THE ROLE OF NAMING SPEED AND PHONEMIC AWARENESS IN READING, SPELLING, AND ORTHOGRAPHIC KNOWLEDGE

by

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ABSTRACT

The purpose of this research was to examine the roles of rapid naming speed and phonological awareness in Grade three children's ability to read, spell, and process orthographic knowledge. In Study One, the role of these two skills was examined in three groups of children identified as having single deficits in either digit naming speed or phonological awareness, or deficits in both skills (i.e., double-deficit group). Results indicated that while deficits in phonological awareness were strongly linked to difficulties with reading words and nonwords, and with spelling dictation skills, slow naming speed skill also contributed to difficulties in these areas. In addition, slow naming speed was connected most strongly to spelling recognition. With respect to orthographic skill, children with naming speed deficits generally struggled more than those with phonological deficits. Children with deficits in both skills performed most poorly on all of the measures given, although in some cases, their performances did not differ significantly from one or the other single deficit groups. The results were generally supportive of the additive effects of phonological and naming speed skills, and confirm previous findings that naming speed provides something important to children's written language skills in addition to the effects of phonological awareness.

Study Two extended these findings through the addition of two control groups: children with good phonological awareness and naming speed skills (i.e., the so-called double asset group), and reading-level matched controls (i.e., Grade One average readers) for the poorest readers, the double-deficit group. 68 Grade Three children divided into four groups based on their naming speed and phonological awareness scores (17 double-asset, 17 with phonological deficits, 18 with naming-speed deficits, and 16 with double-deficits), completed tests of word and non-word decoding, dictation and recognition of spelling words, and various measures of letter-pattern knowledge at the word and subword level. Children in the double-asset group were generally good readers and spellers and performed well on all measures of orthographic knowledge. Children with phonological deficits were relatively poor decoders of words and nonwords, and struggled with spelling dictation tasks but read more quickly than their naming speed deficit peers. Children with naming speed deficits were better decoders, but slower readers, and struggled more with spelling recognition than dictation. On measures of orthographic knowledge, children with naming speed deficits were slower than their phonological deficit peers, although both single deficit groups struggled with orthographic accuracy on many tasks. Children with deficits in both phonological awareness and naming speed struggled the most on all measures of written language. Preliminary comparisons between the double deficit group and their reading-level matched controls revealed a mixed pattern of strengths and weaknesses for the two groups, with the older, dyslexic readers outperforming the control group mainly on tasks involving real words, and the younger, good readers performing the best on the phonological screening measure and in detecting letters in strings with high orthographic structure.

The results of the two studies are interpreted as providing support for the double-deficit hypothesis of language development which suggests that both naming speed and phonological awareness are important for the development of strong reading and spelling skills. Children with deficits in either naming speed or phonological awareness perform more poorly than their double-asset peers on many measures of reading, spelling and orthographic knowledge, while children with deficits in both skills are the poorest readers and spellers.

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Introduction

Wolf and Bowers (1999; Bowers & Wolf, 1993) have proposed a conceptualization of reading disability, the so-called double-deficit hypothesis, that includes two types of somewhat independent weaknesses, one that is measured by phonological awareness, the other by slow naming of simple visual symbols (e.g., digit naming speed). Between these two processes, the field of reading research regards phonological processing to be the best established of these contributors to learning and maintaining reading skills. The process by which naming speed is related to reading however, is still under investigation.

The role of phonological ability has been quite thoroughly examined in the literature, with the conclusion being that a child's ability to recognize and analyze the component sounds in words is very important to being able to recognize and to spell both words and nonwords. Training in phonological awareness contributes to reading by teaching children initially how whole words can be divided into separate phonemes. When such training is supplemented by teaching how phonemes are represented by letters, word recognition is further improved (Bryant & Bradley, 1985).

One of the difficulties in our understanding of how naming speed may be related to reading is the fact that the contribution of naming speed to reading has often been ignored or considered a later stage of phonological processing (Lovett, 1987). However, if the effects of phonological awareness are in fact a precursor of the effects of good naming speed skill, then we would only be able to find children with one of the two possible single deficits. The group of children with good phonological skill but poor naming speed skill found in Lovett's work might be considered to have incompletely developed phonological ability if this hypothesis were true. Ehri (1992) proposed a two-stage process of language development whereby children initially learned to decode words based on phonological, letter-sound correspondence processes. After sufficient exposure to particular words, a second stage occurred where children formed more direct connections between the visual presentation of the letters and the word in their memory. This orthographic representation route is reflected in more automatic (i.e., faster) word recognition. Thus, the two stages focus primarily on phonological processing with amount of exposure leading to later orthographic skill. However, children found with poor phonological awareness skill and good naming speed skill would not fit this pattern.

Recent research (Bowers & Wolf, 1993; Manis, Seidenberg & Doi, 1999; Wolf & Bowers, 1999) has shown that both phonological awareness and processes tapped by naming speed skill contribute unique variance to reading measures, and that there are children who possess one, the other, or both deficits. Within this literature, typically children with one deficit have been found to be moderately poor readers, while those with deficits in both skills are very poor readers.

It has also been proposed that correlates of reading such as phonological awareness or naming speed skill may have a different relationship with reading skills in different subsets of readers. McBride-Chang and Manis (1996) found that naming speed did in fact contribute significant variance above and beyond that contributed by phonological awareness variables. To qualify this however, they noted that naming speed was significantly related to reading only in groups of poor readers, whereas phonological awareness was related to reading skill in good and poor readers. In good readers, a measure of verbal IQ and of phonological awareness were associated with reading.

Torgesen, Wagner, Rashotte, Burgess, and Hecht. (1997) considered the effects of phonological awareness and naming speed skills in children predicting over two years (i.e., predicting reading in Grade Three from phonological and naming skills in Grade One). Whereas naming speed and phonological awareness measured in Kindergarten and Grade One were both important contributors to reading in the early grades (i.e., up to Grade Three) in their study, once children reached Grade Four and Five, the effects of naming speed from Grade Two and Three disappeared when earlier reading ability was controlled using an autoregression technique. They concluded that naming speed may be more important to the earlier stages of reading; as children become better readers, the effects of quick naming either stabilizes or disappears. In short, it is possible that the relationship between phonological awareness, naming speed, and written language skills may differ, depending on the skill level of the reader. In order to understand how normal reading develops, children from all different reading levels need to be investigated.

Insofar as reading research aims to understand how children vary in decoding as well as comprehending what they read, Shankweiler et. al (1999) considered the processes underlying both decoding and comprehension. Although Shankweiler's group did not assess the role of speed of processing, others have hypothesized that naming speed may provide part of the link between good single word decoding and good comprehension. For example, Perfetti (1985) proposed that as children process words more quickly and automatically, they become able to devote their resources to other aspects of reading skill, including comprehension. Young (1993) noted that naming speed was strongly linked to more fluent reading over time for connected text, and proposed that reading fluency was associated with better reading comprehension of connected text.

A more complete understanding of the processes involved in naming speed may help to further our understanding of how children learn how to read. Naming speed itself, however, has several operational definitions and has been assessed in a variety of ways. In fact, Wolf (1991) noted that there has been disagreement among researchers about which type of naming speed task taps processes most important to reading. Naming speed tasks typically require individuals to name a series of easily recognizable symbols as quickly as possible, but the tests have used color naming, object naming, and naming of letters and digits. Wolf found that naming speed for automatized graphological symbols (i.e., letters and numbers) was the most predictive of children's later word recognition scores. However, Wolf also noted that the relationship between naming speed and reading changed as children got older. She noted that in the earlier stages of prereading in Kindergarten, all types of naming speed tasks predicted later reading abilities. This is consistent with recent findings by Catts et al. (1999) who found that speed of animal naming in

Kindergarten was predictive of reading ability in Grade Two. In addition, O'Connor and Jenkins (1999) found that letter naming speed in Kindergarten was a good predictor of reading level in later grades. Later in development, as children begin to develop more rapid processing of digits and letters, the underlying requirements of different types of naming speed (e.g., naming graphological symbols versus naming objects or colours) and different types of reading (word decoding versus reading comprehension) change. For example, by the end of Grade Three, Wolf (1991) noted that the rapid naming of graphological symbols was more strongly related to word decoding than was naming objects or colours, but only indirectly related to reading comprehension tasks through an influence on decoding. As a result, the relationship between digit or letter naming speed and word recognition may be the most important route for investigation of the effects of naming speed on written language processes. Although the effects of naming speed may diminish with progress through school, Wolf found that the strength of the relationship of graphological naming speed to reading decoding scores remained strong into the middle grades.

In addition, Wolf (1991) noted that naming speed tasks can differ in a way other than the type of stimuli presented; for some tasks stimuli are presented all at once on a complete list (i.e., continuous naming speed tasks), and for others, stimuli are flashed one at a time with subjects' speed of naming individual stimuli measured by computer (i.e., discrete trial naming speed tasks). Because these tasks place different demands on individuals, Wolf argues that these two types of naming speed tasks may measure two distinct levels of lexical access and retrieval. Wolf describes discrete-trial naming as a measure of basic subprocesses which do not require rapid scanning, sequencing, or stimulus inhibition, and hence, do not require the integration of as many processes as are required by continuous naming tasks. In contrast, continuous naming speed tasks place demands on the subject to scan symbols in a particular sequence, to screen out symbols not being named at the moment, and overall, greater demands are placed on the ability to integrate temporal information (i.e., to process information from different sources simultaneously, requiring precise timing of different subprocesses). In addition, the continuous task seems to more closely approximate the reading process.

In some studies (e.g., Walsh, Price & Gillingham, 1988) it has been noted that while continuous naming speed tasks correlate significantly with reading variables such as word and nonword decoding and reading comprehension scores, in many cases, the discrete trial naming speed tasks do not. However, other research (Swanson, 1989; Bowers & Swanson, 1991; Bowers, 1995) has indicated that there are differences between average and poor readers on both types of naming speed tasks. It may be that poorer readers are impaired both at the most basic level of cognitive requirements as assessed by discrete-trial naming tasks, and at higher levels of processing required for continuous naming tasks. Overall, continuous naming speed tasks appear to have the stronger correlations with reading, possibly because these tasks tap subprocesses necessary for the development of good reading more completely.

Although many researchers would agree that naming speed and reading are connected, exactly how naming speed is linked to later reading skills continues to be debated. In her review of the naming speed literature, Wolf (1988) noted that the relationship between naming speed and reading may be associative or causal. In an associative relationship, reading and naming systems might share some subprocesses which are, for some reason, not activated quickly. This relationship may stem from a very general processing speed deficit or a third deficit in some more general cognitive process. To date, other research (Bowers, Steffy, & Tate, 1988) has indicated that variables such as IQ or short term memory are unable to account for the relationship between naming speed and reading, leaving unexplored possibilities. If the relationship between naming speed and reading skill is associative, it is unclear which shared subprocesses may be affected.

In contrast, if the relationship between naming speed and reading were causal, then processes underlying slower naming speed might be considered to directly affect the most fundamental reading processes (e.g., word recognition), which could in turn affect higher level processes like reading comprehension. An associative as well as a causal relationship between the processes underlying naming speed and reading has been suggested (e.g., Bowers and Wolf ,1993; Wolf & Bowers, 1999). For example, an underlying precise timing deficit which impacts all types of speeded tasks, including motor skills, might describe an associative relationship between naming speed and reading.

In a study exploring the possibility of a generalized timing deficit in German school children, Wimmer, Mayringer and Landerl (1998) concluded that while naming speed deficits were strongly linked to dyslexia in their sample, children with naming deficits did not show similar deficits in motor speed or balance. Consequently, it may be that slow naming of visual symbols may specifically reflect underlying difficulties in the precise and rapid timing of linguistic codes, that result in a weaker connection between the visual symbol on the page, and the phonological and semantic codes children use to read, and finally to poorer automatic retrieval skills, but not events germane to motor control.

A more causal connection has also been proposed. Bowers and Wolf (1993; Wolf & Bowers, 1999) suggested that naming speed for letters (highly correlated with digit naming speed) may directly influence the ability of children to learn orthographic patterns in words, which would significantly affect children's ability to read efficiently, especially as they get older when phonological decoding skills become insufficient for efficient reading. Orthographic skill represents the ability to note and use knowledge of the letter patterns in visually presented words. Perhaps children with slower naming speed abilities are processing the individual letters in words so slowly that they fail to recognize the common patterns in words, and therefore, develop weaker orthographic knowledge. Recent findings (Bowers, 1996; Bowers, Sunseth & Golden, 1999; Doi & Manis 1996; Manis, Seidenberg & Doi, 1999) have shown digit naming speed to contribute significant variance to several orthographic tasks, giving support to this position. For example, the results using a test developed by Bowers (1996) to assess children's ability to observe and accurately recognize briefly exposed letters in four-letter strings (i.e., the Quick Spell Test) found that performance accuracy was more strongly associated with rapid naming than with phonological awareness, especially when strings of unrelated letters were shown. Perhaps digit or letter naming speed is a marker of an individual's ability to form, access and name orthographic codes. From this view, processes underlying slow naming speed have a causal influence on poor reading because they affect a child's ability to efficiently use orthographic information.

In summary, there is evidence that naming speed processes contribute significant independent variance to reading measures (e.g., Manis et al., 1999; McBride-Chang & Manis, 1996; Sunseth & Bowers, 1996; Wolf, 1991; Wolf & Bowers, 1999), and there are proposals suggesting that naming speed may serve as a marker of children's ability to perform orthographic tasks (Bowers & Wolf, 1993 ; Doi & Manis, 1996). To clarify the interrelationships of these factors, a study is needed to tease apart more precisely the relationships between the two component skills of the double deficit model (i.e., phonological awareness and naming speed) and measures of written language skill, especially those measuring orthography. Torgesen's (1991) caution that studies looking at only specific subgroups of poor readers are limited in the information they can provide on the full reading process leads to studies of both regular-achieving and disabled readers. Although there is a great deal of overlap between the two skills, in normal readers, the double-deficit theory proposes that both phonological awareness and naming speed contribute independent variance to reading outcome measures in both good and poor readers.

The above line of reasoning suggests that by examining the pattern of strengths and weaknesses in children with single and double deficits, the process by which phonological awareness and naming speed are related to reading may become more clear. A study by Krug (1996) considered the patterns of strengths and weaknesses present in single and double deficit readers, compared to children without reading deficits. In Krug's study, double-deficit readers displayed the slowest and most inaccurate reading, weakest phonemic awareness, weakest orthographic knowledge, and poorest memory skills. Krug used measures of spelling, spelling recognition, and an orthographic coding task requiring recognition and memory of letter patterns embedded in nonwords as indicators of orthographic ability. It was noted however, that the double-deficit group performed surprisingly well on a measure of visual-spatial problem solving task, possibly suggesting stronger right hemisphere abilities in comparison to their much weaker language abilities. The single deficit groups in this study performed at a level slightly above that of the double deficit group, but below that of the double asset group. The two single deficit groups did not differ significantly from one another, although overall, the phonological deficit group tended to be more impaired than the naming speed deficit group. The phonological deficit group in comparison to the double asset group demonstrated weaker orthographic knowledge, and poorer scores on a measure of cognitive flexibility. Rate-deficit readers displayed weak "lower-level abilities" but appeared to have intact comprehension skills. Although these findings suggest that deficits in either naming speed, phonological awareness, or both, can impact differently on outcome measures of reading and cognitive ability, the sample size in the Krug study was small (i.e.,16 double asset, 5 double deficit, 4 phonological deficit and 8 rate deficit), and larger investigations of these groups are required in order to strengthen any conclusions.

Although Krug (1996) looked at a number of language abilities in her single and double deficit groups, her study relied on measures of spelling and an unproven measure of orthographic ability. The role of orthographic skill in poor readers was examined more closely by Stanovich and Siegel (1994). In their analysis of poor readers matched to reading-level controls, both groups of children were reading at approximately the same level on scores of simple word decoding. They hypothesized that the older poor readers' skills may have resulted from a somewhat different combination of phonological and orthographic skills than the younger good readers. The authors found that the older dyslexics possessed stronger orthographic skill than their reading level matches, based on the results of the PIAT spelling recognition test, and the Word Likeness task. These tasks tap the recognition of letter patterns in specific words (PIAT) or likely combinations of letters in novel letter strings (Word Likeness). However, on another commonly used measure of orthographic skill, the Orthographic Choice task, the dyslexic group's performance was worse than that of the reading level matches. This task assesses recognition of a specific letter pattern in a real word compared to a letter pattern that would sound like the same word (e.g., room, rume). This result of older dyslexics performing more poorly on a measure of orthographic skills underlines the fact that despite their greater exposure to the words by virtue of age, dyslexics have not gained sufficient information about the specific letter sequences in words.

In line with this view, Reitsma (1983) has suggested that poor readers require more practice with words than reading-level matched younger children in order to improve the speed of processing specific letter strings. Other researchers (e.g., Bowers, 1993; Levy, Bourassa & Horn, 1999) have noted that children with faster naming speed require fewer exposures to any one letter pattern in order to read it more quickly suggesting that children with faster naming speed require fewer exposures to a particular orthographic pattern in order to learn it. Conversely, children with better naming speed skills may benefit more from the print exposure they receive.

In contrast to these views of the centrality of naming speed in orthographic function, Ehri (1992) has suggested that phonological decoding influences orthographic skill development. If both views are correct (i.e., naming speed and phonological coding influence orthographic functioning), it may help to explain why those with double-deficits are more impaired in reading than single-deficit individuals.

Spelling Research

Although the double-deficit hypothesis has been mainly concerned with the component processes associated with reading, there is a significant body of literature which has attempted to understand the relationship between reading and spelling processes in children. There is general agreement that these skills are closely related, but there is less consensus about the nature of the relationship. If phonological awareness and digit or letter naming speed are correlates of reading, and if reading and spelling processes are connected, it follows that phonological awareness and naming speed ability would also have some impact on spelling skill.

In a manner somewhat similar to the reading research described above, researchers have also examined the component processes of spelling. For example, Dreyer, Luke and Melican (1995) initially hypothesized that spelling dictation proficiency would be more directly related to orthographic skills, while reading would be more dependent on phonological skills. In experiments involving Grade Three and Four students, it was noted that, (1) retention of spelling rather than initial mastery was more closely related to later spelling dictation outcome, (2) real-word reading was more strongly associated with spelling dictation than was non-word decoding, and (3), phonological awareness was the component process most related to both spelling dictation and reading outcome measures. Although children tended to use both orthographic and phonological knowledge in spelling dictation tasks, as evidenced by the types of mistakes they made, there was no evidence of the differential relationship of orthographic and phonological component processes to spelling and reading as had been initially expected.

Stage and Wagner (1992) also examined phonological and orthographic knowledge in children from kindergarten to Grade Three using non-word spelling dictation tasks. Again, it was found that measures of phonological awareness (especially Bryant and Bradley's sound categorization task (Bryant & Bradley, 1985)) were the best predictors of spelling dictation ability. In addition, they noted that in the youngest children, a measure of working memory (i.e., letter span task) was also predictive of spelling ability although this effect diminished with increasing age of the subjects. These two studies would suggest that phonological processing is more important in learning how to spell than is orthographic knowledge, at least for spelling dictation tasks. However, whether orthographic knowledge is more important to spelling at other stages of development or to different types of spelling (i.e., spelling dictation versus spelling recognition) was not addressed, nor was the possibility that orthographic knowledge contributes significant unique variance after phonological awareness is considered.

It would appear that measures of phonological processing dominate the spelling literature as well as the reading literature, at least with respect to dictation tasks. Children seem to require a certain level of skill with respect to the use of sound-spelling correspondence in order to perform either task efficiently. Bruck's research (1988) compared developmental dyslexic children ages nine to sixteen with word reading level (RL) matched controls and concluded that both groups appeared to use the same processes for word recognition. In spite of their poorer nonword decoding skills, many dyslexics had reading comprehension scores approximately equivalent to those of their reading-matched controls. Dyslexics however, were more heavily dependent upon contextual cues than RL controls because of their poorer spelling-sound correspondence skills (assessed by their ability to read pronounceable nonwords). That is, the dyslexic group made significantly more errors in their decoding of nonwords than did the RL control group. In the area of spelling dictation, Bruck noted the control children's misspellings were more phonetically accurate than those of dyslexics and that dyslexics failed to use what spelling-sound information they did possess when presented with unfamiliar words, suggesting possibly a failure in strategy rather than simply a failure in ability.

Ehri and Wilce (1987) also examined reading and spelling, and attempted to draw causal connections between spelling and reading processes by teaching prereaders how to spell. They trained one half of the kindergarten students in spelling regular nonsense words phonetically, while the control group received only training in grapheme-phoneme correspondences. They found that the spelling training contributed to the children's' reading abilities. Particularly, this type of spelling training was designed to help children to break down pronunciations into constituent units. Their conclusions suggest that specific phonological training related to spelling may be most helpful in teaching children to read, and that this process (i.e., breaking down words into components) may be an especially important type of phonological skill. However, spelling training was restricted to targets with regular grapheme-phoneme patterns. It is possible that irregular words could be impacted differently by phonological and orthographic skills. For example, one might predict that children with stronger orthographic compared to phonological skills may learn word patterns in a more holistic manner, rather than relying on the sounding out of words in order to spell them. Children with better orthographic skills might therefore perform better on spelling dictation tests of exception words that cannot be easily spelled with a phonological approach, but might rely more on orthographic knowledge. More specific research into this problem containing measures of both spelling and orthographic knowledge is necessary.

In an attempt to separate some of the processes involved in both spelling and reading abilities, Waters, Bruck and Seidenberg (1985) considered groups of good spellers and good readers, good readers and poor spellers (the mixed group), and poor spellers and poor readers in Grade Three children. These children were divided on the basis of spelling scores from the Wide Range Achievement Test - Level (WRAT) and a reading comprehension measure from the Stanford Diagnostic Reading Test. The study attempted to explain why some children appeared to have good reading comprehension skills but very poor spelling skills. They used several classes of regular and exception words, taking into consideration the words' regularity with respect to <u>both</u> spelling and reading. They concluded that Grade Three children make use of spelling-sound correspondence information for both spelling and reading tasks, further emphasizing the role of phonological processing. Although children in the mixed and poor groups possessed poorer spelling-sound information, they also persisted with a phonological strategy. The finding from this study of "mixed" children is relevant to the study of double-deficit reading disabilities. In spite of many performances similar to the poor readers and poor spellers, this group managed to develop good reading comprehension skills (equivalent to those in the "good" group). Additionally, this group's response latencies were more like that of the "good" group. The latency result suggests that the group of "mixed" children, although lacking in certain phonological information, possessed skills that allowed them to respond more quickly than the "poor" group. It is possible that the stronger reading comprehension scores resulted from quicker word recognition, which in turn was influenced by the faster naming speed of this group of children.

