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A COGNITIVE APPROACH TO READING DIFFICULTIES: ASSESSMENT AND REMEDIATION

BY

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To my sister, Despina

And my twin brother, Nikos

Life partners, true companions, and comrades

Toward the long journey

To have a life

That makes a difference

ABSTRACT

This thesis is a three year longitudinal study that examines the diagnosis and remediation of reading difficulties in a group of at-risk children. Ninety students were identified by their kindergarten teachers as being at risk for developing early reading problems. A set of Planning, Attention, Simultaneous processing, and Successive processing tasks (PASS model) along with three phonological coding tasks and three reading measures (Word Identification, Word Attack, and Passage Comprehension) were administered to the participating group from Kindergarten to Grade 2. The aim was to define the cognitive and phonological correlates of reading performance and to examine the children's trajectories of growth. In addition, cognitive remediation was provided to the participants whose reading skills at word reading level were lower than the 26th percentile. Therefore, due to the nature of the study, results are presented in three separate but inter-related sections.

The first section focuses on the prediction of reading skills in Grade 1 from cognitive and phonological measures in Kindergarten. Results indicated that three processes are important in defining early reading skills: phonological, successive, and simultaneous processing. The status of low-average reader as opposed to poor reader and/or non-reader was defined by all three processes. The risk of being a non-reader, instead, was predicted by extremely poor levels of functioning only on the successive and phonological processes.

The second section focuses on short- and long-term effects of remediation. Fifty-eight of the 90 participants were divided into two matched remediation groups and participated in either the PASS Reading Enhancement Program (PREP) or the Meaning-Based Intervention (MNG). Repeated measures ANOVAs showed that the PREP group gained more than the MNG group in terms of word-decoding skills following remediation in Grade 1, a difference that was maintained even after a period of eight months when

participants were re-tested in Grade 2. Moreover, retrospective analysis showed that the cognitive profiles of the Average Gainers of the remediation groups were distinctly different from those of the Low Gainers after remediation. However, no differences were observed between the Average Gainers and the Never-remediated groups after remediation.

Finally, the third section provides further support for the proponents of cognitive remediation, as a more intensive course of PREP was shown to be highly beneficial by significantly increasing the word decoding skills of the present at-risk population.

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CHAPTER I

INTRODUCTION

In the central books of his *Republic*, Plato distinguishes between the final end of philosophical inquiry, which is certainty or *knowledge* regarding what is ultimately true and unchanging, and the *beliefs* that ordinary human beings form and revise in their daily lives. These beliefs are inevitably tinged with speculation and error, as they may lie from being true to not being true, and they pertain to objects that are mutable and elusive. The Platonic ideal of certain knowledge has not only endured as a powerful theme in the Western philosophical tradition, but in science in general. and in the human sciences in particular, it has come to seem chimerical. For example, our scientific understanding of reading is still more than a little tinged with speculation and error and pertains to objects that are mutable and elusive. In reading, as in other areas of educational research, it would be unwise to say that we know all the answers or even that we can be certain of any of them. But we can still aspire to a better understanding of reading than the one we currently have, even if that better understanding raises more questions than it answers. That aspiration has been fundamental to this research project.

The present research is a three-year longitudinal project that focused on diagnosis and remediation of early reading difficulties. The developmental trends of children who experienced reading difficulties were examined from Kindergarten to Grade 2. Moreover, remediation was twice offered to participants who scored below the 26th percentile on both word reading measures of Word Identification and Word Attack, in Grade 1 and Grade 2. Therefore, the results of this longitudinal experiment are reported in three thematically inter-related sections.

First, the study was designed to examine whether phonological and cognitive tasks predict reading acquisition in a participating group of 'at-risk' children. Planning, attention, simultaneous processing, and successive processing tasks together with three phonological coding tasks were administered in Kindergarten to the entire initial group of 90 children identified by their teachers as being 'at risk' for early reading problems. The same tasks, along with the two reading measures (Word Attack and Word Identification), were administered to these participants a year later in Grade 1. Results showed that performance on simultaneous, successive processing and phonological tasks in Kindergarten correlated significantly with reading skills in Grade 1. Moreover, phonological, successive, and simultaneous processing tasks together distinguished between those children who were diagnosed as reading disabled and those who were not, as evident from correlational analysis. The risk of remaining a nonreader, in turn, was predicted by extremely poor levels of functioning on successive and phonological tasks.

Second, the short and long term effects of remediation were examined. In Grade 1, 58 of the 90 participants who experienced reading difficulties were divided into two matched remediation groups: the PREP (PASS Reading Enhancement Program) and Meaning-Based Reading intervention. Both groups received remediation twice a week for 20 minutes over a nine week period. Participants' reading level was assessed pre- and post-intervention using Word Identification (WID) and Word Attack (WAT) tests. Repeated measures ANOVAs showed a significant main effect of Testing Time for both WID and WAT. For WAT, the Testing Time by Remediation Group interaction was also significant; the PREP group gained more than the meaning-based group in terms of decoding skills. Next, the performance of "Gainers" and "No-Gainers" in both groups was compared on several cognitive processing tasks to examine if there were differences in the cognitive profiles of participants who benefited from the remedial treatment and participants who did not. Results indicated that Gainers in the PREP group were characterized by a somewhat higher level of successive, simultaneous, and phonological processing at the beginning of the program. In contrast, Gainers in the Meaning-based program were characterized by higher levels of planning, attention, simultaneous processing, and word-recognition skills.

To test the long-term effects of remediation, after attrition was accounted for in Grade 2, all 58 children still participating in the study were administered the same set of cognitive, phonological, and reading measures. This time, three groups of children emerged based on a retrospective classification with regard to their response to remediation in Grade 1: (a) Never Remediated group (NRE) of 18 children who were never remediated; (b) Average Gainers group (AG) of 13 children who overcame their reading problems after one period of remediation, exceeding the criterion of reading performance above the 26th percentile on both reading measures (Word Identification and Word Attack); and (c) Low Gainers group (LG) of 27 children who still scored on both reading measures lower than the 26th percentile after remediation. The latter two groups of AG and LG consisted of participants from both PREP and Meaning-based intervention programs. Such a retrospective classification and grouping was consider necessary in order to plot the trajectories of growth for proximal (phonological) and distal (cognitive) processes for these three groups. Results from this follow-up analysis showed that in comparison to the Non-remediated group, participants in the remediated group who improved in reading (AG group) were weak in phonological coding at initial pre-testing (in Grade 1), but not at follow-up testing (in Grade 2), whereas those who did not improve (LG group) were weak in some of the cognitive tests as well as in phonological coding even at follow-up testing. Of the two remedial procedures of Grade 1 (PREP vs. Meaning-based approach), those who gained in the PREP group exceeded those who gained in the Meaning-based group in pseudo-word decoding in follow-up-testing as well.

Finally, the third part of my dissertation examines the effects of PREP remediation that was provided to the group of 27 participants (the LG group) in Grade 2. During this final period of remediation, all the participants attended the PREP program which had been shown to be more effective than the Meaning-based remedial program in Grade 1, especially in regard to improvement of word decoding skills. The remediation provided in Grade 2 was slightly different from that of the previous year in terms of length, intensity, and timing. Post remediation scores were obtained for 24 children who fully participated in remediation in the spring of Grade 2. Results showed that, indeed, more intensive PREP remediation appeared to be beneficial for the vast majority (19 of the 24; 79.2%) of poor readers in this sample. It is noteworthy that as a group, these children reached a percentile mean of average performance on Word Attack (47.89 percentile), obtaining a score that was twice as large as their pre-testing score (23.11 percentile) and clearly above the criterion for inclusion in remediation (i.e., the 26th percentile).

Because of the longitudinal design of this study, the literature review of this proposal is divided into three thematically different sections. The first section provides some definitions of reading related issues as well as a review of the relationship between verbal play and nursery rhymes, the development of phonological awareness, and its subsequent effect on reading skills. Particular focus is given to the relationship between the knowledge of nursery rhymes and phonological awareness, as well as the relationship of these early skills with subsequent reading and spelling skills based on evidence from correlational/longitudinal studies. The intent of this section is to draw some conclusions about the cognitive profiles of young children who are at-risk in developing reading difficulties. Children with reading difficulties have long been believed to differ in cognitive processes from their normally achieving peers. There has, however, been considerable difficulty in reaching agreement about the nature of the difference in cognitive processes and in characterizing that difference in a way helpful to overcoming the problem. Consequently, in this part of the literature review experimental work in cognitive psychology is reviewed in order to understand the processes underlying phonological coding, word reading, and comprehension. The PASS theory (Planning, Attention, Simultaneous and Successive processing) and its application in reading are examined along with phonological studies. A discussion of the implications of this review is presented, followed by a final summary and conclusion that considers educational implications and remedial activities for potential or actual reading difficulties.

The second section provides a brief review of some existing approaches to reading remediation that have focused primarily on the improvement of phonological awareness skills. The review is then followed by a presentation of studies that have employed the use of the PASS Remediation Enhancement Program that targets the improvement of successive and simultaneous processes.

CHAPTER II

LITERATURE REVIEW

2.1. Defining reading development

In a review of reading disabilities, Frith (1986) identified four stages in reading development: preschool, pictorial, alphabetic, and orthographic. At the *preschool stage* the child considers all printed words to have a symbolic quality: "a magical combination of strokes, circles, and lines that somehow results in a word that people read" (Das, 1993b, p.159). A child at the *pictorial stage* views all the letters and words as pictorial representations of sounds. At the third stage, the *alphabetic stage*, the child develops an understanding of grapheme-phoneme correspondences, which essentially enables him/her to read printed material. Only when the skills associated with this stage are well established does the child pass to the last stage, the *orthographic*. This stage, which continues through adulthood, enables us to understand the intricacies of phonics and spelling, such as in the words /bough/ and /tough/ (Das, 1993b). According to Frith, it is at the *alphabetic stage* that many children experience reading difficulties.

Perfetti, Beck, Bell, and Hughes (1987), emphasizing the reciprocal relationship between phonemic knowledge and beginning reading, propose what they call the "Activation Model" as an explanation of the development of early reading. Reading, for them as well as for other scholars (e.g., Liberman & Shankweiler, 1979) is a *"secondary language activity"* (p.284) that depends on other primary language processes reflected in speech. Some of these primary processes of reading may also require more advanced cognitive skills than does word reading (Das, Naglieri, & Kirby, 1994). Accepting the major premise that phonological awareness and reading development occur within a mutually supporting relationship leads to the conclusion that phonological awareness is not a unitary ability, but a constellation of abilities that support and guide the child's emerging understanding of the structure of the spoken language (see also Juel, 1988). Based on these premises and in an attempt to explain how word reading emerges, Perfetti et al. (1987) proposed their "Activation Model." In this model, particular emphasis was given to the different stages of phonological sensitivity in children's speech:

(a) At the most immature and earliest stage, *model O*, the participants produce any word in order to satisfy the task demand; for example, instead of the word /can/ they produce the word /telephone/.

(b) At the next stage, *model L*, which is still an immature stage, young readers encode all segments into a word, search the memory for a related word and produce a word; for example, instead of saying the word /dog/, they produce the word /doggies/ or the word /gone/ that share some of the same sounds; meaning associations also influence the kind of response generated in this model.

(c) In *model FL*, a phonemically constrained lexical search is taking place. Young readers try to encode at least some segments into segment strings, they use string constituents to search the lexicon, they set certain criteria and find matches, and finally they produce the word; for example, instead of producing the word /dog/, they may say /hog/, or /go/, or even /August/ (Perfetti et al., 1987, p. 304).

(d) At the *model F* stage, the children try again to encode some segments into segment strings, but this time without having any constraints on their lexical search. The meaning component that was associated with responses at stage 3 is no longer valid; therefore, now, when they attempt to produce the word /dog/, they produce the pseudowords /gog/, /du/, and so on.

(e) At the final stage, *model A* the children encode one segment at a time, try to find an alphabetical match for it, and produce the letter name; /dog/ is segmented clearly into /d/ - /o/ - /g/.

This Activation Model assumes that the spoken word activates an internal representation that connects to both a lexical-semantic network and a lexical-phonemic network. This is a logical assumption because both knowledge base and phonological rules (see e.g., Ehri, 1995) are important for accurate reading of the stimulus word(s). What is missing from this model, however, is an appropriate explanation about the processes and strategic constraints that a child employs in order to select a network pathway and produce an activated node. It seems that activation spreads along these two networks, triggering very common nonanalytic solutions at the first three levels, by either involving repetition of the stimulus or a semantic association to the stimulus as well as rhyming solutions. Alternatively, in the last two stages, segmental solutions replace the semantic lexical solutions that have almost completely disappeared. The child isolates the graphemes, tries to find letter names and employs successive processing in order to produce the stimulus word.

Another approach to reading development is proposed by Marsh, Friedman, Welch, and Desberg (1981), the "Cognitive-developmental theory", which has commonalties with the Activation Model. According to the authors, this theory provides a legitimate description and explanation for the cognitive achievements of learning to read and to write. Two assumptions form the basis for their theory: (a) any cognitive achievement is the result of the interaction of a complex organism within a complex environment and (b) any cognitive process goes through certain stages that change qualitatively with development. Knowledge, strategies, and meta-knowledge are main components of this theory. The term *knowledge* refers to any information and cognitive structures that are present in any given stage of development. Knowledge, therefore, changes in structure as the individual interacts with the environment. *Strategies*, on the other hand, are those processes that the child employs to cope with the environmental inputs. These strategies are joint products that meet the child's constraints and the environmental task demands. Finally, *meta-knowledge* refers to an individual's ability to describe verbally and reflect upon the knowledge and strategies that he/she has and uses.

In relation to reading, Marsh et al. (1981) believe that a more accurate application of their model would be described when reading of pseudowords is involved where high-level cognitive processing strategies are required. Their model yields four distinct stages:

(a) *Stage one:* the child centers his attention on partial information of the visual stimulus, such as the first letter, and associates that with the oral response, whether or not the response matches the task demands. Phonemic segmentation is almost impossible at this stage, because children cannot in practice dissociate themselves from the unanalyzed oral response. This strategy can be seen as parallel to the one described in the Activation model by Perfetti et al. (1987). At the models O and L, children pay attention mainly to the associations of the words or the initial phonemes. In addition, work by Treiman (1983, 1985) has consistently proven that onset sounds are more likely to be discriminated by young participants at this stage. Reading at this stage is a *linguistic guessing strategy* which relies primarily on meaning associations.

(b) *Stage 2:* At this stage, the child typically responds to an unknown word on the basis of its shared segmented features with known words. This is the model FL stage, described by Perfetti et al. (1987), that deals with lexical access constraints where the individual tries to match a novel word with a word from the lexical entities. Once again, the first letter plays a significant role in the word identity but more features are progressively added to this process (e.g., word length, final letter, and so on). The child in this stage operates by employing a *discrimination net mechanism* in which graphic cues are processed only to the extent that they are needed to discriminate one word from another. Novel material that has to be learned by rote may be learned utilizing this strategy.

(c) *Stage 3:* Only at this level does sequential decoding start to become involved in the reading process. Combinational rules are employed to allow the reader to decode the words.

With an increase in the number of items in the print vocabulary, sequential decoding of words becomes necessary. Visual working memory is no longer enough to control the plethora of the printed world. In contrast with the decoding process, word memory is increased as the rote learning strategy and the visual memorization of words gradually diminishes. This transition is not as difficult as it seems considering the fact that the child has moved into the stage of concrete operations (see also Piaget, 1974). Grapheme-letter correspondence is learned with considerable ease once the child has the ability of simultaneously paying attention to both sounds and written graphemes. Meaning associated with learning words also increases as the process of learning the alphabetic principle becomes automatic (see also Liberman, Shankweiler, & Liberman, 1989).

(d) *Stage 4:* Finally, at the fourth stage of the model, the simple sequential decoding that is quite useful for simple word patterns is substituted for a hierarchical decoding that enables the reader to successfully segment the most complicated words. It is not until this stage that the child has the ability to deal with conditional rule patterns and other complex rules of orthographic structure (see also Adams, 1990; Ehri, 1987, 1995).

