both significant predictors.

Separate regression analyses were run for boys and for girls, shown in Table 38, using the same Phase 1 predictors, as outlined above. Differences between boys and girls in the importance of rhyme awareness (rhyme detection) and graphemic and phonemic awareness was shown in these analyses. For boys all the variables entered made significant additional contributions to Phase 2 spelling at the stage at which they were entered, with the model accounting for 65% of the total variance in Phase 2 spelling scores. In the final equation, age ($\beta = .27, p < .01$) was a significant predictor. Rhyme detection at step 4 made a significant incremental improvement in prediction additional to age and Ready to Read ($\beta = .22, p < .05$) and it retained its significance following the inclusion of letter sound knowledge which was a significant predictor at step 5 ($\beta = .60, p < .001$).

For girls only WPPSI IQ, Ready to Read scores and the graphemic and phonemic awareness variables made significant additional contributions to Phase 2 spelling at the stage at which they were entered and the model accounted for 57% of the total variance. In contrast to the boys' analysis, the addition of rhyme detection for the girls' analysis did not make a significant contribution. In the final equation for girls phoneme deletion ($\beta = .29, p < .05$) was the only significant predictor and the phonemic awareness variables accounted for 13.8% of the total variance in girls' Phase 2 spelling scores.

Table 38

Summary of Hierarchical Regression Analyses for Phase 1 Variables Predicting Spelling Ability at the end of the First Year of Formal Schooling (Phase 2)

	All Children (N = 127)			Boys (n = 68)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.049**			.058*			.035
Age	.75 (.28)	.22**		.89(.43)	.24*		.55(.36)	.19	
Step 2			.185***			.165***			.258***
Age	43 (.26)	.13		.56(.40)	.15		.21(.32)	.07	
WPPSI IQ	.51 (.09)	.44***		.52(.14)	.42***		.54(.11)	.52***	
Step 3			.14***			.142***			.127***
Age	.46 (.24)	.14*		.64(.37)	.17		.21(.29)	.07	
WPPSI IQ	.32 (.09)	.28***		.36(.13)	.29**		.30(.12)	.29*	
P 1 R to Read	.14 (.03)	.41***		.13(.03)	.40***		.15(.04)	.43***	
Step 4			.022*			.041*			.011
Age	.57 (.24)	.17*		.88(.37)	.24*.		.24(.29)	.08	
WPPSI IQ	.24 (.09)	.21*		.25(.14)	.20		.25(.13)	.24	
P 1 R to Read	.12 (.03)	.35***		.10(.04)	.31**		.14(.04)	.40**	
Rhyme Detect	.18 (.08)	.18*		.25(.12)	.25*		.12(.11)	.13	
Step 5			.198***			.244***			138**
Age	.51 (.20)	.15*		.84(.31)	.23**		.23(.26)	.08	
WPPSI IQ	-.03 (.09)	-.02		-.00(.12)	-.00		-.01(.13)	-.01	
P 1 R to Read	.01 (.03)	.03		-.02(.03)	-.06		.06(.04)	.16	
Rhyme Det	.12 (.07)	.12		.22(.09)	.22*		.05(.10)	.06	
Phoneme D	.22 (.08)	.22**		.11(.19)	.19		.26(.12)	.29*-	
Letter-names	.02 (.11)	.03		-.04(.15)	-.04		-.06)(.16)	.06	
Letter-sounds	.48 (.12)	.48***		.65(.16)	.60***		.35(.18)	.39	
Total variance explained			59.4%			65%			57%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion.
Standard Error of Beta shown in parentheses (SEB)
*p<.05, **p<.01, ***p<.001.

The next set of regression analyses, shown in Table 39, assessed the predictive relationships between the Phase 1 variables with spelling measured at the end of the children's second year of schooling (Phase 3). For the combined sample of boys and girls all the variables entered made significant additional contributions at the stage when they were entered and the model accounted for 58.7% of the total variance in spelling scores at the end of the second year of school. In the final equation age at Phase 1 was a significant predictor of Phase 3 spelling (β =.16, $p < .05$) for the full sample of children and phoneme deletion (β =.18, $p < .05$), and letter-name knowledge (β =.32, $p < .01$) both made a significant incremental improvement in prediction at step 5 with the block of graphemic and phonemic awareness variables accounting for an additional 17.7% of the total variance in Phase 3 spelling scores.

The separate analysis for boys showed that all variables accounted for significant additional variance at the stage when they were entered with the model accounting for 68.2% of the total variance. In the final equation the only significant Phase 1 predictor of spelling for boys at the end of the second year of school was letter-name knowledge (β =.41, $p < .05$) with the graphemic and phonemic awareness variables accounting for an additional 21.5% of the total variance at step 5.

The analysis for girls revealed that WPPSI IQ and the graphemic and phonemic awareness variables were the only variables which accounted for significant additional variance in girls' Phase 3 spelling scores, and the model accounted for 47.9% of the total variance. In the final equation for girls the only significant Phase 1 predictor of Phase 3 spelling was age (β =.24, $p < .05$). None of the Phase 1 phonological ability variables made a significant incremental improvement in prediction of girls' spelling ability at the end of their second year of school.

Table 39

Summary of Hierarchical Regression Analyses for Phase 1 Variables Predicting Spelling Ability at the end of the Second Year of Formal Schooling (Phase 3)

	All Children (*N* = 127)			Boys (*n* = 68)			Girls (*n* = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.061**			.035			.105*
Age	.83(.29)	.25**		.70(.45)	.19		.90(.35)	.32*	
Step 2			.191***			.235***			.178***
Age	.51(.26)	.15		.31(.40)	.08		.64(.32)	.23	
WPPSI IQ	.51(.09)	.45***		.60(.13)	.50***		.43(.11)	.43***	
Step 3			.137***			.172***			.073*
Age	.58(.24)	.17*		.45(.36)	.12		.65(.31)	.23*	
WPPSI IQ	.31(.09)	.28**		.42(.12)	.35**		.25(.13)	.25	
P 1 R to Read	.14(.03)	.41***		.14(.03)	.44***		.11(.04)	.33*	
Step 4			.021*			.025			.008
Age	.67(.24)	.20**		.59(.36)	.16		.69(.31)	.25*	
WPPSI IQ	.24(.10)	.21*		.33(.13)	.28*		.20(.14)	.20	
P 1 R to Read	.12(.03)	.36***		.12(.03)	.38**		.10(.04)	.31*	
Rhyme Det	.18(.08)	.18*		.20(.11)	.19		.10(.21)	.11	
Step 5			.177***			.215***			.115*
Age	.54(.210	.16*		.35(.30)	.10		.65(.29)	.24*	
WPPSI IQ	-.01(.09)	-.01		.03(.11)	.03		-.00(.15)	-.00	
P 1 R to Read	.01(.13)	.03		.00(.03)	.02		.02(.05)	.05	
Rhyme Detect	.12(.07)	.12		.14(.09)	.14		.04(.11)	.04	
Phoneme D	.17(.09)	.17		.14(.12)	.14		.17(.14)	.20	
Letter-names	.32(.11)	.32**		.41(.15)	.41*		.05(.19)	.05	
Letter-sounds	.22(.13)	.22		.25(.16)	.23		.31(.21)	.36	
Total variance			58.8%			68.2%			47.9%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect= Rhyme Detection, Phoneme D = Phoneme Deletion.
Standard Error of Beta shown in parentheses (SEB)
**p*<.05, ***p*<.01, ****p*<.001.

Phase 2 Predictors of Phase 3 Spelling

In the next series of regression analyses, shown in Table 40, the longitudinal relationship was explored between Phase 3 spelling and the following predictor variables: Phase 2 age (step 1), WPPSI IQ (step 2) Phase 2 spelling (step 3), Phase 2 nonword spelling (step 4), Phase 2 Reading Accuracy (step 5), Phase 2 rhyme detection (step 6) and the graphemic and phonemic awareness variables (phoneme deletion, letter-name knowledge, letter-sound knowledge, and RAN) entered as a block at the final step. Phase 2 nonword spelling was included to explore its relationship with conventional spelling. Reading accuracy scores were also added to the equation to explore the relationship between reading and spelling.

The analysis for all children, shown in Table 40, shows that WPPSI IQ, Phase 2 spelling scores, Phase 2 reading accuracy, and the Phase 2 graphemic and phonemic awareness variables made significant additional contributions at the stage they were entered accounting for 80.3% of the total variance. After accounting for the effect of age and WPPSI IQ at step 3 Phase 2 spelling made a significant incremental improvement and remained the most powerful significant predictor of Phase 3 spelling at step 7 (β =.30, $p < .01$). At step 7 Phase 2 phoneme deletion (β =.30, $p < .001$), and Phase 2 Neale Accuracy (β =.14, $p < .05$), were also additional significant predictors.

The boys' analysis, shown in Table 40, revealed that only WPPSI IQ, Phase 2 spelling scores, and the Phase 2 graphemic and phonemic awareness variables made significant additional contributions at the stage they were entered accounting for 80% of the total variance. The only significant Phase 2 predictors of Phase 3 spelling for boys was phoneme deletion (β =.29, $p < .05$) with the graphemic and phonemic awareness variables accounting for an additional 7.5% of the total variance.

Table 40

Summary of Hierarchical Regression Analysis for Phase 2 Variables and WPPSI IQ (measured in Phase 1) Predicting Spelling Ability at the end of the Second year of formal schooling (Phase 3)

	All Children (N = 123)			Boys (n = 65)			Girls (n = 58)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.020			.000			.085*
Age	.39(.25)	.14		.05(.41)	.02		.64(.28)	.29*	
Step 2			.243***			.32***			.18**
Age	.18(.22)	.07		..12 (.35)	-.04		.44(.26)	.20	
WPPSI IQ[a]	.14(.05)	.50***		.55 (10)	.56***		.34(.09)	.43**	
Step 3			.449***			.39***			.469***
Age	.23(.14)	.08		.08(.23)	.02		.36(.16)	.17*	
WPPSI IQ[a]	.14 (.05)	.16**		.23(.08)	.24**		.05(.06)	.07	
P2 Spell	.59(.04)	.75***		.55(.06)	.70***		.63(.06)	.78***	
Step 4			.002			.01			.000
Age	.25(.14)	.09		.12(.23)	.04		.36(.16)	.16*	
WPPSI IQ[a]	.14(.05)	.15*		.21(.08)	.22**		.05(.06)	.07	
P2 Spell	.54(.07)	.68***		.44(.11)	.56***		.64(.10)	.80***	
P 2 NWSpell	.07(.07)	.09		.14(.11)	.17		-.02(.10)	-.02	
Step 5			.015*			.02			.018
Age	.26(.14)	.09	.	.11(.23)	.04		.37(.16)	.17*	
WPPSI IQ[a]	.12(.05)	.13*		.20(.08)	.21*		.04(.06)	.05	
P2 Spell	.46(.08)	.58***		.37(.11)	.47**		.49(.13)	.61***	
P 2 NW Spell	.05(.07)	.06		.10(.10)	.13		-.08(.09)	-.01	
P 2 Read Ac	.14(.06)	.18*		.13(.07)	.20		.22(.11)	.23	

Table 40 (contd.)

	All Children (N = 123)			Boys (n = 65)			Girls (n = 58)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 6						.00			.000
Age	..25(.14)	.09	.000	.12(.23)	.04		.38(.16)	.17*	
WPPSI IQ[a]	.13(.06)	.14*		.20(.08)	.20*		.04(.07)	.05	
P 2 Spell	.46(.08)	.58***		.36(.11)	.46**		.49(.13)	.61***	
P 2 NW Spell	.05(.07)	.06		.10(.11)	.13		-.08(.10)	0.01	
P 2 Read Ac	.14(.06)	.18*		.13(.07)	.20		.22(.12)	.23	
P 2 Rhyme	-.01(.05)	-.01		.02(.08)	.02		.00(.06)	.00	
Step 7			.074***			.08**			.068**
Age	..23(.12)	.09		.03(.21)	.01		.37(.15)	.17*	
WPPSI IQ[a]	.04(.05)	.04		.06(.08)	.06		-.01(.07)	-.02	
P2 Spell	.24(.08)	.30**		.19(.11)	.24		.26(.13)	.33*	
P2 NW Spell	.04(.06)	.06		.05(.10)	.06		.04(.09)	.05	
P2 Read Ac	.11(.05)	.14*		.12(.06)	.17		.13(.11)	.14	
P2 Rhyme	-.04(.04)	-.05		-.03(.07)	-.03		-.02(.06)	-.04	
P2 Phoneme D	.24(.06)	.30***		.24(.09)	.29*		.24(.09)	.33**	
P2 Letter-names	.10(.06)	.12		.15(.09)	.21		.01(.08)	.02	
P2 Letter-sounds	.02(.05)	.03		.03(.08)	.04		.01(.07)	.02	
P 2 RAN	.07(.05)	.09		.02(.07)	.03		.19(.12)	.16	
Total variance explained			80.3%			80%			82%

Note. P 2 Read Ac = Phase 2 Reading Accuracy, Rhyme = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB)
[a] measured in Phase 1.
*p<.05, **p<.01, ***p<.001.

The girls' analysis, shown in Table 40, also revealed that only WPPSI IQ, Phase 2 spelling scores, and the Phase 2 graphemic and phonemic awareness variables made significant additional contributions at the stage they were entered accounting for 82% of the total variance. At step 7 girls' age at Phase 2 ($\beta = .17, p < .05$), Phase 2 SAST ($\beta = .33, p < .05$) and Phase 2 phoneme deletion ($\beta = .33, p < .01$) were significant predictors of spelling scores at the end of their second year of formal schooling. The path diagrams in Figure 36, 37, and 38 show the pattern of predictive relationships between Phase 1 and 2 variables and Spelling at the end of the first and second years of formal schooling (Phases 2 and 3).