Spelling ability has been assessed using a variety of measures, and it may be necessary to distinguish these procedures more carefully. For example, there are standardized measures of spelling dictation which require individuals to analyze and interpret the various sounds within words. This type of spelling would appear to rely most heavily on good phonological analysis skills. In contrast, standardized measures of spelling recognition require children to visually analyze and interpret the various spelling patterns in words, a skill which might rely more heavily on orthographic or letter pattern knowledge. In order to carefully assess individuals' overall spelling skills, future research needs to include a measure of spelling dictation and of spelling recognition. In addition, the inclusion of words with varying degrees of difficulty, and different levels of word frequency might create subtle differences between good and poor spellers.

In general, it appears that research findings typically emphasize the influence of phonological skills in written language ability and disability (both spelling and reading) but ignore components that might contribute to skill differences. In fact, there is some indication from this literature that some of the children studied in the spelling literature (e.g., "mixed" good readers, poor spellers) might resemble one of the single deficit groups identified in previous reading research. For example, the study by Waters et al. (1985), discussed a group of children whose spelling skills resembled those expected of so-called single-deficit children. Their work suggests that while reading ability may be more connected with faster naming speed skill, spelling dictation scores may be more closely connected to phonological awareness. At this time, the impact of slow naming speed skill in a child with good phonological skill has not been studied with respect to spelling achievement. It would therefore be worthwhile to include measures of spelling skill in any further study of component processes of reading. In a study which includes measures of phonological awareness, digit naming speed, orthographic processing, and various aspects of reading, the addition of spelling measures (i.e., dictation of regular and exception words, and spelling recognition) may help to broaden the scope of past findings, and perhaps serve to provide us with some future avenues of research.

Literature Summary

If phonological awareness and naming speed make independent as well as joint contributions to reading skills, as was suggested by Bowers and Wolf (1993; Wolf & Bowers, 1999), the evidence may be taken as suggestive of different pathways which ultimately combine to lead to good reading. The single deficit groups, while differing on important skills, arrived at a similar overall reading level, falling somewhere in the middle between the very poor double deficit group and the good readers (double asset group). Although single deficit readers were not as poor as children with double deficits, nonetheless, these groups of children required some help in learning to read efficiently and accurately. As was discussed above, Bowers and Wolf (1993) have suggested that naming speed represents a process related to how quickly children learn orthographic patterns -- dependent upon how quickly they recognize individual letters. This process will be modified by print exposure effects, but faster and more accurate reading skills evident in children with fast symbol naming skills may be reflective of greater orthographic skill. Whatever the connection between naming speed and reading -- whether it be orthographic or not -- further understanding of the nature of the contribution of this skill to reading is needed.

The evidence reviewed above suggests that there are at least two cognitive skills contributing to reading outcome, viz., phonemic analysis and symbol naming speed. Further research on these variables may be particularly important to our understanding of how children learn to read. If there are at least two partially independent routes to learning to read, a variety of remediation strategies may provide the best help for children with different types of reading deficits. Having only one skill or the other does not seem to be enough for the development of good reading.

In order to investigate these issues further, the strategy adopted was to select groups of children based on their patterns of strengths and weaknesses in naming speed and phonological awareness and to look for associated patterns in reading, spelling, and orthographic knowledge. Grade Three children were selected and grouped according to their skills in digit naming speed and phonological awareness to fit into one of four groups; double asset children with average or above abilities in both, single deficit children with weaknesses in one skill but at least average ability in the other, and double deficit children with weaknesses in both digit naming speed and phonological awareness. It was believed that by Grade Three, children were beginning to make use of developing orthographic knowledge but had not yet reached the point where naming speed skills might no longer impact directly on their reading ability.

Two studies were conducted to address the following questions:

1) What is the impact of phonological or naming speed deficits alone, or in combination with one another, on tests of reading, spelling, and orthographic knowledge?

a) Do deficits in one area alone make children moderately poor readers with the so-called "double deficit" group being more severely reading disabled?

It was expected that the double asset group would be better than all the deficit groups with the naming speed (NSD) group outperforming the phonological deficit (PD) group. In addition both single deficit groups were expected to be better readers than the double-deficit (DD) group.

b) Do deficit types differ on their patterns of performance on different types of spelling tasks (i.e., dictation vs. recognition)?

It was expected that variations in phonological awareness would have a greater effect on spelling dictation, and naming speed variations would have more effect on spelling recognition, resulting in the PD group performing more poorly on dictation and the NSD group more poorly on recognition relative to one another. The DD group were expected to perform most poorly on all spelling tasks.

c) What about the phenomenon of good readers / poor spellers found in other studies? Do children with that pattern resemble those with good naming speed skills (i.e., PD group) who have compensated in the area of reading by emphasizing orthographic knowledge at the expense of phonology, but are unable to apply their better orthographic knowledge to spelling dictation tasks?

It was expected that the PD group would have better reading than spelling skills, especially when the spelling task was dictation.

d) Does the DD group perform more poorly on all achievement tests? Are deficits additive or does some other pattern occur?

In general, it was expected that the effects of phonological awareness and naming speed would be additive in most cases, with phonological awareness being somewhat more important on decoding tasks (e.g., single word reading and spelling), and naming speed more important on measures of spelling recognition and orthographic skill.

2) Ehri (1992) has argued that orthographic skill is essentially an outcome of highly practiced phonological awareness skills, while others (Bowers & Wolf 1993; Wolf & Bowers,1999) have demonstrated consistently smaller, but almost always significant, independent contribution of naming speed to reading measures in addition to the effects of phonemic awareness. What is the nature of naming speed's relationship to a variety of orthographic tasks, and how do children with single and double deficits perform on a new measure believed to be related to orthographic skill development, the Quick Spell Test (Bowers, 1996)?

It was expected that the PD group would perform better on orthographic measures and other measures hypothesized to be related to orthographic skill compared to the NSD group.

3) How do children with deficits in both phonological awareness and naming speed (i.e., the DD group), expected to be the poorest readers, compare to reading level controls matched on general reading ability for words and non-words? Do children with similar levels of decoding skill have different orthographic skills? Are these differences related to levels of phonological ability or naming speed?

Expectations for this part of the study were less clear given the developmental nature of naming speed (i.e., naming speed scores for grade threes might be higher than expected despite poor reading skills) and the additional practice with reading for children in Grade Three may have helped them to compensate for other skill deficits (i.e., in naming speed and phonological awareness).

STUDY 1

Introduction

Based on many of the findings discussed above, this study set out to explore the patterns of reading, spelling, and orthographic knowledge skills in children classified as having single and double deficits. There were three main purposes for this study. The first was to explore how the two single-deficit groups differ from one another and from double-deficit children on various written language measures. Although it was expected that both types of single deficit children would have moderate deficits in reading and spelling, information about how deficits in one vs. another of these skills was related to specific measures of reading, spelling, and orthographic knowledge was needed. The second goal was to find out how many children fit the single deficit categories in a school based sample. If the hypothesis that naming speed is merely a later stage of phonological processing where children become more efficient with practice, we would not expect to find any children with phonological deficits who were fast namers. The existence of a group of children with good naming and poor phonological skills would provide some evidence that naming speed and phonological awareness are somewhat separate. As well, how predictive are the skills of children with deficits in both areas, the so-called double-deficit children of additional difficulties with reading and spelling? The study also provided further opportunity to explore the relationships among digit naming speed, phonological awareness, reading, spelling and orthographic knowledge. Given other work (e.g., Doi & Manis, 1996), children with poorer naming speed were expected to perform significantly more poorly than children with better speed skills on the various measures of orthography.

In general, it was predicted that children with single deficits in <u>either</u> digit naming speed <u>or</u> phonological awareness would be moderately poor to low average readers and spellers based on findings in similar groups of children using these measures (Sunseth & Bowers, 1997), and that children with deficits in both areas would be very poor readers and spellers. Children in the single-deficit groups were expected to differ from each other with respect to their <u>pattern</u> of spelling skills. Because of what appears to be a sensible link between phonological analysis skills and spelling dictation tasks, and between orthographic knowledge and spelling recognition tasks, it was predicted that children with solely phonological awareness deficits would have poorer spelling dictation than spelling recognition scores. In contrast, children with deficits only in digit naming speed skill were expected to have poorer spelling recognition scores compared to their own spelling dictation scores.

Finally, it was also hypothesized that the pattern of "good-readers, poor-spellers" found by Waters, Bruck, and Seidenberg (1985) might map onto one of the single deficit groups. Those children with poor naming speed but good phonological skill might have relatively good decoding skills as tapped by Word Attack scores, but poorer scores in spelling recognition. In contrast, if children with a single deficit in phonological ability possessed good naming speed skill, this skill might help them to learn to read from an alternate route, based more on orthographic, rather than phonological patterns. Therefore, these children might be relatively good readers based on their Word Identification scores, but possess relatively poor spelling dictation scores.

Method

Participants

All of the participants in this study were in Grade Three. One hundred twenty three children from local public schools were screened using a measure of phonological awareness, a modified 29-item version of the Auditory Analysis Test (AAT) (Rosner & Simon, 1971), and a continuous digit naming-speed task, the RAN-digits (Denckla & Rudel, 1974). This initial screening was given to children individually in a separate, quiet room in the school and required approximately ten minutes.

From this sample, children were selected with a deficit in either phonological awareness or digit naming-speed (i.e., below the 35th percentile for the sample on one skill, and above the 47th percentile on the other), or children who were below the 35th percentile on both skills (i.e., double-deficit children). The single phonological deficit group included several children at the 37th percentile on the AAT in order to reach the desired number of 15 participants in each group. One child was eliminated from consideration because of a diagnosis of Williams Syndrome, a neurological disorder which may have affected her language abilities in unpredictable ways. The only other criterion for subjects' inclusion was that they be reasonably fluent in English. First language, and languages spoken in the home were recorded on permission forms, and children with first languages other than English were informally assessed in casual conversation for their ability to converse in, and understand English. Any questions about a child's fluency in English were resolved by children's classroom teachers. Children considered non-fluent in English were not tested.

The initial selection resulted in 32 single-deficit subjects (15 with a phonological deficit and 17 with a digit naming speed deficit), and 24 children with a double deficit. Initially, the intent had been only to assess children in the single-deficit groups. However, due to additional questions raised, it was decided that testing of children with both deficits would also be useful. Subsequent testing of the double-deficit children for this study occurred several months later in the school year than for the rest of the sample (May as compared to January and February for single deficit children). At the time of additional testing, permission was obtained for only 16 of the original double-deficit sample. However, analyses of the data obtained on the double-deficit group revealed that the 16 children who participated in this study did not differ significantly from the eight who did not participate on measures of digit naming speed and phonological awareness (measures which were given at the same time for all groups). Therefore, the results of this study are based on findings from 32 single-deficit children, and 16 double-deficit children.

The difference in time of testing for the DD group should not have a confounding effect on the overall pattern of the results because it was expected that overall, the DD children would perform more poorly than their peers with only one deficit. Therefore, any extra training and learning in the DD group would only serve to weaken any of the predicted results (i.e., to make the single and double deficit groups look more similar).

Measures

Initially children were given two screening measures, the AAT and RAN digits. The AAT is a phoneme-deletion task which requires individuals to repeat common words with single sounds removed from the beginning, end, or middle of one-syllable words (e.g., say "block" without the /b/). The measure of digit naming speed consists of five digits, repeated ten times in semi-random order on five lines (see Appendix A). Children were shown a page with the digits printed on it in rows and asked to say each number out loud as quickly as they could. Two trials of naming speed were administered, with additional trials added if children varied more than a few seconds from on trial to the next.

All children in the study were individually administered a number of written language tests over two sessions. The instruments used in the study were the Letter-Word Identification, Word Attack, and Spelling Dictation subtests from the revised Woodcock-Johnson Achievement Battery (WJ-R) (Woodcock & Johnson, 1989), the Spelling Recognition subtest from the revised

Peabody Individual Achievement Test (PIAT-R) (Markwardt Jr., 1989), a spelling dictation test (Bruck, 1988), a measure of reading speed and accuracy which consisted of one paragraph taken from the diagnostic edition of the Gray Oral Reading Test or GORT-D (Bryant & Wiederholt, 1991), an Orthographic Choice Test (Olson, Kliegl, Davidson, & Foltz, 1984), the Quick Spell Test (Bowers, 1996), and a Word-Likeness Test (Siegel, Share, & Geva, 1995). Tests were administered in two randomized orders to each participant over two sessions. These variables are described below.

1. The Letter-Word Identification subtest from the WJ-R (Form A) is an individually administered, standardized test of letter knowledge and word identification. It consists of words of increasing difficulty which children are asked to read out loud. For all the WJ-R subtests, children are administered only those items judged to be at their level. A starting point appropriate for children at a late Grade Two level was chosen and children were given earlier items if they did not reach a predetermined degree of competency; children were administered items of increasing difficulty until they reached a ceiling level of a predetermined number of errors.

2. The Word Attack subtest from the WJ-R is an individually administered standardized test of nonword decoding. It consists of pseudowords of increasing difficulty which children are asked to read out loud.

3. The Spelling Dictation subtest from the WJ-R is an individually administered, standardized test of children's spelling ability. It consists of words and components of English grammar (e.g., colons, exclamation points) of increasing difficulty. For many items (i.e., approximately 80%) children are asked to print a word in the space provided. Some items (i.e., approximately 20%) require children to write the appropriate word to be used in a sentence context (e.g., Tim is small, Susan is smaller, but Joe is the very ___). These "usage" items are not scored for spelling errors, but rather for the correct selection of the appropriate word (in the aforementioned case, "smallest"). The proportion of usage and punctuation items administered to each child varied

with the number of items presented based on their skill; however for this study, the items were divided into approximately 20% usage, 20% punctuation, and 60% spelling dictation items. The test was scored according to standardized administration with children receiving only those items between the basal and ceiling levels, and word, usage, and punctuation items all being included in the scoring.

4. The Spelling Recognition subtest of the PIAT-R is an individually administered, standardized test of children's spelling ability. It consists of words of increasing difficulty. For each word, a child is shown four potential spellings and asked to identify the one which is spelled correctly. Again, children are given only those items which would fall within their range of abilities based on a predetermined starting point, and basal and ceiling rules.

5. An additional measure of spelling dictation was also administered. This measure consisted of items taken from three lists developed by Bruck (1988). Children were asked to write the spellings of (a) a list of regular words which are words with rimes which are always spelled the same way (e.g., hand, wife), (b) "regular star" words which have more than one legal spelling pattern for their sound (e.g., boat, share), and exception words which have exceptional pronunciations (e.g., break, touch). The entire list of 30 words was administered to all subjects.

6. Reading Accuracy: Paragraph A3 from the GORT-D (Bryant & Wiederholt, 1991) was included as a measure of reading fluency. Children were presented with a short paragraph (six sentences) and asked to read it out loud as quickly as possible, without making mistakes. The administrator recorded any errors they made. The paragraph was chosen to be at the level of approximately an average Grade Two reader.

7. Reading Speed: In addition to measuring accuracy, the paragraph from the GORT-D was also used as a measure of reading speed. The amount of time taken to read the paragraph was recorded for each subject. Time was measured on a stopwatch.

8. Orthographic Choice Accuracy[1]: Children were shown items on a computer screen and given two buttons - one for each hand. Each item had two alternatives to choose from, consisting of a correctly spelled word and a pseudoword with the same pronunciation as the word (e.g., street, streat). Children were instructed to push the button which corresponded to the correctly spelled word - the button on the left for the word on the left of the screen, the button on the right for the word on the right of the screen. The computer recorded the accuracy of their responses for each item. After a child pressed a button, the words disappeared from the screen, and the examiner cued the next item. This test has three practice trials at the beginning to get children accustomed to the buttons and the demands of the task, but no feedback was given about their performance during the practice trials. This test portion of the task consisted of 24 word pairs. The score reported for each child was the percent of items answered correctly.

9. Orthographic Choice Speed: For each of the items from the Olson (1985) task described above, the computer also recorded the latency of each response in milliseconds. Children were instructed to choose the correctly spelled word as quickly as possible. An average response time for each **correct** response based on the 24 testing trials was calculated for each participant.

10. Word-Likeness Accuracy: This test was developed by Siegel, Share and Geva (1995) to assess children's knowledge of legal and illegal letter patterns in the English language. Children were presented with two pseudowords (called "pretend words") on a computer screen. For each pair, one of the words contains patterns of letters which are found in the English language while the other contains one combination of letters which is not commonly found in the English language (e.g., filv, filk). The child is asked to identify the "pretend word which looks most like a real word" using the same two buttons described above. This task was presented in the same

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[1] This test was originally developed by Olson et al. (1985) as a measure of orthographic knowledge. Because of time restrictions and the fact that the test was originally designed for use with older children, three pairs of words were eliminated from Olson's list. The pairs which were eliminated contained the words with the lowest frequencies from the original 27 items.

manner as the Orthographic Choice task, with a pair of pseudowords presented side by side on a computer screen. The test has three practice trials initially to get children accustomed to the buttons and the demands of the task, but no feedback is given about their performance during the practice trials. This test portion of the task consisted of 17 word pairs and the percentage of correct responses was the score for each child.

11. Word-Likeness Speed: For each of the items from the task described above (Siegel, Share Geva, 1995), the computer also recorded the latency of each response in milliseconds. Children were instructed to choose the most word-like pattern as quickly as possible. An average response time for each **correct** response based on 17 testing trials was calculated for each participant.

12. The Quick Spell Test: This test was designed by Bowers (1996) as a potential new measure of the skills underlying orthographic ability. It assesses an individual's ability to identify letter strings which are presented very briefly (for a quarter of a second). Three types of four letter strings are included in this task; words (e.g., went), pseudo words (e.g., hool), and nonwords (e.g., ncdk). These letter strings are presented one at a time on a computer screen in mixed order, and children are required to name the letters that they have just viewed. Responses were recorded over thirty items, ten of each type in mixed order. The child was also given three practice trials at the start of the test in order to make sure they understood the demands of the task.

Results

Most of the data were analyzed using mixed, repeated measures analyses of variance (ANOVA) procedures to compare children in each of the three deficit groups; children with a single deficit in phonological awareness (PD group), children with a single deficit in digit naming speed (NSD group), and children with deficits in both skills (DD group). In the final analysis there were 15 children in the PD group, 17 children in the NSD group, and 16 children in the DD group, for a total of 48 subjects.

Means and standard deviations for descriptive characteristics of the three groups are contained in Table 1. The groups did not differ significantly from one another with respect to gender ratio ($F(2,45) = .73, p=.49$) or age in months ($F(2,45) = .74, p=.48$).

TABLE 1

Means, S.D.'s (in parentheses), Ranges, and Significance Levels for Age and Gender

	Group				
Measure	**PD group**	**NSD group**	**DD group**	**F stat.**	**(p-value)**
Age (in months)	102.1 (3.2)	103.3 (3.7)	103.4 (3.3)	F=0.74	(p=0.48)
Range	98-107	98-109	97-109		
Gender(#M : #F)	8:7	7:10	10:6	F=0.73	(p=0.49)

There was concern that groups might differ significantly on other variables which could confound our results. Subjects from all three groups came from four different schools, and were tested by three different administrators during screening. The results of analyses on this data are contained Table 2 and Table 3. Subjects from the four schools did not differ in terms of their phonological awareness scores ($F(2,45)=1.7, p=.19$) or their digit naming speed scores

(F(2,45)=.59, p=.63). In addition, the test administrator variable did not have a significant effect on subjects' AAT *(F(2,45)=2.1, p=.14)* or digit naming speed *(F(2,45)=.11, p=.90)* scores.

TABLE 2

Means, S.D.'s (in parentheses), and Significance Levels, for Screening Variables Between Each of the Schools in the Study

	Group				
Variable	**School 1** (n=15)	**School 2** (n=9)	**School 3** (n=9)	**School 4** (n=15)	(p-value)
AAT	16.2 (6.1)	11.8 (5.9)	14.0 (5.0)	16.4 (5.1)	(.19)
DNS (sec)	33.1 (8.0)	37.6 (12.1)	33.5 (6.8)	34.8 (7.0)	(.63)

TABLE 3

Means, S.D.'s (in parentheses), and Significance Levels, for Screening Variables Between Each of the Test Administrators in the Study

	Group			
Variable	**Experimenter 1 (n=28)**	**Experimenter 2 (n=12)**	**Experimenter 3 (n=8)**	**(p-value)**
AAT	16.4 (5.7)	12.9 (5.2)	13.4 (5.5)	(.14)
DNS (sec)	34.5 (8.0)	35.4 (11.2)	33.7 (4.5)	(.90)

It was also possible that children in the DD group, might show poorer phonological skills than the PD group, and slower digit naming speed scores than the NSD group. If the DD group was poorer on either or both measures compared to each of the single deficit groups, many of the analyses could be confounded. ANOVA analyses were performed to determine if these differences were in fact significant. The PD group and DD group were compared on their AAT scores. The DD group was found to have significantly poorer scores than the single deficit group *(F(1,29) =*

6.1, p=.02) on AAT. Although the DD group also performed more poorly on digit naming speed than the naming-speed deficit group, this difference did not achieve significance ($F(1,31) = 3.5$, $p=.07$). Although the DD group differed significantly from the single deficit groups only on AAT, the fact that this group was also slower was considered in the following analyses.

For all of the simple effects comparisons between DD and single deficit groups, parallel covariate analyses, controlling for the effects of either AAT or digit naming speed scores were conducted and will be reported. Between the PD and DD groups, the AAT scores were covaried from the dependent variables, and between NSD and DD groups, naming speed scores were covaried.