The approach of Marsh et al. (1981) to understanding reading development appears to make practical use of the Piagetian theory of cognitive development. For instance, the shift from Stage 2 to Stage 3 is more likely to occur at approximately seven years of age, congruent with the shift from the preoperational stage to the stage of concrete operations in traditional Piagetian terms. What is missing from this theory, as well as from Perfetti et al. (1987), however, is reference to reading difficulties: neither of the authors comment on reading difficulties or on how and when children who experience reading difficulties may be identified using these models. In contrast, Frith (1986) refers to the alphabetic stage as the critical stage where children may first experience difficulties in reading. Accordingly, then, in the Perfetti et al. (1987) model, young readers should encounter reading difficulties at the third stage of model FL, where phonemic rules must be activated in order to read the word(s) appropriately. Similarly, in the Marsh et al. (1981) model, difficulties in reading could be clearly diagnosed when the child enters the second stage, in which he/she has to employ the discrimination net mechanism in order to discriminate one word from another.

Cohen (1980), in discussing reading development, examines the reading tasks administered in different studies to make the distinction between prelexical processing and postlexical processing. Some tasks involve a mixture of pre- and postlexical processes; in other tasks optional strategies employing either pre- or postlexical processing are available; and in some cases, tasks are classified as pre- or postlexical by the researcher on grounds that are somewhat arbitrary. As a general rule, *prelexical processes* include accessing a word in the internal lexicon and extracting the phonological and semantic information stored with the lexical entry; *postlexical processes* consist of semantic and syntactic analyses applied to words in structured combinations. Tasks that require recognition of single words or same-different judgments over pairs of words usually interrogate levels of processing up to and including lexical access, and may provide evidence for prelexical phonological coding. Tasks that require semantic judgments to be made over whole sentences held in the memory include postlexical stages as well. When passages of text have to be read and understood, the reader must integrate successive words in memory and process semantically. Postlexical processes are therefore involved as well as prelexical ones (the same processes are defined in the PASS theory as *successive* and *simultaneous* processes), and any phonological coding that is involved could be occurring at either the pre- or postlexical stage.

Reading theories, such as those discussed above, are necessary for understanding reading development. Certain stages and certain skills associated with them are conceptually clear. What, however, should be given greater emphasis in reading theories should be the *whens* and particularly the *whys* for children not progressing in a way defined by the theoretical stages. The value of breaking development into distinct stages is merely justified when certain performance inconsistencies can be fully explained through the theoretical stages of a model.

The participating population in this longitudinal study has been assessed since the first formal academic year (i.e., Kindergarten) and, therefore, reading development has been examined from the age of 5 years old. The literature review that follows examines the development of reading in stages: from nursery rhymes and alliteration games to phonological awareness skills and from that point to reading (mainly word reading).

2.2. Nursery rhymes, phonological awareness, and reading: An introduction

As we have seen so far in the discussion of reading development, phonological coding appears to take a pivotal role. Indeed, one of the most exciting developments in research on reading over the last two decades is the emerging consensus about the importance of phonological processing abilities in the acquisition of early reading skills (Bryant, Bradley, Maclean, & Crossland, 1989; Torgesen, Morgan, & Davis, 1992; Torgesen, Wagner, & Rashotte, 1994). The evidence for a strong connection between children's awareness of the constituent sounds in words and their success in learning to read seems to be indisputable for many researchers (e.g., Stanovich, 1993). There is evidence that yields a relationship between children's scores in tests involving phoneme or rhyme detection and their level of reading (Bradley & Bryant, 1985, 1988; Kirtley, Bryant, Maclean, & Bradley, 1989). Furthermore, measures of these skills in prereaders are related to their success in reading in later years (Bradley & Bryant, 1988; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993).

The particular interest in phonemic awareness skills seems to be triggered by the work of Elkonin (1963, 1973) on the teaching of beginning reading to Russian children. Elkonin emphasized the creation and re-creation of the sound form of the word from its graphic representation, and spelled out ways of concretely representing the sound structure of spoken words. He was careful to emphasize that the aim "is not the symbolizing of separate sounds, but their separation and modeling as a succession" (Elkonin, 1973, p. 563). Moreover, his aim was to show not only the basic sound units of language, but also how language is constructed from the orthographic and phonological components. A similar line of reasoning can be found in the writing of Samuel Orton (1937). From his clinical experience with developmental dyslexics, Orton suggested, "It is this process of synthesizing the word as a spoken unit from its component sounds that often makes much more difficulty for the strephosymbolic child than do the static reversals and letter confusions" (Orton, 1937, p. 162).

The skills involved in this process, as described by Orton (1937) are today often referred to as *phonological awareness* (Maclean, Bryant, & Bradley, 1987; Torgesen et al., 1994), or *phonemic awareness* (Lewkowicz, 1980). Generally, both terms are defined as one's sensitivity to, or explicit awareness of, the phonological structure of the words in one's language, or rather the ability to perceive a spoken word as a sequence of individual sounds. Iversen and Tunmer (1993) define phonological recoding skill as the ability to translate letters and letter patterns into phonological forms. This ability may include knowledge of correspondences between graphemes or digraphs and single phonemes; correspondences between groups of graphemes and groups of phonemes; analogies (see also Goswami & Bryant, 1992); or all three types of knowledge.

Generally, at the primary level, phonological awareness is frequently assessed by tasks that require sensitivity to rhyme and alliteration. A typical task might involve identifying which of three words begins (or ends) with the same sound as a target word. For older children, phonological awareness is measured by tasks that require children to identify, isolate, or blend the individual phonemes in words. These more difficult measures of phonological awareness might require manipulation or separation of the sounds in words.

For example, they might be asked to pronounce the first sound of a word in isolation or indicate the new word that is produced if a certain sound is deleted from a longer word. Typically, children do not develop explicit phonological awareness until reading instruction begins in the first grade, although they can frequently perform quite well on simpler measures of phonological sensitivity (i.e., rhyme detection tasks) in Kindergarten (see e.g., Bryant & Bradley, 1985).

2.2.1. Knowledge of nursery rhymes and phonological awareness

In the last two decades, interest has been growing in the role of common linguistic routines such as nursery rhymes, action rhymes, and word games in children's development. Specifically, researchers have focused on the role these games play in early childhood and the role that parents play in introducing these games to their young children. At a basic level, it is obvious the routines have a significant role in family life and the interactions between parents and their young children (Bryant et al., 1989). With analysis, it is quite clear that these linguistic games and developed routines between preschool children and their parents often involve awareness of the component sounds in words (Bryant et al., 1989; Maclean et al., 1987).

Rhymes and alliteration are the clearest example of these linguistic games. Nursery rhymes, songs with rhymes, and rhyming games are a part of the life of a typical three- or four- year-old child, and children show an interest in rhymes by attending and making up their own at an early age (Bradley & Bryant, 1988). This acquaintance with rhymes seems to be an important experience for these children. Certainly the recognition and the production of rhymes are clear examples of developed phonological skills. To recognize, for example, that /cat/ and /hat/ rhyme, it must be understood that the two words, though different, have a sound in common, and that this common sound is a segment of those two monosyllabic words. Furthermore, the recognition that single syllables rhyme involves breaking them into /c-at/ and /h-at/ segments.

Nursery rhymes, therefore, appear to be a good starting point for an investigation of the possible origins of phonological skills, and numerous studies have tried to determine whether children's knowledge of nursery rhymes predicts their phonological awareness. In 1972, MacKay argued that people naturally and automatically divide monosyllabic words into the consonants that precede the vowel and the rest of the syllable. Evidence for this distinction came from speech errors in which people mistakenly combined two words. Later, Halle and Vergnaud (1980) argued in favor of the same distinction on the basis of sequential constraints on sequences of phonemes in other languages. They proposed the use of the terms *onset* and *rime* to describe the two speech units suggested by MacKay. The onset consists of the opening consonant or consonant cluster and the rime of the following vowel and end consonant, if there is one. So /c/ would be the onset and /at/ the rime in /cat/.

The onset-rime distinction was then taken up by Treiman (1983). Treiman showed in a series of simple and convincing experiments, that word games that divide spoken syllables at the onset and rime boundary are easier to learn than games that break these units up. For example, when two monosyllables had to be blended together to form a single new syllable, games that involved dividing the two given stimuli after the onset and then blending together the obtained units, resulted in fewer errors than games that divided the syllables at other points.

If these units are natural speech units, they probably play a part in the speech perception of young children as well. Treiman (1985) has claimed that four-year-old children also divide words into onset and rime. This claim was based on a study in which young children were found to isolate the first sound in a word more successfully if it began with a single consonant than if it began with a consonant cluster. Treiman also concluded that even very young children should be able to isolate and detect some single phonemes with ease, though other phonemes could cause them a great deal of difficulty. Thus, the question posed by Treiman's analysis is not whether young children can detect phonemes, but rather whether some phonemes are easier to detect than others.

Some evidence on this question was provided by Content, Kolinsky, Morais, and Bertelson (1986). They gave four- and five-year-old "prereaders" a series of classification and deletion tasks. In the classification task, the children had to judge which of two consonant-vowel-consonant (CVC) words either began or ended with the same consonant as a target word. The deletion task involved working out what a CVC or CVVC word would sound like if a consonant were removed from that word. The classification, though not the deletion results, appeared to support the onset-rime distinction. The children found it easier to learn to judge whether two words began with the same consonant, than whether they ended in the same consonant.

Kirtley et al. (1989) tried to answer this main question of the Content et al. (1986) study, by administering oddity tasks to 64 children. The children's mean age was five years seven months, and their mean IQ was 110. The aim of the first experiment in their study was to see whether it is easier for young children, and particularly for prereaders, to categorize words by the opening phoneme of CVC words than by their end phonemes. The results showed that the children were correct more often in the Opening Sound task than in the End Sound task–a difference found for both prereaders and readers. Still, when all 64 children were treated as a single group, their performance was significantly above chance level in both tasks (Opening Sound, $p < .01$; End Sound, $p < .05$).

In a 15-month longitudinal study, Maclean et al. (1987) attempted to assess children's knowledge of nursery rhymes and their phonological awareness skills, particularly the detection and production of rhyme and alliteration. Their sample contained 66 children, whose average age when selected was three years three months. During the five testing sessions, the children were given two standardized tests: the British Picture

Vocabulary Scale (BPVS) and the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). The mean ratio scale on the BPVS was 104.99 (SD = 12.81) and the mean WPPSI IQ was 111.08 (SD = 12.22). Various phonological awareness tasks were used during the sessions: knowledge of nursery rhymes tasks, detection of rhyme tasks, detection of alliteration tasks, alliteration production tasks, rhyme production tasks, segmenting tasks, and reading words tasks. The results generally suggested that there were strong relationships between the children's knowledge of nursery rhymes and their scores in various tests of phonological awareness. These scores were also consistent with these in the WPPSI. In general, the results in Maclean et al. supported the belief that children acquire phonological awareness long before learning to read through experiences that, at the time, have nothing to do with reading. A more important conclusion, however, arose from these results. The experiences that children have when they are taught rhymes may play an important part in their growing awareness that words and syllables can be broken into, and can be categorized by, smaller units of sound.

The results of the aforementioned studies seem to be consistent with the relationship between the knowledge of nursery rhymes and children's phonological sensitivity. All the researchers found a strong link between an entirely informal experience early in the child's life and a formal skill which the child acquires some years later. The onset-rime distinction (Kirtley et al., 1989) seems to be extremely important in children's phonological development. It seems that preschool children can categorize words on the basis of single phonemes provided that these phonemes coincide with the basic speech unit of the onset (Kirtley et al., 1989; Maclean et al., 1987; Treiman, 1983, 1985). It also appears as though they do not have to be trained to do so (Lenel & Cantor, 1981; Treiman, 1983). Quite clearly children usually take to rhyme and alliteration before they go to school (Bradley & Bryant, 1988; Bryant et al., 1989; Lenel & Cantor, 1981).

Although the above studies are a good start for understanding the basis of reading skills, our knowledge is limited to knowing that a child's skill in tests of sound categorization at the time he/she goes to school plays an important part in learning to read and to spell. For this reason, studies focusing on the relationship between phonological awareness skills and reading and spelling abilities will be reviewed in the following section.

2.2.2. From nursery rhymes to phonological awareness, reading and spelling

Theoretical interest in the roles of speech-sound processes in reading has motivated much of the reading research done by cognitive, developmental, and educational psychologists (Crowder & Wagner, 1991). Research on the acquisition of beginning reading skills suggests that phonological processing abilities may be causally related to the normal acquisition of beginning reading skills, although little is yet known about the specific relationships and mechanisms that may be at work (Bryant et al., 1989; Ehri, 1987; Torgesen et al., 1992; Torgesen et al., 1994; Tunmer & Nesdale, 1985; Wagner et al., 1993; Wagner & Torgesen, 1987).

Taking into account this theoretical framework, it could be hypothesized that children who are relatively strong in phonological awareness in Kindergarten, before reading instruction begins, typically learn to read more easily than those with relatively delayed development in this area. Indeed, research has shown that correlations between performance on phonological awareness tasks in Kindergarten and word-reading skills at the end of Grade 1 usually fall within the range of .4 and .6 (Bradley & Bryant, 1985; Torgesen et al., 1994).

This empirical relationship is consistent with the idea that some degree of awareness of the phonological structure of words helps to make learning to read words a more understandable task for young children (Torgesen et al., 1994). Without awareness of the phonological segments in words, the English alphabetic system of writing is not very comprehendable. The importance of the alphabetic script and grapheme-phoneme correspondence knowledge in the English language has been emphasized elsewhere in work done by Liberman and his colleagues (see e.g., Liberman, Shankweiler, & Liberman, 1989) and has been complemented by others (Jorm, Share, Maclean, & Matthews, 1984; Juel, 1988; Stanovich, Cunningham, & Feeman, 1984).

Three bodies of research on phonological processing have developed in relative isolation from one another to address the role of phonological awareness in early reading skills acquisition. The first and most developed body of work centers on the aforementioned construct of phonological awareness, the awareness of, and access to, the sound structure of one's language (Maclean, Bryant, & Bradley, 1987; Torgesen et al., 1994; Wagner & Torgesen, 1987). The second centers on the construct of phonological coding in working memory, that is, coding information in a second-based representation system for efficient storage in working memory during ongoing processing (Baddeley, 1982, 1992), and the third centers on the construct of retrieval of phonological codes from a long-term store, that is, retrieving pronunciations of letters, word segments, or whole words from long-term storage (Crowder & Wagner, 1991; Torgesen et al., 1992).

Individual differences in performance on tasks representing each of the three phonological constructs have been related to differential success in the acquisition of beginning reading skills. Little is known, however, about the nature of these individual differences (Wagner et al., 1993). In particular, the majority of studies relating phonological processing and beginning reading have included single measures of only one of the three previously mentioned phonological constructs. There are, however, hundreds of studies on phonological awareness. In the following paragraphs, a review of selected "solid phonological studies" is provided as partial evidence for the strong argument for the importance of phonological awareness skills in reading skills acquisition.

One of the earliest studies conducted to explore children's sound-analytic difficulties was conducted by Bruce (1964) using a phoneme elision task. Bruce found that children below a mental age of 7 were unable to perform the task, although errors made by children above age 6 indicated that they were attending to the phonological features of test words. Above age 7, greater success was evident among children from schools emphasizing a phonic approach to reading, although the ability to spell did not predict successful sound analysis. Not surprising, middle sounds were more difficult to extirpate than first or final sounds. Bruce concluded that "a certain level of basic mental ability is necessary before the child can analyze words in this way" (p. 167). Indeed, it is hard to imagine how a child could make sense of instructions to remove sounds from words unless he/she had some means of representing and thinking about sounds as separate entities (see also Rosner and Simon, 1971).