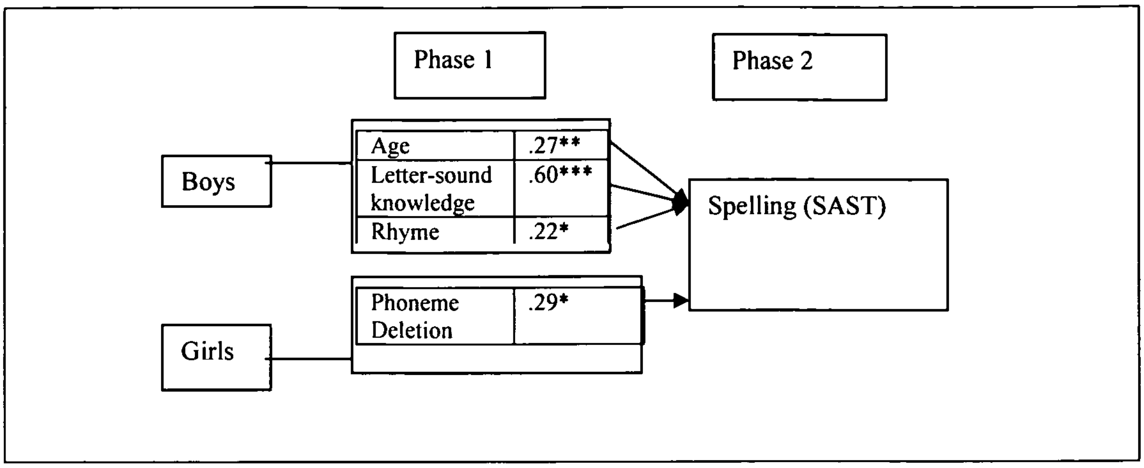

Figure 36 Path diagram showing the predictive relationship between Phase 1 rhyme awareness, and the graphemic and phonemic awareness variables, with Phase 2 spelling for boys and girls. Only the significant predictors are shown. *p<.05, **p<.01, ***p<.001.

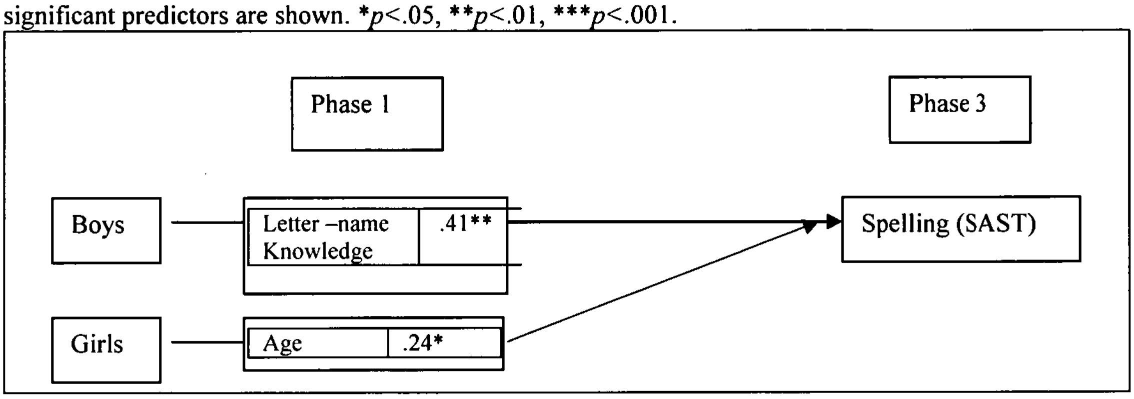

Figure 37. Path diagram showing the predictive relationship between rhyme awareness, and the graphemic and phonemic awareness variables measured in Phases 1 with Phase 3 spelling for boys and girls. Only the significant predictors are shown. *p<.05, **p<.01, ***p<.001.

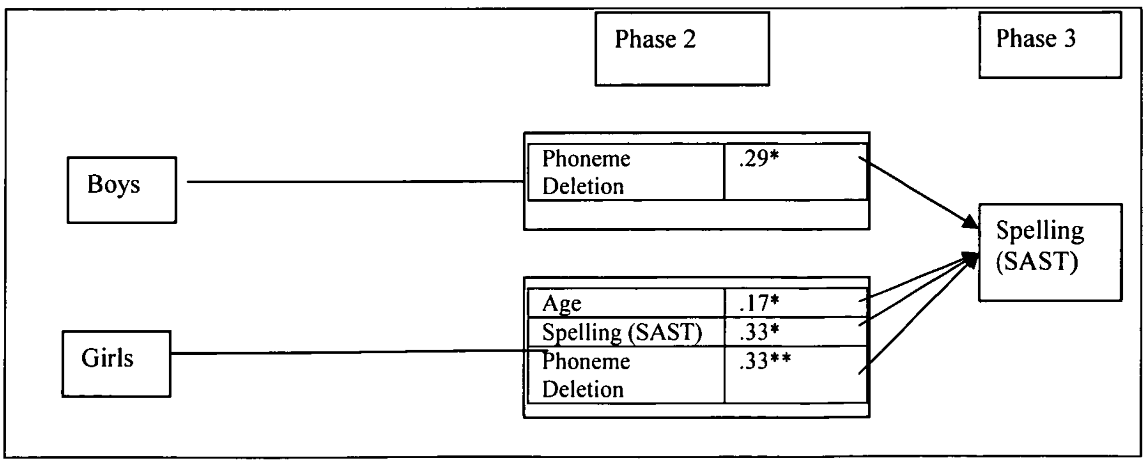

Figure 38. Path diagram showing the predictive relationship between rhyme awareness, and the graphemic and phonemic awareness variables measured in Phases 1 with Phase 3 spelling for boys and girls. Only the significant predictors are shown. *p<.05, **p<.01, ***p<.001.

These analyses of the longitudinal predictors of spelling highlight the important relationship between phonological skills and spelling. According to Ehri (1997) it is knowledge of the alphabetic system, that is, the ability to manipulate and blend phonemes, letter-name knowledge and knowledge of grapheme–to-phoneme-correspondences, that is the critical determinant of spelling development. The present findings support Ehri's proposal. The best predictors of spelling ability at the end of the first year of schooling for all children were, apart from age which was a preliminary control, the graphemic and phonemic awareness variables, specifically, phoneme deletion, and letter-sound knowledge.

The interesting finding in the separate analyses for boys and girls was the importance of Phase 1 rhyme detection ability, together with letter-sound knowledge, in determining spelling ability for boys but not for girls, as was the case with reading accuracy (shown in Table 35). For boys, shown in Table 38, it was rhyme detection, and not phoneme deletion ability that significantly predicted their spelling ability at the end of the first year of school. By the end of the second year of school, Phase 2 phoneme deletion had become a significant predictor of spelling for both boys and girls, suggesting later development of phoneme deletion skills in boys than in girls. That rhyme detection, measured in Phase 2, failed to account for a significant proportion of the total variance in boys' spelling scores may be explained by the ceiling effect in Phase 2 rhyme detection.

None of the Phase 1 phonological variables significantly predicted girls' spelling at the end of their second year of schooling suggesting, as with reading accuracy, that by this stage in their reading and spelling development girls have moved beyond dependence on those early graphemic and phonemic awareness abilities on which boys are still dependent. In investigating the relationship between reading accuracy and spelling ability, Phase 2 reading accuracy was a significant predictor of Phase 3 spelling ability in the analysis for all children but failed to reach significance as a predictor in either of the separate analyses for girls or boys.

The Relationship between Irregular Word Reading and Nonword Reading in the First Two Years of School with Phases 1 and 2 Phonological Awareness Predictors – Rhyme Awareness, and Phonemic Awareness

Regression analyses were run for the full sample of children and for boys and girls separately to investigate the role of rhyme awareness and phonemic awareness (measured in Phases 1 and 2) as predictors of irregular word and nonword reading at the end of the first and second years of schooling (measured in Phases 2 and 3). Once again the estimate weights were used in path diagrams to summarise the relationships. As explained in the introduction to the longitudinal regression analyses (p.182) transformed scores were used for the dependent variable irregular word reading (Phase 2). Raw scores converted into z scores were used for nonword reading.

In all these analyses age was entered at step 1, WPPSI IQ (measured in Phase 1) at step 2, the irregular word or nonword reading measure from that phase (if applicable) at step 3 and rhyme detection at step 4. The graphemic and phonemic awareness variables (determined by the Principal Components Analyses at each phase) were always entered as a block at step 5.

Longitudinal Predictors of Irregular Word Reading

Phase 1 predictors.

The first series of regression analyses, shown in Table 41, assessed the predictive relationships between Phase 1 age, WPPSI IQ, Ready to Read, rhyme detection, phoneme deletion, letter-name and letter-sound knowledge with Phase 2 irregular word reading at the end of the children's first year of formal schooling.

Table 41

Summary of Hierarchical Regression Analysis for Phase 1 Variables Predicting Irregular Word Reading Ability at the end of the First Year of Formal Schooling (Phase 2)

	All Children (N = 140)			Boys (n = 72)			Girls (n = 68)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.047*			.060*			.033
Age	.93(.36)	.22*		1.22(.58)	.25*		.63(.43)	.18	
Step 2			.213***			.178***			.289***
Age	.52 (.32)	.12		.76(.54)	.15		.25(.37)	.07	
WPPSI IQ	.71(.11)	.47***		.72(.18)	.43***		.71(.14)	.55***	
Step 3			.312***			.418***			.147***
Age	.58(.25)	.14*		.94(.36)	.19*		.24(.33)	.07	
WPPSI IQ	.35(.09)	.23***		.37(.13)	.22**		.39(.14)	.30	
P 1 R to Read	.26(.03)	.61***		.30(.03)	.68***		.19(.05)	.46***	
Step 4			.005			.004			.008
Age	.64(.25)	.15*		1.05(.38)	.21**		.27(.33)	.08	
WPPSI IQ	.30(.10)	.20		.32(.14)	.19		.33(.15)	.26*	
P 1 R to Read	.25(.03)	.58***		.29(.04)	.65***		.18(.05)	.43***	
Rhyme Detect	.10(.09)	.08		.11(.12)	.08		.12(.12)	.11	
Step 5			.136***			.136***			.158***
Age	.49(.21)	.12*		.80(.31)	.16*		.23(.28)	.07	
WPPSI IQ	-.01(.09)	-.01		-.00(.12)	-.00		.00(.15)	.00	
P 1 R to Read	.14(.03)	.32***		.17(.03)	.38***		.06(.05)	.16	
Rhyme Detect	.05(.07)	.04		.06(.10)	.04		.06(.11)	.06	
Phoneme D	.11(.09)	.09		.06(.11)	.05		.25(.13)	.24	
Letter –names	.32(.12)	.26**		.30(.16)	.22		.26(.18)	.23	
Letter-sounds	.34(.13)	.27		.46(.16)	.32**		.25(.20)	.23	
Total variance explained			71.3%			77.4%			63.5%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB) Transformed irregular word reading scores used. *p<.05, **p<.01, ***p<.001.

The analysis for all children, shown in Table 41, revealed that all variables, with the exception of rhyme detection, made significant additional contributions at the stage they were entered accounting for 71.3% of the total variance in irregular word reading at the end of the first year of school. Age which was a preliminary control was a significant predictor at step 1 and retained its significant effect through to step 5 (β =.12, $p < .05$). At step 3 Phase 1 Ready to Read accounted for 31.2% of the total variance and retained its significance at step 5 (β =.32, $p < .001$). Of the graphemic and phonemic awareness variables added at step 5, letter-name knowledge (β =.26, $p < .01$) made a significant incremental improvement in prediction additional to age and Phase 1 Ready to Read. Rhyme detection did not add any significant incremental improvement at step 4 in accounting for variance in Phase 2 irregular word reading.

The analysis for boys, also shown in Table 41, showed that age, WPPSI IQ, Ready to read scores and the graphemic and phonemic awareness variables all accounted for additional significant variance in Phase 2 irregular word reading scores when added into the equation with the model accounting for 77.4% of the total variance. Age at step 1 accounted for significant variance (6%) in boys' Phase 2 irregular word reading scores and retained its significance at step 5 (β =.16, $p < .05$). Ready to Read at step 3 accounted for 41.8% of the total variance and retained this effect at step 5 (β =.38, $p < .001$). Of the graphemic and phonemic awareness variables added at step 5 only letter-sound knowledge (β =.32, $p < .01$) made a significant incremental improvement in prediction additional to age and Ready to Read.

The analysis for girls, shown in Table 41, indicated that WPPSI IQ, Ready to Read scores and the graphemic and phonemic awareness variables all accounted for additional significant variance in Phase 2 irregular word reading scores when added into the equation with the model accounting for 63.5% of the total variance. Ready to Read scores at step 3 accounted for 14.7% of the total variance but this effect was not maintained at step 5 in which there were no significant predictors of Phase 2 irregular word reading. Ready to Read scores accounted for a large 41.8% of the total variance in Phase 2 irregular word reading for boys, whereas for girls it accounted for 14.7% of the total variance and this difference in percentages was significant ($p<.001$).

The next series of Regression analyses, shown in Table 42, assessed the predictive relationships between the Phase 1 variables used in the first series of regression analyses with irregular word reading at the end of the children's second year of formal schooling. For the full sample of children all the variables entered made significant additional contributions to the equation at the stage of entry, accounting for 65.8% of total variance. Phase 1 age accounted for 4.4% of the total variance at step 1 and retained its significance at step 5 ($\beta = .11, p < .05$). Ready to Read made a significant incremental improvement in prediction additional to age and WPPSI IQ at step 3 but did not retain its significance when the graphemic and phonemic awareness variables were added at step 5. Rhyme detection made a significant incremental improvement in prediction additional to age, WPPSI IQ and Ready to Read at step 4 and remained a significant predictor following the inclusion of the graphemic and phonemic awareness variables at step 5 ($\beta = .15, p < .05$). Of the graphemic and phonemic awareness variable which accounted for an additional 17% of the total variance in Phase 3 irregular word reading, both phoneme deletion ($\beta = .18, p < .05$), and letter-name knowledge ($\beta = .50, p < .001$) made a significant incremental improvement in prediction additional to age and rhyme detection.

For boys all the variables entered, except for age, made significant additional contributions to the equation at the stage that they were entered, accounting for 75.5% of the total variance. Although Rhyme detection made a significant incremental improvement in prediction additional to Ready to Read at step 4 ($\beta = .23, p < .05$). its effect was diminished to below significance following the inclusion of the graphemic and phonemic awareness variables ($\beta = .15, p = .06$). At the final step Phase 1 letter-name knowledge was the only significant Phase 1 predictor ($\beta = .71, p < .001$) of boy's .irregular word reading at the end of the second school year.

For girls all the variables entered, except for rhyme detection, made significant additional contributions to the equation at the stage that they are entered, accounting for 55% of total variance. In the final equation for girls the only significant Phase 1 predictor of irregular word reading at the end of the second year of schooling was age ($\beta = .20, p < .05$).