Reading Measures

One goal of this study was to determine how children in both single and DD groups performed on standard tests of reading (i.e., W-J (R) Word Identification and Word Attack, Gray-Oral Timed Reading passage). Children with single deficits were expected to be moderately poor readers, while children with double deficits were expected to perform at a significantly lower level. Means for each of the groups are contained in Table 4. Generally, children with standard scores less than 90 on the W-J(R) tests are considered poor readers. In Study One, 20% of the PD group, 18% of the NSD group, and 88% of the DD group had standard scores on Word Identification less than 90.

Children's standard scores for grade for Letter-Word Identification and Word Attack were entered into a 3 x 2 mixed, repeated measures ANOVA with three levels of group as the between subjects factor, and two levels of test as the within subjects factor. Only the between subjects factor of group was found to be significant ($F(2,45)=16.5$, $p<.001$). Simple effects analyses using T-tests revealed that the double-deficit group's scores on Letter-Word Identification and Word Attack were significantly lower than either of the single deficit groups (*$T=4.5$, $p<.001$ and $T=3.42$, $p=.002$ for Letter-Word ID and $T=5.4$, $p<.001$ and $T=2.65$, $p=.014$ for Word Attack*).

However, covariate analyses revealed that the difference between the PD group and the DD group disappeared on the Word Attack test when AAT scores were controlled (*F(1,28)=2,8, p=.11*). This covariate analysis was necessary to control for the double-deficit's significantly worse AAT score compared to the single-deficit (PD) group.

The difference between the PD and DD groups on Word ID remained significant even with the effects of AAT controlled (*F (1,28) = 7.53, p=.010*). Differences between the NSD and DD groups remained significant even when the effects of digit naming were covaried (*F(1,30) = 14.1, p=.001 for Letter Word ID and F(1,30) = 21.9, p<.001 for Word Attack*). In addition, when the two single deficit groups were compared, the NSD groups' scores on both standardized reading tasks were significantly higher than those of the PD group (*T=2.2, p=.04 for Letter-Word ID, and T=4.0, p=.001 for Word Attack).*

When comparing children's word with non-word decoding, only in the PD group did children decode words significantly better than non-words (*T(14) = 2.99, p=.01*). For the other two groups, children's ability to decode words and non-words did not differ significantly (*T(16) = .141, p=.890 for NSD group, T(15)=.485, p=.635 for DD group*)). Only the children in the DD group can be described as poor readers based on their Word ID scores. Children in the PD group might be described as mildly impaired compared to their peers while the NSD group's scores were average.

Group differences were also found on other measures of reading ability. For the GORT reading analyses, all times were converted to reciprocals in order to avoid the positive skews typical of latency measures. Repeated measures ANOVA analyses revealed a main effect of group for reading time *(F(2,45)=51.3, p<.001)* and for reading errors (*F(2,45)=5.01, p=.011*) on the GORT-D passage. Simple effects analyses were used to look at the three groups in comparison to each other on these variables. Children in the PD group read significantly faster than children in the NSD group (*T=2.4, p=.02*), and the DD group was significantly slower than both single deficit groups (*T=7.0, p<.001 for the NSD group, T=7.8,p<.001 for the PD group*).

This pattern of results did not change when covariate analyses were run *($F(1,30)=26.3$, $p<.001$ for the NSD group, $F(1,28)=57.3$, $p<.001$ for the PD group)*. It would seem that children with naming-speed deficits read more slowly than children without them, but that children with deficits in both naming speed and phonological awareness are the slowest readers of the three groups.

Group effects for errors made on the reading passage were less clear. The DD group appeared to make more errors than either of the single deficit groups (*$T=2.5$, $p=.02$ for comparison with the NSD group, $T=2.0$, $p=.06$ for comparison with the PD group*). However, when the covariate analyses were run, neither the PD group, nor the NSD group differed from the DD group in the numbers of errors made (*$F(1,30)=2.7$, $p=.11$ for the NSD group, and $F(1,28)=1.2$, $p=.27$ for the PD group*). The two single deficit groups did not differ from one another significantly in the number of errors made (*$T=1.1$, $p=.27$*).

In summary, DD children were significantly poorer readers on the W-J tests of reading and slower on the GORT passage than either single deficit group. However, PD children were both worse readers on the W-J tests and faster readers on the GORT passage than the NSD group.

TABLE 4

Mean Standardized Grade Scores and S.D.'s (in parentheses) for Tests of Reading

	Group		
Measure	**PD group**	**NSD group**	**DD group**
WJ-R Word Identification	94.1 (9.2) $^{a;d}$	105.1 (18.2) $^{b;d}$	81.5 (11.4) $^{c;d}$
WJ-R Word Attack	89.7 (6.0) $^{a;e}$	104.7 (14.1) $^{b;d}$	82.3 (9.4) $^{a;d}$
GORT-3 Timed Reading	24.8 (12.5) ^{a}	33.9 (8.0) ^{b}	97.6 (35.3) ^{c}
GORT-3 Reading Errors	1.6 (1.8) ^{a}	1.00 (1.0) ^{a}	4.81 (6.0) ^{a}

NOTE: Groups sharing superscripts do not differ at .05 level when appropriate covariate used; a/b/c superscripts refer to group comparisons; d/e superscripts refer to test comparisons within groups

Spelling Measures

Group differences on the standardized spelling measures were also examined. The means and standard deviations for these measures are contained in Table 5. For both spelling dictation and spelling recognition tests, the single deficit children appear to be moderately poor spellers, while the DD group fell significantly below what would be expected for this grade level. For this analysis, children's grade standardized scores for spelling dictation and recognition were also entered into a 3 x 2 mixed, repeated measures ANOVA with three levels of group as the between subjects factor, and two levels of test as the within subjects factor. There was a significant main effect of group membership ($F(2,45)=4.9$, $p=.01$) and type of spelling test ($F(1,45)=8.1$, $p=.007$), but these effects were modified by a significant interaction effect ($F(2,45)=4.1$, $p=.022$).

The interaction appeared due to a different pattern of results on each spelling test for the single deficit groups although the DD group had lower scores on both tests. Moreover, the NSD group scored similarly on the two tests, while the PD and DD groups performed more poorly on dictation than recognition tests of spelling.

This pattern was confirmed by simple effects analyses using T-tests. For dictation, the single deficit groups did not differ significantly from one another in their performance ($T=1.8$, $p=.08$), although the double-deficit group performed significantly worse than either of them ($T=3.5$, $p=.002$ *for the NSD group*, $T=2.2$, $p=.038$ *for the PD group*). Covariate analyses revealed that differences between the DD and the PD group were due to differences in AAT scores rather than to the presence of the additional naming speed deficit ($F(1,28)=1.7$, $p=.20$) whereas for the NSD group, the covariate analyses supported the finding that the DD group was significantly poorer than the NSD group ($F(1,30)=7.4$, $p=.01$). This suggests that a phonological deficit, with or without a naming speed deficit seems to lead to poor spelling dictation scores.

For spelling recognition, again the two single deficit groups did not differ significantly from one another ($T=.66$, $p=.52$), and the double-deficit group's performance was significantly worse than only the PD group ($T=3.0$, $p=.005$). The performance of the DD group and the NSD group on spelling recognition did not differ significantly from one another (*T=1.6, p=.118*). The pattern of results did not change for the covariate analyses *(F(1,28)=4.7, p=.04 for the PD/DD group comparisons, and F(1,30)=.94, p=.34 for the NSD/DD group comparisons*).

Differences between spelling dictation and recognition tests had been predicted, with different patterns for each of the deficit groups. This pattern was reflected in the overall interaction term. There was also an overall effect of dictation being harder than recognition. For the PD and DD groups, scores for spelling dictation were significantly lower than spelling recognition scores (*F(1,14)=6.8, p=.02* and *F(1,15)=6.4, p=.02 respectively*). The findings for the PD group are supportive of the hypothesis that children with good naming speed skill perform better on recognition versus dictation tasks because of an orthographic skill advantage. Contrary to prediction however, within the NSD group, there was no significant difference between spelling recognition and dictation scores (*F(1,16)=.48, p=.50*).

TABLE 5

Mean Standardized Grade Scores and S.D.'s (in parentheses) for Tests of Spelling

	Group		
Measure	**PD group**	**NSD group**	**DD group**
WJ-R Spelling Dictation	82.0 (8.8) $^{ab;d}$	89.2 (13.7) $^{a;d}$	73.8 (11.9) $^{b;d}$
PIAT-R Spelling Recognition	90.9 (10.4) $^{a;e}$	87.6 (17.4) $^{ab;d}$	79.6 (10.4) $^{b;e}$
Bruck Regular Words (/8)	4.7 (1.5) $^{a;d}$	6.1 (1.8) b;d	4.3 (1.8) $^{a;d}$
Bruck Reg. * Words (/8)	4.2 (2.2) $^{a;de}$	4.9 (2.1) $^{a;e}$	3.9 (1.7) $^{a;d}$
Bruck Exception Words (/8)	3.1 (1.7) $^{a;e}$	3.6 (2.2) $^{a;f}$	2.0 (1.0) $^{b;e}$

NOTE: *Groups sharing superscripts do not differ at .05 level when appropriate covariate used; a/b/c superscripts refer to group comparisons; d/e/f superscripts refer to test comparisons within groups*

In order to examine children's spelling dictation skills more thoroughly, an additional measure of spelling dictation was included. The Bruck dictation list included words of three types, simple regular words, slightly more difficult regular words, and exception words. Means and standard deviations for children's scores on these three lists are included in Table 5. The three (group membership) by three (word type) MANOVA analyses revealed a main effect of deficit group ($F(2,45)=4.4$, $p=.018$), and of word type ($F(2,90)=32.6$, $p<.001$) but no significant interaction effect ($F(4,90) = 0.78$, $p=.542$). In general, the NSD group performed better than the PD group, who performed better than the DD group, for all types of words, although some of the individual comparisons failed to reach significance. In addition, regular words were the easiest for all children to spell, followed by the "regular star" words, with the exception words being the most difficult for all children. This pattern was not changed in the covariate analyses. From all of the spelling analyses it would appear that children with single deficits appear to be moderately poor spellers and overall, children with double deficits are the poorest spellers.

Another hypothesis with respect to <u>both</u> reading and spelling skill was based on previous studies which had found groups of children with spelling problems who were nonetheless good readers. It was hypothesized that one of the single deficit groups might be characterized by this pattern of good reading and poor spelling skills. Spelling dictation, recognition, and reading (i.e. Letter Word Identification) measures were considered for this analysis. For spelling dictation and reading, there was a main effect of group ($F(1,30) = 4.3$, $p=.047$) and of type of test ($F(1,30) = 69.8$, $p<.0001$), but no significant interaction effect ($F(1,30) = 1.2$, $p=.279$). Both the NSD and PD groups performed at a significantly higher level on word identification compared to spelling dictation although the children with poorer phonological skills were at an even greater disadvantage on both types of language skill. When only the spelling dictation scores were considered, both NSD and PD groups fit into the category of "good readers/poor spellers".

For spelling recognition compared to reading, there was no main effect of group ($F(1,30) = 0.66$, $p=.421$), but a significant effect of test type ($F(1,30) = 21.9$, $p<.0001$), and a significant interaction effect ($F(1,30) = 10.4$, $p=.003$). Only the NSD group differed in their spelling recognition and reading skills, whereas the PD group's scores were similar for the two types of tests. When spelling recognition was considered, only the NSD group fit this "mixed" definition of good readers but poor spellers.

Orthographic Skill

Children with single deficits in naming-speed were hypothesized to be slower and less accurate than children with only phonological deficits on measures of orthographic skill. Children with deficits in both phonological and naming-speed skills were expected to have the most difficulty. In addition, replication of previous findings on a measure of the ability to quickly process letter strings differing in degree of orthographic structure, the Quick Spell Test (Bowers, 1996) was also sought.

With respect to letter pattern knowledge, children were administered two often-used measures of orthographic knowledge; a Word Likeness task (Siegel, Share, & Geva, 1995), and an Orthographic Choice task (Olson, Kliegl, Davidson, & Foltz, 1985). Means and standard deviations for the percentage of correct responses, and for the latency to correct responses for each of these tests is contained in Table 6. A mixed, repeated measures ANOVA with 3 levels of group, and 2 levels of test type was conducted. For all of the speed measures, mean latency to correct responses were transformed using a natural log transformation in order to remove the skew typical of latency measures.

On measures of accuracy (percent correct) the effect of group membership ($F(2,45)=59.7$, $p< .001$) and type of test ($F(1,45) = 73.9, p<.001$) were significant but these were modified by a significant interaction effect ($F(2,45) = 6.95, p<.001$). The significant interaction effect on the accuracy measures appeared due to the Word Likeness task being much more difficult than the Orthographic Choice task for the NSD and DD groups, although the PD group's scores were roughly equal for the two measures.

For the Orthographic Choice test, children with a naming speed deficit, either alone or in combination with a phonological deficit, were significantly less accurate than their peers with a phonological deficit alone (*T = 8.10, p<.001 & T=8.00, p<.001 respectively*). The PD group's scores were higher than the DD group's even when the effects of AAT were covaried (*F(1,28) = 46.99, p<.001*). In addition, the single deficit naming-speed group, and the double-deficit group's scores were not significantly different from each other (*T=.251, p=.803*), even after covariate analyses (*F(1,30) = .217, p=.645*). For the Word Likeness test, the pattern of results was the same with the PD group outperforming the NSD and DD groups (*T=8.56, p<.001 & T=8.01, p<.001*). Even after covariate analyses (*F(1,28) = 45.86, p<.001*), the NSD and DD groups' scores were statistically equal (*T=1.39, p=.176 and F(1,30) = .302, p=.587*). It would appear that a deficit in naming speed leads to difficulties with orthographic accuracy regardless of the presence or absence of difficulties with phonological awareness.

TABLE 6

Means and S.D.'s (in parentheses) for Tests of Orthographic Knowledge (Latencies are for correct items only)

Measure	Group		
	PD group	NSD group	DD group
Accuracy Scores (Percent Correct)			
Orthographic Choice	94.2 (5.9) $^{a;d}$	64.0 (14.1) $^{b;d}$	62.7 (14.5) $^{b;d}$
Word-Likeness	84.7 (16.6) $^{a;d}$	37.7 (14.1) $^{b;e}$	28.7 (22.1) $^{b;e}$
Latency (milliseconds)			
Orthographic Choice	761(178) $^{a;d}$	2013(743) $^{b;d}$	1894(771) $^{b;d}$
Word-Likeness	1524(2930) $^{a;e}$	4399(2750) $^{b;e}$	4247(2840) $^{b;e}$

NOTE: Groups sharing superscripts do not differ at .05 level when appropriate covariate used; a/b/c superscripts refer to group comparisons; d/e superscripts refer to test comparisons within groups

With respect to latency of responding on the two measures, there was a significant effect of group membership (F(2,45) = 50.23, p<.001) and of test (F(1,45) = 179.06, p<.001), but no significant interaction (F(2,45) = 1.09, p=.345). Children in the PD group responded much more quickly than children in either of the other two groups. In addition, all groups were slower on the Word Likeness task than on the Orthographic Choice Test.

The results for the Quick Spell Test are contained in Table 7. Bowers (1996) results were replicated in this study. A 3 x 3 mixed, repeated measures ANOVA with three levels of group and three types of letter strings was performed. The main effects of group ($F(2,45) = 8.2$, $p=.001$) and of wordtype ($F(2,90)=101.6$, $p<.001$) were significant but moderated by a significant interaction effect ($F(4,90)=10.0$, $p<.001$). Typically, children performed better on words than pseudowords, and most poorly on the nonwords. However, this result was modified by the effect of group membership.

Simple effects analyses were performed on each type of word separately. For words, children in the PD group performed significantly better than children in the NSD group ($T=2.12$, $p=.04$), who significantly outperformed the DD group ($T=4.73$, $p=.001$). Covariate analysis removing the effects of naming speed confirmed the difference between NSD and DD groups ($F(1,30)=9.77$, $p=.004$).

For pseudo words, the two single deficit groups did not differ significantly from one another ($T=0.62$, $p=.535$), although both groups performed significantly better than the DD group ($T=3.04$, $p=.005$ for PD, $T=4.28$, $p<.001$ for NSD). The differences between PD and DD, and NSD and DD were not changed in the covariate analyses ($F(1,28) = 6.36$, $p=.018$ and $F(1,30)=13.60$, $p=.001$ respectively).

For non-words, the pattern was more complicated. The PD group performed significantly better than the NSD group ($T=3.26$, $p=.003$) and the DD group ($T=2.26$, p-.033), even when the covariate of AAT was removed ($F(1,28) = 4.73$, $p=.038$). A simple T-test indicated that the NSD and DD groups did not differ significantly from one another ($T=1.70$, $p=.102$) although the covariate analyses revealed that the DD group in fact, performed significantly better than the NSD group ($F(1,30) = 5.73$, $p=.023$).

TABLE 7

Means and S.D.'s (in parentheses) for Items Correct on the Quick Spell Test (Bowers, 1996)

	Group		
Type	**PD group**	**NSD group**	**DD group**
Word (mean/10)	9.7 (.59) $^{a;d}$	9.2 (.88) $^{b;d}$	7.1 (2.0) $^{c;d}$
Pseudowords (mean/10)	7.5 (1.8) $^{a;e}$	7.8 (1.3) $^{a;e}$	5.6 (1.7) $^{b;e}$
Nonwords (mean/10)	6.1 (2.5) $^{a;e}$	2.9 (3.0) $^{b;f}$	4.3 (1.7) $^{c;f}$

NOTE: Groups sharing superscripts do not differ at .05 level when appropriate covariate used; a/b/c superscripts refer to group comparisons; d/e/f superscripts refer to test comparisons within groups

In general, children with a double-deficit had significantly more difficulty recognizing letters in words and pseudowords than their single-deficit peers. The two single-deficit groups differed from each other only on words, not on pseudowords. One could speculate that this result may arise out of compensatory strategies used by the naming-speed deficit group. Although the results from the orthographic measures suggest that the PD group may have better letter pattern knowledge, the better decoding skills in the NSD group may help them compensate for their slow naming and allow them to identify the letters in pseudowords more accurately and quickly than expected based on their orthographic skills alone.

With respect to nonwords, the pattern of results is more confusing. The PD group performed better on nonwords than the NSD and DD groups as in the Bowers 1996 study. Unlike that study however, children in the DD group did better than those with only a naming speed deficit. This somewhat confusing result should be considered in light of the time span between testing of single deficit and double deficit children. It is possible, given the four month time delay that children in the DD group improved their scores, and if all children had been tested at the same time, different results may have occurred. This result will need to be replicated with groups of children tested closer together before any strong conclusions can be drawn.

Overall, the results of the orthographic test analyses confirm the relationship between digit naming-speed and orthographic knowledge found by Doi and Manis (1996). In the present study, children with slower naming speed, whether alone, or in combination with phonological deficits, were less accurate, and slower, on tests of letter pattern knowledge. The relationship found between naming-speed and orthographic knowledge provides indirect support for the double-deficit hypothesis, suggesting that there are at least two component skills associated with good reading. In addition, the Quick Spell Test results indicate that naming-speed, in combination with phonological awareness, is related to how quickly children process letter sequence information. The special difficulty children with naming speed deficits have recognizing briefly presented letters in novel strings may provide clues for understanding their other difficulties.

Discussion

In general, a number of patterns were revealed by these results. Children with double deficits were worse overall on measures of reading, spelling, and orthography with respect to speed and accuracy. Typically, compared to the NSD group, children in the PD group read less accurately but more quickly, had worse spelling dictation but comparable spelling recognition scores. They also had better novel letter string recognition under brief exposure conditions. Phonological skill appeared to be the most important contributor to children's word and nonword decoding skills; however additional naming speed deficits further decreased children's reading scores. Children in the NSD group were more accurate in their decoding, but generally slower readers. On some occasions, the DD group's performance was similar to that of children in the PD group and on others, to the NSD group. The results here were generally supportive of the additive effects of phonological and naming speed skills and are likely due to each of the deficits affecting different component processes, specifically phonology and orthography. Although deficits in either phonological awareness or naming speed skill may create some difficulties with reading, children with deficits in both of these skills are most at risk for reading problems.

The WJ-R standard reading scores suggested that children in the single deficit groups generally scored within the average range on Word Identification with the NSD group outperforming the PD group. The PD group was below average on nonword reading whereas the NSD group performed at, or slightly above what would be considered average for their grade placement. NSD children had less difficulty with Word Identification than predicted. Other studies (e.g., Bowers, 1995; Krug, 1996; Sunseth & Bowers, 1996) have noted that children with naming-speed deficits alone are moderately poor readers when compared to their double-asset peers. However, in this case, there was no control group of children without deficits in either skill (i.e., the double asset group) for comparison. Future studies will need to compare the single deficit groups with children in a double-asset condition in order to replicate and expand on these findings.

However on standardized spelling tasks overall, children in both single deficit groups fell significantly below what would be expected for their grade on spelling dictation and recognition measures, with the DD group being even further behind in spelling dictation. Overall, we could say that single deficit groups were moderately poor spellers, while children in the DD group were very poor spellers. An estimate of where children in the double asset group would be performing on spelling tasks would again be helpful in order to help place the spelling scores of children in the three deficit groups in some context.

Spelling dictation was more associated with phonological awareness than naming speed, although naming speed also appeared to contribute some amount of variance. For all of the spelling dictation tests, children in the NSD group outperformed children in the PD group, and double deficit children performed most poorly. The connection between phonological awareness and spelling dictation has been found in many studies (Dreyer, Luke & Melican, 1995; Ehri & Wilce, 1987), and this would appear to be one more example.

Children's spelling dictation of different types of words was also examined. Up until this point research has generally emphasized phonological skill in reading and in spelling (Stage & Wagner, 1992; Waters, Bruck & Seidenberg, 1985). In this study, it was hypothesized that children with faster naming speed skills compared to their phonological skill (PD Group) might learn word patterns in a more holistic manner, rather than relying on sounding out words in order to spell them and perform relatively better on spelling dictation tests for exception words which can not easily be spelled with a phonological approach. The results did not support this hypothesis. It is possible that this type of compensatory strategy does not develop until later grades or that the phonological approach to spelling dictation is used by all children regardless of their level of facility in this area, as was suggested by Waters et al.'s findings. They noted that even children with very poor phonological processing skills persisted with a phonological approach to spelling words even when it was not very successful.