Torgesen, Wagner, and Rashotte (1994) used two different models and four different tasks to examine the causal relationships between phonological awareness and reading in 288 children (M = 5 years, 8 months). Children who did not pass a screening measure designed to detect gross articulation difficulties were not accepted into the sample (Bryant & Bryant, 1983; cited in Torgesen et al., 1994). All the measures of phonological awareness did not assess the same construct, but, rather, assessed two distinct but correlated constructs. One of these constructs, *phonological analysis,* was composed of tasks that required children to identify the sounds within the words that were presented as wholes, whereas the other construct, *phonological synthesis*, represented children's ability to blend separately presented phonological segments into whole words. Based on these two constructs, Torgesen et al. used the following four tasks: *Naming Digits-Isolated*, which involved naming digits as rapidly as possible that were presented one at a time on a computer screen, *Naming Digits-Serially*, which required children to name, as rapidly as possible, a series of digits presented on a card, *Naming Letters-Isolated*, which was the same as the

Naming Digits Isolated task, except that high frequency letters were used instead of digits, and finally, *Naming Letters-Serially*, which was the same as the Naming Digits. Because there were two obvious ways in which these tasks differ from one another (digits vs. letters & serial vs. isolated presentation), they tested two different measurement models that reflected these differences.

The correlation between measures of each construct given in Kindergarten and Grade 1 were .87, .71, .78, and .81, for analysis, synthesis, isolated naming, and serial naming, respectively. The correlations between Kindergarten and Grade 2 testing for the same variables were .66, .49, .65, and .62, respectively. These results indicate that individual differences in reading-related phonological skills are remarkably stable during the period in which children are receiving early reading instruction (see also Juel, 1988).

Similarly, Kirtley et al. (1989) examined the relationship between phonological awareness and reading during the second experiment of their study. They developed four different conditions, based on the results of the first experiment, that focused on the onset-rime distinction. Under the first condition, the children had to make their judgments on the basis of a single phoneme. This was a repeat of the first experiment and the aim was to replicate their previous result that the Opening Sound task would be easier for the children than the End Sound task (i.e., /mop/, /lead/, /whip/). In the second condition, the two common words shared a consonant and a vowel, and the odd one contained neither that consonant nor that vowel. Thus, in the Opening Sound task, the two common words shared the same onset (i.e., /cap/, /doll/, /dog/) and in the End Sound task, the same rime (i.e., /top/, /rail/, /hop/). They predicted that both tasks would be easy for children to complete. In the third condition, all three words (the odd one included) either began or ended with the same consonant; however, the odd one contained a different vowel sound and thus, the task involved making a decision about the middle sound (i.e., /lip/, /hop/, /tip/). Because the vowel sound is part of the rime, this meant that all the words had the same onset in the

Opening Sound task (i.e., /cap/, /can/, /cot/) but that the odd word had a different rime from the two common words in the End Sound task. Thus, they predicted that the children would find the Opening Sound task relatively difficult and the End Sound task, relatively easy. Finally, in the fourth condition, the common words either began (Opening Sound) or ended (End Sound) with the same consonant that the odd word did not contain, but all three words contained the same vowel (i.e., /can/, /cap/, /lad/ or /tip/, /hid/, /lid/). Again, they predicted that children would find both of these tasks easy to complete.

The multiple regression analysis, with reading age as the dependent variable, showed a closer relationship between End Sound scores and reading than between Opening Sound scores and reading. There was a particularly strong connection between the task in which children had to categorize words only by their final consonant and the children's reading skills. This relationship suggested that a major step in learning to read may take place when the child learns to break the rime into its constituent sounds by detaching the preceding vowel from the final consonant. In general, though, both Opening and End Sound tasks were strongly related to reading.

Liberman, Shankweiler, Fischer, and Carter (1974), attempting to explain how the child becomes able to segment the sound structure of spoken words and whether this skill is related to reading skills, saw this development as a consequence of intensive instruction in reading and writing, perhaps through cognitive maturation. However, they made the incontestable point that if the beginner is to take advantage of the alphabetic system in learning to read, he/she must become aware of "the phonemic segments in words so that these can be matched up to the corresponding letters in printed words" (p.96).

Liberman and Shankweiler (1979), in a later work, confirm the relationship between phoneme segmentation and early reading acquisition. They cite Helfgott's work (1976), which examined a number of skills in Kindergarten and found that the best predictors of reading achievement, measured (by WRAT - Wide Range Achievement Test) the following year, was the ability to segment spoken CVC words into their three constituent phonemes, with a correlation of r = .75. Studies by Treiman (e.g., 1983), which employed different procedures and populations of children, obtained essentially the same highly significant relationship. These findings lead the authors to conclude that a lack of awareness of phonemic segmentation may be one of the serious roadblocks to reading acquisition.

Similarly, Lenel and Cantor (1981) and Maclean et al. (1987) support the belief that the phonological skills measured at three years of age may be good predictors of early reading competency. The only thing we need, according to these researchers, is to confirm this through longitudinal studies once we have established that preschool rhymes are related to phonological awareness.

We can conclude from these studies, as well as from many similar others and reviews (e.g., Ehri, 1979; Leong, 1986; Lundberg, Olofsson, & Wall, 1980; Stanovich, 1986), that phonological segmentation and reading ability are closely related. However, the evidence presented has been primarily correlational, meaning that individual variations in both capabilities have been produced by "nature". As a result, it is not clear whether one causes the other, and if so, which causes which (see e.g., *the chicken egg debate* by Rayne & Pollatsek, 1989, pp. 341-346). Thus, a very interesting question naturally arises concerning the kind of relationship which exists between phonological awareness and reading: whether, for instance, the improvement of metaphonological skills has a positive effect on the acquisition of both spelling and reading skills. As Perfetti et al. (1987) have proposed, supporting the bidirectional path in correlational designs would leave the reading researchers the opportunity for alternative interpretations. For example, according to Ehri (1979), the correlation can be interpreted in at least two ways: learning to read may be a prerequisite for becoming aware of phonological structures; or, alternatively, linguistic awareness may be a prerequisite for reading skills acquisition. A weaker interpretation is that reading acquisition facilitates the development of linguistic (alphabetic and phonological awareness), and/or linguistic awareness, in turn, is a facilitator for reading acquisition. What Goldstein (1976), in an earlier study, concludes is probably true: "phonological sensitivity would appear to be a facilitator of reading acquisition rather than a prerequisite or merely a consequence" (p. 686).

Longitudinal studies, in which phonological awareness has been assessed in Kindergarten and the progress of reading acquisition has been measured in school (e.g., Lundberg et al., 1980), have to some extent helped to clarify the issue by indicating that phonological awareness may be necessary, but not sufficient, for the acquisition of reading. Because they focus on identifying the predictors of early reading, especially when going beyond the variance accounted for by phonological awareness in reading, longitudinal experiments have provided better explanations. As Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher (1996) have noted, "the use of longitudinal assessments to measure developmental rates makes early detection of learning problems *a realistic possibility*" (p. 15, my emphasis). Guided by this premise, the purpose of the present longitudinal study is primarily to predict the factors that contribute to reading failure or success. Early identification of these factors can lead to more efficient remedial training and assessment of the weak processes of weak young readers. The selected correlational studies presented in the next section, focus on factors that predict early reading in normal distributed populations. Their findings are discussed in relation to the objectives of the current study, which employs 'at-risk' readers.

2.3. Longitudinal studies predicting reading

It has been consistently argued by many researchers in the reading field that longitudinal studies provide clearer and more valid results for the variables involved in reading development (e.g., Blachman, 1994; Ellis & Large, 1988; Francis et al. 1996; Satz

& Fletcher, 1988). A selection of the most well-designed studies of this kind follows. Particular emphasis is given in a discussion afterwards to an examination of the factors that may be used to explain reading disability in young at-risk readers.

One predictive longitudinal study was conducted by Ellis and Large (1988), who traced the reading development of 40 children from five to seven years of age. Ellis and Large showed that the nature of reading skills changes rapidly in the first three years of acquisition. At very preliminary levels of reading, letter knowledge, phonological awareness, and short-term memory (STM) best predict the future of reading development. On the second level, equated by Ellis and Large to Frith's (1986) logographic stage, "holistic visual perception skills" gain significance. Stage 3 capitalizes on the earlier development, but it is again more concerned with phonological awareness, sound-symbol conversion, and auditory STM. Ellis and Large suggest that both letter order and phonological factors are now important, and equate this stage with the alphabetic stage in Frith (1986) and the sequential decoding stage in Marsh, Friedman, Welch, and Desberg (1981). In the last stage, grapheme-phoneme correspondence rules become more extensive and automatic, and grammatical and linguistic knowledge together with analytic visual perceptual skills gain new importance. In sum, Ellis and Large seem to describe a developmental sequence running from recognizing letters to recognizing familiar words by sight, and then further to decoding unfamiliar words and recognizing larger units than individual graphemes. Each step builds on the previous step; at the same time, it is obvious that each step requires different cognitive processes for successful completion.

Following their initial study (Bradley & Bryant, 1983) which established the relationship between nursery rhymes and phonological awareness, Bryant, Bradley, Maclean, and Crossland (1989) examined the possible connections between nursery rhyme knowledge and later reading ability. Their prediction was that early nursery rhyme scores are not related to later reading and spelling, if one controls for the effects of phonological sensitivity at the time of the later reading or spelling measures. If, as they claim, nursery rhymes enhance reading via the child's phonological sensitivity, then controlling for the extent of phonological sensitivity should remove the connection between nursery rhymes and reading. Based on this prediction, they carried out a path analysis with five variables: the children's knowledge of nursery rhymes (at 3.4 years of age), their IQ scores, their rhyme detection (at 4.7 years), phoneme detection (at 6.3 years), and reading (at 6.3 years). The model that they tested was based on this path from nursery rhyme knowledge to reading through rhyme and phoneme detection in order to provide more reliable results (instead of going from nursery rhyme knowledge directly to reading).

The analysis supported their model, by suggesting that nursery rhyme knowledge affects phonological sensitivity (rhyme and phoneme detection), which, in turn, affects reading. Children who were weak on nursery rhyme tests at the beginning of the study still had problems with their reading later on. Bryant et al. (1989) concluded that there is a causal relationship between nursery rhymes and reading. Familiarity with nursery rhymes enhances children's sensitivity to the component sounds in their language and that, in turn, affects their progress in reading and spelling.

In an earlier study, Share, Jorm, Maclean, and Matthews (1984) measured a variety of skills in 543 children at the school-entry level (end of Kindergarten) in order to find predictors of later reading (Grade 1). Their predictor variables included five measures of early literacy skills (name writing, letter names, name reading, letter copying, and recognition and discrimination of letters and numbers), six measures of oral language ability (including a simultaneous verbal task, Northwestern Syntax Screening Test, and a successive task, Sentence Memory, quite similar to two of the tasks used in my study, Simultaneous Verbal and Sentence Repetition and Question; see Method section), two tests of motor skills, and three measures of phonological awareness. Simple correlations between individual attributes at school entry and reading achievement at Kindergarten and Grade 1 indicated that phoneme segmentation, letter names, and letter copying were at the top of the predictors list in reading for both Kindergarten and Grade 1. However, both the Sentence Memory task and the Syntax Screening Test were highly correlated with reading in both years. The Sentence Memory task was also a significant predictor of Grade 1 reading after controlling for the effects of phoneme segmentation, letter copying, sex, and letter name knowledge. These results are consistent with studies that have been conducted using PASS tasks (Das, Naglieri, & Kirby, 1994), which have shown that both simultaneous and successive processing are important determinants of early reading.

Taking a different approach, Juel (1988) traced the reading development of 54 children from Grade 1 to Grade 4. Based on the Simple View of reading and writing, the decoding skills of the children were examined along with both listening and reading comprehension skills. One of the most important findings was that children who were poor readers at the end of Grade 4 entered Grade 1 with little phonemic awareness, and by the end of Grade 4, still had not achieved the level of decoding skill that the good readers had achieved at the beginning of Grade 2. The probability of a child remaining a poor reader throughout the period studied was extremely high (.88), as was the probability of a good first-year reader maintaining a good reading performance in later grades (.87).

The only study that has traced the reading progress of at-risk children on a two-year basis is the study conducted by Felton and Brown (1990). The aim of their study was first, to determine the intercorrelations among phonological processing tasks, and second, to determine the relationship of such tasks to early reading. Eighty one Kindergarten children were drawn from a larger population of 991 children as being at-risk in reading, following certain (ex)inclusion criteria (51 males and 30 females, mean age 6.2 years). The participants were assessed through a series of phonological awareness tasks (e.g., Rhyme Production), phonological recoding in lexical access tasks (e.g., Boston Naming Test), one Phonetic Recoding in Working Memory task, the Word String Memory Test (similar to one of the successive tasks used in my study: see Method section, Word Series task), and reading outcome measures from the Woodcock-Johnson Reading battery. Correlations obtained between Kindergarten research tests and Grade 1 reading without IQ partialled out (i.e., scores from Otis-Lennon Mental Ability Test) showed that rapid naming of letters, objects, and numbers emerged as good predictors of Word Identification and Word Attack scores along with the counting of syllables and initial consonant segmentation. However, with IQ partialled out, none of the independent variables were shown to be good predictors of Word Attack scores, whereas only the former ones (rapid naming variables) were shown to be good predictors of Word Identification scores. According to Felton and Brown, these results seem to be quite contradictory to the results obtained from the majority of the reading-prediction studies which employ populations from the entire reading continuum. In that case, phonological awareness tasks seem consistently highly correlated, with subsequent reading measures comprising the primary predictors of reading ability. However, in the case of an at-risk population, such a prediction is not an easy task, and according to Felton and Brown, requires "the investigation of numerous factors in addition to phonological processing skills" (p.57).

As we have seen from the previously mentioned studies, and retrieving the information we have already obtained from the "solid phonological studies", tracking the development of cognitive processes or abilities through a primary focus on reading-related phonological skills is not an appropriate way to examine a normally distributed reading population, and certainly not an at-risk reading population. Because of the influence of cognitive factors, the relationship to reading acquisition is not so transparent and, therefore, is disregarded (see also, Papadopoulos, Parrila, Das, 1997; Papadopoulos, Parrila, Das, & Kirby, 1997). As Share (1994) further suggests, "the term 'phonological processing' should be reserved strictly for abilities evident in non-reading tasks, and whose development is not primarily contingent on literacy experiences" (p.149).

Assessment of at-risk participants using a set of measures that are not directly related to reading competence, but which can provide us with necessary information to better understand the cognitive processes involved in such a complex activity as reading, appears to be essential. This approach certainly requires a well-grounded theoretical framework that should meet two basic criteria: (a) to treat phonological awareness not as a "unitary, invisible insight or ability", but rather to provide, more operating interpretations of reading disability (Juel, 1988; p. 437) and (b) to go beyond phonological coding in order to detect those cognitive processes that collectively account for an equal variance in early reading ability, in the same way as phonological coding. Stronger support for these arguments is provided when cognitive profiles of at-risk children are examined. The following section provides a selection of the most interesting studies in this investigation.

2.4. Cognitive profiles of children who experience reading difficulties

2.4.1. An introduction to the wonder of understanding reading disability

In one of the most frequently cited articles in the field, Torgesen, Wagner, and Rashotte (1994) argue that phonological processing abilities are causally related to normal acquisition of reading skills. Support for this claim can also be found in the relationship between prereaders' phonological processing scores and their reading development one to three years later (e.g., Bradley & Bryant, 1985). Moreover, children with reading difficulties have been found to perform poorer than their normal-reading peers in tasks as varied as repeating random word or digit series, rapid naming of letters and sounds, or consecutively repeating nonsensical sentences or series of words (Das, Mishra, & Kirby, 1994; Das, Mok, & Mishra, 1993; Kirby, Booth, & Das, 1996; Shankweiler et al., 1995; Watson & Willows, 1995). In a recent review, Share and Stanovich (1995a, p. 9) concluded that "there is virtually unassailable evidence that poor readers, as a group, are impaired in a very wide range of basic cognitive tasks in the phonological domain."

The role that other cognitive processes play in early reading acquisition, however, is an issue considerably less agreed upon. Share and Stanovich (1995a) suggested that phonological deficits have not been found to be attributable to nonphonological factors such as IQ, semantic processing, and visual processing. Considering these suggestions, can we then conclude that phonological processing is an independent "module" of the mind, something that functions independently and is not even developmentally affected by more basic cognitive processes? Or perhaps the alternative is true, and the negative results can be explained by the fact that the researchers have not found the correct underlying cognitive processes to explain phonological processing and reading difficulties.

Even if the phonological processes are independent and "modularized" and reading difficulties do not generalize into tasks unrelated to reading, we still have the problem of unexplained variance in reading ability. Although correlations between phonological processing and word recognition ability are high, they still leave reading variance unaccounted for. In this case, the question is as follows: Do other cognitive processes add to the explanatory power of a model predicting reading acquisition?