Table 42

Summary of Hierarchical Regression Analyses for Phase 1 Variables Predicting Irregular Word Reading Ability at the end of the Second Year of Formal Schooling (Phase 3)

	All Children (N = 127)			Boys (n = 68)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.044*			.019			.093*
Age	.70(.29)	.21*		.52(.46)	.14		.84(.35)	.31*	
Step 2			.213***			.218***			.239***
Age	.36(.26)	.11		.14(.42)	.04		.54(.31)	.20	
WPPSI IQ	.53(.09)	.47***		.59(.14)	.48***		.49(.11)	.50***	
Step 3			.204***			.266***			.090**
Age	.44(.23)	.13		.31(.34)	.08		.55(.30)	.20	
WPPSI IQ	.30(.08)	.26**		.36(.12)	.29**		.29(.12)	.30*	
P 1 R to Read	.16(.02)	.50***		.36(.12)	.55***		.12(.04)	.36*	
Step 4			.027*			.034*			.009
Age	.55(.25)	.16*		.47(.34)	.13		.59(.29)	.21*	
WPPSI IQ	.22(.09)	.19*		.26(.12)	.21*		.24(.13)	.25	
P 1 R to Read	.15(.03)	.44***		.15(.03)	.47***		.12(.04)	.34**	
Rhyme Det	.20(.08)	.20*		.23(.11)	.23*		.11(.11)	.11	
Step 5			.17***			.218***			.119**
Age	.38(.19)	.11*		.08(.27)	.02		.55(.27)	.20*	
WPPSI IQ	-.02(.08)	-.02		-.05(.10)	-.04		.04(.14)	.04	
P 1 R to Read	.05(.03)	.14		.05(.03)	.15		.03(.05)	.08	
Rhyme Det	.15(.07)	.15*		.16(.08)	.15		.05(.11)	.06	
Phoneme D	.17(.08)	.18*		.10(.11)	.11		.19(.13)	.23	
Letter –names	.50(.10)	.50***		.14(.71)	.71***		.15(.17)	.16	
Letter-sounds	.50(.10)	-.01		.15(-.09)	-.09		.21(.20)	.24	
Total variance explained			65.8%			75.5%			55%

Note. P 1 R to R = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB)
*p<.05, **p<.01, ***p<.001.

Phase 2 Predictors of Phase 3 Irregular Word Reading

The regression analyses for all children, and for boys, shown in Table 43, showed that WPPSI IQ, Phase 2 irregular word reading and the block of Phase 2 graphemic and phonemic awareness variables each accounted for additional significant variance at the stage that they were entered in predicting irregular word reading at the end of the second year of formal schooling, with the model accounting for 76.5% of the total variance for all children and 77.7% for boys. For girls, also shown in Table 42, chronological age (in Phase 2), WPPSI IQ, Phase 2 Irregular word reading, and the Phase 2 graphemic and phonemic awareness variables all accounted for significant additional variance at the stage of entry into the equation, accounting for 77.8% of the total variance.

Age was a significant predictor of Phase 3 irregular word reading for girls at step 1 and retained its significance as a predictor at step 5 ($\beta = .16, p < .05$). At step 5 irregular word reading was the most powerful Phase 2 predictor of irregular word reading at the end of the children's second year of schooling for the full sample of children, ($\beta = .49, p < .001$), for boys ($\beta = .50, p < .001$), and for girls ($\beta = .48, p < .001$).

The path diagrams in Figures 39-41 show the pattern of predictive relationships between Phase 1 and 2 variables and irregular word reading at the end of the first and the second years of formal schooling.

Table 43

Summary of Hierarchical Regression Analyses for Phase 2 Variables and WPPSI IQ (measured in Phase 1) Predicting Irregular Word Reading Ability at the end of the Second year of Formal Schooling (Phase 3)

	All Children (N = 123)			Boys (n = 65)			Girls (n = 58)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.008			.004			.038*
Age	.31(.32)	.09		-.27(.53)	-.06		.75(.35)	.27*	
Step 2			.244***			.25***			.248***
Age	.05(.28)	.01		-.47(.47)	-.11		.47(.31)	.17	
WPPSI IQ[a]	.58(.09)	.50***		.64(.14)	.50***		.19(.08)	.51***	
Step 3			.425***			.437***			.388***
Age	.16(.19)	.05**		-.23(.30)	-.05		.44(.21)	.16*	
WPPSI IQ[a]	.23(.07)	.20**		.26(.10)	.20*		.19(.1)	.19*	
P2 Irreg Read	.70(.06)	.72***		.67(.07).	.72***		.77(.10	.70***	
Step 4			.002			.009			.014
Age	.19(.19)	.06		-.18(.31)	-.04		.45(.22)	.16*	
WPPSI IQ[a]	.20(.07)	.17**		.20(.11)	.16		.18(.09)	.19	
P2 Irreg Read	.69(.06)	.71***		.65(.07)	.70***		.77(.10)	.70***	
Rhyme Detect	.06(.07)	.06		.14(.10)	.11(.20)		.01(.08)	.01	
Step 5			.086***			.078**			.067*
Age	.15(.17)	.04		-.26(.28)	-.06		.44(.20)	.16*	
WPPSI IQ[a]	.15(.17)	.06		.01(.11)	.01		.12(.09)	.12	
P2 Irreg Read	.07(.07)	.49***		.46(.08)	.50***		.53(.11)	.48***	
Rhyme Detect	.48(.06)	-.003		.02(.10)	.02		-.03(.08)	-.04	
Phoneme D	.24(.08)	.24**		.24(.11)	.23*		.26(.11)	.28*	
Letter –names	.15(.08)	.15		.20(.11)	.22		.10(.110	.09	
Letter-sounds	.03(.06)	.13		.04(.10)	.04		.-2(.09)	.02	
RAN	.07(.07)	.08		.02(.10)	.03		.06(.16)	.04	
Total variance			76.5%			77.7%			77.8%

Note. P 2 Irreg Read = Phase 2 Irregular word Reading, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion
[a] measured in Phase 1 *p<.05, **p<.01, ***p<.001.

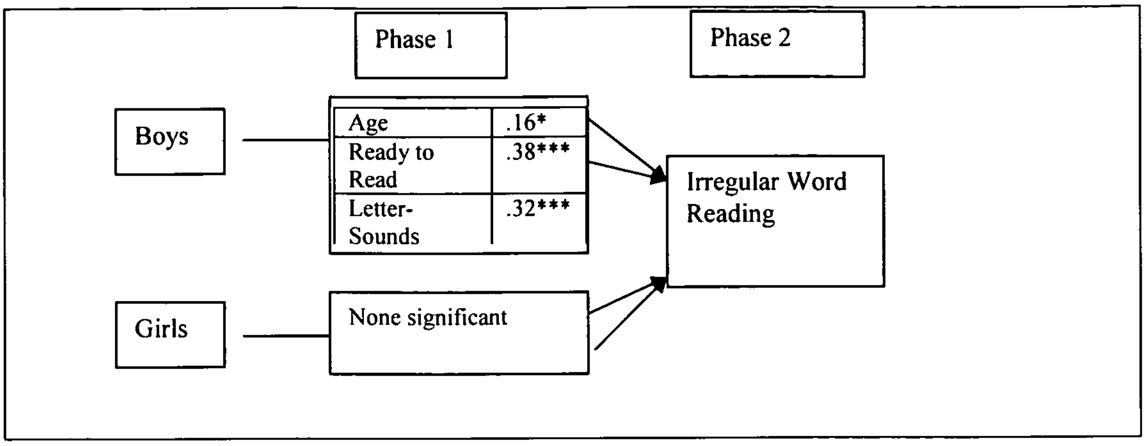

Figure39. Path diagram showing the predictive relationship between Phase 1 rhyme awareness, and the graphemic and phonemic awareness variables, with Phase 2 irregular word reading for boys and girls. Only the significant predictors are shown. **p*<.05, ***p*<.01, ****p*<.001

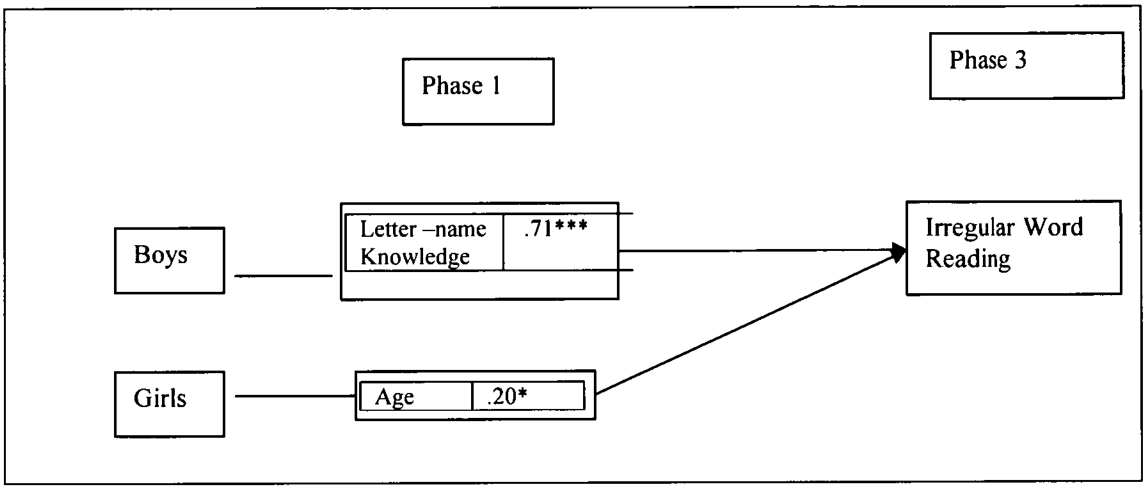

Figure 40. Path diagram showing the predictive relationship between rhyme awareness, and the graphemic and phonemic awareness variables measured in Phases 1 and 2 with Phase 3 irregular word reading for boys and girls. Only the significant predictors are shown. **p*<.05, ***p*<.01, ****p*<.001.

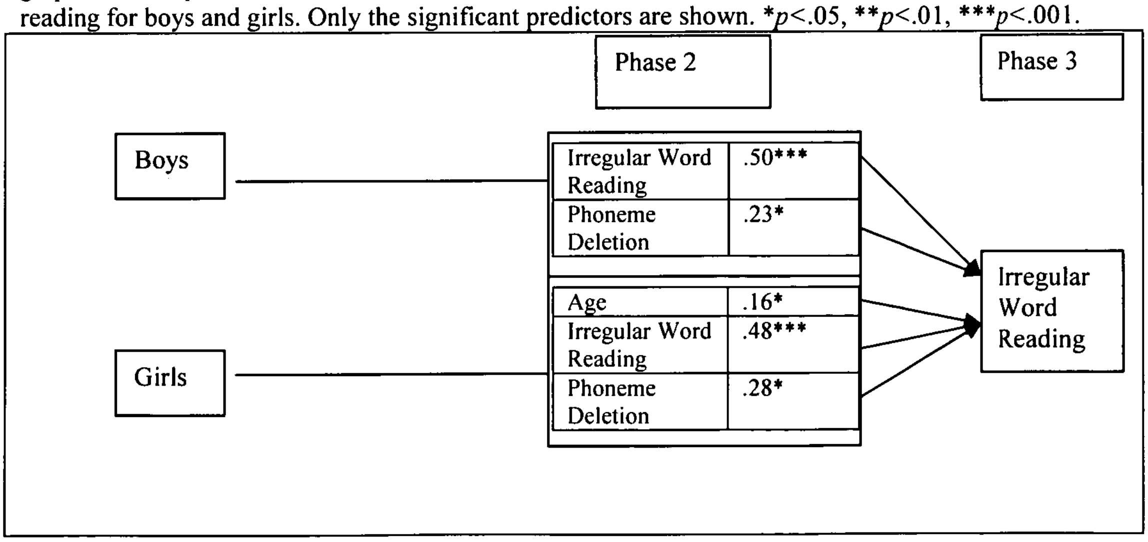

Figure 41. Path diagram showing the predictive relationship between rhyme awareness, and the graphemic and phonemic awareness variables measured in Phases 1 and 2 with Phase 3 irregular word reading for boys and girls.. Only the significant predictors are shown. **p*<.05, ***p*<.01, ****p*<.001

Longitudinal Predictors of Nonword Reading

Phase 1 Predictors

The first series of regression analyses, shown in Table 44, assessed the predictive relationships between Phase 1 age, WPPSI IQ, rhyme, phoneme deletion, letter-name and letter-sound knowledge and Ready to Read with Phase 2 nonword reading at the end of the children's first year of formal schooling. The analysis for all children showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 57.9% of the total variance in nonword reading at the end of the first year of school. For the full sample of children Phase 1 Ready to Read at step 3, made a significant incremental improvement in prediction, accounting for 23.2% of the total variance, and retained its significance at step 5 (β =.18, $p < .05$). Phase 1 rhyme detection made a significant additional incremental improvement additional to Phase 1 Ready to Read and retained its significance following the inclusion of the graphemic and phonemic awareness variables at step 5 (β =.19, $p < .01$). Of the block of graphemic and phonemic awareness variables, which accounted for a significant additional 13.2% of the total variance in Phase 2 nonword word reading, letter-sound knowledge (β =.24, $p < .05$), and phoneme deletion (β =.29, $p < .01$) were both significant predictors additional to Phase 1 Ready to Read..