Children's performance on spelling dictation versus spelling recognition tasks was also examined. It was hypothesized that phonological skill might be more closely linked to spelling dictation tasks especially for regular words. In comparison, there is also some suggestion that naming speed skills may be linked to the ability to recognize the patterns in words and to perform spelling recognition tasks quickly and accurately, even for irregular words. Based on these arguments, it was predicted that children in the PD group would have poorer spelling dictation than recognition, while children in the NSD group were expected to have poorer spelling recognition than dictation scores. As predicted, the PD group's scores for spelling recognition were significantly higher than their dictation scores. Unlike the prediction, the NSD group did not differ on their scores for the two types of spelling tasks although their scores were similar to the PD group's spelling recognition levels.

At first glance the PD group's better performance on recognition than dictation might be attributed to better orthographic skills exhibited on other tasks. However, the DD group also performed better on tests of recognition than on tests of dictation despite having the poorest orthographic skills. Further investigation of these patterns will be required in order to fully understand these findings.

The pattern of good readers/poor spellers found in the work of Waters et al. (1985) seem to best fit children in the NSD group who were better readers than children in other groups yet were poor spellers on both tests. We need to look more closely at the "mixed" groups in other studies in order to begin to understand why some children struggle more with spelling than with reading, despite the many skills common to both tasks. This problem is further complicated by the wide variety of reading and spelling measures used in previous studies.

Overall, the results from the analyses of the orthographic measures in this study confirm the relationship between digit naming-speed and orthographic knowledge found by Doi and Manis (1996). In the present study, children with slower naming speed, whether alone, or in combination with phonological deficits, were less accurate and slower, on tests of letter pattern knowledge. Bowers and Wolf (1993) noted a connection between naming speed and orthographic knowledge and proposed that this link may arise because of fast namers' ability to process letters quickly enough to recognize letter patterns. If children are decoding words in a slow letter by letter fashion they may fail to learn common letter patterns in English. Children with faster naming speed may be able to note and access this type of letter pattern knowledge more easily than their slower naming peers.

We should make note of one problem with the percentage correct scores for the Word Likeness task shown in Table 7. For this orthographic task, children were asked to choose between two pretend words and select the "pretend word" which looked most like a real word. For the NSD and DD groups, both of which performed most poorly on this task, the scores indicate choices which were lower than what one would expect based on chance alone. If children had no idea about which word contained the illegal spelling pattern (and hence possessed little letter pattern knowledge), we would have expected that they still would have responded at about a chance level - 50%. Instead, it would appear that children in these two groups may have been choosing the incorrect word for some particular reason. When looking over the list of items, it is difficult to determine just what the reason for children making this incorrect choice so frequently might be.[2]

Overall, the results from Study One provide support for the double-deficit hypothesis of reading. Children who possess difficulties in only one skill differed from one another in some

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[2] This particular measure of orthographic skill has been criticized by some (Vellutino, Scanlon, & San Chen, 1995). These authors noted that it is often difficult for literate adults to accurately distinguish between the orthographically "correct" and illegal items. They noted that the critical bigrams for the correct choices occur infrequently or not at all in four letter English words. This problem however, would have resulted in poorer performances for all groups and the PD group's good performance (i.e. 85% correct) would be unlikely. It is possible that the incorrect choices are stranger or more novel to children with poor orthographic knowledge resulting in selection of unique items (i.e. a novelty effect). Replication is required before other conclusions can be drawn.

components of reading and spelling, and from children with deficits in both naming speed and phonological processing. A deficit only in phonological skill was related to several factors : poorer word and nonword decoding skills, more difficulty producing the correct spelling of a word, and better overall orthographic skill as well as text reading speed when compared to children with only a deficit in naming speed skill. Naming speed deficits alone were linked to both average reading skill and slower text reading but moderately poor spelling performance, and to significantly poorer orthographic skill in comparison to children with a phonological deficit. These children had less success processing illegal letter strings presented briefly which may provide clues to why these children fail to develop orthographic knowledge. Once children have such knowledge however, they can use it to enhance the processing of legal letter strings. Children with deficits in both skills demonstrated significantly poorer reading and spelling scores than their single-deficit peers, although in the area of orthographic skill, there is evidence that the extra deficit in phonological awareness contributes little on top of the naming speed deficit.

STUDY 2

Introduction

A replication of this investigation of the double-deficit model of reading was needed, refining some of the procedures and measures. Changes included the use of a stricter criterion for group membership amoung Grade Three children. To qualify as having a deficit, children needed to be below the 30th percentile on screening measures. The criterion for assets was performance above the 50th percentile. In addition to the three deficit groups assessed in Study One, two new groups were added in the second study for comparison purposes; third grade children who scored above the 50th percentile on both the AAT, and digit naming speed - the so-called "double asset" group, and a reading level control group of Grade One children matched on reading ability to the DD children. Having a group of Grade Three readers with no deficits should help us to determine just how much a single deficit impairs reading in comparison to no deficits. The presence of the reading-level matched (Grade One) control group may also reveal whether the reading pattern of various groups is similar to that of normally-developing younger readers. .

Measures for the second study were similar to the first with a few modifications. The groups were selected using the same screening measures discussed above (a continuous list version of the digit naming speed test, and the Auditory Analysis Test). Reading measures remained essentially the same, including the Letter-Word Identification and Word Attack subtests from the WJ-R, and a paragraph from the GORT-3 (Wiederholt & Bryant, 1992) to assess speed and accuracy of reading. The actual paragraph was changed however, because children consistently encountered difficulties with uncommon words in the initial paragraph like "bow-wow". The new paragraph was of the same length and difficulty level.

The spelling measures in this study were altered significantly. The previously used WJ-R spelling dictation subtest was difficult to interpret due to the inclusion of punctuation and usage items. For Study Two, the spelling dictation scores came from the revised version of the Test of

Written Spelling (Larsen & Hammill, 1994) which included a list of regular words and one of exception words and possessed adequate reliability and validity, and appropriate norms. This test replaced both the WJ-R spelling dictation subtest and the Bruck lists of regular and exception word spelling. The PIAT-R spelling recognition test was used again in this study.

For the measures of orthography, a wider range of orthographic measures assessing knowledge at different levels was included. The same version of the Olson Orthographic Choice (Olson et. al, 1985) and the Word Likeness Test (Siegel et al, 1995) assessed knowledge at a word and subword level respectively. In addition, based on one criticism of the Siegel et al. task (Vellutino, Scanlon & Chen, 1995), the instructions were modified slightly to make the task more clear, and feedback was provided during practice in order to ensure that children understood the requirements. A second list of easier items taken from a measure used by Massaro et al. (1980) was added to the Word Likeness test in order to be able to use this test with younger children, and to help assess some of the difficulties encountered with the Siegel et al. task in the previous study. In addition, another test of letter pattern knowledge, recently developed by Hultquist (1996) was included. By including a range of orthographic tests appropriate for different skill levels, better understanding of the proposed link between naming speed and orthographic skill might be gained. The Quick Spell Test (Bowers, 1996) which assesses the quick identification of several types of letter strings and which is hypothesized to relate to orthographic knowledge was also included.

The list of measures given to the reading level (RL) control group (i.e., Grade One children) differed from those given to the rest of the Grade Three children. Difference in ages and tolerance for longer tasks led to the elimination of the longest orthographic task, the Hultquist embedded word task. In addition, the spelling dictation measure was eliminated out of concerns that many children in Grade One might not yet be familiar with this type of task. At this age, many children are encouraged to make use of invented spellings of words rather than focusing on correct spelling. Finally, the more difficult of the two Word Likeness tasks, the Siegel et. al list was not given to the Grade One children. Because we have two measures of a similar skill (i.e., two Word Likeness tasks) at different levels of ability, comparison of RL controls on the easier word likeness task seemed more informative. The other measures were given to the Grade One children in the same manner as to the Grade Three children.

Many authors argue that reading level control groups can help to equate good and poor readers on variables such as exposure to print, and type of reading activities (e.g., Rack, Snowling, & Olson, 1992; Vellutino, Scanlon & Chen, 1995) in a way which matches by chronological age do not allow. The crux of many arguments is that children of the same age and differing reading level will have had very different reading histories and experiences. That is, children who are good readers are more likely to seek out and persist with reading tasks, whereas children who struggle more with reading are more likely to avoid reading as much as possible. Comparing children at the same reading level permits one to argue that deficiencies in the older poor readers may have caused their poor reading, whereas variables which differentiate good and poor readers of the same age may be an effect of reading experience. However, this argument encounters a number of problems (e.g., it is still difficult to assume that poor readers at one level have had the same experiences as younger, good readers). Our objective in this study was to compare Grade Three poor readers (i.e., the DD group) with younger children matched on their ability to decode single words (i.e., Word Identification scores), and to observe the degree of similarity in various component processes, without making causal inferences about the nature of the difference.

Most reading-level matched studies focus on groups of older readers and therefore, their reading level controls are older than the Grade One children proposed here. In addition, it has been suggested that children do not begin to develop orthographic knowledge until they are at least in Grade Three (e.g., Juola, Schadler, Chabot, McCaughey, 1972; McCaughey, Juola, Schadler, & Ward, 1980), suggesting that the Grade One reading level matched children in this study will be at a particular disadvantage, although more recent studies (e.g., Golden, 1997) have found proficiencies on simple orthographic tasks as early as Grade two. The study of the orthographic skills of Grade One reading level controls may shed some light on the relationship between naming speed, phonological awareness and orthographic skill in very young children.

Other arguments about interpreting results from reading level control groups focus on the way children are matched. Vellutino, Scanlon, and Chen (1995) note that matching two groups of children on word decoding skills does not guarantee a match on other variables (i.e., exposure to orthographic patterns). In general, they note that the quality of the matching seems to be poorer as the age gap between the two groups widens; they also note that this type of design tends to favour the older (i.e., deficit bearing) group. They suggest that children matched using word identification scores are likely to be equivalent on orthographic measures but give few reasons and little evidence to support this position.

Overall, expectations for this study were guided by the results of Study One. It was expected that the single-deficit groups would perform moderately poorly on standardized tests of reading and spelling when compared to the double-asset group. In addition, it was expected that the DD children would have the lowest scores on all of the measures of reading, spelling, and orthography. Children with only poor phonemic skills were expected to be quicker on timed tasks, but have lower dictation scores relative to their spelling recognition scores. It was hypothesized that children with only poor naming speed skills would be slower in their reading and have relatively more difficulty with orthographic tasks.

Hypotheses about the performances of the reading level control group were less clear. The reading level control group was expected to have better phonological awareness skills than the Grade Three double deficit group as assessed on the AAT. This prediction was based on the results of previous studies using RL controls and because children in the DD group were selected because of a deficit in this area. Differences between the two groups with respect to their digit naming speed were more difficult to predict. Because of a strong developmental contribution to naming speed scores, it was likely that children in the RL control group would have slower digit naming speed scores in spite of the fact that the Grade Three group was selected partly because of their slow naming speed. Previous results obtained by Swanson (1989) suggest that good readers in Grade One have slower digit naming speed scores than poor readers in Grade Three. However, it was predicted that although children in Grade Three possess a number of advantages because of the extra time they have spent learning to read, they would still perform more poorly than younger controls on some general measures of written language ability. We expected that the Grade Three poor readers would perform at a roughly equivalent level on spelling recognition when compared to their reading level matches because of the tradeoff between a longer exposure to specific instruction about letter patterns, but weaker overall phonological skill.

No predictions about the two group's performance on orthographic tasks were made. Competing possibilities made RL controls' behaviour on these tasks uncertain. Grade One children may not yet make use of orthographic knowledge in their reading, their stronger phonemic awareness skills may lead to stronger letter pattern association knowledge, but may be negatively affected by similar or slower digit naming speed times.

Method

Participants

The participants in this study were 68 children in Grade Three, and 15 children in Grade One. Two hundred and one children, from ten classrooms in five local public schools, were screened using a measure of phonological awareness, a modified 29-item version of the Auditory Analysis Test (Rosner & Simon, 1971), and a continuous digit naming-speed task, the RAN-digits (Denckla & Rudel, 1974). The response to permission forms sent home was greater than 80% for the sample. The initial screening was given to children individually in a separate, quiet, room in the school and required approximately ten minutes.

From this sample, we selected "double-asset children" who were above the 50th percentile for the sample on both measures (AAT >= 19, naming speed >= 1.81 items/second), so-called single deficit children with a deficit in either phonological awareness or digit naming-speed (i.e., below the 30th percentile for the sample on one skill, and above the 50th percentile on the other), or children who were below the 30th percentile on both skills (i.e., double-deficit children). The 30th percentile cutoff for the AAT was 14 or below, and 1.60 items/second or below for naming speed. This selection resulted in 69 double-asset children (DA group), 17 children with phonological deficits (PD group), 18 children with speed deficits (NSD group), and 29 children with double deficits (DD group). From the double-asset and double-deficit groups, children were randomly selected to give approximately equal cell sizes (n=17 and n=16 respectively). The only additional criterion for subjects was that they be reasonably fluent in English. First language, and languages spoken in the home were recorded on permission forms, and children with first languages other than English were informally assessed in casual conversation for their ability to converse in, and understand English. If there were any question about a child's fluency in English, researchers deferred to children's classroom teachers for a judgment about fluency. Children considered non-fluent in English were not tested. Only six children out of 201 had first languages other than English. All of these children obtained results placing them in the double-asset group, although only two of them were randomly chosen for inclusion in this study. The initial selection resulted in 17 double-asset children, 35 single-deficit subjects (17 with a phonological deficit and 18 with a digit naming speed deficit), and 16 children with a double-deficit.

Grade Three children were screened in January of the school year, and individually tested in February, and March of the same year. The group of 15 Grade One children were selected as reading level matches for the double-deficit group after all of the Grade Three children had been tested. It was necessary to obtain an approximate Grade equivalent score on the Letter-Word Identification subtest from the Woodcock-Johnson Achievement battery for the double-deficit Grade Three children in order to determine what level of Grade One readers were required. The DD group on average was found to be reading at the level of children in Grade 1.9. In May of the school year, Grade One teachers from two schools were asked to nominate children in their class whom they considered to be average readers. Once permission was obtained from parents and the children, this group of children was seen for one session during which they were given the screening measures, and a subset of the Grade Three testing measures discussed above. Children in Grade One were <u>not</u> given the Test of Written Spelling dictation test, the Siegel et. al (1995) Word Likeness task, or the Hultquist (1996) Embedded and Nonembedded word lists. Each session took approximately one hour. This group of children was matched on the range of DD Grade Three children's raw scores from the Letter-word I.D. subtest. All Grade One children obtained scores on this test within the same range as the double-deficit Grade Three group.

<u>Measures</u>

In addition to the screening measures (AAT and Digit Naming Speed) described in Study One, Grade Three children in the study were individually administered a number of written language tests over two sessions. The instruments used in both Study One and Two were the Letter-Word Identification, and Word Attack subtests from the revised Woodcock-Johnson Achievement Battery (WJ-R), the Spelling Recognition subtest from the revised Peabody

Individual Achievement Test (PIAT-R), an Orthographic Choice Test (Olson, Kliegl, Davidson, & Foltz, 1985), the Quick Spell Test (Bowers, 1996), and one Word Likeness Test (Siegel, Share, & Geva, 1995). In order to try and avoid the below chance results from the Word Likeness Test found in Study One, the directions for the Word Likeness Task were modified slightly to place more emphasis on children choosing the word that looked more like a real word, and feedback was provided for the sample items of the Word Likeness task in Study Two. Tests used only in Study Two were the Test of Written Spelling (Larceny & Hammed, 1994), a measure of reading speed and accuracy which consisted of one paragraph taken from the third edition of the Gray Oral Reading Test or GORT-3 (Wiederholt & Bryant, 1992), an additional Word-Likeness Test (Massaro, Taylor, Venezky, Jastrzembski & Lucas, 1980), and the Hultquist (1996) Embedded and Nonembedded Word test. The new tests added to Study Two are described below.

1. The Test of Written Spelling, third edition, TWS-3 (Larceny & Hammed, 1994) was used as a replacement for the Bruck Dictation task to provide a more standardized comparison test. It is an individually administered, standardized spelling dictation test containing two lists of words in order of increasing difficulty. The first list, Predictable Words, is a measure of skill in spelling words that conform to phonic rules, while the second list, Unpredictable Words, is a measure of skill in spelling irregular words. Children are given a subset of all items depending on their range of abilities according to basal and ceiling cutoff scores.

2. Reading Speed & Accuracy: Instead of paragraph A3 from the GORT-D (Bryant & Wiederholt, 1991), paragraph A3 from the GORT-3 (Wiederholt & Bryant, 1992) was included as a measure of reading fluency. Children were presented with a short paragraph (six sentences) and asked to read it out loud as quickly as possible without mistakes. The administrator recorded any errors. The paragraph was chosen to be at the level of approximately an average Grade Two reader. Length of time to finish the paragraph was also recorded.

3. Embedded and Nonembedded Word Task Accuracy: This test developed by Hultquist (1996) taps children's' ability to locate a real word within a string of unrelated letters. In its original format, the task was presented as a paper-and-pencil list of "embedded words" (e.g., lkjdeersd) and non-embedded words (e.g., deer), with 34 items in each list. Children were asked to read all of the words on each list (i.e., embedded or non-embedded) out loud and the time to complete each list was recorded. His study compared a group of reading disabled (RD group) children to reading age controls (RLC group). He found that it took all groups longer to read the embedded items compared to the nonembedded ones, and the RD group made significantly more errors overall. Both groups made more errors on the embedded words compared to the non-embedded ones, although the RD group made more errors at the subword level (i.e., errors associated with vowel confusion or omission of letters in consonant blends). In addition, Hultquist's test correlated somewhat with other, more accepted measures of orthographic processing, the Orthographic Choice, and Homophone Choice test (Stanovich, West, and Cunningham, 1991), believed to be measures of whole word units, but was hypothesized to be more importantly a measure of subword orthographic processing.

The hypothesis that slow namers may have difficulty picking up the letter patterns of words quickly seemed relevant here. It was expected that children with naming speed deficits would struggle more than their peers to find the hidden words, and if they could find the words, would take significantly longer to do so. The Hultquist test was modified for this study so that children were shown "embedded" words (e.g., pdkqeachcz) one at a time on the computer and asked to read the real word hidden within the string into a microphone (i.e., "each"). The examiner coded the accuracy of each response. To compare this ability with an individual child's ability to read words which are not so disguised, scores were compared to that for a list of words matched on frequency and difficulty which were not embedded (e.g., like). This task contained 5 practice and 34 test items for each list. For each of the 68 test items described above (Hultquist, 1996), the computer recorded the latency of responding in milliseconds. An average latency score for correct responses for each subtest was calculated for each child.

Results

Most of the data was analyzed using 2 x 2 (phonological awareness by speed) analysis of variance (ANOVA) procedures to compare children in each of the four Grade Three groups: children with no deficits (DA group), children with a single deficit in phonological awareness (PD group), children with a single deficit in digit naming speed (NSD group), and children with deficit in both skills (DD group). When necessary, post hoc tests were conducted comparing either all four groups or only the three deficit groups using the Bonferroni procedure to protect against chance significance. The four groups were entered into a Bonferroni post-hoc analysis in order to see if the three deficit groups differed from the DA asset group. Because in most cases, the DA group outperformed all of the deficit groups often by quite a large margin, separate 3-group Bonferroni post-hoc analyses were used to prevent the large difference between the DA group and the deficit groups from masking differences between the deficit groups themselves. Children in the double-deficit group were compared to children in the reading level control group using T-test analyses. The reading level control group (RLC group) consisted of 15 Grade One children reading at approximately the same level as the Grade Three double-deficit children. The reading level control comparisons are discussed at the end of this results section, separately from the rest of the analyses.

Means and standard deviations for some of the variables of the four Grade Three groups are contained in Table 8. The groups did not differ significantly from one another with respect to age in years ($F(3,64) = 1.24, p=.30$).

There was a possibility that groups might differ significantly on other variables which could confound the results. Subjects attended five different schools, and were tested by two different examiners during the screening session. The results of analyses on this data are contained Table 9 and Table 10. Subjects from the five schools did not differ in terms of their phonological awareness scores ($F(4,63)=.026, p=.99$) or their digit naming speed scores ($F(4,63)=.33, p=.86$).

In addition, the test administrator variable also did not have a significant effect on subjects' AAT *(F(1,66)=2.1, p=.15)* or digit naming speed *(F(1,66)=.058, p=.81)* scores.

TABLE 8

Means, S.D.'s (in parentheses), ranges, and Significance Levels for Age

	Group					
Measure	**DA group**	**PD group**	**NSD group**	**DD group**	**F stat.**	**(p-value)**
Age	8.55 (.29)	8.52(.24)	8.65 (.27)	8.49(.27)	F=1.24	(p=.48)
(Age range)	8.2-9.1	8.1-9.1	8.2-9.1	8.1-9.0		

TABLE 9

Means, S.D.'s (in parentheses), and Significance Levels, for Screening Variables Between Each of the Grade Three Schools in the Study

	Group						
	School 1 n=8	**School 2** n=17	**School 3** n=16	**School 4** n=14	**School 5** n=13	**F-value**	**(p-value)**
AAT	17.0 (2.3)	17.2 (1.6)	17.0(1.6)	17.7 (1.8)	17.2(1.8)	.026	(.99)
DNS (items/second)	1.6 (.14)	1.8 (.10)	1.7 (.10)	1.8 (.11)	1.8(.11)	.330	(.86)

There was some concern that children in the DD group, might also show poorer phonological skills than the PD group, and slower digit naming speed scores than the NSD group. Means and standard deviations for the AAT and digit naming scores for all five groups are contained in Table 11. If the DD group was also poorer on each component measure than each of the single deficit groups, many of the analyses might be confounded. Using T-tests, the DD group was not found to be significantly poorer on their AAT scores when compared to the PD group(*T(31) = .046,* *p=.96*), nor did the DD-NSD comparison reach significance (*T(32) = 1.61, p=.12*). These results indicated that the double-deficit children did not have poorer phonological skills or additional slowness relative to the single deficit group. Therefore, differences between double-deficit and single-deficit groups are likely to be the result of the presence of the second deficit.