The search for the relevant cognitive processes has to be constrained, however. The first constraint, also acknowledged by Share and Stanovich (1995b), is that the suggested cognitive processes, as well as the tasks that are used to operationalize them, have to be theoretically meaningful and appropriate in terms of reading acquisition. The second, educational constraint is that the diagnosis of such processes is not alone sufficient, but should further have implications for remediation (Das, Papadopoulos, Parrila, & Kirby, 1997; Papadopoulos et al., 1997; Parrila & Papadopoulos, 1996). The PASS (planning, attention, simultaneous, and successive) model's cognitive processes and the tasks used to operationalize them meet both these constraints (Das, Parrila, & Papadopoulos, 1997). The relations between PASS components and reading skills have been recently explained elsewhere (see e.g., Das, Naglieri, & Kirby, 1994; Kirby, Booth, & Das, 1996). In terms of this research, it is sufficient to say that successive processing, in particular, has consistently correlated highly with early reading abilities (see e.g., Das, Mishra, & Kirby, 1994; Kirby, Booth, & Das, 1996).

2.4.2. Differentiating good from poor readers

In the context of information-processing models of reading, it is assumed that understanding texts involves the coordination of a number of cognitive processes ranging from phonological awareness (Adams, 1990; Cataldo & Ellis, 1988; Kirby, Beggs, & Martinussen, 1995; Torgesen, Wagner, & Rashotte, 1994; Wagner & Torgesen, 1987) to decoding and word reading (Byrne, Freebody, & Gates, 1992; Das, Mishra, & Kirby, 1994; Freebody & Byrne, 1988; Frith, 1992). Several studies have also tried to show the significance of memory span to reading and comprehension as a function of cognitive processing speed (Bisanz, Das, Varnhagen, & Henderson, 1992; Das, Mensink, & Mishra, 1990; Das & Mishra, 1991; Das, Mok, & Mishra, 1993), as well as the role attention plays in such a complex activity as reading (Das, 1993a; Gardner, 1979; Hynd, Morgan, Edmonds, Black, Riccio, Lombardino, 1995; Hynd, Semrud-Clikeman, & Lyytinen, 1991; Light, Pennington, Gilger, & DeFries, 1995; Rudel, 1985; Snart, Das, & Mensink, 1988).

Despite the numerous attempts to identify the cognitive processes involved in reading and the causal factors for reading disability, no definite results appear. One reason for this may be a lack of specificity in the operational definition of the term *reading disability*. The use, for instance, of mental age and IQ as the critical measures separating good from poor readers (see e.g., Dolch & Bloomster, 1937) did not seem to provide the appropriate means for such a distinction. As Stanovich (1986) states, letter recognition and phonological awareness not only exceed mental age (as measured by IQ tests) in predicting successful reading acquisition, but seem causally related to reading acquisition. This implies that only when children do have these skills, can reading instruction be fruitful. In addition, individual differences in these two skills seem quite independent of mental age (as measured by IQ tests), suggesting that they may be acquired by children of high and low mental age alike (Biemiller, 1978; Stanovich, 1986). Various studies have also shown no significant differences between high and low IQ groups on reading measures (Das, Mensink, & Mishra, 1990; Hurford, Schauf, Bunce, Blaich, & Moore, 1994; Kirby, Booth, & Das, 1996; Snart, Das, & Mensink, 1988). Hurford and his colleagues (1994) found that intelligence has no effect on children's performance on tests for reading or phonological processing. In addition, Siegel (1989a, 1989b, 1992) states that the use of intelligence tests might prevent some children, who are reading disabled in some way from being identified. Alternatively, Torgesen (1988) argues that measures of intelligence are important in demonstrating, particularly in research settings, that academic or performance differences between groups with reading disabilities and comparison groups are not the result of intellectual differences.

As I have argued so far, the lack of a theoretical framework that could present both a comprehensive, modern account of cognitive processes (especially those regarding reading, see also Share & Stanovich, 1995b) and the appropriate instruments with which to measure them appears to be a second serious impediment to progress. To balance this, many researchers have tried, instead, to identify subtypes of childhood dyslexia in order to increase current knowledge of specific reading difficulties and to provide effective treatment (Masutto, Bravar, & Fabbro, 1994; Watson & Willows, 1995). Such an approach, however, does not necessarily solve the problem. Different subtypes of children with reading difficulties may be accompanied by certain characteristics and analogous neurolinguistic and neuropsychological deficits, but much needs to be done to understand the causes and processes underlying the different types of dyslexia (Masutto et al., 1994).

Some researchers are trying to understand reading difficulties by examining the processes involved in reading of "skilled" readers. In an attempt to describe the cognitive and linguistic processes that operate concurrently, automatically, and synchronously in the "skilled" reading and understanding of text, Ehri (1995) defines the following linguistic and cognitive processes as mediators: (a) the knowledge of the language, (b) the knowledge of the world, (c) metacognitive knowledge, (d) memory of the text, (e) knowledge of the grapho-phonic system, and (f) the lexicon access. *Knowledge of language* consists of the syntactic, the semantic, and the pragmatic perspective of language, and enables readers to process sentences and their meanings. *Knowledge of the world* includes both encyclopedic and experiential knowledge and supplies readers with a background for understanding new ideas in a text. *Metacognitive knowledge* is the monitoring of readers to verify that the information provided by the text makes sense and meets specific purposes. Alternatively, *memory of the text* enables readers to keep in mind previously processed meanings and consequently to interpret incoming text with relative ease. *Knowledge of the grapho-phonic system* involves knowing the correspondence between letters and sounds and how the letters can be transformed into blends of the sounds of known words. Finally, *lexical knowledge* refers to the readers' vocabulary held in memory. Some of these words are known by speech, and some are known by print, or rather by sight.

Research in the field of reading has dealt with all these six processes. Research that focuses on phonological awareness corresponds to the grapho-phonic process (Bradley & Bryant, 1985; Kirby et al., 1995; Kirtley, Bryant, MacLean, Bradley, 1989; MacLean, Bryant, & Bradley, 1987; Torgesen, Wagner, & Rashotte, 1994; Wagner & Torgesen, 1987). Using a variety of tasks (i.e., rhyming tasks, blending tasks, phoneme manipulation tasks, and phonemic segmentation tasks), it has been shown that phoneme awareness, the ability to analyze words into consonant and vowel segments, is necessary for mastery of an alphabetic writing system (Cataldo & Ellis, 1988). It has also been shown that the patterns of performance of poor readers in phonological tasks indicate that their awareness of sounds is so weak that it prevents them from becoming relatively good readers (Byrne et al., 1992; Hurford et al., 1994). Besides, their performance on measures of phonological coding usually shows a stable pattern across two or three years (e.g., Watson & Willows, 1995), justifying the so-called phenomenon of *Matthew effects* (Stanovich, 1986): the "rich-get-richer" and the "poor-get-poorer".

One of the representative studies in the area of reading, which focuses on phonological awareness and subsequent reading skills, is a recent study conducted by Hurford et al. (1994). Hurford and his colleagues examined the development of phonological and reading skills in 171 students (98 males, 73 females) from the beginning of Grade 1 to the end of Grade 2 in four consecutive testing periods. Based on their reading and intelligence scores at the end of Grade 2, these students were placed into nondisabled, reading disabled, or "garden-variety" poor reading groups. The subsequent analysis showed that, although each group made gains in phonological processing, significant differences in both phonological awareness and reading measures were found between the participants without reading problems and the other two groups. The most important finding of the study, however, was that reader-group membership at Time 4 could be very accurately determined from students' Time 1 scores. All of the children in the two groups with reading problems were correctly identified, and only 3 of the 148 children in the group without reading problems were misclassified by the end of the project. According to Hurford et al., this result indicates that children at risk for reading difficulties can be very accurately identified very early in their academic experiences.

Alternatively, Shankweiler et al. (1995) conducted a study to explore the possibility that poor readers in the early elementary grades have difficulties in the morphological and syntactic domains that cannot be explained by a unitary phonological deficit. In terms of Ehri's (1995) interactive model, their work would more appropriately describe the knowledge-of-language domain. Comprehensive testing of linguistic and nonlinguistic abilities was carried out on 353 children, aged 7.5 to 9.5 years, and representing a wide range of intelligence levels, recruited for disabilities in reading, arithmetic, and attention. The experimental language tasks measured phonological, morphological, and syntactic components. The phonological measures included tests for phonological awareness (i.e., phoneme deletion) and verbal short-term memory (i.e., random word sequences, digit sequences, and sentence repetition). In the morphological awareness measures, children were asked to extract the base from the derived form, using the same close procedure to prompt production of the target word (e.g., get the word /fourth/ from the target word /four/). In the tests for syntax, a sentence-picture matching procedure was used (see Simultaneous Verbal task in the Method section). Tape-recorded versions of syntactically unambiguous or ambiguous sentences were presented and their corresponding pictures were presented synchronously by computer. Syntactic complexities centered on relative clauses, passives, control properties of adjectives, and pronoun co-reference.

The findings affirmed that deficits in phonologically driven tasks (i.e., random word sequences, digit sequences, and sentence repetition) are a common denominator in children with reading disability. In addition, the morphology-dependent skills were found to be deficient in poor readers. The syntax test, in contrast, did not discriminate good from poor readers either in numbers of errors or in distribution of errors across the various syntactic constructions. The failure to find differences between good and poor readers in the latter case indicated that the children's problems with this sentence comprehension task were not related to the (chiefly phonological) differences that distinguished the good and poor readers.

The work by Shankweiler et al. (1995) could be reasonably incorporated in the PASS (Planning, Attention, Simultaneous, and Successive processing) model developed over the last two decades by Das and his colleagues (Das, 1993a; Das et al., 1990; Das & Mishra, 1991; Das, Mishra, & Kirby, 1994; Das et al. 1993; Kirby, Booth, & Das, 1996; Snart et al., 1988). Based on Luria's (1966) work on adults with brain damage, the model offers a view of intelligence and individual differences that is consistent with neuropsychological and cognitive research. It is suggested that two out of the four components of the model, simultaneous and successive processing should be most highly related to reading skills, with simultaneous processing more strongly related to comprehension and successive processing more strongly related to word decoding (Das et al., 1994; Kirby & Williams, 1991). These predictors derive from the need for simultaneous processing in the relating of meaningful units and their integration into higher level units, and from the involvement of successive processing in the sequential analysis and blending of phonemes and syllables (Kirby et al., 1996). If that is the case, then simultaneous processing could be matched on an abstract level with both memory of text and lexicon access, as defined in the interactive model proposed by Ehri (1995). Alternatively, successive processing appears to require both knowledge of language and knowledge of the grapho-phonic system. Planning, finally, requires metacognitive knowledge, whereas knowledge base seems to support the whole model.

In a recent study, Kirby, Booth, and Das (1996) investigated the PASS components that best differentiate children with reading disabilities from normally achieving children, and those that differentiate high-IQ children with reading disabilities from average-IQ children with reading disabilities. The 30 children in the sample of this study represented approximately 40 percent of the children with reading disabilities within the 9.5 to 11.8 year age range in the same school board jurisdiction. Participants in the control group were selected either from the same classrooms (chronologically matched) or from the same schools and performed equivalent reading skills as the children with reading disabilities (reading abilities matched). Reading ability was measured with the Word Attack, Word

Identification, and Passage Comprehension subtests of the Woodcock-Johnson Psycho-Educational Battery. In conjunction with these measures, two measures of planning, two attention measures, two measures of simultaneous processing, and four measures of successive processing were used to better identify the cognitive profiles of good and poor readers. The results supported the first two hypotheses of this study: that the average-IQ children with reading disabilities would perform the same as their reading age controls and worse than their chronological age controls on a variety of cognitive measures linked theoretically to reading disability. The first and the latter group were significantly different in two measures of successive processing (i.e., Naming Time & Word Series, $p < .001$ and $p < .05$, respectively), one planning task (i.e., Planning Connections, $p < .05$), one simultaneous processing task (i.e., matrix analogies, $p < .001$), and all the four reading measures (for all of them, $p < .001$).

Similarly, Snart, Das, and Mensink (1988) conducted a study with high- and low-IQ students with and without reading disabilities, in order to examine the cognitive processes of these four different groups in the areas of successive, simultaneous processing, attention, and planning. In general, the results showed that the advantage high IQ gives to LD (Learning disabled) students is associated with higher than average simultaneous processing, but this advantage appears to be lost in successive processing. The selective attention tasks with physical and name match requirements again revealed the superiority of the participants without reading disabilities over the participants with reading disabilities only when lexical access, rather than direct visual matching, was required. The planning tasks also discriminate between the children with and without reading difficulties. These results seem to verify the interactive model proposed be Ehri (1995), in which lexical access and metacognitive knowledge are essential processes for effective reading and subsequent comprehension of a text.

Das, Mensink, and Mishra (1990) also investigated the cognitive processes that better separate good and poor readers, examining the performance of 45 children (24 boys and 21 girls) with reading problems and 95 children without reading problems on a series of twelve tests from the Das-Naglieri Cognitive Assessment System (CAS) Experimental Test Battery. The MANCOVA (Multivariate Analysis of Covariance) results on good and poor readers showed that four of the PASS tasks distinguished them clearly; these required articulation, although three of them measured successive processing, while the fourth (i.e., Stroop Color-Word) was a selective attention test. Nevertheless, this test also requires successive processing because it involves rapid naming of color of words in sequence. Two additional tests, one planning and one simultaneous, also discriminated between the participants when the contrast in reading disability was reduced by considering three reading groups (i.e., good, average, and poor), rather than two. In general, the authors stated that "...discriminating the good from poor readers requires a group of cognitive tests which involve speech articulation" (p. 431).

Almost identical results were revealed in two other similar studies conducted by Das, Mishra, and Kirby (1994) and by Das (1993a). In the first one, all three successive processing measures that were used (i.e., Word Series, Naming Time, and Speech Rate) were quite successful in distinguishing between children with and without reading problems. The two groups also differed significantly on three other measures that required articulation or phonological coding (i.e., expressive attention, receptive attention, and phonemic segmentation). In the second study, groups of readers, matched according to reading level on the one hand and according to school Grade on the other, were compared in two attention tasks from the CAS Battery. The participants with reading problems appeared to have deficiencies in selective attention at the reception stage (Posner tasks) as well as at the stage of expression (Stroop test) and performed significantly differently from participants without reading problems. Das (1993a) states that this difference is reasonable, considering that both tasks used in the study require phonological coding in one part, but do not require it in the other part (i.e., physical match, color naming).

Another very interesting study that focused on the investigation of the cognitive processes of poor and good readers is the study conducted by Watson and Willows (1995). The purpose of this study was to investigate possible causes of written language difficulties among individuals who have no apparent oral language deficits. To meet this aim, preliminary screening tests were used to select a sample of children among whom reading achievement varied widely, but oral language and nonverbal reasoning were at average levels or above. The potential contribution of a range of processing factors (i.e., auditory-linguistic, visual/symbolic processing, and processing of linguistic/symbolic connections) to reading success and failure at early and later stages of reading development was examined. This was achieved by comparing the performance of first graders who were successful in reading acquisition at the performance levels of both age-matched and reading-level-matched students who were experiencing difficulty (n = 25 for each group). The processing factors were entered in a R-factor analysis (principal factor with a varimax rotation) in order to summarize the interrelationships among them. The factor loadings obtained in Factor Analysis of the initial 19 test battery measures were as follows: Factor 1, symbolic processing/memory; Factor 2, rapid automatized naming; and Factor 3, visual processing.

Significant differences were observed between the chronological age-matched groups on four measures from the symbolic processing/memory factor (i.e., visual form of sounds, reading symbols, spelling, and digit span) and two measures involving the rapid naming of letters and numbers from the rapid automatized naming factor. According to Watson and Willows (1995) these results make it conceivable that a deficiency in basic processing (short-term/working memory) is the underlying problem that results in deficiency in achievement (reading/spelling). These results seem to be consistent with other two studies by Das and his colleagues (Das & Mishra, 1991; Das, Mok, & Mishra, 1993), where it was shown that children with reading disabilities were found to have a short memory span, slow naming time, and slow speech rate. In the reading-level-matched group comparison, significant differences were observed on six of the seven variables that made up the symbolic-processing memory factor (i.e., spelling, reading symbols, digit span, visual form of sounds, sound blending, and sound analysis) as well as on the measure within the visual processing factor that involved remembering sequences. The latter result appears to be highly correlated with the successive processing discussed previously in studies conducted by Das and his colleagues (Das, 1993a; Das et al., 1994; Das et al., 1990; Kirby et al., 1996; Snart et al., 1988).