Table 44

Summary of Hierarchical Regression Analysis for Phase 1 Variables Predicting Nonword Reading Ability at the end of the First Year of Formal Schooling (Phase 2)

	All Children (N = 140)			Boys (n = 72)			Girls (n = 68)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.021			.025			.019
Age	.49(.29)	.14		.63(.47)	.16		.37(.33)	.14	
Step 2			.154***			.17***			.138**
Age	.20(.27)	.06		.27(.44)	.07		.14(.32)	.05	
WPPSI IQ	.47(.10)	.40***		.57(.15)	.42***		.36(.11)	.38	
Step 3			.232***			.37***			.060*
Age	.24(.23)	.07		.41(.33)	.10		.14(.31)	.05	
WPPSI IQ	.22(.09)	.19*		.30(.12)	.22*		.21(.13)	.22	
P 1 R to Read	.18(.03)	.53***		.23(.03)	.64***		.09(.04)	.29*	
Step 4						.037*			.050*
Age	.38(.23)	.11	.040**	.65(.33)	.16		.20(.30)	.07	
WPPSI IQ	.12(.09)	.10		.18(.12)	.14		.10(.14)	.11	
P 1 R to Read	.16(.03)	.45***		.20(.03)	.56***		.07(.04)	.23	
Rhyme Detect	.24(.08)	.24**		.26(.10)	.24*		.23(.11)	.27*	
Step 5			.132***			.14***			.227***
Age	.32(.20)	.10		.64(.29)	.16*		.19(.26)	.07	
WPPSI IQ	-.09(.09)	-.08		-.07(.11)	-.01		-.19(.13)	-.20	
P 1 R to Read	.06(.03)	.18*		.09(.03)	.26**		-.02(.04)	-.07	
Rhyme Detect	.19(.07)	.19**		.21(.09)	.19*		.15(.10)	.18	
Phoneme D	.29(.08)	.29**		.37(.10)	.32**		.29(.12)	.36*	
Letter –names	.08(.11)	.08		.06(.14)	.06		-.08(.16)	-.09	
Letter-sounds	.24(.12)	.24*		.27(.15)	.23		.43(.18)	.53*	
Total variance explained			57.9%			73.8%			49.4%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB)
*p<.05, **p<.01, ***p<.001

The separate analyses for boys and girls, shown in Table 44, revealed some important differences in the relative importance of the phonological variables as predictors of nonword reading at the end of the first year of formal schooling. As with the full sample the separate boys' analysis showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 73.8% of the total variance in nonword reading at the end of the first year of school. Phase 1 age accounted for a significant 2.5% of the total variance retained its significance as a predictor at step 5 (β =.16, $p < .05$). Ready to Read scores made a significant incremental improvement in addition to age and WPPSI IQ and retained its significance following the addition of the phonological awareness variables at steps 4 and 5 (β =.26, $p < .01$). Both phonological awareness variables also accounted for significant additional variance. Rhyme detection made a significant incremental improvement in prediction additional to Ready to Read at step 4 and retained its significant effect following the addition of the graphemic and phonemic awareness variables (β =.19, $p < .05$). The block of graphemic and phonemic awareness variables further improved the prediction adding 13.6% of the total variance in boys' nonword reading at the end of the first year of formal schooling. Of the graphemic and phonemic awareness variables phoneme deletion (β =.32, $p < .01$) was the only significant predictor for boys in addition to Ready to Read and rhyme detection..

As with the analysis for boys the analysis for girls showed that all variables, with the exception of age, made significant additional contributions at the stage they were entered accounting for 49.4% of the total variance in nonword reading at the end of the first year of school, considerably less variance than was accounted for by these variables in the boys' analysis. In the final equation for girls the graphemic and phonemic awareness variables accounted for 22.7% of the total variance in their Phase 2 nonword reading scores Of the graphemic and phonemic awareness variables, phoneme deletion (β =.36, $p < .05$), and letter-sound knowledge (β =.53, $p < .05$), were significant predictors. For boys the Phase 1 graphemic and phonemic awareness variables accounted for a lesser 13.6% of the total variance and the difference between these two percentages was significant ($p<.05$). Phase 1 Ready to Read scores accounted for just 6% of the total variance in Phase 2 nonword reading for girls and its contribution was not significant. For boys however Ready to Read scores accounted for a much larger and significant proportion of the total variance in Phase 2 nonword reading scores (37%) and the difference between these two percentages was significant ($p<.001$).

The next series of regression analyses, shown in Table 45, assessed the predictive relationships between the Phase 1 variables used in the previous series of analyses with nonword reading measured at the end of the second year of school (Phase 3). For the full sample of children all the variables entered made significant additional contributions to the equation at the stage that they were entered, accounting for 57.1% of total variance. Age (β =.13 $p < .05$) remained a significant predictor at step 5. Both rhyme awareness (step 4) and the graphemic and phonemic awareness variables (step 5) accounted for significant additional variance. Rhyme detection made a significant incremental improvement in prediction at step 4 in addition to Ready to Read and retained its significant effect at step 5 following the inclusion of the graphemic and phonemic awareness variables (β =.16, $p< .05$). The graphemic and phonemic awareness variables, of which both phoneme deletion (β =.37, $p < .001$) and letter-name knowledge (β =.32, $p < .01$), were significant predictors, accounted for a further 14.5 % of the total variance in nonword reading scores at the end of the children's second year of schooling.

Table 45

Summary of Hierarchical Regression Analyses for Phase 1 Variables Predicting Nonword Reading Ability at the end of the Second Year of Schooling (Phase 3)

	All Children (N = 127)			Boys (n = 68)			Girls (n = 59)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			.040*			.016			.083*
Age	.66(.29)	.20*		.47*(.45)	.13		.83(.36)	.30*	
Step 2			.186***			.223***			.157**
Age	.35(.27)	.11		.10(.41)	.03		.57(.34)	.20	
WPPSI IQ	.50(.09)	.44***		.58(.13)	.48***		.41(.12)	.41**	
Step 3			.172***			.247***			.060*
Age	.43(.24)	.13		.26(.34)	.07		.58(.33)	.20	
WPPSI IQ	.28(.09)	.25**		.37(.12)	.31**		.24(.14)	.24	
P 1 R to Read	.15(.03)	.46***		.17(.03)	.53***		.10(.05)	.30*	
Step 4			.028*			.042*			.005
Age	.53(.24)	.16*		.44(.34)	.12		.61(.34)	.21	
WPPSI IQ	.20(.09)	.18*		.26(.12)	.21*		.21(.15)	.20	
P 1 R to Read	.13(.03)	.40***		.14(.03)	.44***		.10(.05)	.28*	
Rhyme Detect	.20(.08)	.20*		.26(.11)	.25*		.08(.13)	.09	
Step 5			.145***			.15***			.14*
Age	.43(.21)	.13*		.32(.30)	.09		.54(.31)	.19	
WPPSI IQ	.01(.09)	.01		.05(.11)	.04		.02(.16)	.02	
P 1 R to Read	.04(.03)	.11		.04(.03)	.13		.04(.05)	.01	
Rhyme Detect	.15(.07)	.16*		.21(.09)	.21*		.03(.12)	.03	
Phoneme D	.36(.09)	.37***		.34(.12)	.32**		.39(.15)	.44*	
Letter –names	.32(.12)	.32**		.33(.15)	.33*		.17(.20)	.17	
Letter-sounds	-.06(.13)	-.06		-.08(.16)	-.07		.02(.23)	.02	
Total variance explained			57.1%			68%			44.3%

Note. P 1 R to Read = Phase 1 Ready to Read, Rhyme Detect = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB)
*p<.05, **p<.01, ***p<.001.

For boys all the variables entered, except for age, made significant additional contributions to the equation at stage of entry, accounting for 68% of total variance. In the final equation the both rhyme awareness and the graphemic and phonemic awareness variables accounted for a significant amount of the total variance. Phase 1 rhyme detection made a significant incremental improvement in prediction at step 4 and retained its significant effect following the inclusion of the graphemic and phonemic awareness variables at step 5 (β =.21, $p < .05$). The graphemic and phonemic awareness variables, of which phoneme deletion (β =.32, $p < .001$), and letter-name knowledge (β =.33, $p < .05$) were both significant predictors, accounted for an additional 15.2% of the total variance.

For girls only WPPSI IQ, Ready to Read and the graphemic and phonemic awareness variables made a significant contribution. In the final equation the only significant Phase 1 predictor of Phase 3 nonword reading was phoneme deletion (β =.44, $p < .05$), with the graphemic and phonemic awareness variables accounting for13.8% of the total variance in girls' nonword reading scores at the end of their second year of schooling. For girls rhyme detection at step 4 did not make a significant incremental improvement in prediction as it did for boys.

Phase 2 predictors of Phase 3 Nonword Reading

The regression analyses, shown in Table 46, for all children, and for boys separately showed that WPPSI IQ, Phase 2 nonword reading and the block of Phase 2 graphemic and phonemic awareness variables each accounted for additional significant variance at the stage that they were entered in predicting nonword reading at the end of the second year of formal schooling. For the total sample of children the model accounted for 76.2% of the total variance, while for boys the model accounted for 83.6% of the total variance. For the girls only WPPSI IQ, and Phase 2 nonword reading accounted for significant additional variance at the stage of entry into the equation, accounting for 71% of the total variance in their nonword reading scores at the end of their second year of schooling. These regression analyses are shown in Table 46.

For the full sample of children nonword reading in Phase 2 was the most powerful predictor of Phase 3 nonword reading at step 3 and retaining its high level of significance as a predictor at step 5 after the inclusion of the phonological awareness variables for all children (β =.57, $p < .001$), for boys (β =.55, $p < .001$), and for girls (β =.57, $p < .001$). Once Phase 2 nonword reading scores had been accounted for, Phase 2 phoneme deletion was the only other significant predictor of Phase 3 nonword reading scores for the full sample of children (β =.28, $p < .001$), with the block of graphemic and phonemic awareness variables accounting for an additional 6.2% of the total variance. For boys at step 5 phoneme deletion was a significant predictor(β =.36, $p < .001$) additional to Phase 2 nonword reading and the block of graphemic and phonemic awareness variables accounted for an additional 7.1% of the total variance. In contrast, for girls no other Phase 2 variable was a significant predictor of nonword reading scores at the end of their second year of school. The path diagrams in Figures 42-44 show the pattern of predictive relationships between Phase 1 and Phase 2 variables and nonword reading at the end of the first and the second years of formal schooling (Phases 2 and 3).

Table 46

Summary of Hierarchical Regression Analysis for Phase 2 Variables and WPPSI IQ (measured in Phase 1) Predicting Nonword Reading Ability at the end of the Second year of Formal Schooling (Phase 3)

	All Children (N = 123)			Boys (n = 65)			Girls (n = 58)		
Variable	B(SEB)	β	ΔR^2	B (SEB)	β	ΔR^2	B (SEB)	β	ΔR^2
Step 1			. .004			.009			.060
Age	.23(.32)	.07		-.39(.52)	-.09		.70(.37)	.24	
Step 2			.228***			.270***			.172**
Age	.12(.18)	-.01		-.59(.45)	-.14		.45(.35)	.16	
WPPSI IQ[a]	.21(.06)	.48***		.65(.14)	.52***		.44(.13)	.42**	
Step 3			.478***			.481***			.438***
Age	.13(.18)	.04		-.21(.27)	-.05		.35(.23)	.12	
WPPSI IQ[a]	.21(.06)	.18**		.22(.27)	.18*		.21(.09)	.20	
P2 NW Read	.73(.05)	.75***		.22(.09)	.78***		.76(.09)	.70***	
Step 4			.000			.005			.002
Age	.13(.18)	.04		-.18(.27)	-.04		.31(.24)	.11	
WPPSI IQ[a]	.21(.07)	.18**		.18(.09)	.15		.24(.10)	.24	
P2 NW Read	.74(.06)	.75***		.70(.07)	.76***		.80(.10)	.72***	
Rhyme Detect	.02(.06)	.02		.10(.09)	.08		-.01(.09)	-.06	
Step 5			.062***			.071***			.038
Age	.09(.16)	.03		-.29(.24)	-.07		.30(.25)	.11	
WPPSI IQ[a]	.09(.07)	.08		.05(.09)	.04		.14(.11)	.14	
P2 NW Read	.56(.06)	.57***		.51(.08)	.55***		.63(.12)	.57***	
Rhyme Detect	-.04(.06)	-.04		.05(.08)	.01		-.01(.10)	-.06	
Phoneme D	.28(.08)	.28***		.38(.10)	.36***		.14(.13)	.15	
Letter –names	-.06(.08)	-.01		-.01(.10)	-.01		.00(.13)	.00	
Letter-sounds	.01(.06)	.01		-.02(.09)	-.02		.08(.11)	.08	
RAN	.13(.07)	.13		.09(.08)	.10		.16(.19)	.11	
Total variance			76.2%			83.6%			71%

Note. P 2 NW Read = Phase 2 Nonword Reading, Rhyme Det = Rhyme Detection, Phoneme D = Phoneme Deletion. Standard Error of Beta shown in parentheses (SEB)
[a] measured in Phase 1 *p<.05, **p<.01, ***p<.001.

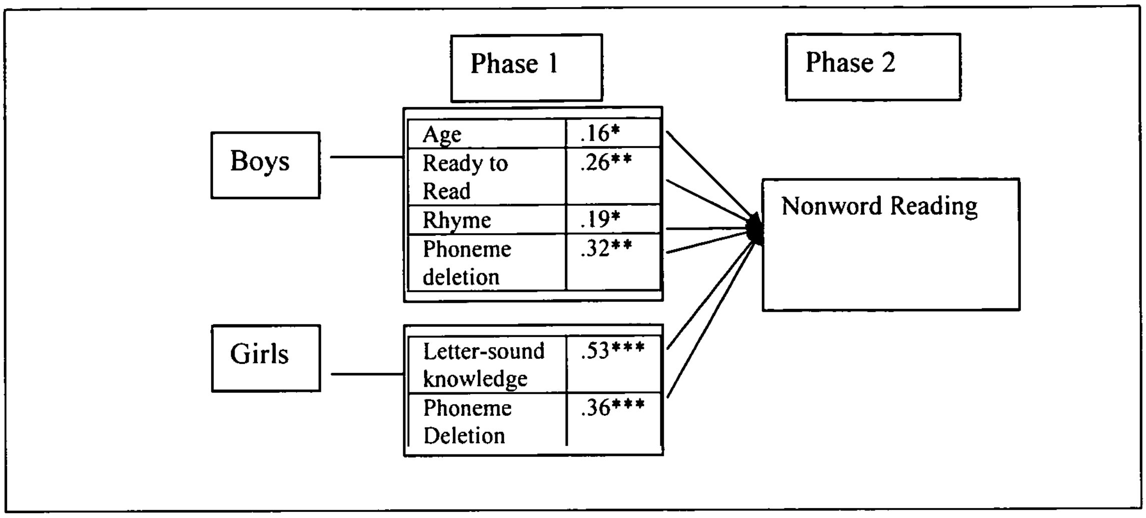

Figure 42. Path diagram showing the predictive relationship between Phase 1 rhyme awareness, and the graphemic and phonemic awareness variables with Phase 2 Nonword Reading for boys and girls. Only the significant predictors are shown. *p<.05, **p<.01, ***p<.001