TABLE 10

Means, S.D.'s (in parentheses), and Significance Levels, for Screening Variables Between Test Administrators in the Study

	Group			
Variable	**Experimenter 1** n=28	**Experimenter 2** n=12	**F-value**	(p-value)
AAT	17.9 (.8)	15.3 (1.6)	2.09	(.15)
DNS (items/second)	1.76 (.054)	1.78 (.098)	0.058	(.81)

TABLE 11

Means and S.D.'s (in parentheses) for Screening Variables for each group in the Study

	Group				
Variable	**DA Group** n=17	**PD Group** n=17	**NSD Group** n=18	**DD Group** n=16	**RLC Group** n=15
AAT (/29)	23.2 (3.2)	11.4 (2.4)	22.4(2.6)	11.3 (2.7)	16.1(5.4)
DNS (items/second)	2.1 (.29)	2.1 (.16)	1.5 (.13)	1.4 (.18)	1.4(.29)

Reading Measures

For the analysis of single word decoding, children's standard grade scores for Letter-Word Identification and Word Attack tests were entered into separate 2 x 2 ANOVA's. For Letter-

Word Identification, there were overall main effects of phonological ability *($F(1,64) = 43.3$, $p<.001$)* and of speed (*$F(1,64) = 16.0$, $p<.001$*) but no significant interaction effect (*$F(1,64) = 1.76$, $p=.190$*). For Word Attack, the main effects of phonological ability and speed were also significant (*$F(1,64) = 56.2$, $p<.001$ & $F(1,64) = 15.4$, $p<.001$*) although these were modified by a significant interaction effect (*$F(1,64) = 4.32$, $p=.042$*) indicating that although NSD children have more difficulty than their double-asset peers, PD children are less affected by the addition of a naming speed deficit. With post-hoc tests for Word Attack, 4-group analyses indicated that all of the deficit groups differed significantly from the DA group (*$MSE(64)=185.37$, $p<.001$ for PD, $p<.001$ for NSD and $p<.001$ for DD*). In the 3-group analyses, the PD group and the DD group performed significantly worse than the NSD group (*$MSE(48) =83.47$, $p=.001$ for PD and $p<.001$ for DD*) although the PD and DD groups did not differ from one another (*$MSE(48) = 83.47$, $p=.184$*). These results suggest that children with phonological deficits, alone or combined with naming speed deficits, have more difficulty in decoding novel words than those with only naming speed deficits who in turn struggle with this task more than their double asset peers.

TABLE 12

Mean Standardized Grade Scores and S.D.'s (in parentheses) for Tests of Reading

	Group			
Measure	**DA group**	**PD group**	**NSD group**	**DD group**
WJ-R Word ID	116.9 (16.0)	92.2 (9.1)	100.3 (16.3)	83.8 (6.9)
WJ-R Word Attack	120.1 (22.2)	88.4 (7.8)	100.2 (11.9)	82.3 (6.5)
GORT-3 Time	15.3 (4.6)	21.3 (4.8)	31.5 (13.8)	37.1 (11.1)
GORT-3 Errors	0.12 (.33)	0.41 (.80)	1.28 (2.7)	2.06 (1.8)

The reading category of the four groups according to standardized test conventions indicated that the DA and NSD groups performed in the above average and average range respectively. Children in the PD group could be classed as moderately poor readers, particularly in the area of Word Attack, and the DD children were very poor readers (at the 12-13th percentile according to test norms). Generally, children with standard scores less than 90 are considered poor readers. In Study two, none of the DA group met this criterion, 24% of the PD group, 33% of the NSD group and 94% of the DD group had standard scores less than 90.

In general it would appear that children who possess deficits in both naming speed and phonological awareness are the poorest at decoding words and nonwords. The effects of both deficits are simply additive in the case of Word Identification, but for Word Attack, the effect of a phonological deficit appears to carry more weight. Children who possess only deficits in speed are significantly better at decoding nonwords than their peers who have difficulty with phonological awareness.

Group differences were also found on other measures of reading ability. 2 X 2 ANOVA analyses for reading time revealed main effects of phonological ability ($F(1,64) = 17.0, p<.001$) and speed ($F(1,64) = 67.4, p<.001$) moderated by a significant interaction effect ($F(1,64) = 4.7, p=.034$) on the GORT-3 passage. The interaction reflects the relatively greater negative impact of naming speed than phonological ability on speed of reading. The 4-group post-hoc analyses indicated that all of the deficit groups were significantly slower than the DA group ($MSE(64) = 146.4, p<.001$ *for all groups*), although 3 group analyses indicated that the NSD group was slower than the PD group ($MSE(48)=67.5, p=.001$). The PD group was faster than the DD group ($MSE(48) = 67.5\ p<001$), and the NSD and DD group did not differ significantly from one another ($MSE(48)=67.5, p=.216$).

With respect to the number of errors made on the reading passage, the analyses revealed only a main effect of naming speed ($F(1,64) = 11.8, p=.001$). No significant effects of phonological ability ($F(1,64) = 1.73, p=.193$) or interaction effects ($F(1,64) = .358, p=.552$) were found. In general, very few errors were made, and only the DD group made significantly more errors than the DA group, suggesting that while naming speed affected the overall pattern, it was most apparent with combined deficits.

Spelling Measures

On both spelling dictation and recognition measures, the single-deficit children were found to be moderately poor spellers, while the double-deficit group fell far below the level expected for this grade level. The means and standard deviations for these measures are contained in Table 13.

For the initial analysis, children's Grade standardized scores for *spelling dictation* (predictable and unpredictable words) were entered into a 2 X 2 (phonological ability by speed) X 2 (word type), mixed, repeated measure ANOVA. The overall analysis revealed significant main effects of both phonological ability ($F(1,64) = 19.47, p<.001$), speed ($F(1,64) = 14.98, p<.001$) and word type ($F(1,64) = 13.25, p=.001$), with unpredictable words having more errors than predictable ones. There were no significant interaction effects. For dictation scores on both types of words, children in the DA group performed much better than children in either of the single deficit groups, with scores for the DD group being the poorest. This suggests that the effects of speed and phonological ability assist in the process of spelling dictation for both types of words (i.e., predictable and unpredictable) and that both skills seem to be equally useful. The fact that there were no significant interaction effects allowed us to collapse across word type in later analyses of dictation scores, using children's standard grade scores for the total dictation task.

For *spelling recognition,* a 2 X 2 (phonological ability by speed) ANOVA analysis on the PIAT spelling recognition test also revealed only main effects for phonological ability ($F(1,64) = 8.63, p=.005$) and speed ($F(1,64) = 24.10, p<.001$) with no significant interaction effect ($F(1,64) = 3.31, p=.073$). Children with either phonological or speed deficits performed more poorly on this test than the DA group and better than the DD group, suggesting contributions of both phonological ability and speed to spelling recognition skills. The trend for an interaction effect led to further post hoc analyses. Three-group post-hoc analyses revealed that the single deficit groups did not differ significantly from one another (*MSE(48)=51.67, p=.223*). Although the PD group was significantly better than the DD group, the NSD group was not (*MSE(48) = 51.67, p=.024 for PD, p=.942 for NSD*). This suggests that while either a naming speed or a phonological deficit causes children's spelling recognition scores to drop, the naming speed deficits have slightly more weight in affecting spelling recognition scores.

TABLE 13

Mean Standardized Scores and S.D.'s (in parentheses) for Tests of Spelling

	Group			
Measure	**DA group**	**PD group**	**NSD group**	**DD group**
TWS-3 Spelling (Standard Scores for age):				
Predictable words	103.47 (10.5)	89.35 (10.2)	91.72 (6.0)	84.94 (6.6)
Unpredictable words	97.47 (14.5)	88.24 (9.03)	88.17 (10.7)	80.88 (6.8)
PIAT-R (Standard Scores for grade):				
Recognition	96.53 (13.7)	85.82 (7.0)	81.39 (8.5)	78.88 (5.5)

Another question focused on comparison between spelling recognition versus dictation tests. Because of the different demands of each of the spelling tasks, it was predicted that children with adequate naming speed (i.e., the PD group) would perform significantly better on spelling recognition versus spelling dictation tests given the stronger emphasis on orthographic, rather than phonological skills within the recognition test. Overall spelling results are presented in Table 14. Spelling results were analyzed using 2 X 2 (phonological ability by speed) X 2 (recognition versus dictation) mixed repeated measures ANOVA. Significant main effects of phonological ability ($F(1,64) = 20.7, p<.001$) and speed ($F(1,64) = 25.1, p<.001$) were modified by a significant interaction effect of test by phonological ability ($F(1,64) = 4.5, p=.038$).

TABLE 14

Mean Standard Scores and S.D.'s (in parentheses) for Tests of Reading & Spelling

	Group			
Measure	**DA group**	**PD group**	**NSD group**	**DD group**
Word Identification (WJ-R): (*Standard Scores for grade*)	116.9 (16.0)	92.2 (9.1)	100.3 (16.3)	83.8 (6.9)
Spelling Dictation for total words (TWS-3) *(Standard Scores for age)*	99.4 (12.9)	86.2 (11.0)	88.6 (7.8)	74.6(19.1)
PIAT-R *(Standard Scores for grade)*	96.53 (13.7)	85.82 (7.0)	81.39 (8.5)	78.88 (5.5)

The interaction result reflects a different pattern of scores on the tests for the NSD group compared to other groups. NSD and DD did not differ significantly from one another on the recognition task ($MSE\ (48) = 51.67, p=.109$), but did for spelling dictation, where the NSD group performed significantly better than the DD group ($MSE(48) = 175.64, p=.010$). In addition, on the dictation task, the NSD group's performance was not significantly different from that of the DA group ($MSE(64)=173.54, p=.109$).

The pattern of group performances was the same in both Study One and Study Two, finding PD>NSD>DD for spelling recognition, and NSD>PD>DD for spelling dictation although the differences between groups was not always significant. DA, PD, and DD children had similar spelling dictation and recognition scores while the NSD group had lower recognition than dictation scores.

In summary, children with single deficits appeared to be moderately poor spellers, while children with double deficits were very poor spellers, especially on dictation tasks. For spelling recognition, the DD group's scores, while still below that of their single-deficit peers, was not significantly poorer those of the NSD group. These results provide limited support for the idea that phonological ability may be more important in spelling dictation and naming speed skills more important in recognition tasks.

Reading - Spelling Interactions

Another hypothesis with respect to both reading and spelling skill was based on previous studies that found groups of children with spelling problems who were nonetheless good readers. We wanted to know if either of the single-deficit groups would be characterized by this pattern of good reading and poor spelling skills. For this analysis, we considered both spelling recognition and dictation (total score) measures.

Letter-Word Identification and one of the two spelling measures (recognition or dictation) were entered into mixed, repeated measure 2 X 2 (phonological ability by speed) X 2 (reading versus spelling test type) ANOVA's. Means and standard deviations for all measures are contained in Table 14. For *reading with spelling recognition* there were significant main effects of phonological ability ($F(1,64) = 29.76, p<.001$), speed ($F(1,64) = 22.28, p<.001$), and test type ($F(1,64) = 132.11, p<.001$), modified by a significant interaction between test-type and phonological ability ($F(1,64) = 40.50, p<.001$). The pattern was the same for *reading with spelling dictation* with main effects of phonological ability ($F(1,64) = 40.22, p<.001$), speed ($F(1,64) = 19.35, p<.001$) and test type ($F(1,64) = 45.13, p<.001$) all modified by a significant interaction between phonological ability and test type ($F(1,64) = 4.49, p=.038$).

The main effect of test type in both comparisons indicated better reading than spelling skills. The phonological ability by test type interaction for each analysis reflected a different pattern of scores for groups. For dictation, children in the NSD group performed better than their PD peers for both spelling and reading. In contrast, on the recognition task, the interaction demonstrates a crossover pattern between reading and spelling such that children who had stronger reading scores (the NSD group) had poorer spelling recognition skills.

The interaction effects also reflected a pattern of smaller differences between reading and spelling scores for groups with phonological deficits compared to the large difference between reading and spelling for NSD group. For both spelling recognition and dictation comparisons, it appears that the single deficit groups were more similar to each other on spelling tasks than on reading tasks.

It would appear that while for the various reading tests, difficulties with phonological skill seemed to be of primary importance (i.e., children with naming speed deficits were generally better readers than children with phonological deficits), for spelling tasks, this was not the case. In fact, for spelling recognition, deficits in naming speed carried slightly more weight. We have hypothesized that naming speed ability may help children learn to recognize the correct spellings of words, but as we saw from our reading analyses, they also require good phonological skill in order to decode words accurately. In short, a pattern of strong differences between better readers / poor spellers is more apt to be seen within the NSD group.

Letter Pattern Knowledge

Children with single deficits in naming-speed were expected to be slower and less accurate on measures of orthographic skill. Children with deficits in both phonological and naming-speed skills were expected to have the most difficulty. In addition, the study aimed to replicate previous findings on a measure of perception of letter strings of varying orthographic structure, the Quick Spell Test (Bowers, 1996) and to investigate the effects of naming speed and phonological ability on a new orthographic measure (Hultquist, 1996).

Children were administered three recognized measures of orthographic knowledge: two Word Likeness tasks (Massaro, Taylor, Venezky, Jastrzembski & Lucas, 1980 ; Siegel, Share, & Geva, 1995), and an Orthographic Choice task (Olson, Kliegl, Davidson, & Foltz, 1985). Means and standard deviations for the percent correct, and for the latency to correct responses for each of these tests is contained in Table 15. A 2 X 2 (Phonological ability by speed) X 3 mixed, repeated measures ANOVA with 3 levels of test was conducted. For speed measures, mean latency to correct responses were transformed using a natural log transformation in order to remove the skew typical of latency measures.

On measures of accuracy (percent correct), the overall analyses revealed significant main effects of phonological ability ($F(1,64) = 19.63, p<.001$), speed ($F(1,64) = 12.92, p<.001$) and test type ($F(2,128) = 44.25, p<.001$) as well as interactions between phonological ability and speed ($F(1,64) = 4.42, p=.039$), and test type with phonological ability ($F(2,128) = 5.50, p=.005$) and speed ($F(2,128) = 7.33, p=.001$). Only the three way interaction of all factors was not significant ($F(2,128) = 2.40, p=.095$). To help interpret the interaction, the tests were examined individually using 2X2 (phonological ability by speed) ANOVA's.

For the *Orthographic Choice accuracy*, there were no significant effects ($F(1,64) = .48, p=.493$ for phonological ability, $F(1,64) = .81, p=.373$ for speed or their interaction $F(1,64) = .03, p=.866$), and it appeared that ceiling effects were in effect for all groups. For the *Massaro Word Likeness test*, main effects of phonological ability ($F(1,64) = 18.20, p<.001$) and speed ($F(1,64) = 16.10, p<.001$) were modified by a significant interaction ($F(1,64) = 5.75, p=.019$). In this case the DA group performed significantly better than all the deficit groups (*MSE(64) = 76.16, p<.001 for PD, p<.001 for NSD and p<.001 for DD*) but the deficit groups did not differ from one another (*MSE (48) = 100.62, p=1.00 for PD and NSD, p=.998 for PD and DD, p=.769 for NSD and DD*); it did not matter whether children had phonological deficits, speed deficits or both.

Finally, for the *Siegel et al. Word Likeness task*, again main effects of phonological ability ($F(1,64) = 14.60, p<.001$) and speed ($F(1,64) = 50.86, p<.001$) were modified by a significant interaction ($F(1,64) = 6.30, p=.015$). In this case, as was the case for the Massaro et al. test, deficit groups were all significantly less accurate than the DA group (*MSE (64) = 163.47, p<.001* *for PD, p<.001 for NSD and p<.001 for DD*), but again, all deficit groups were statistically equal (*MSE(48) = 194.15, p=1.00 for PD and NSD, p=.241 for PD and DD, p=.601 for NSD and DD*), in spite of the fact that the DD group appeared to be poorer. Although the DD group's mean scores were lower than those of the single deficit groups, high levels of variability seen in the large standard deviations make it difficult to find groups significantly different from one another.

Speed of Responding

Latency measures produced patterns similar to those for accuracy. There were significant main effects of phonological ability ($F(1,64) = 15.1, p<.001$), speed ($F(1,64) = 62.7, p<.001$) and test type ($F(2,128) = 52.92, p<.001$) all modified by significant interaction effects between phonological ability and speed ($F(1,64) = 9.5, p = .003$) and between test type and speed ($F(2,128) = 5.48, p=.005$). The interactions between test and phonological ability ($F(2,128) = 2.75, p=.068$ and the three way interaction ($F(2,128) = .541, p=.584$) were not significant. Simple effects were again conducted separately for each of the three tasks.

For the *Orthographic Choice* latency, only the main effect for speed was significant ($F(1,64) = 19.15, p<.001$). Effects of phonological ability ($F(1,64) = 3.02, p=.087$) and the interaction ($F(1,64) = 3.62, p=.062$) did not reach significance. For the *Massaro et al. Word Likeness task* latency scores there were significant main effects of phonological ability ($F(1,64) = 16.0, p<.001$) and speed ($F(1,64) = 62.8, p<.001$) modified by a significant interaction term ($F(1,64) = 9.9, p=.002$). Similarly, for the *Siegel et al. Word Likeness test*, main effects of phonological ability ($F(1,64) = 14.60, p<.001$) and speed ($F(1,64) = 50.86, p<.001$) were modified by a significant interaction ($F(1,64) = 6.30, p=.015$) between phonological ability and speed.

In summary, for the Orthographic Choice task, having a naming speed deficit, either alone or in combination with a phonological deficit, was associated with slower performance. However, for the Word Likeness tasks, children were affected by both phonological deficits and speed deficits, with children in the DD group being most affected. In addition to these additive effects, it appeared that the contribution of naming speed carries greater weight than phonological deficits in latency measures when making a word likeness choice, whether on an easier or more difficult task (i.e., NSD slower than PD). Thus, naming speed deficits are important contributors to the speed with which children can identify correct from incorrect spellings of words (i.e., Orthographic Choice), and both speed and phonological ability are required to help children determine whether pseudowords are consistent with the rules of the English language or not (i.e., Word Likeness tasks).

TABLE 15

Means and S.D.'s (in parentheses) for Tests of Orthographic Knowledge

	Group			
Measure	**DA group**	**PD group**	**NSD group**	**DD group**
Percent Correct:				
Orthographic Choice	91.9 (9.5)	90.5 (10.5)	89.9 (13.1)	87.8 (8.9)
Word-Likeness:				
Massaro et al.	99.4 (1.7)	85.3 (9.3)	85.8 (9.0)	81.9 (11.8)
Siegel et al.	92.7 (8.5)	73.4 (14.6)	70.9 (12.2)	64.7 (15.0)
Latency for Correct Item Responses (ms):				
Orthographic Choice	1702.5(566.9)	2456.8(915.8)	3422.2(1875.4)	3254.5(1430.0)
Word-Likeness:				
Massaro et al.	1639.5 (553.3)	3139.2 (935.6)	4517.6 (1348.0)	5128.8 (2196.9)
Siegel et al.	2212.8 (814.8)	4040.5 (1629.4)	5414.2 (1184.0)	6736.1 (2866.6)

Quick Spell Test

QST results, contained in Table 16 were obtained from a 2 x 2 x 3, mixed, repeated measures ANOVA with two levels of speed and phonological ability and three types of letter strings was performed. Results indicated significant main effects of phonological ability ($F(1,64) = 50.1$, $p<.001$), speed ($F(1,64) = 73.0$, $p<.001$), and word type ($F(2,128) = 86.2$, $p<.001$), all moderated by significant interactions between phonological ability and speed ($F(1,64) = 7.3$, $p=.009$), word type by phonological ability ($F(2,128) = 8.0$, $p=.001$), and of word type by speed ($F(2,128) = 3.3$, $p=.041$). The three way interaction was not significant ($F(2,128) = 2.17$, $p=.118$). To investigate these interactions more closely, each type of letter string was examined in separate, 2 X 2 (phonological ability by speed) ANOVA analyses.

For *word strings*, there were significant main effects of phonological ability ($F(1,64) = 12.27$, $p=.001$) and speed ($F(1,64) = 29.74$, $p<.001$) but no significant interaction effect ($F(1,64) = .86$, $p=.358$). For *pseudoword strings*, significant main effects of phonological ability ($F(1,64) = 29.55$, $p<.001$) and speed ($F(1,64) = 42.32$, $p<.001$) were modified by a significant interaction effect ($F(1,64) = 5.70$, $p=.020$). In this case, the DA group performed significantly better than the three deficit groups ($MSE(64) = 2.40$, $p<.001$ *for PD*, $p<.001$ *for NSD, and* $p<.001$ *for DD*), although the deficit groups' performances were similar to one another. For *non-word illegal strings*, main effects of phonological ability ($F(1,64) = 63.72$, $p<.001$) and speed ($F(1,64) = 70.89$, $p<.001$), were again modified by a significant interaction effect ($F(1,64) = 10.01$, $p=.002$). For this type of letter string, although the DA group was significantly better than all of the deficit groups ($MSE\ (64) = 2.19$, $p<.001$ *for PD*, $p<.001$ *for NSD and* $p<.001$ *for DD*), the DD group was significantly worse than the two single deficit groups ($MSE(48) = 2.15$, $p=.002$ *for PD and* $p=.004$ *for NSD*), although the PD and NSD groups did not differ from one another ($MSE(48) = 2.15$, $p=1.00$).

Overall, it appears that children performed better on words than pseudowords, and most poorly on the nonwords. For words, both phonological ability and naming speed were important with children having more difficulty with either a phonological or naming speed deficit and DD children performing most poorly. For pseudowords, it appeared that it did not matter much which type of deficit children had; a deficit in either naming speed or phonological ability or both was likely to impact their performance about the same amount. The interaction effect for pseudowords seems to have arisen because the DA group's performance was so much better than the other three. For non words, deficits in either ability hurt children's performances, with deficits in both causing children to have the most difficulty. The effect of illegal nonwords was greatest for the DD group.