A different kind of approach for examining the cognitive patterns of poor readers was developed in two longitudinal studies by Freebody and Byrne (1988) and Byrne, Freebody and Gates (1992) where they examined the relation of word-reading strategies used by second and third Grade students to their comprehension, reading time, and phonological awareness. In both studies, the authors focused on the students' relative reliance on decoding versus sight-word associations, and on the relations between their use of these strategies and their performance on other reading-related measures. In the first study, students were clustered on the basis of their performance on grade-appropriate lists of irregularly spelled words (e.g., /laugh/) and nonsense words (e.g., /lemat/). Based on this discriminant pattern, four different groups of students were identified in each grade: (a) a large group performing substantially above average on both measures, (b) a smaller group performing substantially below average on both measures, and (c) two crossover groups. One of these crossover groups, which Freebody and Byrne called "Chinese" readers, performed substantially worse on their reading of nonsense words relative to irregular words. The other crossover group, "Phoenician" readers, showed the opposite pattern: superior performance on nonwords relative to irregular words. Thus, whereas the Chinese students were impaired in decoding relative to their word-specific knowledge, the Phoenicians could decode adequately but displayed below-average stocks of sight words.

In both grades, on the measures of reading comprehension, reading time, and phonological awareness, the good readers were superior to the other groups combined, and the poor readers were worse than the rest. Comparison of the Chinese and Phoenicians revealed that the former were faster readers than the latter at both Grade levels, confirming the picture of Phoenicians as "plodders" who lack automaticity in their reading (Nicolson & Fawcett, 1990). In reading comprehension, an interesting Chinese-Phoenician interaction emerged at each grade: in Grade 2, the Chinese readers scored higher on comprehension than the Phoenicians, whereas in Grade 3 the pattern was reversed. The authors interpreted this interaction as suggesting that word-specific associations may serve a student adequately up to Grade 2, but that failure to acquire and use efficient decoding skills would begin to take its toll on reading comprehension by Grade 3. They speculated that the loosening of vocabulary controls in reading material, which occurs after Grade 2, may strain memory resources for sight words, and in the absence of decoding skills, comprehension may deteriorate. This pattern is supported by Ehri's (1995) work as well. According to her findings, sight words are secured in memory through the application of letter-sound knowledge. The sight-word strategy, however, cannot always enhance effectiveness in reading. Sounding out letters and blending them into pronunciations that approximate real words (the so-called phonological coding) is a more secure strategy, which readers may employ to read words they have never seen before.

2.4.3. Summary and conclusions on the wonders of reading disability

In the first part of the foregoing review I discussed the relevance of phonological coding as a core deficit in reading disability, as well as the irrelevance of IQ in determining core deficits in reading disability. Although it seems from the review of all of the above studies that these two points are generally accepted, investigating the cognitive profiles of poor readers does not appear to be an easy task.

In general, all of the reviewed studies affirm the interactive model proposed by Ehri (1995), denoting six different processes involved in successful reading. The information-processing deficits of the poor readers appear usually to be associated with certain cognitive profiles. Poor readers seem to have difficulty in any kind of phonologically driven tasks such as random word sequences or word series, digit sequences or rapid naming of letters and sounds, sentence repetition and speech rate (Das et al., 1994; Das, 1993a; Das & Mishra, 1991; Das et al., 1994; Kirby et al., 1996; Shankweiler et al., 1995; Snart et al., 1988; Watson & Willows, 1995). They were also found to have weak morphology-dependent skills (Shankweiler et al., 1995) and inferior performance compared to their chronologically matched peers on measures of planning (Kirby et al., 1996; Snart et al. 1988) and measures of attention (Das, 1993a; Das et al., 1990; Snart et al., 1988). The results appear to be contradictory only in the case of simultaneous processing, where the chiefly phonological differences between the good and poor readers are not seen to be always related to this type of processing (Kirby et al., 1996; Shankweiler et al., 1995; Snart et al., 1988).

Reduced memory span in poor readers is also evident in a variety of verbal materials, including digits, letters, unrelated strings of words, and sentences, as well as namable objects, and even nonsense shapes that can be verbally encoded (Das & Mishra, 1991; Das, Mok, & Mishra, 1993; Jorm, Share, Maclean, & Matthews, 1984; Siegel, & Ryan, 1988; Watson & Willows, 1995). It could be argued, however, that short-term memory deficit appears to be specific to tasks requiring phonological coding, because there is no reliable evidence for memory deficits when phonological coding is not required, as in visuospatial or motor tasks (Baddeley, 1986; Jorm, 1983). Jorm (1983) noted that when verbal coding was controlled, these between-group differences generally disappeared.

A closer examination of these deficits with regards to reading and comprehension, does affirm the pattern that phonologically driven tasks, successive tasks, and attention tasks, are more strongly related to word decoding, whereas planning and simultaneous tasks are more strongly linked to comprehension. If that is the case, then by linking phonological coding and articulation to successive processing, we can account for the association between short-term memory span and reading, a factor that is also found to be very weak in the reading performance of unskilled readers (Kirby et al., 1996).

Thus, there is irrefutable evidence that poor readers, as a group, are impaired in a very wide range of cognitive tasks in the phonological domain. This applies to both specifically disabled readers and "garden-variety" poor-readers (Stanovich, 1988).

If I were to recommend continued research in the field, I would comment further on the two studies in the review conducted by Freebody and Byrne (1988) and Byrne et al. (1992), which examine the presence of potential subtypes in the population with reading difficulties (i.e., dysphonetic-dyseidetic subtypes, see also Boder, 1973). It seems that looking for the presence of potential subtypes, each of which represents a unique pattern of difficulty, is an alternate way of conceptualizing the multiple processing deficits that characterize developmental reading disability (Parrila, Das, Kirby, & Papadopoulos, 1998; Papadopoulos & Parrila, 1997; Parrila & Papadopoulos, 1996). It appears that children who have specific reading difficulties occupy a multidimensional space within which they can be classified into more homogeneous subgroups based on differing levels of attainment. In that sense, then a *categorical model* can be applied (Ellis, 1985) that could be used to determine the best and most effective training for remediation for each subtype of reading disability. If, for example, successive processing is the locus of the difficulties encountered by children with reading difficulties of a certain subtype, then improving successive processing skills in these children would consequently improve their basic word-level skills as well.

2.5. Remediation studies

2.5.1. Introductory thoughts

> The point is *not* to suggest that children can learn skills that they do not have to begin with. That would be worth little note. Rather, it is that under suitable training conditions, performance may change quickly and abruptly, as if the training were operating as an extended set of instructions. The child then demonstrates substantial competence in what earlier appeared to be a non-existent skill.
>
> (Calfee, Fisk, & Piontkowski, 1975, p.30)

For some researchers and probably for some practitioners in the area of reading difficulties, the above statement may represent the ultimate goal of providing remedial training; targeting already existing skills makes sense to a certain extent. It seems to be convenient, especially when the training program one employs can address only certain reading-related skills. Aiming at improving, for instance, the phonological skills of weak readers, one can emphasize primarily the strengthening of these skills *per se*, but if the treatment does not prove to be appropriate for the particular treatment group, or for some participants of this group, should no further support be provided? Should skills that are not transparent but intimately related to reading be disregarded? And if they are, how long will the effects of the experimental treatment last?

Ehri (1979) provides a legitimate answer to these questions, noting that "if the target skill in training studies is central to reading acquisition process, effects of the experimental treatment may last only temporarily, because learning to read involves acquisition of many other capabilities besides those under the influence of the target [reading related] skill" (p.100). Despite this call to train poor readers on more than a single aspect of their reading skills, a considerably large body of reading-training studies that focus only on providing training in phonological reading skills still exists. It basically emerges from the findings of the "diagnosis research" that indicate that phonological skills are highly related to subsequent reading skills. I review some of these studies in the remainder of this section. Particular attention is paid to the manner in which the treatment and control groups were identified and matched, the outcome measures used, and the length and intensity of the treatment programs.

2.5.2. Reading remediation studies focusing on phonological awareness skills

Studies, such as those conducted by Lundberg and his colleagues in Denmark (e.g., Olofsson & Lundberg, 1983) and Byrne and his colleagues in Australia (e.g., Byrne and Fielding-Barnsley, 1993), indicate that young readers can be made more aware of phonological rules in the spoken and written language before the formal instruction typically offered in the first year of schooling. It seems that most of the research on phonological training tries to exemplify what Adams (1990) has concluded in her review: "The evidence is compelling: Toward the goal of efficient and effective reading instruction, explicit training of phonemic awareness is invaluable" (p. 331).

Several studies have shown that younger readers can be taught to segment words into syllables, and syllables into phonemes, or even categorize words based on single sounds (of initial, middle, or final sound), which of course requires a higher level of phonological awareness (e.g., Lundberg, Frost, & Petersen, 1988). Yet, it has been shown in other studies that the training of phonological awareness may have beneficial effects on reading and spelling (e.g., Ball & Blachman, 1991; Bradley & Bryant, 1983; Fox & Routh, 1984; Lundberg, Frost, & Petersen, 1988; Williams, 1980). This, however, does not seem to be consistently true, especially when post-test scores on nonword reading measures are examined (e.g., Word Attack from Woodcock-Johnson reading Mastery Test; see Barker & Torgesen, 1995) or in real-word reading measures (e.g., Word Identification scores; Blachman, Ball, Black, & Tangel, 1994). It should be mentioned, however, that in these latter studies some significant improvement was shown on the measures for the phonologically trained group over the period of time, but that this progress did not significantly differentiate this group from the participating control groups.

Following the longitudinal design of their study, Bradley and Bryant (1983, 1985) conducted a training study with 65 of the children who had low scores on the sound categorization tasks (i.e., had obtained approximately 30 percent of the correct answers) during the second year of the study. The British version of the Peabody Picture Vocabulary Test (EPVT), gender, and age at the beginning of the project (i.e., nursery vs. primary school) were also used as matching variables for the control groups. Four groups were thereafter formed for the experiment: an experimental group trained on sound categorization alone and taught to categorize pictures of objects on the basis of common sounds (e.g., rhyme and alliteration); an experimental group trained on sound categorization and given experience with plastic letters (developing, therefore, the letter-sound correspondence); a control group trained on conceptual categorization (categorizing the same pictures on the basis of semantic categories); and a control group who received no training. The training for children in the first three groups involved 40 individual sessions spread over a two-year period. The results indicated that the first and the second group outperformed both control groups in both post-test reading and spelling measures, with the group who had been trained to make the connections between sound categorization and letter strings doing even better than the group who had received only the sound categorization training. Consistent results were even obtained in a follow-up study conducted three years after the experimental study, with the second experimental group still obtaining the highest scores on reading and spelling measures (Bradley, 1988).

Going beyond the design of the Bradley and Bryant study (1985), Ball and Blachman (1991) examined whether the combination of sound categorization with the letter knowledge training in letter training itself would make a difference. To answer this question they conducted a study in which 90 nonreading Kindergarten children were randomly assigned either to a treatment group who received instruction in phonological awareness plus letter names and letter sounds or to one of the two control groups. In the first control group, children were given instruction in a variety of language activities (e.g., listening stories) as well as letter-name and letter-sound instruction that was identical to the treatment group. No treatment was provided for the children of the second control group. None of the participating children had obtained raw scores on the pretest greater than 3 on the Woodcock Word Identification Subtest. Instruction in the first two groups was provided in twenty-minute sessions, four times a week, for a period of seven weeks. After the intervention, results indicated that the group who had received both the phonological awareness training (e.g., moving tiles to represent each sound in the spoken word) and the letter-sound correspondences training significantly outperformed both the control groups in phoneme awareness and reading and spelling measures. It is also noteworthy that the group that had received instruction on letter-sound conversions did not differ from the treatment group in measures assessing letter-sound knowledge. Nevertheless, these children did not differ from the untrained group in any of the above post-test measures. Thus, it appears that phonological awareness training, when provided along with letter-sound correspondences training, may play an important role in early reading and spelling acquisition.

In a more recent study, Blachman, Ball, Black, and Tangel (1994) examined the effectiveness of phonological awareness training on the word-recognition and spelling of low-income, inner-city Kindergarten children. One of the major concerns of this study was to examine the effectiveness of the training program when provided by the teachers in their classrooms. Eighty-four treatment children and 75 control children were matched in terms of age, sex, socioeconomic status, PPVT-R scores, phonemic segmentation ability, letter-name and letter-sound knowledge, and reading ability before the intervention. The treatment group received approximately 13 hours of instruction in phoneme segmentation and letter sounds and names. Post-testing revealed significant differences between the two groups on measures of phoneme segmentation, letter-sound knowledge, reading of phonetically regular words, reading of phonetically regular nonwords, and developmental spelling. No group differences, however, were observed on the Word Identification scores of the Woodcock Johnson Reading Mastery Tests-Revised, although it was a practical real-word reading measure. In other words, significant progress of the treatment group on phonetically regular words was evident only for words that included those eight letters introduced and broadly used in a series of words during phoneme awareness instruction. It should be noted, however, that this particular group of children could be generally assumed to be at-risk for reading difficulties, simply because of their background. As these children came from a low socioeconomic background it would have been more accurate if they had been described as being disadvantaged rather than at-risk, given the manner in which the term "at-risk" is used in my research.

In contrast, a follow-up study (Blachman, 1994), which involved children in Grade 1, targeted populations whose cognitive skills were likely more similar to those of the at-risk children who participated in my research. By the end of Kindergarten, all treatment children from the previous study were rank-ordered based on their scores on word-reading ability, letter-name and letter-sound knowledge and phoneme segmentation scores. Children who had scored lowest during Kindergarten received additional phoneme awareness and letter-name and letter-sound instruction for about 12 weeks during Grade 1. Yet, this treatment was followed by a special first-Grade reading program that continued to facilitate the development of phonological skills by putting more emphasis on the alphabetic code. At the end of Grade 1, the treatment children significantly outperformed the control children on measures of phonological awareness and letter-name and letter-sound knowledge, three measures of word recognition (including a measure of nonword reading), and two spelling tests. Thus, Blachman's results indicate that an alternative reading curriculum in which both length and complexity of treatment have increased (i.e., to continue fostering skills on phonological awareness, alphabetic coding, and automaticity) can be more beneficial for the homogeneous at-risk reading population.

There are many other reading remediation studies that I would like to cover in this section, but instead I will conclude this review by presenting first the results of a study where a computerized program was used for ameliorating reading-related difficulties in Kindergarten children, and second, the results of a study where a paradigm of the very popular Reading Recovery Remediation program was applied. Lastly, I will discuss the effectiveness of the different training programs currently in use.

Barker and Torgesen (1995) evaluated the effectiveness of computer-assisted instruction in developing the phonological awareness skills of 54 at-risk Grade 1 students. At-risk students were defined rather liberally as those who scored at or below the 40th percentile on Word Identification (Woodcock Reading Mastery Test - Revised [WRMT-R]) and below the 50th percentile on Sound Categorization (Wagner, Torgesen, Laughton, Simmons, & Rashotte, 1993). The participants were randomly assigned to one of the three conditions: computerized phonological awareness training, computerized training in alphabetic decoding skills (which provides practice in learning to decode medial vowel sounds in short words), and a computer-control group who spent an equal amount of time with several programs designed to provide practice in basic math skills. Each group received approximately eight hours of training. The results showed that participants exposed to the phonological awareness training made significantly greater improvements on three of the four measures of phonological awareness and on Word Identification than the participants from the other two groups. Differences were less obvious for the fourth phonological awareness task, Phoneme Blending, and for the two nonword reading measures (Word Attack from the WRMT-R, and an experimental nonword reading task). The authors interpreted these findings as suggesting that it was easier to use analytic reading skills to pronounce real words than nonwords because children have already had a lexical entry for real words, and so they merely had to generate an approximation from phonology in order to read the word correctly.