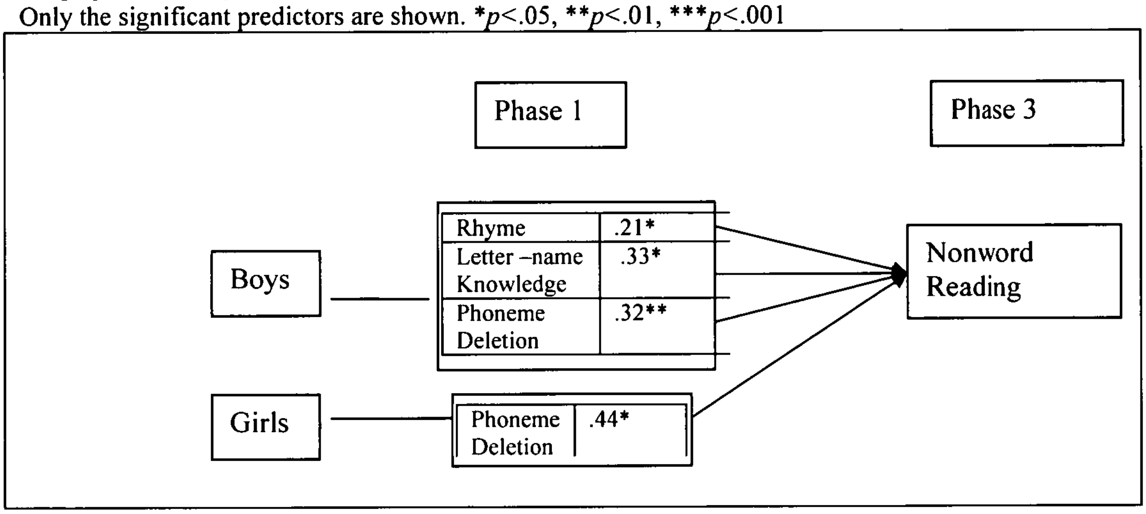

Figure 43. Path diagram showing the predictive relationship between Phase 1 rhyme awareness, and the graphemic and phonemic awareness variables with Phase 3 Nonword Reading for boys and girls. Only the significant predictors are shown. *p<.05, **p<.01, ***p<.001

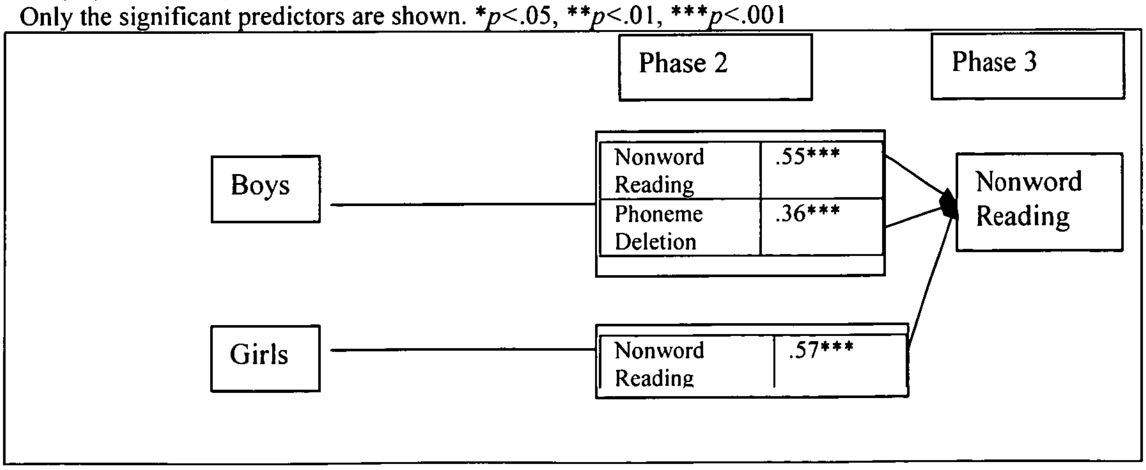

Figure 44. Path diagram showing the predictive relationship between Phase 2 rhyme awareness, and the graphemic and phonemic awareness variables with Phase 3 Nonword Reading for boys and girls. Only the significant predictors are shown. *p<.05, **p<.01, ***p<.001

These findings in relation to the best predictors of performance in nonword reading provide evidence that boys rely on both phonemic awareness strategies and rhyming strategies to decode unfamiliar words. For boys both Phase 1 rhyme detection and phoneme deletion were significant predictors of nonword reading at the end of both the first and the second years of formal schooling whereas for girls phoneme deletion was a significant predictor but rhyme detection failed to significantly predict nonword reading at the end of either the first or second years of schooling. That rhyme detection did not remain a significant predictor of nonword reading for boys when measured in Phase 2 is most likely explained by the strong ceiling effect in rhyme detection in Phase 2.

Coltheart and Leahy (1992) found that young readers demonstrated the use of both grapheme-phoneme and body (rime) units in oral reading of nonwords and the present findings suggest that this may be the case more for boys than for girls. The Martin and Pratt Nonword Reading Test (2000) contains a mixture of words which contain a body (rime) found in common words (e.g., *rint, kig, og,* and *vot*) and words which contain bodies which are rare or nonexistent (e.g., kuch, oiz, neopth).

Key Findings from the Longitudinal Regression Analyses

In summary the key findings from the longitudinal regression analyses were:

1. WPPSI IQ (short-form) measured in Phase 1 was significantly correlated with all the reading and spelling measures but failed to significantly predict any of the reading and spelling outcome measures after the inclusion of the phonological and reading measures in the predictive equations.
2. Reading readiness as measured by the Ready to Read Test in Phase 1 was significantly correlated with all reading and spelling measures for both boys and girls in both Phases 2 and 3 (shown in Table 34). The hierarchical regression analyses showed that reading readiness at the beginning of the study was a significant predictor of Phase 2 reading accuracy, irregular word reading, and nonword reading for boys (Tables 35, 41, and 44), and in Phase 3 (the end of the second year of formal schooling) it remained a significant predictor of reading accuracy for boys (Table 36), after taking account of the contribution of the Phase 1 phonological measures. For girls Ready to Read failed to predict neither reading accuracy, nor irregular word reading, nor nonword reading at the end of the first or second years of school.
3. Rhyme detection ability measured in Phases 1 and 2 was significantly correlated with all the Phase 2 reading and spelling measures for both boys and girls (Table 34), although not as strongly as was phoneme deletion. However for girls rhyme detection failed to make a significant additional contribution to the prediction of any of the reading or spelling measures at the end of either the first or the second year of school after including the graphemic and phonemic awareness variables. For boys rhyme detection ability measured in Phase 1 remained a significant predictor of nonword reading ability at the end of both the first and the second

years of school, and a significant predictor of both reading accuracy and spelling ability at the end of the first year of school following the inclusion of the graphemic and phonemic awareness variables.

4. Phase 1 letter-name knowledge was highly correlated with all the Phases 2 and 3 reading and spelling outcome measures. In the hierarchical regression analyses it remained a significant predictor of all Phase 3 reading and spelling measures, that is, reading accuracy, spelling, irregular word reading, and nonword reading, after including all variables entered into the regression equation, for boys but not for girls. For girls none of the Phase 1 variables significantly predicted reading accuracy or nonword reading scores at the end of the second year of schooling.
5. The finding that early letter-name knowledge is so critically important for boys, but not girls' reading and spelling at the end of their second year of schooling may be related to developmental differences between boys and girls. Although speculative, the general finding of the importance of early skills, suggests that boys are relying on these earlier skills to compensate for slower development of phonemic awareness and a slower response to instruction in the alphabetic principle, when compared with girls.
6. The most powerful predictor of girls' spelling ability at the end of the first year was their phoneme deletion scores at the beginning of the study, suggesting that girls are relying heavily on their phonemic awareness skills for their spelling. For boys, however, letter-sound knowledge in addition to their rhyme detection scores significantly predicted their spelling ability at the end of the first year. This suggests reliance on larger units of sound perhaps to compensate for less developed phonemic awareness skills (for boys phoneme deletion scores were not a significant predictor of spelling at the end of the first year).

7. In the regression analyses predicting nonword reading ability at the end of the first year from the initial measures at Phase 1, letter-sound knowledge, together with phoneme deletion made a significant contribution to girls' nonword reading suggesting that girls are also relying predominantly on their phonemic awareness to read nonwords. The significant Phase 1 predictors of nonword reading at the end of the first year of school for boys after inclusion of all the variables were phoneme deletion, rhyme detection, and also Ready to Read, once again suggesting that boys, while also using phonemic awareness, are also relying on strategies involving the use of larger units of sound to read nonwords as indicated by the significance of both their rhyme detection and Ready to Read scores as predictors.
8. For girls by the end of their second year of school (Phase 3) none of the Phase 1 phonological measures significantly predicted reading accuracy, irregular word reading, or spelling ability, with the exception of Phase 1 age which was a significant predictor of girls' spelling and irregular word reading. For nonword reading at the end of the second year phoneme deletion measured at the beginning of the study remained a significant predictor for girls.
9. For both girls and boys graphemic and phonemic awareness skills were strongly related to their achievement in both reading and spelling, however developmentally boys appear to be lagging behind girls in the development of these skills. The findings provide evidence that in addition to a heavy reliance on graphemic and phonemic awareness skills boys also rely on strategies associated with larger units of sound. This is in contrast with the girls in this study for whom rhyming skills (early phonological awareness) were not a predictor of later reading and spelling skills.

10. The finding that rhyme detection measured in Phase 2 was not a significant predictor of any of the reading or spelling measures in Phase 3 after allowance for the other variables in the regression analyses should be interpreted in light of the strong ceiling effect in the rhyme detection test in Phase 2, which resulted in the scores being negatively skewed with little differentiation between scores.

CHAPTER 10

General Discussion and Conclusions

This thesis investigated phonemic and rhyme awareness and their relationship with reading and spelling in beginning readers. The longitudinal design of the study enabled an analysis of the developmental patterns in boys and girls over their first two years of school. Two main research questions were addressed. The first question focussed firstly on girls' and boys' performance on tasks measuring letter knowledge (both names and sounds), phonemic awareness and rhyme awareness and examined whether girls would show more developed letter knowledge and phonemic awareness earlier than boys, secondly on whether this would contribute to more accurate reading and spelling performance, and thirdly on the extent of any disadvantage for boys if efficient phonemic awareness is delayed. The second question examined graphemic and phonemic awareness and rhyme awareness as concurrent and longitudinal predictors of reading and spelling performance.

The results from Principal Component analyses and from Analyses of Covariance conducted in each of the three phases showed that girls were significantly more accurate on both graphemic and phonemic awareness measures than boys of the same age. The Principal Components analyses in each phase were used as the initial analyses to examine underlying processes. These analyses produced a graphemic and phonemic awareness factor in each phase which was defined by high loadings from letter-name and letter-sound knowledge, phoneme deletion, and in Phases 2 and 3 also included RAN of letters. The consistent finding across all three phases of the presence of a factor based on high loadings from both letter knowledge variables and phoneme deletion but not the rhyme awareness variables is consistent with Share's (1995) proposal that letter-sound knowledge and phonemic awareness are critical "co-requisites" (p.161) in reading acquisition and is also consistent with Yopp's (1988) proposal that rhyme awareness tests are measuring a different phonological skill. The distributions of boys' and girls' scores on this factor showed that there were significantly more girls than boys of the same age with more highly developed graphemic and phonemic awareness skills and this occurred despite the boys' generally higher cognitive ability.

Analyses of Covariance, controlling for differences in age and cognitive ability, in each phase, and across the three phases showed that girls were significantly more accurate on the phoneme deletion task (which measured the ability to hear and manipulate phonemes within a spoken word) and demonstrated significantly more accurate letter knowledge. Denckla and Rudel's (1976) rapid automatised naming (RAN) of letters, which required the participant to name an array of familiar letters in serial order as quickly as possible, was used to measure speed of processing. Girls demonstrated significantly faster processing speeds, in both Phases 2 and 3, than boys and this may best be explained by their superior knowledge of letter-sound correspondences. Wagner and Torgesen (1987) suggested that poor knowledge of letter-sound correspondences may account for much of the variance in performance on RAN tasks in young children in general. The current findings show that this is particularly so for boys due to their significantly slower development of letter-name and letter-sound knowledge. The effect sizes of the significant differences between boys and girls were generally small in Phase 1 but increased to moderate for some of the variables by Phase 3 with the more difficult Phase 3 phoneme deletion task explaining a moderately large 9% of the variance between girls and boys.

The second part of the first research question investigated whether earlier letter knowledge and phonemic awareness leads to more accurate reading and spelling performance at an earlier stage. Girls were significantly more accurate spellers than boys, with no significant differences between girls and boys overall in reading performance. Whereas boys were perhaps able to compensate for their poorer graphemic and phonemic awareness ability through the use of other strategies in reading (particularly in Phase 2), they were unable to do so for spelling. Caravolas et al. (2001) and Ehri (1997) showed that spelling is critically dependent on phonemic awareness and letter sound knowledge. Many of the boys in this study had incomplete alphabetic knowledge and so were still in Ehri's (1997) partial alphabetic stage whereas a large number of the girls had moved into the full alphabetic stage of spelling acquisition (Ehri).

Even though the boys had less developed graphemic and phonemic awareness, at the end of the first year of school boys and girls were achieving at a similar level in reading accuracy. By the end of the second school year the girls had begun to move ahead of the boys, although the difference still did not reach significance. This does suggest that boys were able to use strategies other than phonemic awareness strategies to sustain their reading accuracy in their first year of school, however by the end of the second year the use of other strategies was unable to sustain their progress and this particularly affected the lower achieving boys. Given Stuart and Coltheart's (1988) proposal that a more intelligent child, who is not yet capable of phonological analysis, confronted with the task of learning to read will have at his or her disposal more strategies available to memorise the printed words than a child with lower intelligence, cognitive ability may be acting as a protective factor for those boys with higher cognitive ability in their early reading endeavours.

There was no difference between boys' and girls' combined irregular word and nonword reading in Phase 2; however by Phase 3 girls' combined irregular word and nonword reading scores were significantly higher than those of the boys indicating that girls made greater progress than boys in irregular word and nonword reading between the end of the first and second years of school. This may be explained by the demand for solid phonemic awareness to underpin not just nonword reading but also irregular word reading. The dependence of irregular word reading on phonemic awareness is consistent with Ehri's (1992) view that phonemic awareness is the basis not only of decoding unfamiliar words such as nonwords, but also for reading sight words.

To answer the third part of the question regarding the extent of the hypothesised disadvantage for boys in reading and spelling acquisition, separate histograms for girls and boys allowed a comparison of score distributions in the letter knowledge, phonemic awareness, reading and spelling measures. These comparisons showed that in many cases there was a significant overlap between boys and girls. However they also clearly and consistently show important differences between boys and girls particularly in relation to the proportion of children in the lower achieving ends of many of the distributions.