Although it was expected that the two single-deficit groups would differ most substantially from each other on the QST word and pseudoword strings because of the relationship between naming-speed and orthography noted in Study One, in fact, the two groups had similar scores. This result may have arisen out of compensatory strategies used by the naming-speed deficit group. Although the results from the orthographic measures suggest that the PD group may have better letter pattern knowledge, the better decoding skills in the naming-speed deficit group may help them to identify the letters in pseudowords more accurately and quickly. Unlike Study one, NSD children did not differ from PD children on illegal strings. However, the DD children identified fewer illegal letter strings than other groups. This pattern of results is more in line with expectations -- and therefore contrasts with the results of the first study where DD children tested several months after NSD children surpassed the latter group on illegal nonwords.

TABLE 16

Means and S.D.'s (in parentheses) for Items Correct on the Quick Spell Test

	Group			
Type	**DA group**	**PD group**	**NSD group**	**DD group**
Word (mean/10)	9.7 (.77)	8.1 (1.8)	7.3 (1.1)	6.4 (2.1)
Pseudowords (mean/10)	9.2 (.95)	6.2 (1.6)	5.8 (1.3)	4.7 (2.2)
Nonwords (mean/10)	8.8 (1.5)	4.8 (1.7)	4.7 (1.2)	2.9 (1.4)

Embedded and Nonembedded Word Task

The means and standard deviations for children's scores on this task (Hultquist, 1996) are contained in Table 17. For the purposes of the analyses, all of the latency scores for correct items were transformed using a natural log transformation. Accuracy and latency results were entered into separate 2 x 2 x 2, mixed repeated measures ANOVAs with two levels of speed and phonological ability and the two levels of words (i.e., embedded and nonembedded).

For the accuracy scores there were significant main effects of phonological ability ($F(1,64) = 53.1$, $p<.001$), speed ($F(1,64) = 22.4$, $p<.001$) and word type ($F(1,64) = 101.7$, $p<.001$), as moderated by significant interactions between word type and phonological ability ($F(1,64) = 16.0$, $p<.001$), and word type by speed ($F(1,64) = 5.2$, $p=.026$). The interaction between phonological ability and speed ($F(1,64) = .16$, $p=.692$) and the three way interaction ($F(1,64) = .44$, $p=.508$) did not reach significance. To help understand the interaction effects, separate 2 X 2 (phonological ability by speed) ANOVAs were performed for each type of word (i.e., embedded versus nonembedded).

For the *embedded word strings*, the results indicated main effects of phonological ability ($F(1,64) = 63.77$, $p<.001$) and speed ($F(1,64) = 25.59$), $p<.001$) but no significant interaction effect ($F(1,64) = .379$, $p=.540$). For the *nonembedded word strings* there were also main effects of phonological ability ($F(1,64) = 26.72$, $p<.001$) and speed ($F(1,64) = 12.21$, $p=.001$) and the interaction effect did not reach significance ($F(1,64) = .008$, $p=.930$). The overall interactions of phonological ability and speed with word type appeared to result from the fact that these effects were stronger on the more difficult task - the embedded word list.

In general, the double-asset group had the best performance, followed by the NSD group, then the PD group, with the DD group having the poorest performance. This is in contrast to the other orthographic tasks discussed above, where children in the NSD group typically had performances poorer than or equal to children in the PD group. It seems that having a deficit in either phonological ability or naming speed hurt children on both tasks, and that the effect of deficits was additive.

Performance on the embedded list was the score of most interest in analyzing children's accuracy on the Hultquist task. In order to rule out differences resulting purely from underlying reading ability, the embedded scores were analyzed with the scores on the non-embedded words for each child used as a covariate. The results discussed above were not affected by the covariate analyses, revealing main effects of phonological ability ($F(1,63) = 25.74$, $p<.001$), speed ($F(1,63) = 11.11$, $p=.001$), and the covariate ($F(1,63) = 47.50$, $p<.001$), but no significant interaction effect ($F(1,63) = .536$, $p=.467$).

With respect to *latency scores* for the Hultquist task, main effects of phonological ability ($F(1,64) = 4.30$, $p=.042$), speed ($F(1,64) = 12.63$, $p=.001$) and word type ($F(1,64) = 495.11$, $p<.001$) reached significance, but there were no significant interaction effects between phonological ability and speed ($F(1,64) = 2.15$, $p=.148$), between word type and phonological ability ($F(1,64) = .19$, $p=.667$), word type and speed ($F(1,64) = 2.15$, $p=.157$), or between all three variables ($F(1,64) = 2.37$, $p=.128$).

TABLE 17

Means and S.D.'s (in parentheses) for Embedded/Nonembedded Word Task

	Group			
Type	**DA group**	**PD group**	**NSD group**	**DD group**
Percent Correct:				
Embedded	95.3 (5.1)	69.8 (13.1)	78.5 (14.9)	56.7 (13.1)
Nonembedded	99.0 (2.3)	84.6 (11.3)	89.2 (13.1)	75.3 (14.3)
Latency (ms)				
Embedded	3526.2 (1615.5)	5308.1 (2305.1)	5755.1 (2932.1)	5389.3 (1907.1)
Nonembedded	1170.9 (567.8)	1399.4 (405.2)	1890.4 (957.1)	2056.5 (965.7)

The possibility that differences in children's embedded reading scores might be affected by their overall reading speed on non-embedded items was considered and covariate analyses where children's speed of reading nonembedded strings was covaried from their embedded reading times were run. In this case, there were no main effects of phonological ability ($F(1,63) = 1.18$, $p=.283$) or speed ($F(1,63) = .000$, $p=.289$) and no significant interaction effect ($F(1,63) = 3.43$, $p=.069$). Only the main effect of nonembedded word latency was significant ($F(1,63) = 27, 73$, $p<.001$), suggesting the embedded words which were assumed to measure orthographic speed gave no additional information beyond the simple isolated word effects .

In summary, on the Hultquist task, it took children longer to read embedded words compared to nonembedded words and children with both phonological deficits and naming speed deficits were slower than their double asset peers, but these differences appeared to be explained completely by differences in children's regular (i.e. nonembedded) word reading. In addition, children with deficits in either phonological or naming speed skills were equally likely to have difficulty in locating a word embedded within a string of distracter items quickly, and children with all types of deficits seem to have the same amount of trouble.

In the present study, children with either slower naming speed, or with phonological awareness deficits were less accurate on some tests of letter pattern knowledge while those with naming speed deficits, either alone or combined with phonological deficits were slower in making their choices. Similarly, the Quick Spell Test results indicate that deficits in either naming speed or phonological ability made children less accurate on all types of letter strings, and that children with deficits in both areas performed the worst in most cases. This was especially true for the more difficult non-word strings in Study Two.

Reading Level Control

The final analyses involved comparisons between children in the DD group and their reading level controls (RLC group). After testing of the Grade Three children was completed, it was found that children in the DD group were reading at approximately a Grade 1.9 level according to their grade equivalent scores on the Word Identification subtest of the Woodcock-Johnson. To match this group, in May and June of the school year, we requested that Grade One teachers from two schools select children in their classes who were reading at a fairly average level. These Grade One children who received parental permission were then given the screening measures and many of the regular testing measures. Children were not individually matched on reading level but scores on the WJ-R Word Identification subtest for all children in the Grade One group were within the range of scores found for the Grade Three DD group. To compare the two groups, independent samples T-tests were conducted between the DD group (n=16) and the RLC group (n=15). Means and standard deviations for the two groups are contained in Table 18.

Although the RLC group was matched to the DD group for Word Identification over a range, the two groups did show a significant mean difference with the DD group performing at a higher level (*T(26.9)=2.07, p=.049*). This suggests that even children with deficits in phonological and naming speed skill read words somewhat better than the children selected as average readers in Grade One. In spite of this however, the two groups were in fact equivalent on the Word Attack subtest (*T(26.4)=1.63, p=.115*), a purer measure of children's decoding skills insofar as these "words" would be unfamiliar to all children. This finding suggests that the two groups had roughly equivalent decoding skills and that the RLC group was a reasonable control group.

Screening Measures

On the *AAT*, the RL control group's scores were significantly higher than those obtained for the DD group (*T(20.3)=3.12, p=.005*). A different blend of abilities was associated with *word and nonword decoding* for the DD and Grade One groups, with the DD group being particularly weak in phonological ability. The latter finding suggests that children in Grade One have developed stronger phonological awareness skills in spite of the shorter amount of time spent on reading skill instruction. The DD group did not differ from the RLC group on the *digit naming speed task* (*T(22.4)=.049, p=.962*) which suggests that children with naming speed deficits are able to access mental information such as digits at approximately the same speed as an average Grade One child.

Reading and Spelling Measures

Children with better phonological skills may be expected to also have better decoding skills; however, the scores from the *Word Attack subtest* do not support this idea. In spite of having better phonological skill, the Grade One children had decoding skills that were equivalent to the DD group. This may be because the DD group being that much older, received more specific instruction and practice at decoding, although they have not yet mastered the skill of manipulating the various sounds in words required for the AAT. This finding seems somewhat surprising in light of the fact that the phonological skill required to perform a task like the AAT is often considered one of the later developing phonological skills, thought to occur in synchrony with basic decoding skills.

On the other reading measure used, the *GORT-3 passage*, the results were again mixed. Although the two groups read with approximately the same accuracy level ($T(19.0)=1.03$, $p=.316$), children in the DD group read significantly faster ($T(28.3)=3.60$, $p=.001$). Although the strong connection found between reading speed and digit naming speed above might suggest that the two groups should read at a similar speed, the RLC group's relative inexperience with reading may affect their speed and override this connection.

With respect to *spelling recognition*, again the DD group's performance was better than that of the RLC group ($T(26.5)=6.01$, $p<.001$). Again, the increased amount of exposure to reading and spelling that the Grade Three children have is likely to have improved their scores. They have seen more words or have seen the same words more times and therefore seem to be better at recognizing the correct spellings of more words.

TABLE 18

Means, S.D.'s (in parentheses), and Significance for Comparisons Between DD and RLC groups

	Group		
Variable	**DD (n=16)**	**Reading Level Ctrls (n=15)**	**T-value (p-value)**
AAT *(mean / 29)*	11.3 (2.7)	16.1 (5.4)	3.12 (.005)
DNS *(item/second)*	1.37 (.18)	1.36 (.29)	0.049 (0.96)
Word ID *(W-scores)*	459.19 (9.2)	451.47 (11.4)	2.07 (.049)
Word Attack *(W-scores)*	465.25 (9.25)	471.53 (11.95)	1.63 (.115)
GORT-errors	2.06 (1.8)	3.27 (4.17)	1.03 (.316)
GORT-time *(seconds)*	37.09 (11.12)	65.68 (28.84)	3.60 (.001)
PIAT *(raw scores)*	41.63 (3.79)	32.20 (4.84)	6.01 (.0001)
Orth. Chc. *(% correct)*	87.75 (8.93)	61.53 (12.06)	6.84 (.0001)
Orth. Chc. *(latency in ms)*	3254.50 (1429.97)	5208.60 (1824.96)	3.34 (.002)
Wd. Like *(% correct)*	81.87 (11.82)	78.67 (15.86)	.635 (.531)
Wd. Like *(latency in ms)*	5128.81 (2196.93)	4021.00 (1833.07)	1.40 (.172)
QST-words *(mean/10)*	6.37 (2.09)	9.20 (1.01)	4.83 (.0001)
QST-pseudo. *(mean/10)*	4.69 (2.18)	6.53 (1.73)	2.62 (.014)
QST-nonwds. *(mean/10)*	2.94 (1.44)	3.00 (2.10)	.096 (.924)

Orthographic Skill

For the orthographic measures the results differed depending on the test used. For the *Orthographic Choice task*, children in the DD group were more accurate and faster than the RLC group (*T(25.7)=6.84, p<.001 and T(28.8)=3.34, p=.002 respectively*). For the *Massaro Word Likeness* task, the two groups did not differ with respect to accuracy (*T(25.8)=.635, p=.531*) or latency of correct responses (*T(28.8)=1.40, p=.172*). We should recall however, that the

Orthographic Choice task involves real words and again, the difference in amounts of print exposure may have worked to the benefit of the DD group. For the *Word Likeness task*, all of the items consist of nonwords which may limit somewhat, the effects of print exposure, and reveal that the two groups do not in fact, differ significantly with respect to their abstract orthographic knowledge. Given the relationships found between naming speed and orthography in the past, it was expected that these two groups would show similar levels of orthographic knowledge given their equivalent digit naming speed scores and this was indeed the case.

The final measure of a skill thought to be related to orthographic knowledge for these groups was the *Quick Spell Test*. In general, the RLC group outperformed the DD group on this task performing significantly better on words ($T(22.0)=4.83$, $p<.001$), and pseudowords ($T(28.2)=2.62$, $p=.014$), although they were not significantly better on the nonword items ($T(24.5)=.096$, $p=.924$). It is possible that the RLC group's better phonological skill as indexed by their higher AAT scores helped the Grade One children on the word and pseudoword items. This skill would not however, assist them on the nonword items and it was here that the two groups did not differ. This result may provide further support for the connection between naming speed skill and the ability to identify letter strings with little orthographic structure.

In situations involving reading level control groups, it is difficult to tease apart the effects of exposure to print and more time spent in specific reading instruction from the effects of naming speed and phonological awareness skills. In many cases however, the two groups performed at similar levels on tasks which did not involve whole words, and which therefore would likely be less affected by print exposure. Thus, the reading level controls and DD group were similar on digit naming speed, word likeness measures and QST nonwords, while the DD group was better on the orthographic choice, spelling recognition, and speed of reading tests where the additional exposure to words may have added independent variance to scores. Curiously, the younger readers identification of letter strings with more orthographic structure (i.e., words and pseudowords) was better than that of the DD group, suggesting a processing strength which may be associated with their better AAT scores. Perhaps their better phonological skills were of more assistance in this area.

Result Summary for Study One and Study Two

Overall, children in the double asset group fell into the category of very good readers with children in each of the single deficit groups falling in the average or somewhat below range, and children in the double deficit group falling into the category of very poor readers. The pattern of differences among the deficit groups was similar in both Study One and Two. Children with phonological deficits performed more poorly than their naming-speed deficit peers, and in all cases, children with both deficits were the poorest readers, on average, reading in the bottom 13% of Grade Three children. It would appear that for reading, both naming speed and phonological deficits contribute something to children's skill level, but phonology appeared to be most important, especially for non-word reading. In addition, when groups of children in this study were compared to other studies of so-called "poor readers", approximately 30% of each of the single deficit groups, and 90% of the double deficit group met the criteria for poor reading of a standard score of less than 90 on Letter-Word Identification. This suggests that the majority of poor readers in other research are likely double-deficit children, and that single deficit children are much less common in these groups.

With respect to text reading accuracy, while the three deficit groups did not differ from one another in Study One, in Study Two, all three deficit groups were significantly less accurate than the double asset group, and both the NSD and DD groups made more errors than the PD group. In both Study One and Two, children in the NSD group were more accurate in decoding both words and nonwords in isolation, but struggled more with reading connected text. In both studies, children in the NSD group read text passages more slowly than children in the PD group. Children with deficits in both naming speed and phonological awareness were slower readers than those with single deficits, although the difference between NSD and DD groups was significant only in Study One.

The pattern of results in Study Two for spelling dictation scores was similar to that found for reading, with the DA group outperforming the NSD group who did better than the PD group, while the DD group's performance was always the worst. This pattern was obtained for both regular and exception words. The pattern changed however for the spelling recognition task where the PD group did better than the NSD group although this difference did not reach significance in either study.

The change in pattern between spelling recognition and dictation may reflect the difference in how each of the single deficits contributes to spelling ability. It appears that although phonological ability and naming speed both play a role in spelling dictation and recognition, phonological ability may be more important in a dictation task compared to spelling recognition, and that speed skills or lack thereof show up more on tests of spelling recognition.

The pattern of "good readers / poor spellers" was also examined. In general, all four groups of children had more success with reading than spelling, regardless of the type of spelling task. Even the double asset group demonstrated this pattern. It may be that the norm groups differed for the different tests or that the emphasis placed on reading over spelling skill in the classroom in recent years in our school system may have pushed children's abilities in one direction. This pattern of better reading versus spelling skill was most obvious in the NSD group. For the PD and DD groups, reading scores were higher than dictation scores, but reading was roughly equal to scores in spelling recognition. The fact that the gap between reading and spelling scores seemed to be the greatest in the NSD group, especially between reading and spelling recognition, may push us to look more closely at the link between naming speed and spelling. The effects of slower naming speed seemed to hurt children's spelling recognition more than their reading, in spite of average phonological ability. This pattern was also seen in Study One.

The hypothesis that naming speed is linked with orthographic knowledge received mixed support in these studies. With respect to accuracy scores, in Study One, the PD group generally outperformed the NSD group, and the NSD and DD groups' performances did not differ. This suggested that children with naming speed deficits, either alone, or in combination with phonological deficits were equally poor in their orthographic knowledge, and supported the link suggested between naming speed and orthographic skill. In Study Two, the two single deficit groups tended to perform in a similar fashion with deficits in either phonological awareness or naming speed relating in an additive fashion.

With respect to latency of responding on orthographic measures, the results suggested close links between naming speed and speed of responding to orthographic tasks. Having a phonological deficit alone slowed children down somewhat, but having a naming speed deficit alone made children much slower and on the more difficult orthographic tasks, the DD group's performance was worse even than that of the NSD group. In Study One as well, naming speed had larger effects on latency of response to orthographic tasks.

For the QST test, all groups performed best on words, followed by pseudowords, with illegal nonword strings being the most difficult for all groups. Although we expected children with better naming speed to outperform the NSD group on words and pseudowords for the QST test, there was no difference between the two single deficit groups on this measure in either Study One or Study Two. On pseudowords, deficits in either naming speed or phonological awareness seemed to impact children about the same. Performance on illegal nonwords strings was most impaired in the DD group for Study Two, and for the NSD group in Study One.

For the Hultquist task, it had been predicted that children with slower naming speed would perform more slowly and more poorly on embedded items. Although children with slower naming speed were generally slower in their responding on all of the items, all differences between groups in speed of responding appeared to be explained by speed of regular (i.e., nonembedded) word reading. Children with deficits either in naming speed or phonological awareness were less accurate than the double asset group, but did not differ significantly from one another. Although it had been assumed that children with poorer orthographic ability (i.e., the NSD group) would find the embedded word task more difficult than those with better orthographic ability (i.e., the PD group), this result did not occur. The pattern of results for accuracy on this task more closely mirrored the results of word and nonword decoding measures, with the NSD group performing better than the PD group, rather than the other way around.

The final comparisons involved using a reading-level match control group for the DD group in order to find out more about how children reading at approximately the same level (i.e., matched on nonword decoding) performed on the numerous tasks . A pattern of the RLC group having some skills better than the DD group, some similar, and some worse was found. The Grade Three DD group was actually better at reading real words and read more quickly than their Grade One counterparts. In contrast, the RLC group had significantly higher AAT scores.

The tasks that appeared to be most influenced by naming speed (e.g., spelling recognition and orthographic knowledge) in the Grade Three comparisons did not show the same pattern of results here. Despite similar naming speed with the RLC group, the DD group's score on spelling recognition was better than that of the RLC group, which, given their longer experience with language and likely greater exposure to print was not surprising. On the Orthographic Choice Task where real words were included, the DD group did better than the RLC group. In contrast, on the Quick Spell Test, the RLC group performed better on words and pseudo-words but the two groups were equal on the non-words.

The effects of exposure to print as well as independent effects of phonemic awareness and naming speed skill may account for the pattern of differences and similarities between these two groups. Tests using real words (i.e., spelling recognition and orthographic choice) showed effects of print exposure, while tasks involving unfamiliar patterns (i.e., word likeness, QST nonwords), showed patterns more in fitting with their naming speed scores. The reading level controls performed better than the DD group only on AAT and detecting letters in strings with high orthographic structure. Replication of these complex patterns is needed before the task of understanding them is addressed. However, the complexity of the patterns underscores the many influences on reading that must be considered; simply looking at the level of phonological awareness is not sufficient.

General Discussion

Overall, the results of these two studies confirm previous results suggesting the importance of naming speed in understanding the processes of reading, writing, and orthographic skills (Bowers, 1999; Manis, Doi & Bhadha, in press; Wolf & Bowers, 1999). Consistent with these previous studies, it appears that phonological awareness contributes more to decoding of isolated words, particularly to nonwords, and to spelling dictation, while naming speed is particularly important to the speed at which children read and respond to orthographic tasks. These results suggest that knowing how children perform on various phonemic awareness tasks is not sufficient for our understanding of the components of written language in both average readers, and those children with more difficulties in reading.

What is the relationship of phonological awareness and naming speed to reading skill?

This study provided additional support for the presence of a significant number of children meeting the criterion for so-called single deficits. Although many other studies have taken into account the presence of children with phonological deficits, the so-called PD group (e.g., Lovett, 1987; Shankweiler et. al, 1999; Vellutino & Scanlon, 1987; Wagner et al, 1993), the possibility of children having deficits in naming speed alone while possessing at least average skills on phonological tests (i.e., the NSD group) has often been overlooked, or naming speed has been grouped as simply another phonological processing variable (e.g., Catts, Fey, Zhang, & Tomblin, 1999).

Similar to other studies which have found that phonological awareness as assessed by phoneme deletion may be the most important discriminating factor for separating good and poor word or non-word decoders (Shankweiler et al. 1999), phonological awareness had a significant effect on many of our reading measures. In general, children with poor phonological awareness skills performed more poorly on decoding tasks than children with poor naming speed skills. The factor often overlooked, however, is that children with slower naming speed perform more poorly than their double asset peers, and that naming speed does seem to be more closely linked to reading fluency than Shankweiler and his colleagues proposed. The findings in both Study One and Two fit with results by other researchers (e.g., Manis, Seidenberg & Doi, 1999; O'Connor & Jenkins, 1999; Wolf & Bowers, 1999) that found that phonological processing is important to reading tasks such as word and nonword decoding , spelling, and orthographic knowledge. However, naming speed is also important to many kinds of written language tasks, and in some cases, was more closely related to measures of orthographic knowledge than was phonological awareness.