Iversen and Tunmer (1993), after making a thorough critique of the methods operationalized by the Reading Recovery (RR) program as outlined by its founder, Marie Clay (1985), conducted research where a modified Reading Recovery program was compared to the traditional one. They hypothesized that children selected for Reading Recovery would learn to read much more quickly if they received systematic instruction designed to make them conceptually aware of the interrelatedness of the visual patterns and sounds shared by different words. Gough and Juel (1991) referred to this awareness as "cryptanalytic intent"; the child "must grasp the idea that there is a system of correspondences to be mastered" (p. 51). Three carefully matched groups (those participants who performed at the lowest levels of the Diagnostic Survey [Clay, 1985], and the Dolch Word Recognition Test [Dolch, 1939, cited in Iversen & Tunmer, 1993]), each with 32 Grade 1 children, were formed: a modified Reading Recovery (MRR) group, a standard Reading Recovery group (SRR), and a standard intervention group (SI). The children in both MRR and SRR groups received regular RR lessons, whereas the children in the MRR group also received explicit training in phonological recoding skills as part of their lesson. The aim of the instruction incorporated in the MRR program was to make the children more aware that words with common sounds often share spelling patterns. The procedures were very similar to those developed by Bryant and Bradley (1985). The children in the SI group received the support services normally available to at-risk readers (i.e., Chapter One program and Literacy state-program). Two more control groups of average readers were drawn from the same classrooms from which the RR groups had been drawn. These group were included in the study, because a major aim of the RR program is to bring problem readers up to a level of reading performance at, or above, class average. The children in the RR program received 30-minute lessons, 4 times a week. Remediation was discontinued when both teachers (the classroom teacher and the trainer) agreed that a child had achieved a reasonable degree of independence in reading and was reading at average level or above the level of his/her peers. Results showed that both RR groups significantly outperformed the control groups as well as the SI group in all phonological measures, both the Diagnostic Survey measures and the Dolch Word Recognition test. The difference between SI and RR groups, however, could be due to the manner in which the instruction had been delivered, rather than to the effectiveness of the RR program per se: the RR groups had been remediated on an one-to-one basis, whereas the SI group had been remediated in small groups of six students. Subsequent comparisons with the average respective readers in the same classrooms, however, confirmed the results, indicating that the RR groups performed as well as the classroom controls, and in some cases, even better. It should also be noted that, surprisingly, the SRR group outperformed the MRR group on the phoneme deletion task. The most significant finding, however, according to Iversen and Tunmer (1993), is the difference in the mean number of lessons until remediation was discontinued between the two RR groups. Although the two groups performed at very similar levels at discontinuation, the SRR group took much longer to reach the same point of reading competence than the MRR (M of lessons = 57.31 and 41.75 for SRR and MRR groups, respectively). Subsequent correlational analysis for each group separately indicated that the two RR groups were carefully matched and that these results were not due to the inclusion of more "slow learners" in the SRR group. All the correlations between group membership and postmeasures were negative and of the same magnitude to the correlations of the two groups combined.

To summarize, the above studies have produced inconclusive evidence regarding the efficacy of phonologically-based remediation programs for enhancing the reading performance of at-risk children. Using a group of children who were loosely defined as at-risk, Barker and Torgesen (1995) found significant improvements in Word Identification, but not in Word Attack (that is, a pseudoword reading test). Moreover, for the critical measures used in that study, Word Attack and Word Identification, the computerized phonological awareness training group had pre-test means of .67 (SD = 1.0) and 7.83 (SD = 4.3) respectively. The post-test means were 2.94 (SD = 3.3) and 16.78 (SD = 9.6). The large standard deviations raise an interesting question regarding the differential reaction to training: Obviously, some of Barker and Torgesen's participants did not benefit from training in phonological awareness. How did they differ, then, from those who did?

Blachman (1994), on the other hand, reported improvement in treated at-risk children compared to control children after a year-long intervention - a financially taxing proposition. This study raises the question of whether to modify the reading curriculum, although if the curriculum works effectively for most children, this is not likely to occur. In contrast, the effects of the phonological training provided to the participants of the Blachman et al. (1994) study were limited only to words that comprised the same letters that had been used in the training sessions. The transfer of knowledge had gone through the "low road" (Salomon & Perkins, 1989) and thus it should be considered too narrow because it was based on a number of identical elements; hence pessimism surrounding the "generalizability of strategy training ... has become widespread" (Das et al. 1994, p. 168).

Iversen and Tunmer's study made clear that having a more phonologically driven training program may be more beneficial than a "meaning based program", as shown by pre- and post-test measures on standard and modified versions of the Reading Recovery Program. The criterion of discontinuation used for all the children is probably what makes this study more valuable. Only Bradley and Bryant's work (1985), a 2-year longitudinal study, appears to meet the needs of the current research. For this reason, it is probably one of the most often cited studies in the literature. Training-positive effects were maintained even three years later. Yet, from this study, the question emerging is: "Would a shorter intervention be as effective in reintegrating poor readers into mainstream reading classes?"

Blachman (1994) argues that "given what we know about hard-to-teach children, there is no reason to think that 12 weeks of *any* intervention will be a panacea" (p. 290). This point coincides with what Ehri had argued about the nature of the training provided. Solid phonological training does not always produce long-lasting effects. More importantly, it does not secure a procedure that can successfully treat the heterogeneity of the reading disabled population (see "Discussion" by Torgesen, Wagner, & Rashotte, 1994). Increasing the intensity of the program and the timing of treatment may produce more stable results. But will the bridging of instructional components be ensured as well? Results from the Blachman et al. (1994) study make this assumption quite uncertain. In addition, results, such as those in the Barker and Torgesen study (1995), leave a lot of questions unanswered about the validity of the phonological training because trained strategies cannot be applied to reading irregular words. As Gough and Juel (1991) noted that although we do not know the exact mechanism by which the phonological coding operates, "we do know how to measure it: the child's mastery of phonological coding is directly reflected in his ability to pronounce pseudowords" (p. 51). Does that mean that the participants in the Barker and Torgesen study are not phonologically aware after the training? Probably not. What they are lacking, however, is many other capabilities, besides those under the influence of the target reading-related skill, which were noted by Ehri (1979). They have not mastered certain processes that may at least facilitate their reading.

Given the fact that the population that exhibits reading difficulties is heterogeneous, and also given the consideration that different characteristics of the training programs may interfere with the results, it would be reasonable to recognize that training on phonological awareness, by itself, may have only a limited effect on reading achievement.

The PASS Reading Enhancement Program developed by Das and his colleagues tries to exemplify what Ehri (1979) has proposed. Aiming at improving the information processing strategies - specifically, simultaneous and successive processing - that underlie reading, while at the same time avoiding the direct teaching of word reading skills, such as phoneme segmentation or blending, appears to secure the transfer of principles in reading. Its effectiveness is discussed in the next section after a review of several studies that apply it to populations older than my study recruits.

2.6. PASS Reading Enhancement Program (PREP)

2.6.1. Introducing PASS Reading Enhancement Program (PREP)

> Transfer is an integral part of not only learning, but development. When learning and development are considered to be blended together, transfer may become the essential ingredient for children's cognitive growth.
>
> (Das et al., 1994)

Keeping Das' view on transfer in mind, what kind of learning are we then targeting to transfer in a reading retarded population? Brown and Campione (1986) have discussed the conditions of successful transfer in a number of papers. They primarily give emphasis to principles as targets of transfer. These are based on inductive inferences arising out of children's experience with the tasks, rather than on the explicit teaching of principles. The children practically come up on their own with the principles or the essential ingredients that comprise them. Following Vygotsky (1962), however, they recommend that learning take place in collaboration with peers and experts (see "Zone of Proximal Development", Vygotsky, 1978). This means that when an adjustable and temporary support is provided to the learners to better facilitate the conceptual understanding of a set of similar problems (those based on the same principles), then transfer of learning becomes possible.

Based on this premise, and choosing the "rocky road" as defined by Salomon and Perkins (1989), the PASS Reading Enhancement Program was designed to improve selected aspects of children's information processing skills and to increase their word reading and decoding abilities (Parrila, Das, Kendrick, Papadopoulos, & Kirby, 1997). PREP is an alternative to direct training of strategies for the remediation of reading skills and is based on the notion that transfer of principles can be facilitated through inductive, rather than deductive, inference. Accordingly, the remedial training is structured in such a way that the inductive inference should occur spontaneously with an internalization of principles and strategies rather than through deductive rule learning (Vygotsky, 1962; Campione & Brown, 1987; Das, Mishra, & Pool, 1995). Remedial training of this kind is more likely to ensure transfer of learned principles and produce strategies for novel situations with higher rates of success. In deductive strategy training - as occurs in most of the phonological training studies - the students are given a principle or strategy that they have not produced themselves, and thus, which they have not necessarily internalized. Consequently, most of the time, they have no sense of "ownership" over the strategy or principle and no comprehensive sense of its usefulness. The Vygotskian perspective argues instead for the importance of the students' "ownership" of a strategy or principle acquired through the normal inductive process and generalized from experience (Das et al., 1994). This does not mean that the teacher should not guide the experiences encountered, nor that adults should not assist in the generalization process. The point is that the strategy will be used by the student only when it has been internalized by inductive learning. The global-process training experience in the PREP program aims to accomplish this. Learning is implicit rather than explicit. The strategy or the principles are not verbalized, but the learner acquires a sense of where they should be applied.

The PASS Reading Enhancement Program has been constructed to induce successive and simultaneous processing while including training in the planning and promotion of selective attention. A set of eight to ten tasks are usually selected for the remedial training. Each task has a "global" process training form and a content-related "bridging" form and has three levels of difficulty and passage from one level to the next is contingent upon at least an 80 percent success rate in that level. The program is typically given for 15 to 20 hours, once or twice a week, spread over 12 weeks or more. Not too much time is spent on any one task lest it may result in overlearning which leads to the "welding of the skill and works against transfer" (Das et al., 1994, p. 173). A description of the tasks that are used in the current study is presented in the Methodology section that follows the PREP studies review.

2.6.2. Studies using the PASS Reading Enhancement Program (PREP)

Earlier studies using experimental versions of PREP produced positive results (see e.g., Brailsford, Snart, & Das, 1984; Krywaniuk & Das, 1976; and the review in Das et al., 1994) in terms of both cognitive processing tasks and reading performance. Later studies have generally concentrated on demonstrating the positive effects of cognitive training on participants' reading performance.

Das, Mishra, and Pool (1995) used PREP with a group of 51 Grade 3 and 4 students with reading difficulties who exhibited delays of at least 12 months on either the Word

Identification (WID) or Word Attack (WAT) subtest of the WRMT-R. Participants were first divided into two groups, PREP remediation and a no-intervention control group. The PREP group received 15 sessions of training involving groups of two students over a period of 2 1/2 months. Children in the control group participated in regular classroom activities. After the intervention, both groups were tested again on the reading measures (WID and WAT tests). The results indicated that, although both groups gained during the intervention period, the PREP group gained significantly more on both WID and WAT, as shown by a significant Group x Time interaction in ANOVA results. In the second study, children from the control group received either the global or the bridging component of the PREP for the same length of time. Neither of these groups benefited from the program to the same extent as the original PREP group, who received both components.

Carlson and Das (1997) used a small-group version of the PREP for underachieving Grade 4 students in Chapter 1 programs. In this study, students were instructed during two 50-minute sessions per week for three months. Both the PREP and the control groups (22 and 15 students, respectively) continued to participate in the regular Chapter 1 program. Word Identification and Word Attack reading tests from the WRMT-R were administered before and after the remediation. The results showed significant improvement following training in PREP, as well as significant Group x Time interaction effects. Several replication studies completed in the same school district have essentially reproduced the original results with children from Grades 3, 4, 5 and 6, and with bilingual (Spanish-English) and monolingual (English) children (Carlson, 1996). Moreover, these results have been consistent even when the remedial sessions have included up to ten participants.

Finally, the effectiveness of a modified version of PREP (for an older group) was studied by Boden and Kirby (1996). A group of Grade 5 and Grade 6 students, who were identified a year earlier as poor readers, were randomly assigned to either a control or an experimental group. The experimental group received the PREP training in groups of four students for approximately 14 hours, whereas the control group continued normally with regular classroom instruction. The results revealed in this study were similar to those in previous studies, with the treatment group significantly outperforming the control group on both WID and WAT reading measures. Yet, in relation to the previous year's reading scores, the PREP group performed significantly better than the control group.

When the results of these studies are taken together, the effectiveness of PREP in remediating deficient reading skills during the elementary school years becomes clear. What these studies are lacking, however, is the control condition of a competing program with a carefully matched group of children. In addition, none of these recent PREP studies examined the effectiveness of the PREP program with a population younger than Grade 3. These needs were met during the first years of the longitudinal research of my work. A general description and the logic behind this longitudinal project are provided in the following section before the methodology chapter.

2.7. Introduction to the present longitudinal study

The present study consists of a part of a four-year longitudinal reading project being conducted in Edmonton, Alberta, and Kingston, Ontario, Canada. Since October 1994, when the Early Reading Diagnosis and Remediation Project started, our work has concentrated on two types of "nonphonological cognitive processes": (a) those that are intimately related to reading and that may contribute to the development of other reading-related skills such as phonological processing skills, successive and simultaneous processing, and (b) those that allow the successful deployment of phonological and other skills, such as attention and planning skills. More specifically, we have thus far attempted to predict early reading development within the sample of at-risk children (Papadopoulos, Parrila, & Das, 1997; Papadopoulos, Parrila, Das, & Kirby, 1997), to identify distinct cognitive profiles of this at-risk population based on a combination of both phonological and nonphonological cognitive tasks (Parrila, Das, Kirby, & Papadopoulos, 1998; Parrila & Papadopoulos, 1996), and to remediate reading difficulties by training the underlying cognitive processes using the PREP program (Das, Papadopoulos, Parrila, & Kirby, 1997; Das, Parrila, & Papadopoulos, 1997; Papadopoulos, Das, & Parrila, 1997; Parrila, Das, Kendrick, Papadopoulos, & Kirby, 1997).

In October 1994, Kindergarten teachers were asked to identify children from their classrooms who could be at-risk for the development of reading difficulties. Research has shown that judgments made by teachers about the children's reading levels are generally confirmed by the subsequent reading scores of these children (see e.g., Fox & Routh, 1980). Teachers were asked to include one to three students from their classrooms who were not well-prepared to learn to read in Grade 1, based on a list of (ex)inclusionary criteria (see 3.1.1. section). A total of 101 children was selected accordingly. Due to attrition from year 1 to year 2, however, the analysis has been conducted on results from 90 participants.

During the first year (January to May 1995), scores were obtained for all children on both phonological (Rhyme Production, Sound Isolation, and Phoneme Elision) and cognitive tasks (Planned Search, Planned Connections, Expressive Attention, Receptive Attention, Simultaneous Verbal, Figure Memory, Word Series, Sentence Question and Repetition, and Speech Rate; all from the standardized version of Das-Naglieri Cognitive Assessment System [DN-CAS], 1993). The main purpose of this data collection was to have data available from Kindergarten to predict later reading in Grade 1.

In the second year, half-way through of Grade 1 (January to March 1996), the same tasks were administered along with two reading measures from the Woodcock Reading Mastery Test-Revised (Woodcock, 1987); The Word Identification and the Word Attack subtests. Right after the analysis of the data, using a strict criterion for inclusion in the remediation (at or lower than the 26th percentile on both reading measures), two groups of children emerged: (a) a group of children who were still nonreaders or poor readers and comprised two-thirds of the sample and (b) a group of children who showed somewhat competent reading scores and who eventually remained out of the remedial training. The first group of children was further divided into a group participating in the PREP remediation program and a group participating in a "meaning-based program" (see methodology section).

Finally, in the third year of the study, follow-up testing examining the differential long-term effects of the remediation in Grade 1 took place. The participants were administered the same set of cognitive, phonological, and reading measures, along with the Passage Comprehension test (Woodcock, 1987; see methodology). In addition, only PREP remediation was provided to the 27 participants who still experienced reading difficulties, despite the fact that they had already attended either a PREP or Meaning-based remediation program and had gone through almost two years of formal reading instruction.