The disadvantage for boys in reading and spelling was restricted to lower achieving boys. Whereas there had been no significant difference in the proportion of boys and girls in the bottom and top quartiles of the distributions of scores for the reading measures at the end of the first year of school, there were significantly greater proportions of boys than girls in the bottom quartile of the distributions for Neale Accuracy, Neale Comprehension, and Irregular word reading by the end of the second year of school. Girls and boys were equally represented in the top quartiles of these reading measures. In contrast to the findings for reading, the disadvantage for boys in spelling was evident from the start with a greater ratio of boys to girls in the bottom quartiles of the distribution of spelling (SAST) scores at the end of both the first and the second years of school. As with the reading measures, differences in the top quartile in spelling were not significant. The finding that the disadvantage for boys in reading and spelling was restricted to those boys who were average to below average is consistent with Alexander and Martin's (2000) conclusion, based on a large sample of Tasmanian children, that the average score of girls was generally higher than boys but that the sex difference was restricted to lower scoring boys.

There was a general disadvantage for boys across the full range of scores for some of the more difficult tasks in Phase 3. These included letter-sound knowledge, phoneme deletion, RAN, and also the d2 test of attention. This outcome is consistent with the hypothesis postulated by Jaeger et al. (1998) that sex differences are more likely to occur in phonological processing tasks as the complexity of the task increases.

The second research question explored differences between boys and girls in the role of graphemic and phonemic awareness and rhyme awareness in reading and spelling acquisition using a series of Hierarchical Regression analyses. The findings from these regression analyses are based on numbers which are smaller than optimal (68 boys and 59 girls in Phase 3) and caution is needed in their interpretation. The validity of the research findings would be strengthened with increased numbers and this is recommended for further investigations. Given the considerable research evidence (e.g., Muter et al., 1998; Muter & Snowling, 1998; Hulme et al., 2002) supporting the direct role of phonemic awareness in reading and spelling together with the equally critical role of letter-sound knowledge (Share, 1995) it was expected that graphemic and phonemic awareness would be of critical importance for both girls and boys. It was also predicted that rhyme awareness (awareness of larger units of sound) would play a more direct role in the reading and spelling acquisition of boys than girls

Graphemic and phonemic awareness was an important concurrent and longitudinal predictor of both reading and spelling acquisition supporting previous research findings however different developmental patterns were evident for girls and boys in the current study. Phoneme deletion ability measured at the beginning of the study was a significant predictor of reading accuracy and spelling at the end of the first year of school for both girls but not boys. For boys rhyme awareness, as measured by the rhyme detection task, was the phonological awareness variable that made a significant incremental improvement in prediction, not phoneme deletion. This suggests that girls' beginning reading and spelling development was more heavily dependent on phonemic awareness skills than was the case for boys who were still relying to a greater extent on rhyming strategies.

Many researchers have argued that children's knowledge about letters is one of the most reliable longitudinal predictors of reading success in young children (e.g., Adams, 1990; Muter et al., 1998; Stuart & Coltheart, 1988). Bowey (1994) found a strong relationship between high letter-knowledge and the development of phonemic awareness even in children who were nonreaders. Phase 1 letter-name knowledge in the current study was a powerful longitudinal predictor of all boys' reading and spelling measures at the end of their second year of school. Those boys with lower letter-name knowledge at the beginning of the study were poorer readers and spellers at the end of the study and it could be hypothesised that those boys who began the study with higher letter knowledge may have had the edge on those boys with lower letter-knowledge in developing phonemic awareness which was able in turn to foster their reading and spelling development. For the girls in this study early letter-name knowledge failed to predict any of their reading and spelling measures at the end of the study.

At the end of the first year of school RAN was a significant concurrent predictor of reading accuracy and irregular words for girls but not boys. The close relationship for girls between RAN and reading accuracy and irregular word reading but not nonword reading and spelling, which are heavily dependent on phonological processing, is consistent with Manis et al.'s (2000) finding of a stronger association between RAN and orthographic skills. That this occurred for girls but not for boys may be explained by girls' more developed phonological skills which according to Share (1995) are essential to expand the development of proficient orthographic processing.

There are clear developmental differences evident from these findings which indicate that boys were slower to develop good graphemic and phonemic awareness skills and because of this slower development they depended on them for a considerably longer period of time than girls for both reading and spelling. By the end of the second year of school girls no longer depended on those early graphemic and phonemic awareness variables on which the boys were still dependent for both reading and spelling

Although there is a wealth of empirical evidence supporting the direct role of phonemic awareness in reading and spelling acquisition (e.g., Duncan et al., 1997; Hatcher & Hulme, 1999; Hulme et al., 2002; Muter et al., 1998, Muter & Snowling, 1998) the role of rhyme awareness in reading and spelling acquisition is less clear. Goswami and Bryant's (1990) influential theoretical position gives a direct role to rhyme awareness in word recognition that is independent of phonemic awareness, however this has been disputed by many of the small unit theorists for example Muter et al. (1998) who found that rhyming skills were not a determinant of early reading skills.

In the current study there was a much stronger relationship between early rhyme awareness with both reading and spelling ability at the end of both the first and the second years of schooling for boys than for girls. For girls, rhyme detection ability measured at the beginning of the study failed to predict any of the reading measures or spelling ability at the end of either the first or the second year of school. At the end of the second school year rhyme production was a significant concurrent predictor of all reading measures and spelling for boys, whereas for girls it failed to predict any of concurrent reading and spelling measures. These findings suggest that boys were using rhyming strategies to a greater extent than girls and that larger units of sound such as rhymes continued to play a developmentally complementary role to small units (Goswami, 2002) for boys to a significantly larger extent than for girls. The use of multiple measures of rhyme awareness and phonemic awareness is recommended for future research in this area to strengthen the validity of the current findings.

The Regression analyses highlighted a greater importance of early reading readiness (as measured by the Ready to Read Test) for boys than for girls. Phase 1 Ready to Read scores were entered into the regression equation after age and WPPSI IQ to control for the autoregressive effects of earlier reading ability before examining the contribution of rhyme awareness and the graphemic and phonemic awareness variables. The differences between boys and girls in the proportion of variance in reading accuracy at the end of both the first and the second school years accounted for by the Ready to Read test was unexpected.

Both reading ability and letter-name knowledge measured at the beginning of the study, that is, within the first three months of commencing school, were strong longitudinal predictors of boys' reading ability at the end of their second school year. This indicates that it was early skills rather than those skills developed through instruction at school that were determining boys' reading performance two years on and those boys who started school with greater reading readiness and knowledge of letter-names had an advantage over those boys who began school as non-readers with less developed letter-name knowledge. This was not the case for the girls for whom those early skills were not predictive of their later reading and spelling performance and who were using phonemic awareness skills in the first year of reading to a significantly greater extent than boys.

The ability to predict reading failure from preliteracy skills assessed in the beginning months of a child's schooling can enable appropriate instruction programmes to be implemented early. The current findings support the proposal (e.g., House of Representatives Standing Committee on Education and Training, 2002) that literacy underachievement, in particular in spelling, is more prevalent in boys and importantly highlight a difference in the learning styles of the boys and girls in this study.

As there is substantial evidence indicating that phonemic awareness only develops as a consequence of instruction in learning to read an alphabetic script (Share, 1995) which fosters the development of explicit and conscious awareness of the phonological structure of words (Liberman, 1991) appropriate learning experiences are crucial. It can be concluded from the present results that girls benefited from reading instruction during their first year of formal reading instruction to a considerably greater extent than boys, and hence were able to use their developing graphemic and phonemic awareness in reading and spelling tasks to a greater extent than boys in these early stages of their reading and spelling development. There are a number of possible explanations for this discrepancy, including developmental differences in the acquisition of graphemic and phonemic awareness, differences in concentration levels in the classroom, and numerous environmental factors such as SES, and teacher skills and classroom management styles.

Differences in socioeconomic status were controlled by using children from not only high and low economic status city areas but also children from a rural school. As the boys and girls came from the same schools these differences are not likely to be the outcome of differences in teaching styles and skills. Girls had significantly better concentration than boys in the measure of attention given to the children in Phase 3 which supports the view that girls on the whole were better able than boys to focus mental effort on the task at hand in the classroom. The findings also provide evidence for the presence of developmental differences between boys and girls in acquiring good phonemic awareness.

Sex differences have been found in hemispheric processing in tasks requiring phonological analysis in fMRI studies (e.g., Pugh et al., 1997; Shaywitz et al., 1995; Weekes et al., 1999), and Frith and Vargha-Khadem's (2001) lesion study showed that these differences emerge in young children. Frith and Vargha-Khadem proposed that a lack of access to right hemispheric phonological processing may disrupt the smooth acquisition of literacy skills in boys and this suggests that the development of letter-sound knowledge and phonemic awareness may not happen as readily in boys as in girls. The current findings support this hypothesis although whether differences in hemispheric processing are the cause of this disruption could only be determined by conducting neuroimaging studies on the children, which was not within the scope of the current study.

Systematic phonics instruction has proven superior to other forms of instruction including whole language, in helping children learn to read (Ehri, Nunes, Stahl, & Willows, 2001). The goal of phonics instruction is alphabetic knowledge, which is critical to the development of phonemic awareness. Given that boys' letter-name and letter-sound knowledge was significantly lower throughout the three phases of the study than that of the girls, the findings from the current research strongly suggest that systematic phonics instruction, although benefiting all children, would be particularly salient for boys to teach them the connection between written and spoken language through systematic instruction in the use of grapheme-phoneme conversion rules. This would ensure that they are provided with the best opportunity to develop a thorough awareness of phonemes.

There remains considerable controversy surrounding the relative benefits of phonics and whole language programs for helping beginners learn to read (e.g., Adams, 1990; Foorman, 1995), however Ehri et al. (2001) found that phonics instruction improved reading ability more than non-phonics instruction in beginning readers. While the teachers of the children throughout the three phases of this research were generally eclectic in their approach to reading instruction with the majority using a combination of phonics and whole language approaches these findings suggest that a more formal approach would be beneficial especially in this early stage of the children's reading development, particularly in the first two years of schooling, and particularly for boys. Ehri et al. found that the effects of systematic phonics instruction were larger when phonics instruction began early than when it began after first grade. Foorman, Francis, Fletcher, Schatschneider, and Mehta (1998) also showed that there are considerable advantages for at-risk beginning readers if reading instructional programs emphasize explicit instruction in the alphabetic principle. Systematic phonics instruction also improves spelling skill in younger students (Ehri et al., 2001), and given the poor spelling performance of the boys in this study, compared with the girls, would help children in the first two years of school to acquire the full alphabetic knowledge needed to learn to spell accurately.

Bowey (2002) highlighted the importance of children being at a developmental level that prepares them for phonemic awareness instruction to avoid discouraging children who are not developmentally ready for it. Based on Goswami and Bryant's (1990) proposal that large phonological units act as a developmental precursor to a focus on phonemes, larger-unit programs which teach children to decode subunits such as *st, ap, eam,* as chunks (Ehri et al., 2001) may be developmentally more appropriate as a precursor to instruction focusing on smaller-units of sound providing children with an explicit awareness of rhyme. This may be particularly so for boys who have been shown in the current study to move to a greater emphasis on phonemic awareness skills at a later stage of reading acquisition than girls, and for whom rhyme awareness contributes in a direct way to reading and spelling acquisition.

This research has highlighted differences between boys and girls in the role of rhyme awareness and phonemic awareness in early reading and spelling acquisition. Differences in score distributions for letter knowledge and phonemic awareness across the three phases of the study indicated a significant male disadvantage in phonemic awareness skills. Whereas many boys were able to compensate for their poorer letter knowledge and phonemic awareness ability through the use of other strategies for reading, they were unable to do so for spelling which is critically dependent on phonemic awareness. Boys were significantly poorer spellers overall than the girls. There was no significant difference, however, between the proportions of girls and boys in the top quartile of spelling scores. In reading acquisition by the end of the study there were significantly more boys than girls underachieving, however, as with spelling, there were equal numbers of boys and girls in the high achieving end of the distributions. The current findings indicate that the disruption to boys in both reading and spelling acquisition is restricted to those boys with average to below-average skills.

Whereas the indirect role played by rhyme awareness in reading is clear research focusing on the direct role of rhyme awareness in reading and spelling acquisition has produced conflicting results with some researchers supporting a direct role for rhyme awareness (e.g., Goswami & Bryant, 1990) and others claiming it has no direct role (e.g., Muter et al., 1998). The current research provides evidence to support an alternative view hypothesising that the role of rhyme awareness in reading and spelling acquisition is not uniform across boys and girls. This view proposes a direct role for rhyme awareness in the reading and spelling acquisition of boys but not that of girls in the initial two years of reading and spelling acquisition.

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APPENDICES

Appendix 1

Instructions for administration of Nonword repetition Task

I am going to show you some pictures of some animals. Some of these animals are rare animals in Australia. Each of these animals has an unusual name, which you won't have heard before. Listen carefully as I say the animal's name. After I have told you the animal's name I want you to repeat it for me. Then I'll ask you again to tell me the name so I want you to listen very carefully as I say the name and then I want you to try hard to remember it.

Are you ready to begin? We'll start with some practice names.

Present practice items: Give as much feedback and practice as necessary to ensure that the child understands what is required.

Give practice items in both conditions – Immediate and delayed.

When you are confident that the child understands the test begin with item 1. "Now we will start – remember to listen very carefully to each animal's name and say it exactly as I say it. I will ask you to say each animals name twice, the first time will be immediately after I say the animal's name, then after a short delay I will ask you to say it again."

Note any omissions or additions for both conditions.

Criteria for stopping: Complete all twenty items with each child

Stimuli for the Nonword Repetition task

Practice items: Prindle, Skiticult

Experimental items: Dopelate, Glistering, Pennel, Bannifer, Underbrantuand, Hampent, Stopograttic, Woogalamic, Ballop, Altupatory, Commerine, Commeecitate, Tafflest, Loddernapish, Barrazon, Empliforvent, thickery, Voltularity, Rubid, Bannow

Appendix 2

Word Span Task Stimuli

Word span forwards task

ball, cot
not, tan
sun, wait, call
sail, bed, hot
gate, said, lot, hill
ran, dot, led, nail
log, fill, need, man, hate
goat, pill, bait, lead, fun
mate, ride, gun, boat, fall, pan
head, bill, date, tall, fan, seed
late, van, kill, bun, red, tail, got
mail, dog, wide, run, coat, will, can

Word span backwards

dog, wide
late, red
bed, hot, sail
sun, call, wait
said, lot, gate, hill
led, nail, ran, dot
log, hate, need, man, fill
fun, bait, goat, pill, need

Appendix 3

Instructions for the Symbol-matching task

For condition one the children were told that they were about to see two rows of symbols in the centre of the computer screen, as well as two boxes, side by side below the two rows of symbols, one labeled "same" and the other "different". The children were instructed to look at the two rows of symbols and to click either the "same" or "different" box, making their decision as quickly as possible. Three practice items were then completed with the experimenter assisting where necessary to ensure that the task was fully understood. At the completion of the three trials the child was asked "Are you ready?" When the child clicked the Yes box the first of the 10 test items appeared. At the completion of the first condition (symbols), the it was explained that in the second task two rows of upper case, or "big" letters would be seen instead of symbols.