Although the single-deficit groups are often dismissed as too small or obscure to warrant attention, in the samples of regular Grade Three classrooms used for Study One and Two, children in the PD and NSD groups made up approximately 8-12 % and 9-14% of the overall populations respectively. All three so-called deficit groups (i.e., PD, NSD and DD groups) were found within a regular classroom sample in both Study One and Two, and have also been found in other, more recent work (e.g., Bowers & Wolf, 1993; Bowers, Sunseth & Golden, 1999; McBride-Chang & Manis, 1996; Manis, Seidenberg, & Doi, 1999; Wolf & Bowers, 1999) making use of similar selection criteria. This suggests that there are a significant number of children in the regular school system with difficulties in either phonological awareness, or naming speed. It is possible that these children may be overlooked because of their fairly average word decoding skills, but in fact they require assistance in learning to read and spell as well as their peers. It was also notable that similar percentages of PD and NSD children were found to be reading disabled when defined by falling below standard scores of 90 on word decoding.

Overall, children with deficits in both phonological awareness and naming speed, those considered the so-called double-deficit group, made up 14% of all Grade Three children screened in Study Two, and 20% in Study One where the criterion for admission was less stringent. These children would, on average be classified as poor readers by the criterion of most reading studies, and appeared in higher numbers in these studies than was previously predicted (Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997).

Ehri's (1992) two-stage model of recognition proposes that children first learn to decode using individual letter names and known letter-sound correspondences to decipher word pronunciations. This is followed later by a more direct visual-phonological sight route which allows children to access pronunciations more quickly from visual characteristics or letter patterns in the word's spelling, eventually resulting in increased orthographic pattern recognition. Once a child has had repeated practice with phonologically decoding a particular word several times, the faster, more direct, visual process takes over, replacing the slower, phonological route. This theory emphasizes the role of phonological processing in learning to decode words and concludes that weaker phonological skills can disrupt the development of orthographic processing. This model is useful in explaining how children with poor phonological skill struggle with orthographic skills, but is less helpful in understanding how children can possess average phonological skills (i.e., NSD group), but continue to struggle with some written language tasks.

The goal of understanding the source of skills in decoding words and nonwords is merely a first step in the understanding of how children make use of these skills in order to comprehend what they read. Many consider decoding, and more importantly, efficient decoding, a first step on the way to comprehension. For example, Perfetti's verbal efficiency theory (1985) suggested that children who process single words more automatically or with ease are those who have better fluency and comprehension skill. That is, as children recognize words more quickly and automatically, they are able to attend more to the meaning contained therein. Others (e.g., Rupley, Willson and Nichols, 1999) have adopted Carver's (1993) reading theory model as a method of understanding written language and reading comprehension which includes a wide range of variables including decoding and speed which all combine to produce good comprehension of written text. However, in an emphasis on phonological processing, cognitive speed is often overlooked or dismissed as unimportant by researchers such as Shankweiler et. al

(1999). Although it can be assumed that word decoding may be a precursor to reading comprehension, Shankweiler's study suggests that good decoders do not always end up as good comprehenders.

Although comprehension was not directly assessed in these studies, there is evidence that one of the steps between the decoding of isolated words and good reading comprehension is reading fluency (Young, 1993). That is, as children read more quickly and more smoothly, their comprehension improves. This makes some intuitive sense as it seems very difficult for children to follow what they are reading when they are involved in a very effortful, letter-by-letter decoding of each word. The measure of reading fluency in both Study One and Two found that children in the NSD group read much more slowly, thus less fluently than those in the PD group. In addition, both studies found children who could be considered good decoders/ slow readers (i.e., NSD group) and fast but poor decoders (i.e.. PD group). Further examination of the comprehension of these groups of children is required in order to understand more fully the role naming speed may play in children's ability to comprehend what they are reading.

One further qualification for the role of naming speed in reading is that, in some studies, the connection has been noted only in those children who could be classified as poor readers (McBride-Chang & Manis, 1996), or early readers (Torgesen et al., 1997). It has been proposed that only groups of early or poor readers will show a connection between naming speed and reading skills, and that once children become average or good readers, this connection is lost. Torgesen et al. (1997) noted that since the effects of naming speed disappeared once earlier reading level was controlled for, that it was a contributor only to early level reading skills. Manis and his colleagues, in their examination of somewhat younger children, found that both naming speed and phonological ability predicted growth in Grade Two reading when earlier reading ability was controlled for through autoregression. They also noted that naming speed was often a stronger contributor to orthographic tasks than was phonological awareness. It seems that, at least in the early primary grades, naming speed is an important predictor of written language skills and the results in both Study One and Two were supportive of this. Further research in older children will be required in order to determine whether the influence of naming speed becomes less important over time, and for what level of reading.

In order to examine the relationship of naming speed, phonological ability and written language, children of all reading levels were included in this study - the subjects were obtained from regular Grade Three classrooms without prior selection for reading ability. However, the screening criteria had large effects on categorizing children as good or poor readers. Children with faster naming speed and better phonological ability fell into the category of very good readers.

An additional criterion for classifying the children was also considered. Poor readers are often defined as those with a standard score of less than 90 on a word decoding task. When using a criterion cutoff of a standard score less than 90 on the Word Identification task, none of the children in the Study Two double-asset group met this criterion. For each of the single deficit groups, using the same cutoff, there were similar numbers of poor readers (i.e., approximately 20% in Study One and approximately 30% in Study Two). The DD group contained primarily poor readers (i.e., approximately 90%) suggesting that this group may match well onto groups of poor readers used in other studies. The presence of more so-called "poor readers" in the second study was not surprising given the stricter criterion for inclusion in the deficit groups. These findings provide evidence that the poor readers studied in other research likely contain a large number of double-deficit children and that the single-deficit groups as measured in these studies may not map onto findings of other research which rely on single word decoding scores for definitions of poor reading.

The results of the examination of "poor readers" in each deficit group highlight the much higher incidence of so-called poor readers in the DD group compared to the PD group. The differences between the DD and PD groups were found even in Study Two even though the DD group's AAT scores were not significantly poorer than the PD group's. The fact that children with phonological and naming speed deficits were much poorer readers than those with phonological deficits alone lends further support to the idea that there is more to poor reading skills than merely deficits in phonological awareness.

In addition, given the lower scores on Word Identification of the PD group compared to the NSD group in both studies, it was expected that there would be more "poor readers" in the PD versus the NSD group but this was not the case. This resulted from the much more variable nature of scores in the NSD group across both studies, with children ranging from very poor readers to well above average. The high rates of variability within this group may account for some of the difficulties experienced by researchers in accurately identifying these children.

In general, while the effects of phonological awareness deficits on the reading measures seemed to be more important (i.e., children in the PD group struggled more with reading words and non-words), children with deficits only in naming speed still performed more poorly than children in the double-asset group. In addition, children with deficits in both phonological awareness and naming speed were the poorest readers. Naming speed seemed to play more of a role in determining how quickly children could read while phonological awareness seemed to have little effect on speed of reading. It might also surprise some to discover that the inclusion of these single deficit groups reveals children who could be classified as relatively good, but slow readers (i.e., NSD group), and relatively poorer, but faster readers (i.e., PD group).

What is the relationship of naming speed to spelling measures?

The relationship between naming speed and spelling measures is even more poorly understood than the relationship between naming speed and reading. As with reading, phonological awareness has been long thought of as the most important predictor of spelling skill (e.g., Dreyer, Luke & Melican, 1995; Stage & Wagner, 1992; Waters, Bruck & Seidenberg, 1985). However, the connection between phonological awareness, naming speed and spelling has been further complicated by the lack of consistency in spelling measures (e.g., spelling dictation or spelling recognition). To begin to understand the differences in these tasks, spelling dictation and spelling recognition measures were included in both studies. It was proposed that phonological awareness and naming speed might contribute differently to the two types of spelling measures, with naming speed more closely linked to spelling recognition, and phonological awareness to spelling dictation.

Support was found for only some of the studies' hypotheses with respect to the relationship between each of the single deficits and various types of spelling measures. Because of the link found in other studies between naming speed and orthographic skills, and the fact that spelling of exception or irregular words is sometimes considered a measure of orthographic skill, it was proposed that children with deficits in naming speed would have more difficulties than their peers when it came to spelling irregular or exception words. It was also proposed that children with better phonological decoding skills (i.e., the NSD group) would find spelling dictation easier, while children with poorer phonological but better naming speed skills (the PD group) might find spelling recognition to be an easier task.

The hypotheses made with respect to spelling were not fully supported. Overall, spelling dictation was found to be most similar to word decoding skills, in that it seemed to be most strongly linked to phonological awareness as predicted. Similar results were found by Dreyer, Luke & Melican (1995) who concluded that phonological awareness was most related to both reading and spelling. The researchers did note, however, that children used both phonological and orthographic knowledge in their spelling dictation as evidenced by the types of errors they made. To take this idea one step further, it was hypothesized here that children with good and poor orthographic skills might apply different strategies to different types of words (i.e., regular or exception words).

In both Study One and Two, the type of word to be spelled played little role in children's spelling dictation -- although exception words were more difficult overall, they were equally so for all groups. There was, however, some suggestion that naming speed may be more linked to spelling recognition than to dictation skill. A significant interaction effect suggested that naming speed may be more important, or at least equally important to spelling recognition skills as were phonological awareness skills, although phonological skills were more strongly connected to spelling dictation.

While the relationship between phonological awareness and spelling dictation seems more intuitively obvious, it is difficult to explain why naming speed may be particularly important to spelling recognition skill. One path proposed by Wolf and Bowers (1999) views better naming speed to be a means whereby children learn the connection between letters commonly seen together more quickly and efficiently, thus developing better orthographic knowledge. The presence of this better letter-pattern knowledge may allow children to more accurately recognize correct spellings of words.

Naming speed may contribute to children's written language skill via its connection with the effectiveness of repetition and practice effects. While Reitsma (1983) proposed that poor readers require more practice than good readers in order to learn the precise sequence of letters in words, others (e.g., Levy, Bourassa & Horn, 1999;Young, 1993) have noted a more specific connection whereby children with slower naming speed require more repetition to learn new words than do children with faster naming speed. That is, children with slower naming speeds require many more exposures to words in order for their recognition to become accurate as well as automatic. Children with better naming speed may require less practice in order to recognize correct spellings, and thus, children with faster naming speeds in the same grade, who are hypothesized to have roughly equal amounts of exposure to the same words may show an advantage on spelling recognition.

In summary, the results of Study One and Two were consistent with many previous studies that found phonological awareness skills contributing substantially to good spelling dictation skills. In comparison, children with better naming speed seemed to have a slight advantage on spelling recognition tasks. The proposed link between naming speed and orthographic skill (Wolf

& Bowers, 1999) may help to explain this discrepancy, as spelling recognition is generally thought to be more closely linked to letter pattern knowledge. While it is possible to decode many words on the basis of their spelling-sound correspondences alone, measures of spelling recognition that include words with less regular word patterns, may rely more on children's knowledge of common letter patterns (i.e., orthographic skill). In addition, naming speed may help children develop better letter pattern knowledge or benefit from the spelling practice they receive, thus facilitating the process of better spelling recognition.

What skills contribute to the pattern of "good readers/ poor spellers?

While it was proposed that children with single deficits might best fit Waters, Bruck, and Seidenberg's (1985) categorization of "good readers / poor spellers", when single word decoding skills were considered along with both spelling dictation and spelling recognition, in general, all of the groups met the criterion of better readers than spellers to some extent. This pattern was most obvious however, in the NSD group as predicted. The larger discrepancy within the NSD group especially for reading versus spelling recognition, suggests a possible connection between this pattern and speed of processing as poorer naming speed skills appeared to hurt spelling somewhat more than reading.

Waters, Bruck and Seidenberg (1985) proposed that children who fell into the category of better readers than spellers may have persisted in applying a mainly phonological decoding strategy to their spelling in spite of having relatively poor phonological awareness skills. The researchers proposed that this group may have been able to compensate for poorer phonological awareness skills when reading (i.e., by using a more wholistic approach), although this approach may have been less effective with spelling. This theory might best fit children in the PD group who could perhaps use their better naming speed skill as a compensatory device, but fails to explain why this discrepancy was largest in the NSD group. For the NSD group, stronger phonological skills may have worked more to their advantage on reading rather than spelling.

In addition to the idea that some children may be better able to compensate on some tasks than others, it is also important to consider the factors evident within the tests themselves. The differences between spelling and reading might be explained in Study Two by the fact that these skills were measured on different tests. This was not true however, in Study One where both the Word Identification and spelling dictation tasks were from the same test. One other possible discrepancy arises from the use of tests normed exclusively in the United States on Canadian children. It is possible that this same pattern of good readers and poor spellers might not be so evident in a sample of American children where the curriculum may differ. These findings require replication in samples of Canadian and American children in order to confirm these findings.

What contributes most to orthographic skill?

While the connections between phonemic awareness and rapid naming and reading and spelling help us to understand what cognitive processes might be involved in written language tasks, a better understanding of why these skills might be important is needed. Although the focus in reading and spelling research has often been on phonological processes, it is accepted by many that there are at least two routes to reading: one focused more on spelling-sound correspondences or "sounding out" words (i.e., phonological route), and a route connected to the more automatic process of letter pattern knowledge (i.e., orthographic route). While the phonological route is often presented as the earliest route to reading and spelling (Ehri, 1992), orthographic processing is considered to be a more direct link between the visual features of a word presented on a page and an encoded representation in memory (Stanovich, 1992).

As proposed by Wolf and Bowers (1999), it appears that the link between naming speed and written language skills may be mediated through orthographic knowledge skills. They have proposed that the underlying processes in naming speed can interfere with the formation of connections between phonemes and orthographic patterns at the subword and the word level in two ways. Slow naming speed may limit the quality of the orthographic codes in memory as children with slower processing speed may not form the links as readily as their faster naming peers, and children with slower naming speed may require an increased amount of practice in order to make the connections between phonemic codes and orthographic patterns more readily available. Support for a link between orthographic knowledge and naming speed as found in previous studies (e.g., Bowers, 1993; Doi & Manis, 1996; Manis, Seidenberg & Doi, 1999) was partially supported by the findings in both studies that children who were slow namers were slower in responding to all types of orthographic tasks and in some cases, less accurate than their peers with faster naming speed skill. Better naming speed was linked to greater orthographic accuracy in Study One, while deficits in both naming speed and phonological skill were linked to poorer orthographic accuracy in Study Two. In addition, some further support was noted above as children in the NSD group also seemed to have somewhat more difficulty in recognizing the correct spellings of words compared to their faster naming peers.

The final measure included under the rather broad definition of orthographic skills was the Hultquist (1996) embedded words task. This measure fit with the other orthographic measures in speed of responding only. It provided further evidence that children with slower naming speed respond more slowly than those with faster naming speed but the ability to locate words quickly within the nonsense string seemed to be related mainly to a child's ability to decode single words in isolation quickly. The fact that some words were embedded within nonsense strings served only to slow all children down somewhat.

The overall pattern of results for the orthographic measures are consistent with those of Manis, Seidenberg and Doi (1999) who used similar measures of orthographic knowledge and who found that RAN was strongly related to many aspects of early reading acquisition, above and beyond those of phonological ability, particularly to measures of orthographic accuracy and speed. Manis and his colleagues proposed that slower processing as assessed on measures of RAN might be both an effect of slower overall processing as well as an underlying cause of difficulties processing orthographic information. They also noted that while some researchers (e.g., Catts, Fey, Zhang & Tomblin,1999; Torgesen et al., 1997) view naming speed as another variation of phonological processing, that RAN does actually capture something unique. The results of both Study One and Two are supportive of Manis, Seidenberg and Doi's work in that children without phonological deficits (i.e., the NSD group), nonetheless performed more poorly than their double asset peers on many measures of written language, especially on orthographic tasks.

Although not a measure of orthographic knowledge per se, the Quick Spell Test (Bowers, Sunseth, & Golden, 1999) was included in this research in order to assess children's ability to identify letter strings of varying levels of orthographic structure presented briefly. Overall, the results suggested that word strings were easier than pseudowords, which were again easier than illegal nonword strings, for all groups of children to identify. It was predicted that the PD group would perform better than the other deficit groups on this task because of their faster naming speed but this was not the case. Both the NSD and PD groups were approximately equivalent in their performance on word and pseudoword strings, although they still performed more poorly than the DA group in Study Two. Perhaps the NSD group was able to compensate for slower naming speed with their better phonological ability, making the two single deficit groups more equal than was predicted.

As was predicted however, children with deficits in either naming speed or phonological awareness struggled considerably more than their double asset peers on the illegal non-word strings. However, the NSD group's performance was worse than the PD group's only in Study One (the two groups were equal in Study Two). One possible explanation for the apparently larger effects of naming speed on non-word strings in Study One, is that on these items, the NSD group would not be able to compensate through the use of better phonological skill as this would provide little assistance on this type of task. Why this pattern was not replicated in Study Two, and how the phonological deficit affects performance on nonword strings remains unexplained at this time.

What is the role of naming speed and phonological awareness in a reading level control group?

The results of the comparison between the double deficit (DD) group and the reading level control (RLC) group provided some support for the idea that children with reading disabilities are not merely behind in their learning. If reading disabilities resulted from some sort of lag in skill development, we would have expected the Grade Three poor readers to have a relatively similar pattern of skills when compared with the younger group matched on non-word decoding. Instead, a pattern of the Grade One RLC group having some better skills, some similar skills, and some skills which were worse than the DD group was noted. In spite of similar nonword decoding skills, the RLC group nonetheless possessed better phonological awareness skills and the two groups were roughly equivalent on naming speed. Although the RLC possessed better phonological awareness, it appears that the higher degree of print exposure helped the Grade Three DD group more with tasks involving whole words (e.g., spelling recognition and orthographic choice). Tasks which involved unfamiliar words (e.g., word likeness and QST nonwords) were more nearly equivalent for the two groups, a finding that could be expected based on the similar naming speed scores. The RLC group outperformed the DD group only on the AAT and QST words and pseudowords.

These studies are consistent with other findings (e.g., Rack, Snowling, & Olson, 1992; Vellutino, Scanlon & Chen, 1995) from reading level control studies in that the older, poor (i.e., double deficit) readers, in spite of their difficulties seem to have benefited somewhat from their greater exposure to many words. It also suggests that children with reading difficulties do not necessarily approach written language tasks in the same way as normally developing readers do, possibly relying more on whole-word knowledge rather than using their poorer decoding strategies in reading and spelling. However, replication of these results with similar populations and measures is required before the implications can be more thoroughly addressed.

In general, the results of both Study One and Two support the theory that it is necessary to understand more than just a child's phonological ability when assessing his/her ability to read and spell. Although phonological awareness skills seem to contribute a larger amount of variance to several reading and spelling tasks, children with at least average phonological skill but slow naming struggle with some aspects of reading and spelling. The presence of both types of single deficit groups argues against the theory that phonological awareness is the only skill necessary for proficiency in written language tasks. Children with deficits in either phonological awareness or naming speed are at risk for poorer reading and spelling achievement as well as poorer orthographic knowledge. As indexed by many of the measures of reading, spelling, and orthography, deficits in both naming speed and phonological awareness appear to put children at the highest risk for poor academic achievement. All of these results support the idea that more research into the role of naming speed is necessary in order to more fully understand the development of reading, spelling, and orthographic skill in both normally developing and poorer readers.

References

Berninger, V.W., Abbott, S.P., Greep, K., Reed, E., Hooven, C., & Abbott, R.D. (1995, April). Single, double, and triple deficits in impaired readers at the end of first grade: Individual differences in learner characteristics and response to intervention. Paper presented at the annual meeting of the Society for Research in Child Development, Indianapolis, IN.

Bowers, P. (1995). The Phonological-core deficit and the double-deficit hypotheses for developmental reading disorders: Implications for diagnosis and intervention. Paper presented at SRCD symposium, April, 1995.

Bowers, P. (April, 1996). The effects of single and double deficits in phonemic awareness and naming speed on new tests of orthographic knowledge. Paper presented at the annual meeting of the Society for the Scientific Study of Reading, New York, NY.

Bowers, P.G., Steffy, R., & Tate, E. (1988). comparison of the effects of IQ control methods on memory and naming speed predictors of reading disability. Reading Research Quarterly, 23, 304-319.

Bowers, P. & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skill in dyslexia. Reading and Writing: An Interdisciplinary Journal, 5, 69-85

Bruck, M. (1988). The word recognition and spelling of dyslexic children. Reading Research Quarterly, Winter, 51-69.

Bryant, B.R. & Wiederholt, J.L. (1991). Gray Oral Reading Tests - Diagnostic, Austin, TX: PRO-ED

Bryant, P.E. & Bradley, L. (1985). Children's reading problems. Oxford, England: Blackwell.

Catts, H.W., Fey, M.E., Zhang, X., & Tomblin, B. (1999). Language basis of reading and reading disabilities: Evidence from a longitudinal investigation. Scientific Studies of Reading, 3(4), 331-361.

Denckla, M. & Rudel, R.G. (1974). Rapid 'automatized' naming of pictured objects, colors, letters and numbers by normal children. Cortex, 10, 186-202.

Doi, L.M. & Manis, F.R. (1996). The impact of speeded naming ability on reading performance. Paper presented at the meeting of the Society for the Scientific Study of Reading, New York, N.Y.

Dreyer, L.G., Luke, S.D., & Melican, E. (1995). Children's acquisition and retention of word spellings. In V.W. Berninger (Ed.) The varieties of orthographic knowledge II: Relationships to phonology, reading, and writing (pp. 291-320). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Ehri, L.C. (1992). Reconceptualizing the development of sight word reading and its relationship to recoding. In P.B. Gough, L.C. Ehri, & R. Treiman (Eds.). Reading Acquisition, (pp. 107-314). Hillsdale, NJ: Erlbaum.