The next section presents the methodology of this study in further detail. Results follow, thereafter, providing answers about the nature of the deficits/cognitive profiles of at-risk readers, the prediction of their reading skills, and the differential outcomes of their remedial training in Grade 1 and Grade 2.

CHAPTER III

METHODOLOGY

> Reading progress must be monitored rather than simply measured once at the end of the year.
>
> (Ehri, 1979, p. 100)

3.1. The First two Years of the Study

The main objectives of the first two years were two-fold:

(a) To study what cognitive and phonological skills in Kindergarten predict reading and subsequent reading disability in Grade 1 in an at-risk sample of children, and

(b) To offer remediation to those students who experience reading difficulties, achieving a word reading score below the 26th percentile. The experiment examined the importance of cognitive remediation, choosing a theory-driven cognitive remediation program, the PASS Reading Enhancement Program (PREP). The current experiment was an extension of the approach followed by earlier PREP studies with three important changes: (1) the control condition was a competing program (Meaning-based approach) given to a carefully matched group of children; (2) the participants were beginning readers in Grade 1 and therefore younger than the Grade 3 to Grade 6 participants in the previous studies; and (3) the training was shorter in duration than in most of the previous studies. The more stringent control condition was seen as an important test of the efficacy of PREP. The use of younger participants, though, also challenged PREP's efficacy.

3.1.1. Participants

Ninety students (34 females) from 31 public schools in Edmonton, Canada, were identified by their Kindergarten teachers as being at-risk for developing reading difficulties in Kindergarten and subsequently included in this study. Teachers were asked to include 1 to 3 students from their classrooms whom they thought to be particularly ill-prepared to learn to read in Grade 1. Children were included if they exhibited one or more of the following problems: (a) slow development in terms of language, (b) slow speech rate, (c) sequencing difficulties (e.g. problems in reciting a list of things or problems in remembering and following three or more directions given at once). On the other hand, they were excluded from the sample if they were: (a) students whose problems were primarily emotional in nature, (b) students with sensory handicaps (impaired vision or hearing), (c) students with developmental disabilities (i.e., mental retardation), or (d) ESL students. The mean age of this group was 67.4 months (SD = 3.6) during the first testing in Kindergarten, and 76.8 months (SD = 3.6) during the second testing in Grade 1. In Kindergarten, children were tested from January to May 1995, whereas in Grade 1, children were tested from January to March 1996. The reading curricula of the participating schools were putting more emphasis on phonological factors involved in reading and literacy.

3.1.2. Measures

3.1.2.1. Cognitive processing tasks

3.1.2.1.a. The PASS theory

An introduction to the PASS theory has already been provided in an earlier section of this manuscript (see section 2.4.2 on differentiating good from poor readers). It is considered necessary, however, to outline adequately the theoretical constructs of the PASS model before the tasks associated with it are presented.

The PASS model identifies three operational units important to the understanding of mental functioning: Attention-Arousal, Simultaneous and Successive processing (information coding), and Planning (Das, Naglieri, & Kirby, 1994). The maintenance of attention and regulation of cortical tone, the processing and storing of information, and the management and direction of mental activity comprise the activities of the operational units that work together to produce cognitive processing (Luria, 1966; Das, et al. 1994).

Arousal-Attention comprises basic behaviors, such as the orienting reflex (Pavlov, 1942), as well as instances of complex attentional behavior involved in discrimination learning and selective attention. Attention involves the allocation of resources and effort. Some reading disabled children may be misdiagnosed as having an attention deficit, depending on the type of attention tests used. If the tests contain material that requires phonological coding, such as detecting a number or letter among other numbers and letters, these children will score low on attention simply because they cannot code the letters, numbers, and words phonologically (Das, Mishra, Kirby, 1994).

The second functional unit includes the Simultaneous-Successive coding of information. Simultaneous processing involves the arrangement of incoming information into a holistic pattern, or a gestalt, that can be "surveyed" in its entirety. For example, sight recognition of whole words involves this kind of processing as does comprehension of the meaning of a sentence or a paragraph (Das, 1988). Successive processing refers to the coding of information into discrete, serial order where the detection of one portion of the information is dependent on its temporal position relative to other material. It is used in skills such as word decoding and spelling, where the child has to pay attention to the sequence or succession of letters in the word.

Successive processing is broader than the specific tests for phonemic awareness, syntax awareness, or even short-term memory, which have been identified as the core 'processes' that separate dyslexics from normal readers (Siegel, 1993; Ellis, 1993). The relation between short-term memory and phonological coding has been established by Baddeley and his colleagues (see e.g., Baddeley, 1992; Gathercole & Baddeley, 1990). The direction, or path, from short-term memory span to word decoding ability, as shown by Das and his colleagues (e.g., Das & Mishra, 1991), passes through two tests taken together: Speech Rate (Repeat 'egg, bus, leaf' as fast as you can ten times) and Word Series. These tests are conceptually related to successive processing.

No task, however, solely requires simultaneous or successive processing, it is a matter of emphasis. For example, reading a word certainly involves sequencing, but also blending (simultaneous processing). Some dyslexics may use the visual pattern of the word to recognize it — an instance of simultaneous processing — and fluent readers automatically code the words even being unaware of coding, except when a difficult or unfamiliar word demands phonological coding. Reading single words thus involves either sight reading or reading by sound, assembling a pronunciation, and then actually articulating the word. The last two activities involve both processes.

The last major function to evolve developmentally is planning and decision making. Luria (1966) referred to planning as that which consists of programming, regulation, and verification of behavior. All of these are required in writing a composition and, to a lesser extent, in comprehension. The PASS model and the tests for measuring the four processes provide tools for analyzing processes associated with dyslexia, several of the studies reviewed in Das, Naglieri, and Kirby (1994) suggest.

3.1.2.1.b. Planning tasks

Ten tests taken from the standardization version of Das-Naglieri Cognitive Assessment System (DN-CAS; Das & Naglieri, 1993) were used to assess participants cognitive processing skills.

Planned Search. This task is based on the Visual Search task originally used by Teuber, Battersby, and Bender (1949) to identify visual search deficits after celebral lesion. It has recently been found to load on the planning factor described by Naglieri, Das, Stevens, & Ledbetter (1991), Naglieri, Prewett, and Bardos (1989), and by Naglieri and Das (1988). Planned Search requires the participant to develop an efficient scanning strategy to find a particular target on the page. The version that was used in this study consisted of 16 items, with each item consisting of two tasks per page. The target pattern was located in a small box at the center of each task and the subject was instructed to take note of the target pattern and to find an identical pattern among those in the distracting field. The first four items required the participants to find a figure (e.g., boy, bird) among numbers; the second required participants to find numbers among numbers; the third to find figures among figures; and the last asked the participants to find letters among letters. Each item was timed from the point the page was exposed to the moment the second target was found. The participant's score was the time taken to complete all items.

Planned Connections. This paper and pencil task is based on the Trail Making task of the Halstead-Reitan Battery, and has been used as a marker task for planning in several studies (e.g., Ashman & Das, 1980; Naglieri et al., 1991; Naglieri, Prewett, & Bardos, 1989). Some of the strategies used in this type of the task involve scanning the page for the next target, looking back to the last target to know what comes next, looking at only the portion of the page most likely to have the next target, and repeating the number series aloud as the task is completed (Naglieri & Das, 1990). The Planned Connections task requires the subject to develop some effective way to connect sequential stimuli (numbers 1-2-3-4-5-...), which are quasi-randomly distributed on a page. In this study, the task consists of six items: the first two items required the child to join in sequence the numbers from one to five, the next two had numbers up to ten, the fifth one had 15 numbers, and the last item, up to number 25. The participant used a red pencil to join the numbers and his or her Planned Connection score was the combined time to complete items 1 to 6.

3.1.2.1.c. Attention tasks

Expressive Attention. This task is based on the Stroop task (1935) and has been widely used as a measure of interference (see McLeod, 1991, for a recent review). The version used in the first two years of this study was composed of three pages, all of them containing animals. Participants were shown animals that were either "small" (a butterfly, a mouse, a bird, and a frog) or "big" (an elephant, a whale, a horse, and a dinosaur). In Item 1, all of the pictures were of the same physical size (i.e., all animals were present in a relatively big size, regardless of their relative actual size); in Item 2, the size of the pictorial representation was in accordance with actual size differences (i.e., pictures of small animals were smaller than pictures of large animals); and in Item 3, the pictorial presentations of the animals did not follow their actual size, but instead, small and big animals could be presented either as small or big. The participants were required to label all pictures in the item as representing either big or small animals. The participant's Expressive Attention score was the ratio score of the item 3 completion time divided by the number of correct responses in this item. In the Grade 2 testing, the original Stroop task with color-names was used as the Expressive Attention task. Again, the ratio score, which derived from the division of time by number of correct responses in item 6 was used as the participant's Expressive Attention score.

Receptive Attention. This task was developed by Naglieri and Das (1987) based on the work of Posner and Boies (1971). In the first and second years of the study, the participants were given four sheets consisting of 50 picture pairs each (trees, fruits, flowers, birds, houses, or human faces) arranged in a matrix form. In the first two items, the participants' task was to underline only those pairs of pictures that were visually alike (picture matching). Alternatively, in the last two items, the participants were instructed to underline those pairs that belonged to the same taxonomic category (name matching). The participant's Receptive Attention score was the combined time to complete items 3 and 4 divided by the total number of correct responses in these items. The version of this task in the Grade 2 testing used letters instead of images.

3.1.2.1.d. Simultaneous processing tasks

Simultaneous Verbal. This 29-item task involved the evaluation of logico-grammatical relationships by the participants, when asked to point to one of the six pictures that corresponded with a verbal statement, such as "the ball in a basket on a table." The time limit for each item was 45 seconds and the task was discontinued after four consecutive errors. The test was scored for the number of correct responses.

Figure Memory. This task consisted of 20 geometric designs, such as a triangle or a square, presented to the participant one at a time for a period of five seconds each. Following the presentation of a particular target design, the participant was given a more complex design in which the target design was embedded. The participant was then asked to outline the original target design with a red marker. For a response to be scored correct, all lines of the design had to be indicated without any additions or omissions. The task was discontinued after four consecutive failures. The participant's score was the total number of items correctly reproduced.

3.1.2.1.e. Successive processing tasks

Word Series. The recall of digits and words has been shown in numerous studies reported by Das, Kirby, and Jarman (1979) to load on the successive factor. In this study, this test required the subject to repeat series of words in the same serial order that the examiner used. The series increased in length from two to nine words. All of the nine words used were highly familiar and phonetically dissimilar. The number of series recalled in correct serial position (left justified) constituted the Word Series score of the participant.

Sentence Repetition and Questions. This task consisted of two parts. First, the participant had to repeat and then answer questions about nonsensical sentences in which the content words had been replaced by color words (e.g., "The yellow greened the blue"). Thus, the participant could use syntactic cues, but no semantic cues to remember the sentences or to answer the questions. The participant's score was the number of correctly reproduced sentences plus the number of correctly answered questions. Both parts were discontinued after four consecutive failures.

Speech Rate. In this task, the participants were required to repeat three familiar and phonetically dissimilar words (e.g., "Man, Cow, Key") as quickly as possible, ten times, and the total time was recorded as the Speech Rate score.

3.1.2.2. Phonological coding tasks

Rhyme Production. This task was developed by Maclean, Bryant, & Bradley (1987), and it was originally used as a measure of phonological awareness in children of three to five years of age. In this task, the child was asked to report a word that rhymed with one the experimenter had just spoken. Before the test started, each child was given a series of practice trials that involved forced choices. In the five experimental trials, the child was simply asked to "Say a word which rhymes with __________ (e.g. /tail/)". Both nonsense words and real words were accepted as correct responses. The five words used in this version were: *land, goat, shop, tail, and hen*, and the participant's score was the number of correctly matched words (maximum five).

Sound Isolation. This task was originally developed and used by Wagner, Torgesen, Laughon, Simmons, and Rashotte (1993) in a study that compared alternative models of young readers' phonological processing abilities. In this test, children were asked to repeat the first, last, or middle sound in a word. Six practice items and 15 test items consisting of three- and four- phoneme, one- and two-syllable words were included. The task was discontinued after four failures among the last seven items. The participant's score was the number of correct items.

Phoneme Elision. This task also was first used by Wagner et al. (1993). In this task, children were asked to repeat a word after deleting an identified phoneme. The specific instructions were as follows: "Say the word /cat/. Now say the word /cat/ without the /k/". All phonemes to be deleted were consonants, the position of which varied randomly. After deleting the target phoneme, the remaining phonemes formed a word (e.g., /seed/ without the /d/ leaves /see/). Six practice items and 15 test items consisting of three- to five-phoneme, one- and two-syllable words were used. The task was discontinued after four mistakes in the last seven items. The participant's score was the number of correct items.

3.1.2.3. Reading measures

All three reading measures were taken from Woodcock Reading Mastery Test-Revised (Woodcock, 1987).

Word Identification: This test required the participant to identify isolated words that appeared in large type in the test book. The term *identification* implies that the participant may respond correctly to a stimulus word even though he/she has had no personal experience with the word. As participants proceeded through the items, they encountered words that appeared less and less frequently in written English. For an answer to be scored correct, the participant had to produce a natural reading of the word within about five seconds. It was not assumed that the participant necessarily knew the meaning of any word correctly identified. The version used in this study consisted of 106 items arranged in order of difficulty.

Word Attack: This test required the participant to read either nonsense words (letter combinations that are not actual words) or words with a very low frequency of occurrence in English. The test measures the participant's ability to apply phonic and structural analysis skills in order to pronounce words with which he/she may be unfamiliar. All participants began the Word Attack test by responding to two sample items. If the participants failed a simple item, training was continued until the participants completed the item correctly. The test began with simple consonant-vowel combinations and concluded with multi-syllabic nonsense words to determine a participant's ability to apply structural analysis skills. The form of this test contained 45 items arranged in order of difficulty. Total correct responses to words was the score obtained by the participant.

Passage Comprehension: This task required the participant to read a short passage (usually two to three lines long) and to identify a keyword missing from the passage. A blank line represented the missing word. To complete the item, a participant had to understand not only the sentence containing the missing word, but the remaining sentences as well. This requirement demonstrated that the participant had comprehended the entire passage. Before starting the test, the examiner instructed the child to read each passage silently and then to fill the blank with a suitable word. A sample item was also administered in order to ensure that the participant had understood what he/she was required to do. The version used in this study contained 68 items. The participant's total score was the number of correctly filled blanks. This tasks was administered to participants only in Grade 2, as both a pre- and post-test.

3.1.2.4. Validity of the CAS measures

The CAS test battery used in the present study was being validated in the U.S. for commercial use, and therefore, no manual existed that would report validity and reliability measures based on this battery. However, there is already a fair amount of data to support the validity of the model and the tasks. *Validity* is defined here as the "degree to which empirical data and theoretical rationales support the adequacy and appropriateness of interpretations and actions based on test scores" (Messick, 1989, p. 13). This definition leads to three central questions: Is the theoretical rationale underlying test interpretation sufficiently substantiated? Is the theoretical interpretation of test scores supported by empirical studies with different populations? And, how is the use of these scores relevant in terms of social competence?

The selection of tasks for the CAS has been based primarily on the theoretical considerations of the underlying cognitive processing demands of the suggested tasks. These demands have been constructed in accordance to Luria's theory of the functional units of the brain, and are presented in section 3.1.2.1.a. This theoretical approach has been validated by several factor analytic studies. Several exploratory factor analyses have confirmed the relative independence of planning, simultaneous processing, and successive processing (e.g., Ashman & Das, 1980; Das & Dash, 1983; Das & Heemsbergen, 1983; Garofalo, 1982; Naglieri et al., 1989). The attention factor has been added to the model more recently. However, it has already been found to be separate from the other three factors in several studies (e.g., Das, Mensink, & Janzen, 1990; Naglieri, et al., 1991) and to capture attention problems in school populations (e.g., Papadopoulos, Das, Kodero, & Soloman, 1998). These factors have been consistently found, despite differences in the age, sex, achievement, or the socio-economic state of the participants.