Before the administration of the third condition the experimenter explained that this time the top row would contain upper case "big" letters and the lower row lower case "little" letters. As with condition one, conditions two and three were preceded by three practice trials. For condition two the children were instructed to decide whether the rows contained the same letters, in the same order. For condition three the children were instructed to decide whether the two rows contained the same letters in the same order regardless of how they looked. The letter sets were comprised of consonants.

Stimuli for Symbol Matching Task

trial 1		trial 2		trial 3	
	$+&#	FMJY	FMJY	FMJY	fmjy
$+&#	$&#+	FMJY	FMKY	FMJY	fmky
&=+$	&=+$	PMFY	PRFY	PMFY	prfy

test 1		test 2		test 3	
inputbox1	inputbox2	inputbox1	inputbox2	inputbox1	inputbox2
$+&#	$+&#	FMJY	FMYJ	FMJY	fmyj
$+&#	$&#+	FMJY	FMDY	FMJY	fmdy
&$=@	&=$@	PFMY	PMFY	PFMY	pmfy
#&+$	#+&$	PYMJ	PYMG	PYMJ	pymg
#$&+	#$&+	MPYJ	MHYJ	MPYJ	mhyj
&#=$	&#=$	MJYF	MJYF	MJYF	mjyf
&$+#	&$+#	JYPF	JYPF	JYPF	jypf
%$=@	%$=@	JMYF	JYMF	JMYF	jymf
%+$*	%+*$	YPMJ	YTMJ	YPMJ	ytmj
$+&#	$&+#	YPMJ	NPMJ	YPMJ	npmj

Appendix 4

Irregular Word reading Test

Was, one, come, work, pretty, break, sugar, eye, shoe, head, good, give, friend, touch, answer, bowl, sure, busy, blood, iron, island, stomach, soul, ceiling, circuit, tongue, tow, chorus, cough, lose, sword, ton, routine, yacht, choir, champagne, drought, tomb, nought, foreign, distraught, brooch, plover, bouquet, sovereign, trough, depot, colonel, scythe, gauge, debris, meringue, pint, schism, beret, indict, regime, quay, benign, ninth, bough, righteous, heirloom.

Appendix 5

Nonword spelling Test

Kig, yil, juf, vot, og, en, fonk, rint, kuch, glax.

Any valid phonological spelling was marked correct, e.g., either *guf* or *juf* was accepted for "juf".

Appendix 6

Rhyme Production Test

Instructions:
I am going to say a word, and I want you to say a word that has the same ending sound as quickly as you can. Here's an example – For the word ***hair*** *a word with the same end sound is* ***pair,*** *or* ***care, or bear.*** *Now I want you to practice – here's the first word and remember to say your word as quickly as possible.*

1. *Day*
2. *Bell*

Experimental trials

Experimental word	**Response**	**Reaction time**	**Score**
dish			
car			
boat			
train			
ball			
mouse			
dog			
rake			
hive			
tent			

Appendix 7

Sound categorisation task

Condition 1: Rhyme categorisation

Instructions: I am going to say four words one after the other. Listen carefully as I say each one and when I finish saying the four words I want you to tell me which word did not rhyme with the others

Rhyme categorisation	**score**
Practice items	
Hot, rot, pot, *log*	
Dig, ship, tip, lip	
Test items	
Sock, *dog,* lock, rock	
Rob, mob, *jog,* knob	
Big, *pit,* wig, dig	
Job, knob, sob, *rot*	
Bat, mad, had, pad	
Lip, *hit,* dip, chip	
Kid, tick, wick, lick	
Gap, wrap, *mad,* tap	
Pig, dig, wig, *bid*	
Rob, *nod,* mob, job	
Total	

Instructions: Once again I am going to say four words one after the other. Listen carefully as I say each one and when I finish saying the four words I want you to tell me which word begins with a different sound than the other three

Alliteration Categorisation	**score**
Practice items	
Top, tin, tell, *gas*	
cap, bed, boss, bit	
Test items	
cup, *get,* can, cough	
Pick, pad, *get,* pen	
Gas, *tell,* give, gun	
Dot, pig, pack pen	
Dog, duck, *tap*, dig	
Bit, back, bell, *dog*	
Cut, cap, *dip*, cog	
Tin, bell, back, bus	
Dig, cap, come, cot	
Peg, *tap*, pin, pen	
Total	

Appendix 8

Grapheme-phoneme deletion task stimuli

Grapheme/Phoneme Deletion Task: Condition 1 Response Sheet

Condition 1: Auditory Presentation - Orthographic Response Required

Word	**Letter**	**Phon response**	**Ortho response**	**Other**
Practice items				
dare	d	air	are	
boat	t	bow	boa	
Test items				
cone	c	own	one	
barge	g	bar	bare	
pearl	l	purr	pear	
pretty	r	pity	petty	
thought	Final t	thaw	though	
past	s	part	pat	
sweat	w	set	seat	
broad	b	roared	road	
		Total:		

Grapheme/Phoneme Deletion Task: Condition 2 Response Sheet

Condition 2: Visual Presentation - Phonological Response Required

Word	**Letter**	**Phon response**	**Ortho response**	**Other**
Practice items				
stew	t	sue	sew	
gent	n	jet	get	
Test items				
past	s	part	pat	
sweat	w	set	seat	
broad	b	roared	road	
pearl	l	purr	pear	
thought	final t	thaw	though	
pretty	r	pity	petty	
cone	c	own	one	
barge	g	bar	bare	
	Total:			

Grapheme/Phoneme Deletion Task: Condition 3 Response Sheet

Condition 3: Auditory Presentation - Phonological Response Required

Word	**Letter**	**Phon response**	**Ortho response**	**Other**
Practice items				
dare	d	air	are	
boat	t	bow	boa	
Test items				
beard	d	beer	bear	
snow	s	no	now	
meant	t	men	Mean	
climb	c	lime	Limb	
bread	r	bed	Bead	
cast	s	cart	Cat	
hind	n	hide	Hid	
friend	r	fend	fiend	
	Total:			

Grapheme/Phoneme Deletion Task: Condition 4 Response Sheet

Condition 4: Auditory Presentation - Phonological Response Required

Word	**Letter**	**Phon response**	**Ortho response**	**Other**
Practice items				
stew	t	sue	sew	
gent	n	jet	get	
Test items				
climb	c	lime	limb	
hind	n	hide	hid	
bread	r	bed	bead	
beard	d	beer	bear	
meant	t	men	mean	
friend	r	fend	fiend	
snow	s	no	now	
cast	s	cart	cat	
	Total:			

Appendix 9

Nonword spelling Test

Zil, hif, fent, telk, biv, brug, smest, cank, resh, chox

Appendix 10

The Processes Underlying the Relationships Between Phase 2 Variables including the Symbol-matching Variables

To investigate the underlying processes that have created the relationships between the Phase 2 variables, the raw data for all reading and processing variables measured in Phase 2 were entered into a Principal Components analysis with varimax rotation. RAN scores were converted to z scores and the positive and negative signs reversed to overcome the problem of smaller scores representing better scores. The analysis included all Phase 2 variables including the symbol matching measures. Using Kaiser's criterion of extracting only factors with an eigenvalue ≥ 1 the analysis yielded three factors which together accounted for 72.38% of the variance. The

Kaiser-Meyer-Olkin measure of sampling adequacy (.926) was very good for the analysis and reflects the strong positive correlations in the data.

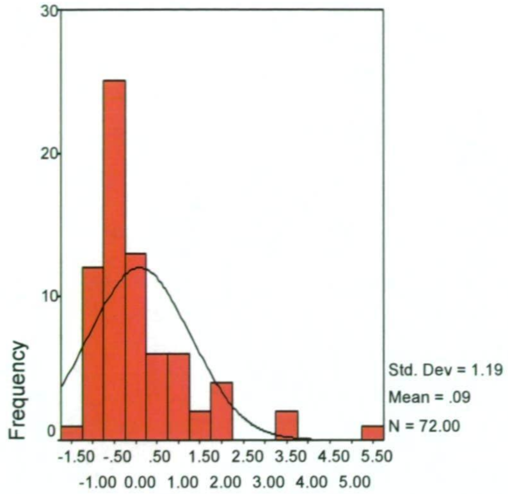
The factors identified in the three-factor solution, shown in Table 12 A, are clearly defined, although rhyme detection was again a complex variable, as in Phase 1, loading weakly onto factors one and two. The two spelling measures loaded moderately onto both factors one and two, although more strongly onto the second factor and will therefore be determined as forming part of the second factor. Factor 1, accounting for 35.08% of the variance has been interpreted as a reading ability factor, defined by high loadings (in the .8 to .9 range) from the three Neale measures (Accuracy, Comprehension, and Rate) and the word identification measures (the Woodcock Word Identification Test, and irregular word reading) and also the Martin and Pratt Nonword Reading Test. Factor 2, accounting for 24.83% of the variance, has been interpreted as a graphemic and phonemic awareness factor because of the high loadings from phoneme deletion (.69), letter-name knowledge (.83), letter-sound knowledge (.73), RAN letters (.78) and the two spelling measures (in the .6 range). The third factor accounting for 12.47% of the variance has been interpreted as a symbol-matching factor because of the high loadings from the three symbol-matching tasks.

Table 12 A

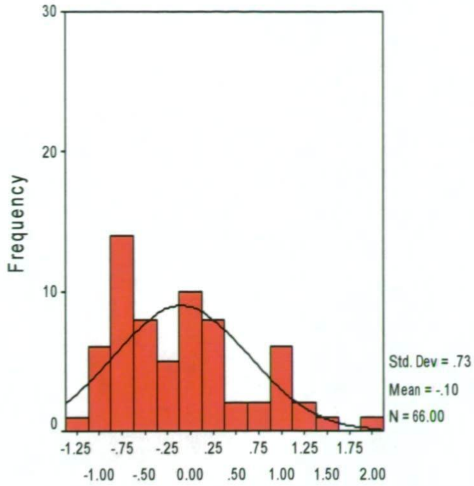
Raw Score Loadings on Rotated Factors from the Principal Components Analysis with Varimax Rotation

	Component		
	Reading	Graphemic and Phonemic Awareness	Symbol-Matching
Neale Accuracy	.93		
Neale Comprehension	.84		
Neale Rate	.84		
Irregular Word Reading	.89	.32	
Nonword Reading	.80	.38	
Woodcock Word Identification	.84	.46	
Rhyme Detection	.31	.37	
Phoneme Deletion	.45	.69	
Letter-Names		.83	
Letter-Sounds		.73	
RAN Letters		.78	
SAST	.61	.64	
Nonword Spelling	.53	.60	
Symbol-match (S)			.83
Symbol-Match (UC)			.80
Symbol-Match (MC)			.60
% Variance	35.08%	24.83%	12.47%

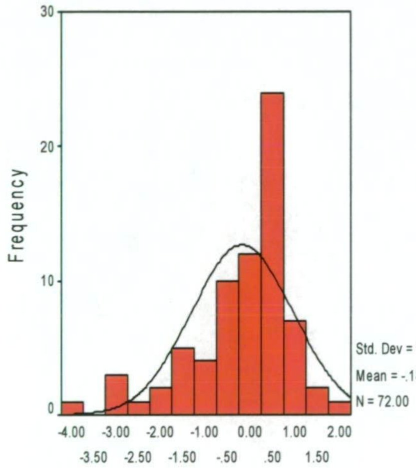
Note. Only loadings above .3 are shown



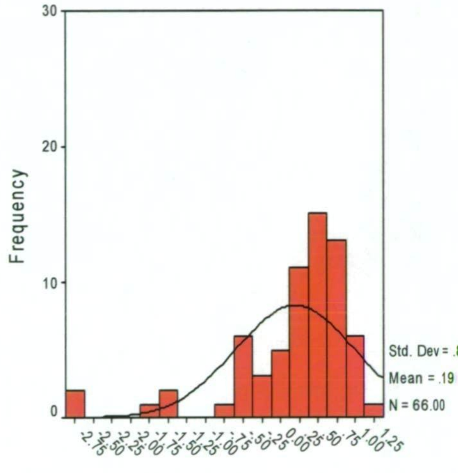
Reading Ability Factor Scores



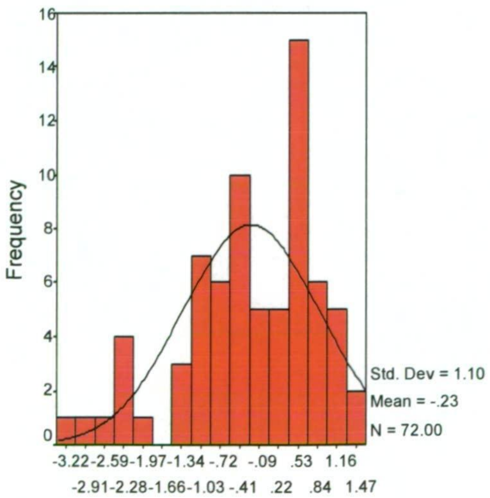
Reading Ability Factor Score



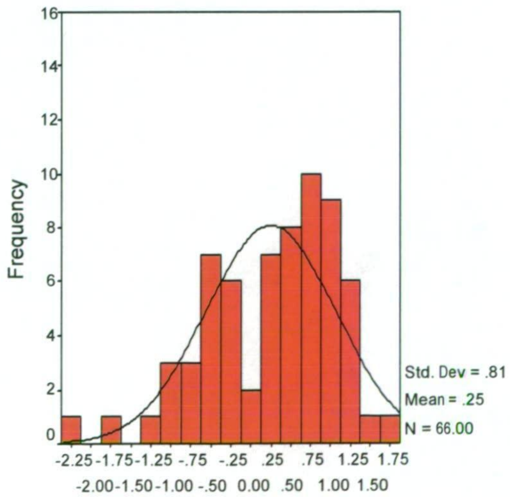
Graphemic & Phonemic Awareness Factor Scores



Graphemic & Phonemic Awareness Factor Scores



Symbol Matching Factor Scores



Symbol Matching Factor Scores

The Effect of Sex on Factor Scores

A 2[Sex: boys, girls] x 3 (Factor score: reading ability, graphemic and phonemic awareness, symbol matching) ANOVA was used to analyse the effect of sex on the children's performance on the factor scores. There was a significant main effect of sex, F (1,136) = 5.07, MSE = .97, p<.05, but no effect of factor score, F (1,272) =.01, MSE = .97, n.s.