Ehri, L.C., & Wilce, L.S. (1987). Does learning spelling help beginners learn to read words? Reading Research Quarterly, Winter, 47-64.

Hultquist, A. (1996). Orthographic processing in reading disabled students and reading age controls: Whole word and subword units. Unpublished doctoral thesis from the American International College School of Psychology.

Juola, J.F., Schadler, M., Chabot, R.J., McCaughey, M.W. (1972). The development of visual information processing skills related to reading. Journal of Experimental Child Psychology, 25, 459-476.

Krug, C. (1996). The diagnostic implications of the double-deficit hypothesis: An investigation of fifth-grade readers classified by phonological awareness and visual naming speed.

Paper presented at the meeting of the Society for the Scientific Study of Reading, New York, N.Y.

Larsen, S.C. & Hammill, D.D. (1994). Test of Written Spelling, Third Edition. Austin, TX. PRO-ED.

Levy, B.A., Bourassa, D.C., & Horn, C. (1999) Fast and slow namers: Benefits of segmentation and whole word training. Journal of Experimental Child Psychology, 73, 115-138.

Lovett, M.W. (1987). A developmental approach to reading disability: Accuracy and speed criteria of normal and deficient reading skill. Child Development, 58, 234-260.

Manis, F.R., Doi, L.M., & Bhadha (in press). Naming speed, phonological awareness and orthographic knowledge in second graders. Journal of Learning Disabilities.

Manis, F.R., Seidenberg, M.S., & Doi, L.M. (1999). See Dick RAN: Rapid naming and the longitudinal prediction of reading subskills in first and second graders. Scientific Study of Reading, 3(2), 129-157.

Markwardt Jr., F.C. (1989). The Peabody Individual Achievement Test - Revised (PIAT-R). American Guidance Service Inc. Circle Pines, Minnesota.

Massaro, D.W., Taylor, G.A., Venezky, R.L., Jastrzembski, J.E. & Lucas, P.A. (1980). Letter and word perception: Orthographic structure and visual processing in reading. Amsterdam: North-Holland.

McBride-Chang, C. & Manis, F.R. (1996). Structural invariance in the associations of naming speed, phonological awareness, and verbal reasoning in good and poor readers: A test of the double deficit hypothesis. Reading and Writing: An Interdisciplinary Journal, 8, 323-339.

McCaughey, MW., Juola, J.F., Schadler, M., & Ward, N.J. (1980). Whole word units are used before orthographic knowledge in perceptual development. Journal of Experimental Child Psychology, 30, 411-421.

O'Connor, R.E., & Jenkins, J.R. (1999). Prediction of reading disabilities in Kindergarten and First Grade. Scientific Study of Reading, 3(2), 159-197.

Olson, R.K., Kliegl, R., Davidson, B.J., & Foltz, G. (1985). Individual and developmental differences in reading disability. In G.E. MacKinnon & T.G. Waller (Eds.) Reading Research: Advances in Theory and Practice, Vol. 4.

Rack, J.P., Snowling, M.J., & Olson, R.K. (1992). The nonword reading deficit in developmental dyslexia: A review. Reading Research Quarterly, 27(1), 29-53.

Reitsma, P. (1983). Printed word learning in beginning readers. Journal of Experimental Child Psychology, 36, 321-339.

Rosner, J. & Simon, D.P. (1971). The Auditory Analysis Test: An initial report. Journal of Learning Disabilities, 4(7), 384-392.

Rupley, W.H., Willson, V.L., & Nichols, W.D. (1998). Exploration of the developmental components contributing to elementary school children's reading comprehension. Scientific Studies of Reading, 2(2), 143-158.

Shankweiler, D., Crain, S., Katz, L., Fowler, A.E., Liberman, A.M., Brady, S.A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J.M., Stuebing, K.K., Shaywitz, S., & Shaywitz, B.A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. Psychological Science, 6, 149-156.

Shankweiler, D., Lundquist, E., Katz, L., Stuebing, K.K., Fletcher, J.M., Brady, S., Fowler, A., Dreyer, L.G., Marchione, K.E., Shaywitz, S.E., & Shaywitz, B.A. (1999). Comprehension and decoding: Patterns of association in children with reading difficulties. Scientific Studies of Reading, 3(1), 69-94.

Siegel, L.S., Share, D., & Geva, E. (1995). Evidence for superior orthographic skills in dyslexics. Psychological Science, 6(4), 250-254.

Spring, C. & Capps, C. (1974). Encoding speed, rehearsal, and probed recall of dyslexic boys. Journal of Educational Psychology, 66, 780-786.

Spring, C. & Perry, L. (1983). Naming speed and serial recall in poor and adequate readers. Contemporary Educational Psychology, 8, 141-145.

Stage, S.A. & Wagner, R.K. (1992). Development of young children's phonological and orthographic knowledge as revealed by their spellings. Developmental Psychology, 28, 287-296.

Stanovich, K.E. (1992). Speculations on the causes and consequences of individual differences in early reading acquisition. In P.B. Gough, L.C. Ehri, & R. Treiman (Eds.). Reading Acquisition, (pp. 307-342). Hillsdale, NJ: Erlbaum.

Stanovich, K.E. & Siegel, L.S. (1994) Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable variable-difference model. Journal of Educational Psychology, 86, 24-53.

Sunseth, K. & Bowers, P. (May, 1996). The contributions of phonemic awareness and naming speed to language: The double deficit hypothesis. Paper presented to the biannual Waterloo Child Development Conference, Waterloo, ON.

Sunseth, K. & Bowers, P.G. (August, 1996). A double-deficit hypothesis of reading: Phonemic awareness and speed. Paper presented at the 104th Annual Meeting of the American Psychological Association, Toronto, Ontario.

Sunseth, K. & Bowers, P.G. (March, 1997). The relationship between digit naming speed and orthography in children with and without phonological deficits. Paper presented at the Annual Conference for the Society for the Scientific Study of Reading, Chicago, IL.

Swanson, L. (1989). Analyzing naming speed-reading relationships in children. Unpublished doctoral dissertation, University of Waterloo, Ontario.

Torgesen, J.K. (1991). Subtypes as prototypes: Extended studies of rationally defined extreme groups. In L.V. Feagars, E.J. Short & L.J. Meltzer (Eds.), Subtypes of Learning Disabilities, Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Torgesen, J.K., Wagner, R.K., Rashotte, C.A., Burgess, S., & Hecht, S. (1997). Contributions of phonological awareness and rapid automatic naming ability to the growth of word-reading skills in second to fifth-grade children Scientific Studies of Reading, 1(2), 161-185.

Vellutino, F.R., & Scanlon, D.M. (1987). Phonological coding, phonological awareness, and reading ability: Evidence from a longitudinal and experimental study. Merrill Palmer Quarterly, 33, 321-363.

Vellutino, F.R., Scanlon, D.M., & Chen, R.S. (1995). The increasingly inextricable relationship between orthographic and phonological coding in learning to read: Some reservations about current methods of operationalizing orthographic coding. in V.W. Berninger (ed.) The Varieties of Orthographic Knowledge II: Relationships to Phonology, Reading, and Writing, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Wagner, R.K., Torgesen, J.K., Laughon, P., Simmons, K., & Roshette, CA. (1993). Development of young readers' phonological processing abilities, Journal of Educational Psychology, 85, 83-103.

Walsh, D., Price, G., & Gillingham, M. (1988). The critical but transitory importance of letter naming. Reading Research Quarterly, 23, 108-122.

Waters, G.S., Bruck, M., & Seidenberg, M. (1985). Do children use similar processes to read and spell words? Journal of experimental child psychology, 39, 511-530.

Wiederholt, J.L., & Bryant, B.R. (1992). Gray Oral Reading Tests, Third Edition, Austin, TX: PRO-ED.

Wimmer, H., Mayringer, H., & Landerl, K. (1998). Poor reading: A deficit in skill-automatization or a phonological deficit? Scientific Studies of Reading, 2(4), 321-340.

Wolf, M. (1991). Naming speed and reading: The contribution of the cognitive neurosciences. Reading Research Quarterly, 26(2), 123-141.

Wolf, M. & Bowers, P.G. (1999). The double-deficit hypothesis for the developmental dyslexias. Journal of Educational Psychology, 91, 415-438.

Woodcock, R.W. & Johnson, M.B. (1989). Woodcock-Johnson Psycho-Educational Battery - Revised. Allen, Tx: DLM Teaching Resources.

Young, A.R. (1993). Determinants of oral reading fluency and expressiveness in poor and average readers. Unpublished doctoral dissertation. University of Waterloo.

Young, A., & Bowers, P.G. (1995). Individual difference and text difficulty determinants of reading fluency and expressiveness. Journal of Experimental Child Psychology, 60, 428-454.

APPENDIX A

PHONOLOGICAL AWARENESS MEASURE

AUDITORY ANALYSIS TEST (Rosner & Simon, 1971)

Instructions:
"Now we're going to play a different word game. I'd like you to say cowboy (show picture of cow and boy). Now say it again, but without the boy (cover picture of boy with one hand). Say toothbrush (show picture of tooth and brush). Now say it again, but without tooth (cover picture of tooth with one hand)."

E. If child makes an error on either practice item, correct and repeat instructions with practice items. Always pronounce letter sound, not letter name. Items read across rows.

E. Write down incorrect responses. If word is articulated incorrectly, note and take into consideration when scoring response. If child fails to give a response, repeat item once. If child still does not respond, score 0 and continue.

Discontinue: 10 consecutive errors

"Say birth(day) - now say it again, but without the day" __________
"Say car(pet) - now say it again but without the pet" __________

bel(t)	________	(m)an	________	(b)lock	________
to(ne)	________	(s)our	________	stea(k)	________
(l)end	________	(s)mile	________	plea(se)	________
(g)ate	________	(c)lip	________	ti(me)	________
(sc)old	________	(b)reak	________	ro(de)	________
(w)ill	________	(t)rail	________	(sh)rug	________
g(l)ow	________	st(rain)	________	s(m)ell	________
de(s)k	________	st(r)eam	________	s(m)ack	________
s(k)in	________	s(w)ing	________	c(l)utter	________

APPENDIX B

DIGIT NAMING SPEED MEASURE

RAPID AUTOMATIZED NAMING (R.A.N.) - DIGITS (Denckla & Rudel, 1976)

Instructions:
"I am going to show you a sheet with many numbers on it. I want you to say each number out loud, just as fast as you can. I want you to read the numbers across the rows this way (Indicate left to right motion across each row down to bottom of the page). Remember to say them as fast as you can."

E. Administer two trials with intervening AAT task between trials. Record time to complete task and number of errors. If the child reads in the wrong direction, correct immediately. Score to be used for data is items per second. The average of the two trials should be used unless one trial has three or more errors. In this case, use only the time for the trial with the fewest errors.

Stimulus set:

2	**6**	**4**	**9**	**7**	**2**	**6**	**4**	**7**	**9**
9	**7**	**2**	**6**	**4**	**7**	**2**	**9**	**4**	**6**
7	**4**	**6**	**2**	**9**	**4**	**6**	**2**	**9**	**7**
4	**6**	**2**	**7**	**9**	**2**	**4**	**9**	**7**	**6**
6	**2**	**7**	**9**	**4**	**7**	**6**	**2**	**4**	**9**

APPENDIX C

WORD RECOGNITION MEASURE

Woodcock-Johnson Psycho-Educational Battery - Revised (Woodcock & Johnson, 1989):
Letter - Word Identification Subtest (Form A)
Basal: 6 lowest-numbered items correct
Ceiling: 6 highest-numbered items failed

Test Items:

1) picture of chair
2) picture of book
3) picture of dog
4) picture of cat
5) O
6) S
7) A
8) z
9) G
10) D
11) m
12) h
13) j
14) to
15) in
16) dog
17) as
18) get
19) was
20) his
21) when
22) fixed
23) must
24) about
25) part
26) knew
27) because
28) faster
29) whole
30) shoulder
31) island
32) correctly
33) since
34) personal
35) experiment
36) distance
37) bounties
38) process
39) doubtful
40) moustache
41) cologne
42) hesitating
43) masculine
44) sufficient
45) domesticated
46) preyed
47) therapeutic
48) significance
49) bouquet
50) apparatus
51) diacritical
52) debutante
53) trivialities
54) expostulate
55) stochastic
56) ubiquitous
57) enceinte

APPENDIX D

NONWORD RECOGNITION MEASURE

Woodcock-Johnson Psycho-Educational Battery - Revised (Woodcock & Johnson,1989):
Word Attack Subtest (Form A)

Basal: Item 1
Ceiling: 6 highest-numbered items failed

<u>Test Items:</u>

1) tiff
2) nan
3) rox
4) zoop
5) lish
6) dright
7) jox
8) feap
9) gusp
10) snirk
11) yosh
12) tayed
13) grawl
14) loast
15) sluke
16) thrept
17) wheeg
18) mibgus
19) splaunch
20) quantric
21) lindify
22) saist
23) knoink
24) whumb
25) mafreatsun
26) phigh
27) deprotenation
28) paraphonity
29) coge
30) apertuate

APPENDIX E

SPELLING DICTATION MEASURE

Woodcock-Johnson Psycho-Educational Battery - Revised (Woodcock & Johnson,1989):
Dictation (Form A)
Basal: 6 lowest-numbered items correct
Ceiling: 6 highest-numbered items failed
(S) = Spelling Item *(P) = Punctuation Item* *(U) = Usage item*

Test Items:

1) "mark"
2) "scribble"
3) "line"
4) "circle"
5) Z
6) E
7) (*S*) O
8) (*S*) X
9) (*P*) D
10) (*P*) Y
11) (*P*) i
12) (*P*) . (period)
13) (*S*) l
14) (*S*) he
15) (*S*) six
16) (*S*) green
17) (*S*) house
18) (*P*) !
19) (*U*) men
20) (*S*) table
21) (*U*) tallest
22) (*U*) teeth
23) (*S*) don't
24) (*S*) dresses
25) (*S*) walked
26) (*S*) I'll
27) (*U*) children
28) (*S*) comb
29) (*S*) purchase
30) (*S*) garage
31) (*U*) most elegant
32) (*P*) Dayton, Ohio
33) (*U*) knives
34) (*S*) cough
35) (*P*) Front Street
36) (*P*) Smith
37) (*P*) French
38) (*U*) oxen
39) (*S*) annually
40) (*S*) fifty-one
41) (*S*) etc.
42) (*P*) foxes'
43) (*S*) accept
44) (*S*) embarrassed
45) (*S*) arrogance
46) (*P*) night's
47) (*U*) crises
48) (*S*) omniscient
49) (*S*) per se
50) (*S*) bizarre
51) (*S*) inflammation
52) (*S*) camaraderie
53) (*U*) oases
54) (*S*) crevasse
55) (*S*) soliloquy
56) (*S*) millenniums

APPENDIX F

SPELLING RECOGNITION MEASURE

Peabody Individual Achievement Test - Revised (Markwardt Jr., 1989):
Spelling Subtest

Test Items:
Point to the item that is different: (from four choices)

1. m
2. f
3. a
4. d
5. h
6. e.
7. a
8. m
9. b

Find the letter: (from four choices)
10. m
11. e
12. v

Point to the word: (from four choices)
13. see
14. toy
15. on
16. it
17. am
18. dog
19. hat
20. good
21. top
22. not
23. did
24. bed
25. car
26. that
27. star
28. cow
29. fast
30. bad
31. when
32. show
33. give
34. why
35. glass
36. trip
37. head
38. girls
39. learn
40. also
41. pages
42. an
43. heat
44. slowly
45. first
46. weather
47. reason
48. activities
49. sugar
50. shoulder
51. electricity
52. moment
53. usually
54. exciting
55. perhaps
56. holiday
57. soldiers
58. source
59. purpose
60. position
61. method
62. disease
63. political
64. chocolate
65. ordinary
66. arrived
67. marriage
68. definition
69. various
70. pressure
71. determined
72. according
73. difference
74. bouquet
75. minimum
76. occasionally
77. pageant
78. bulletin
79. originally
80. physician
81. pamphlet
82. immediately
83. inaugurate
84. solemn
85. supplementary
86. melancholy
87. representatives
88. nuisance
89. sufficiently
90. bankruptcy
91. epistle
92. apocryphal
93. proficiency
94. picnicking
95. infamy
96. pyorrhea
97. conscientious
98. souvenir
99. inoculate
100. saponaceous

APPENDIX G

REGULAR AND EXCEPTION WORD SPELLING DICTATION

Spelling Dictation (Bruck, 1988)

Test Items:

Regular Words:

hand	hit
met	ran
sharp	string
strong	take
took	wife

*Regular * Words:*

boat	door
first	hair
keep	late
learn	rain
real	share

Exception Words:

both	break
choose	come
does	done
great	heard
sure	touch

APPENDIX H

REGULAR AND EXCEPTION WORD SPELLING DICTATION (STUDY 2)

Test of Written Spelling - Third Edition (TWS-3) (Larsen & Hammill, 1994)

<u>Predictable Word List:</u>

stop	bed	let	plant	him	went	next
spring	storm	spend	shake	when	hardly	strong
able	pile	tardy	strange	section	hospital	signal
brandish	expect	fourty	district	legal	political	entire
salute	institution	overwhelm	visualize	baste	retaliate	wistful
tranquil	ambiguous	continuity	notary	laborious	navigable	linguistic
panorama	negotiate	credulous	gauntlet	finesse	variance	gregarious
tertiary						

<u>Unpredictable Word List:</u>

yes	she	us	name	two	much	myself
people	who	eight	knife	everyone	uncle	knew
nineteen	sure	enough	canyon	fountain	electricity	pardon
awful	terrible	bicycle	community	unify	agriculture	original
nucleus	fallow	collar	campaign	hypothesis	audible	
tangible	luminous	verify	suffice	cyst	opaque	zealous
havoc	champagne	affront	versatile	requisite	facsimile	
affidavit	liaison	feign				

APPENDIX I

READING FLUENCY MEASURES

STUDY ONE
GRAY ORAL READING TESTS - DIAGNOSTIC (GORT-D)
Form A (Bryant & Wiederholt, 1991)

Timed Reading Passage A-3 :

One day some children were playing in the snow. They were making snow animals. One of the animals was a dog. Soon the spotted dog next door came out of the house. When he saw the snow dog, he said, "Bow-wow." The children laughed, "Now we have a dog that can bark."

STUDY TWO
GRAY ORAL READING TESTS - THIRD EDITION (GORT-3)
Form A (Wiederholt & Bryant, 1992)

Timed Reading Passage A-2:

The girl likes to ride her new bike. It is yellow with white stars. She can ride very fast. But she goes slowly when she sees a car. She stops at the red light. She goes when it turns green.

APPENDIX J

ORTHOGRAPHIC CHOICE TEST

Modified Orthographic Choice Forced-Choice Task (Olson, Kleiegl, Davidson, & Foltz, 1984)

This test is administered on a computer.

Word Pair List:

room / rume	wrote / wroat
young / yung	word / wurd
snow / snoe	rain / rane
take / taik	store / stoar
goat / gote	choose / chooze
please / pleese	every / evry
easy / eazy	few / fue
face / fase	hole / hoal
hurt / hert	keep / keap
roar / rore	learn / lurn
smoke / smoak	nice / nise
tape / taip	scare / scair
bowl / boal	skate / skait
clown / cloun	thumb / thum

Computer records latency and accuracy of each item.

APPENDIX K

WORD LIKENESS TASKS

Word Likeness Tasks: (Massaro, Taylor, Venezky, Jastrzembski & Lucas, 1980; Siegel, Share, & Geva, 1995)

Both tasks are administered on a computer.

Siegel et al. Word List:
filv / filk
tolz / tolb
powl / lowp
dlun / lund
fant / tanf
miln / milg
togd / togn
wolg / wolt
moke / moje
jofy / fojy
cnif / crif
bnad / blad
hift / hifl
gwup / gnup
nitl / nilt
clid / cdil
vism / visn

Revised Massaro et al. Word List:
nmtaou / mauton
blayer / rbleya
thaber / rtbeha
ebrgdi / begrid
eclnga / caleng
siflet / eflsti
emrtsa / tasmer
thomer / hretmo
primet / rtpeim
epylra / rapley
erplyu / yulper
ramine / rniema
elsrtu / surtel
lsepmi / pimsel
snigel / nglesi
dtsera / sarted
vartle / tlerav
sartil / irltsa
drunet / edtrnu
rntewi / triwen

APPENDIX L

QUICK SPELL TEST

The Quick Spell Test (Bowers, 1994)
The items are presented on a computer.

Word List:

that (w)	kile (p)	vklh (n)	went (w)	come (w)
dlhw (n)	meft (p)	wame (p)	nwtl (n)	will (w)
tath (p)	lswk (n)	have (w)	thid (p)	mvhw (n)
like (w)	tmht (n)	nase (p)	tclv (n)	with (w)
hool (p)	tnws (n)	vole (p)	dust (p)whis (p)	
lkwn (n)	stin (p)	look (w)	when (w)	ncdk (n)

(w) = word
(p) = pseudoword
(n) = nonword

APPENDIX M

EMBEDDED WORD TASK

Embedded Word Task (Hultquist, 1996)

Embedded Word List	**Nonembedded Word List**
Test Items	Test Items
cvbdeepdmg	lip
tjlhzmilkb	rich
hwqyfunvnp	mile
bhbnvneckd	sun
npmqsickqr	sir
bhgcropwxq	pipe
ktbhuntjlw	jump
pdeckzmlrx	size
dkxvpmuchc	tell
yfdclubdcn	boy
lrjpdkeepm	church
hdztxflyqs	pole
kbnestdpwj	pie
xoldkbvnpw	turn
dklhdropjt	sell
vmudcbdcxz	sum
kzmlhungbh	ice
npcvbackjh	fur
bhcellrqjl	egg
hfdkbigcnb	side
xklhbirdfq	left
ktestbnpjz	style
ktruckpjrq	step
hxoilhgbvn	cake
vlegjhcbdf	mix
fzswimlwqk	spell
jtpztbagfd	rock
bhgunpmfxb	lie
pjgirlwjwz	pick
kqyxfdeerx	kept
bhpmlrunbh	desk
mlightqrxw	hurt
kbnvmqrodp	die
ztermqhpwq	dry