The interaction between sex and factor score, shown in Figure 12 A, was significant F (1,272) = 4.49, MSE = 1.95, p <.05. One way sex ANOVAs on the factor scores showed that there was no significant differences between boys and girls on the Reading factor scores, F (1,137) = 1.30, MSE = 95, p >.05. whereas girls' scores (.19) were significantly higher for graphemic and phonemic awareness than boy's scores (-.18), F (1,136) = 4.78, MSE =.95, p <.05. Girls (.25) also achieved higher scores than boys (-.23) on the symbol-matching factor, F (1,136) = 7.81, MSE =.95, p <.01.

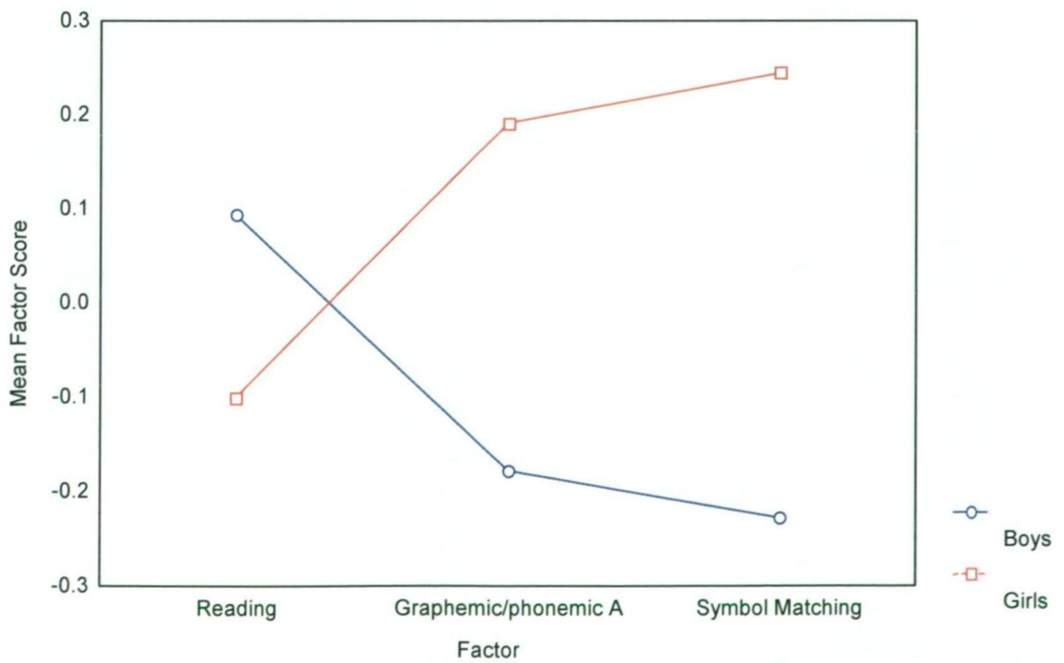


Figure 12 A. The effect of sex on reading ability, graphemic and phonemic awareness, and symbol matching factor scores.

Appendix 11

Phase 1 Analyses (Chapter 6)

2 way Analysis of Variance for all Time 1 measures with sex as between-subjects factor in each analysis

Effect	*df* effect	*df* error	*MS* effect	*MS* error	*F*	*p*	Partial Eta Squared	Observed Power
WPPSI BD	1	151	3.07	38.51	.08	.78	.00	.06
WPPSI Voc	1	151	21.97	45.30	.49	.49	.00	.11
Short-form WPPSI IQ	1	151	69.18	212.74	.33	.57	.00	.09
PPVT	1	151	291.18	255.05	1.14	.29	.01	.19
Rhyme detection	1	151	.50	10.89	.05	.83	.00	.06
Phoneme deletion	1	151	77.00	29.02	2.65	.11	.02	.37
Phoneme deletion (beginning)	1	151	13.81	9.65	1.43	.23	.01	.22
Phoneme deletion (end sound)	1	151	28.67	8.17	3.51	.07	.02	.46
Speech rate	1	151	.00	.05	.00	.10	.00	.05
Letter names	1	151	138.23	60.43	2.29	.13	.02	.32
Letter sounds	1	151	116.94	60.72	1.93	.17	.01	.28
NW repetition (Immediate)	1	151	18.96	40.71	.47	.50	.00	.10
NW repetition (Delay)	1	151	185.9	69.70	2.67	.11	.02	.37
Word Span (Fwd)	1	151	1.46	1.45	1.01	.32	.01	.17
Word Span (Bwds)	1	151	1.96	1.68	1.17	.28	.01	.19
Symbol match	1	150	.25	2.73	.09	.76	.00	.06
Upper-case symbol match	1	150	5.69	2.27	2.51	.12	.02	.35
Mixed-case symbol match	1	150	7.91	4.45	1.78	.18	.01	.26
Ready to Read	1	151	.37	8.84	.04	.84	.00	.06

Alpha = .05

The effect of sex on Phase 1 Factor Scores (1 = Sex, 2 = Factor)

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
1	1	151	.81	1.00	.81	.37	.01	.15
2	2	302	.02	.97	.02	.99	.00	.05
12	2	302	4.84	.97	4.96	.008	.03	.81

Post hoc one-way ANOVAs

Effect	df effect	Df error	MS effect	MS error	*F*	*p*
Factor 1	1	151	4.78	.98	4.91	.028
Factor 2	1	151	1.82	.10	1.82	.18
Factor 3	1	151	3.89	.98	3.97	.048

The effect of sex on pre-literacy measures of phonological awareness, alphabet knowledge, Ready to Read, nonword repetition (immediate, and delay), and symbol matching (symbols, upper-case letters, and mixed-case letters) controlling for differences in age and WPPSI IQ.

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
Rhyme Detection	1	149	.07	8.65	.01	.93	.00	.05
Phoneme Deletion	1	149	106.13	22.75	4.67	.03	.03	.57
Letter-names	1	149	217.14	40.31	5.39	.02	.04	.64
Letter-sounds	1	149	198.79	38.87	5.11	.03	.03	.61
Ready to Read	1	149	1.78	7.35	.24	.62	.00	.08
NW repetition (immediate)	1	149	38.77	31.17	1.24	.27	.01	.20
NW repetition (delay)	1	149	263.45	50.99	5.17	.02	.03	.62
Symbol match (symbols)	1	149	.93	2.42	.39	.54	.00	.10
Symbol match (upper case)	1	149	8.27	2.10	3.95	.049	.03	.51
Symbol match (mixed-case)	1	149	10.38	3.69	2.81	.10	.02	.39

The effect of sex on phoneme deletion controlling for differences in letter-sound knowledge, age, and WPPSI IQ

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
Phoneme Deletion	1	148	17.20	15.61	1.10	.30	.01	.18

The effect of sex on phoneme deletion controlling for differences in nonword repetition (delayed), age, and WPPSI IQ

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
Phoneme deletion	1	148	107.18	44.93	2.39	.13	.02	.34

Appendix 12

Phase 2 analyses (Chapter 7)

The effect of sex on Factor scores

The effect of sex on Phase 2 Factor Scores (1 = Sex, 2 = Factor)

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
1	1	137	.00	1.03	1.03	.97	.01	.15
2	1	137	.01	.97	.01	.93	.00	.05
12	1	137	5.50	.97	5.69	.02	.04	.66

Post hoc one-way ANOVAs

Effect	df effect	df error	MS effect	MS error	*F*	*p*
Factor 1	1	137	4.78	.88	.88	.35
Factor 2	1	137	5.65	.97	5.85	.12

Paired samples t-tests (post hoc)

	Paired differences					
Paired Sample	Mean	Standard Deviation	Std Error of Mean	t	df	Sig
Boys' Factor 1 & Factor 2	.27	1.69	.20	1.34	71	.18
Girls' Factor 1 &factor 2	-.29	.96	.12	-2.48	66	.02

The effect of sex on reading and spelling (age at P2 and WPPSI IQ entered as covariates)

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
1	1	136	2.84	1.33	2.14	.15	.02	.31
2	1	136	2.81	.26	.16	.69	.00	.07
12	1	137	5.50	.26	10.86	.00	.07	.91

Paired samples t-tests (post hoc)

	Paired differences					
Paired Sample	Mean	Standard Deviation	Std Error of Mean	t	df	Sig
Boys' Neale Acc & SAST	.19	.86	.10	1.91	71	.06
Girls' Neale Acc & SAST	-.21	.53	.06	-3.23	67	.002

Post hoc one-way Sex x Ability ANOVAs

Effect	df effect	df error	MS effect	MS error	*F*	*p*
Neale Acc	1	138	.11	.98	.11	.74
SAST	1	138	4.13	.98	4.23	.042

Appendix 13

Phase 3 Analyses (Chapter 8)

The effect of sex on Factor scores

The effect of sex on Phase 2 Factor Scores (1 = Sex, 2 = Factor)

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
1	1	125	6.43	.96	6.72	.01	.05	.73
2	1	125	.02	.97	.02	.89	.00	.05
12	1	125	3.70	.98	3.78	.054	.03	.49

Post hoc Sex x Factor score ANOVAs

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta squared	Observed Power
Factor 1	1	125	.19	1.01	.19	.67	.00	.07
Factor 2	1	125	9.94	.93	10.7	.001	.08	.91

The effect of sex on phonological awareness (age at P3 and WPPSI IQ entered as covariates)

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
1	1	123	9.17	.98	9.39	.003	.07	.86
2	1	123	1.53	.48	3.23	.08	.03	.43
12	1	123	3.59	.48	7.56	.007	.06	.78

Post hoc Sex x Phonological Awareness ANOVAs

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta squared	Observed Power
Rhyme Production	1	125	.00	1.01	.23	.64	.00	.08
Phoneme Deletion	1	125	11.12	.92	12.07	.001	.09	.93

The Grapheme-Phoneme Deletion Task

The effect of sex on performance on the Grapheme-Phoneme Deletion Task across auditory and visual presentations and orthographic and phonological instructions

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta Squared	Observed Power
Sex	1	125	81.88	7.45	10.99	.001	.08	.91
Presentation	1	125	5.34	2.09	3.43	.067	.03	.45
Instructions	1	125	160.42	2.09	61.93	.000	.331	1.0
Presentation x sex	1	125	.25	2.09	.16	.69	.00	.07
Strategy x sex	1	125	10.52	2.09	4.06	.046	.03	.52
Presentation x instructions	1	125	812.68	2.09	389.77	.000	.76	1.0
Presentation x Instructions x sex	1	125	10.34	2.09	4.96	.028	.04	.60

Post hoc Sex x Instruction ANOVAs

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta squared	Observed Power
Phonological	1	125	151.09	12.72	11.89	.001	.09	.93
orthographic	1	125	33.70	7.36	4.58	.034	.04	.57

Post hoc Sex x Instruction x presentation modality ANOVAs

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta squared	Observed Power
Auditory Phonological	1	125	64.06	5.31	12.07	.001	.09	.93
Visual orthographic	1	125	18.15	3.28	4.58	.02	.04	.65
Auditory Orthographic	1	125	2.39	1.89	1.26	.26	.01	.20
Visual Phonological	1	125	18.39	3.20	5.74	.02	.04	.66

Appendix 14

Longitudinal analysis (Chapter 9)

Differences between boys and girls over time on Phonological skills

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta squared	Observed Power
Sex	1	122	7.38	3.57	2.07	.15	.02	.30
Time	2	244	.003	.73	.01	.99	.00	.05
Phono awareness	1	122	.02	.73	.02	.88	.00	.05
Sex x Time	2	244	.83	.40	2.09	.13	.02	.42
Sex x Phono awareness	1	122	5.23	.73	7.58	.01	.06	.78
Time x Phono awareness	2	244	.07	.44	.15	.85	.00	.07
Sex x Time x Phono awareness	2	244	.37	.44	.84	.43	.01	.19

Differences between boys and girls over time on letter-names and letter-sounds

Effect	df effect	df error	MS effect	MS error	*F*	*p*	Partial Eta squared	Observed Power
Sex	1	121	594.45	124.64	4.77	.03	.04	.59
Alphabet	1	121	285.10	11.08	25.72	.00	.17	1.0
Time	1	242	4743.29	24.30	195.20	.00	.62	1.0
Sex x Time	1	242	13.26	24.30	.55	.58	.01	.13
Sex x alphabet	1	121	.13	11.08	.01	.91	.00	.05
Time x alphabet	2	242	112.70	8.19	13.76	.00	.10	1.0
Sex x time x alphabet	2	242	7.28	8.19	.89	.41	.01	.20

Differences between boys' and girls' reading and spelling ability over time

Effect	df effect	df error	MS effect	MS error	F	p	Partial Eta squared	Observed Power
Sex	1	122	6.00	3.45	1.74	.19	.01	.26
Time	1	122	.20	.24	.83	.36	.01	.15
Ability	1	122	.03	.29	.09	.77	.00	.06
Sex x Time	1	122	.22	.24	.91	.34	.01	.16
Sex x Ability	1	122	3.04	.29	10.52	.002	.08	90
Time x Ability	1	122	.00	.10	.00	.97	.00	.05
Sex x Time x Ability	1	122	.42	.10	4.40	.04	.04	.55

Post hoc Sex x Ability ANOVAs

Phase 2

Effect	df effect	df error	MS effect	MS error	F	p
Sex	1	138	1.45	1.73	.84	.36
Ability	1	138	.00	.26	.01	.92
Sex x Ability	1	138	2.78	.26	10.84	.00

Phase 3

Effect	df effect	df error	MS effect	MS error	F	p
Sex	1	125	4.90	1.85	2.65	.11
Ability	1	125	.00	.12	.03	.87
Sex x Ability	1	125	.69	.12	5.55	.02

Differences between boys' and girls' irregular and nonword reading ability over time

Effect	df effect	df error	MS effect	MS error	F	p	Partial Eta squared	Observed Power
Sex	1	122	1.17	3.61	.32	.57	.00	.09
Time	1	122	.18	.27	.65	.42	.01	.13
Word type	1	122	.03	.18	.15	.70	.00	.07
Sex x Time	1	122	1.81	.27	6.63	.01	.05	.72
Sex x Word type	1	122	.12	.18	.66	.42	.01	.13
Time x Word type	1	122	.03	.12	.27	.60	.00	.08
Sex x Time x Word type	1	122	.00	.12	.00	.98	.00	.05