3.1.2.5. Validity of the phonological measures

For the phonological measures used in this study, there is no other source of relevant validating data except the various studies that have used these kind of measures. The theoretical rationale behind choosing these phonological measures is that they are considered to measure adequately the readers' phonological processing abilities (Wagner et al., 1993) and the rhyme and alliteration skills of pre-school children (Maclean, et al., 1987). During the first two years of our study, these measures seemed to complement this requirement.

3.1.2.6. Validity of the Woodcock subtests

Norming data, content validity data as well as concurrent validity and reliability data are available for these widely used reading tests (Woodcock, 1987). In addition, grade- and age- equivalence scales are available for all reading tests. These continuous-year norms also form the basis for the percentile rank and standard score table. Woodcock percentile ranks or standard scores are based on the distance a participant's score is from the median value for the reference group at any tenth of a year for Grades K.0 to 16.9, at any month for Ages

5-0 to 18-11, and at one-year intervals beginning with age 19. The Standard Errors of Measurement (SEM) for Grades 1 and 2 are as follow: on Word Identification, SEM = 5.2, on Word Attack, SEM = 4.9, and on Passage Comprehension, SEM = 5.9 (Woodcock, 1987, p. 99).

3.1.3. Procedure

While in Kindergarten, the participants attended three individual testing sessions lasting from 20 to 40 minutes each. During these sessions, participants were administered the cognitive and phonological tasks. Approximately one year later, in Grade 1, the same participants were administered the same set of cognitive and phonological tasks along with the two reading measures (Word Identification and Word Attack). All testing took place during school hours in a quiet room in each of the participants' respective schools.

3.2. Reading remediation — Year 2

3.2.1. Participants and remediation groups in Grade 1 (year 2)

All 90 participants were retested on the cognitive and phonological measures (see procedure above) and 61 of the initial 90 students (22 of which were female) from 31 different schools scored below the 26th percentile on both Word Attack and Word Identification (WRMT-R) in January of Grade 1 and were included in the remediation. In this group, there was an attrition of three participants during the intervention. The mean age for this group was 76.6 months (SD = 3.8). After identifying the final sample, two matched remediation groups were formed. One group attended the PREP remediation program and the other attended the meaning-based instruction program. The mean ages were 76.4 (SD =

3.2) and 76.8 (SD = 4.4) months, for PREP and Meaning-based groups, respectively. Gender distributions were also equal with 11 females in each group. Moreover, of the 61 participants in the remediation programs, 46 (75%) were Caucasian, 9 (15%) were Native Canadian, 4 (6%) were Asian, 1 (2%) was east Indian, and 1 (2%) was African-Canadian. The socioeconomic status of this group was as follows: 43 (70%) were from middle to upper-middle income families and 18 (30%) were from lower-middle income families.

Remediation group matching was performed by clustering participants on the basis of 14 standardized criterion variables, which included nine cognitive processing tasks, three phonological processing tasks, and two reading tasks (Word Attack and Word Identification). Based on a matrix of either distances or similarities between pairs of cases, I used the *single linkage technique* (or nearest neighbor technique) to define the remediation groups. At the first step of grouping, following a dendrogram, the first cases with the smallest distance (or largest similarity) formed a cluster which was then allocated in one of two remediation groups. At the second step of matching, larger clusters of participants (4 to 6 children) were matched with their nearest neighbors using the Squared Euclidean dissimilarity method (which provided me with the smallest coefficients between participants) and divided them into different groups. Towards the end of the process, when eight participants remained and the coefficients grew larger, using discretion, I ended up with manageable groups and a balanced design.

Indeed, although matching took place simultaneously in 14-dimensional space, the subsequent ANOVAs on raw scores showed no significant differences between the groups on any of the 14 variables (all ps > .220). Table 1 presents the means, standard deviations (in parentheses), and F-values on cognitive, phonological and reading measures for the PREP and Meaning groups before remediation in Grade 1.

Table 1.

Scores in Winter of Grade 1 on Cognitive, Phonological, and Reading Tasks for Remediated Groups (PREP vs. Meaning).

	Remediation Groups				
	PREP Group (n = 29)		Meaning-based Group (n = 29)		
Variables	Mean	(SD)	Mean	(SD)	F-values
Planned Search	260.81	(88.96)	244.23	(80.05)	0.45
Planned Connections	65.18	(29.75)	67.93	(26.53)	0.16
Expressive Attention	2.53	(3.00)	2.38	(1.25)	0.06
Receptive Attention	8.17	(2.48)	8.86	(3.34)	1.53
Simultaneous Verbal	12.43	(3.65)	11.97	(3.11)	0.40
Figure Memory	5.83	(2.67)	5.93	(2.47)	0.01
Word Series	7.00	(2.97)	6.84	(2.46)	0.01
Senten. Rep. & Ques	9.27	(5.41)	9.35	(4.82)	0.11
Speech Rate	144.27	(29.13)	154.45	(45.40)	1.29
Rhyme Production	2.23	(2.16)	2.35	(2.04)	0.01
Phoneme Elision	1.80	(2.38)	2.42	(3.22)	0.61
Sound Isolation	2.27	(2.95)	2.97	(3.34)	0.79
Word Identification	3.90	(3.78)	3.39	(3.42)	0.73
Word Attack	0.30	(0.65)	0.16	(0.37)	0.55

3.2.2. Procedure

Remediation took place over two months during the spring of Grade 1 year and consisted of 18 twenty-minute sessions, which were conducted during school hours by trained experimenters (graduate students). Participating students worked individually or in groups of two or three, depending on the number of students receiving particular remediation in their schools. The variation in the groupings was similar across both programs in the beginning of the remediation. However, due to attrition, the final numbers were not completely equal. Specifically, students in the PREP received remediation as follows: nine students received remediation individually, 14 students were placed in groups of two, and six students were placed in groups of three. In the meaning-based program, seven students received remediation individually, 16 students were placed in groups of two, and six students were placed in groups of three.

3.2.3. Assessment tasks

As mentioned before the same set of cognitive and phonological tasks administered to the participants in Kindergarten were given along with the two word reading tasks as pre-test measures in Grade 1 as well. Only the two reading tasks were administered to the participants as post-test measures.

3.2.4. Remediation programs and remedial tasks

3.2.4.1. PASS Reading Enhancement Program (PREP)

Of the 10 tasks included in PREP, the following eight were selected for use with the participants of the present study: Window Sequencing, Connecting Letters, Joining Shapes, Matrices, Related Memory Set, Transportation Matrices, Tracking, and Shape Design. The same tasks were used in both first (in Grade 1) and second remediation (in Grade 2). What follows is a description of each of these tasks, including the levels that were administered and any modifications made to ensure that the participants could successfully complete the tasks (given that the program was originally designed for students at the middle elementary level). The tasks are listed in the order in which they were administered. The presentation of these tasks has been adapted by Parrila, Das, Kendrick, Papadopoulos, and Kirby (1997).

Window Sequencing. The focus of this task is successive processing. In the global component, the student's task is to reproduce a series of chips that vary in color and shape in the same order in which they are presented by the instructor. The chips are presented one at a time, left to right, through a '2 x 2' inches window. Each chip appears in the window for approximately one second. The series ranges in length from three to six chips. Four series of each length are presented per session, for a total of 12 items. There are three levels of difficulty in this task. Difficulty Level 1 involves sequences of two different types of chips (circles and squares) and holds the color as a constant. Difficulty Level 2 involves different colored chips (white, yellow, blue, and black) and holds the shape as a constant. In Difficulty Level 3, both the color and shape of the chips are manipulated. In the present study, only Levels 1 and 2 were used. The task was adapted for the age group by limiting the length of each series to three shapes for Level 1 and four shapes for Level 2.

The student's task in the bridging component is (a) to reproduce a series of letters in the same order in which they are presented by the instructor and (b) to state the word that is spelled by the letters. The letters, which the student views for approximately one second through a '2 x 2' inches window, are presented one at a time or in consonant or vowel combinations. There are three levels of difficulty as well as a preliminary level, each corresponding to the phonetic complexity of the words used. Only the Preliminary and Level 1 items were used with the participants in Grade 1. Level 2 was included for some participants in Grade 2.

Connecting Letters. Connecting Letters is predominantly a successive processing task. In the global component, the student is required to follow a line to find which letter on the left side of a page is connected to which letter on the right side of a page. Each stimulus card contains five letters on each side. The student is presented with each card individually. He/she is then required to write (or say) all of the connections. After the initial trial, the instructor directs the student's attention to any errors so that corrections can be made. There are three levels of difficulty. Three cards are presented at one difficulty level during a single session. Difficulty Level 1 contains strings that are color-coded to aid in scanning. Difficulty Level 2 contains black lines only. Difficulty Level 3 contains black lines as well as distracter lines that are not connected to any letters. For the purposes of this study, only the first two levels were used.

In the bridging component, the student is presented with a stimulus card with a column of five letters on the left side of the page and a column of five letters on the right side of the page. The letters are connected with lines that run across the page. Along these lines, there are more letters. Sometimes the letters are presented alone, and sometimes they are in small groups (consonant or vowel blends, or digraphs). Together, the sequence of letters on each line forms a word. Each line is color coded. The student is required to follow each line, mentally connect the series of letters that run across the page, and state the word that is spelled by the letters. Three levels of difficulty and a preliminary level are provided; each corresponds to the phonetic complexity of the words. Only the Preliminary level and Level 1 were administered to the participants in Grade 1, while Level 2 was introduced to some participants in Grade 2.

Joining Shapes. This task's focus is also successive processing. The purpose of the global component is to join a series of geometric shapes in response to (a) a series of verbal instructions and (b) a set of rules provided by the instructor. The shapes —triangles, squares, and hexagons— are presented in rows on a sheet of paper. Each row of triangles, squares, or hexagons is always separated by a row of circles. Within each session, six items with varying numbers of rows are presented. The first two items contain one row of triangles and one row of squares, with a row of circles in-between. The third and fourth items contain one row of triangles, one row of squares, and one row of hexagons, with rows of circles in-between. The fifth and sixth items contain a row of hexagons, a row of triangles, a row of squares, and another row of hexagons, with rows of circles in-between. These items are presented on two different stimulus cards. There are three levels of difficulty; each corresponds to the number of consecutive instructions to which the student responds. Levels 1 and 2 were included in the present study.

The format for the bridging component is as follows. On a sheet of paper, several rows of letters are presented to the student. The purpose of the task is to join the letters from the top row to the bottom row —moving diagonally from left to right and following a set of rules— to produce a word. When the student reaches the bottom, he/she uses the last letter of that word as the first letter of the next word, and then proceeds back to the top in the same manner to produce another word. This is continued until the student reaches the end of the sheet. The student is required to tell the instructor the words that he/she has formed. There are three levels of difficulty as well as a preliminary level; each corresponds to the length of the words included in the level. Only the Preliminary level and Level 1 words were administered in Grade 1, while Level 2 was also administered to some participants in Grade 2.

Matrices. Successive processing is the focus of the Matrices task. In the global component, the student is required to memorize a sequence of randomly chosen letters displayed within a five-cell matrix. The matrix is designed as a cross: there is one central cell, with one cell on each of its four sides. Each cell of the matrix contains one number (Matrix Numbers) or one letter (Matrix Letters). The student is shown the complete matrix containing one number or letter in each of the five cells. He/she is then asked to write (or say) the sequence in order, as the instructor points at each cell of a blank matrix. If the student has difficulty reproducing the sequence, he/she is shown the matrix numbers or letters in five stages, with only one number or letter being revealed at a time. After progressing through the sequence, the student is again asked to recall the sequence. This task was modified for Grade 1 students by eliminating the top and bottom cells for Level 1 and eliminating the bottom cell for Level 2. Thus, for Level 1, students were required to remember numbers in three cells only, and for Level 2, they were required to remember letters in four cells only. For several students this modified version of the task was used as the introductory one in Grade 2 too. Later on, some of them proceeded into the regular form of the task.

In the bridging component, the student memorizes the position and sequence of a series of words presented on a cross matrix by using the procedures that were learned during Matrix Numbers and Matrix Letters. There are ten series of words. The first five series of words have been classified at a Grade 3 level of reading difficulty, and the next five series of words are at a Grade 4 level of reading difficulty. Each series consists of five words arranged in a five-cell matrix, with one word in each cell. Four of the words are semantically related, one is not. In Part 1, the student is required to recall the words in their correct position and order. In Part 2, the student is required to identify the four related words and explain why the fifth word does not belong. Only Part 1 was included in Grade 1.

Related Memory Set. The Related Memory Set task involves both successive and simultaneous processing. The student's task in the global component is to match the front half of an animal with its appropriate back half. The animal pictures are line drawings on '3 x 3' inches cards. Three fronts are presented in a column on the left side of a page and one back is presented on a card placed on the right side of the page. The student is required to point to the front that matches the back. After making this prediction, he/she then places the front and back together to determine whether the response was correct. The student is then allowed to alter his/her prediction as necessary. There are three levels of difficulty; each corresponds to the difficulty of discrimination required. Levels 1 and 2 were included in this study.

The purpose of the bridging component is (a) to choose the proper front half of a word to match the back half and (b) to read the word. The student chooses from three front portions of words placed on the left-side of a page in a column. To the right of this column is the back half of one of the words. He/she is required to draw a line between one of the fronts and the appropriate back and to read the word. There are three levels of difficulty as well as a preliminary level; each corresponds to the complexity of the words. The present study included only the preliminary level, Level 1, and Level 2.

Transportation Matrices. In the global component of this successive processing task, the student is required to reproduce a series of transportation pictures in the correct order. The pictures are presented in a single-line matrix strip divided into sections (cells). The entire strip is shown, and then each individual picture in the strip is shown from the student's left to right on a horizontal line. There are three levels of difficulty: Level 1 contains six four picture series; Level 2 contains three four and three six picture series; Level 3 contains six picture series. Only items from Level 1 and 2 (Sets [a] and [b]) were used.

The student's task in the bridging component is to reproduce a series of letters in the correct order, and then read the word that is formed by the letters. The letters are exposed on a single-line matrix divided into cells to match the number of letters in the word. The letters are presented together, and then one at a time in their respective positions on the matrix. There are three levels of difficulty as well as a preliminary level; each corresponds to the phonetic complexity of the words. There are 15 words for each level. The Preliminary level and Level 1 and 2 words were administered to the participants, with the Level 2 being introduced in Grade 2.

Tracking. In the global part of this simultaneous processing task, the student is presented with a line drawing map of a "village" (Tracking Map I) and tracking cards illustrating a path from a starting point to either a numbered house (Level 1) or a lettered tree (Level 2). The tracking cards outline the roads and street intersections of the village map. The student's task is to survey each card and the village map, and then locate the number of the house or the letter of the tree on the map. Level 1 was included in Grade 1, while Level 2 was also included in Grade 2.

The bridging component involves a floor plan of West Edmonton Mall on which several key features are identified. The student is allowed some time to become familiar with the locations of the various key features. He/she is then given a series of printed passages (eight in total), one at a time. Each passage specifies a point of departure and two to four key features (listed randomly in the passage) to be visited by the student. Each passage also contains a constraint (e.g., time) under which the student is required to operate. The student's task is: (a) to read each passage as it is presented (with as much assistance as is required); (b) to identify the point of departure and the key features that are to be incorporated into the visit; and (c) to use the floor plan to trace a path that will begin at the designated point of departure, incorporate all of the specified features, and move through the mall as quickly as possible. The student begins with a passage that specifies two key features (including the point of departure) and finishes with a passage that specifies four features. In this study, when necessary, instructors read the passages to the participants.

Shape Design. Shape Design is predominantly a simultaneous processing task in which the student is required: (a) to study a design that is presented for ten seconds and (b) to reproduce the design with the colored shapes provided. The shapes include circles, rectangles, squares, and triangles in three colors (red, blue, and yellow) and two sizes. The stimulus cards consist of designs composed of these shapes. The designs range from a simple combination of three shapes, differing only in color, to a complex combination of six shapes differing along dimensions of color, shape, and size. The task is divided into three difficulty levels with six items in each. Only Levels 1 and 2 were used.

On the bridging component, student is required to read a phrase or story from a card that describes how two to five animals are arranged in relationship to one other. The student visualizes the scene with the animals positioned appropriately. With the reading card turned face down, he/she then arranges plastic figures to correspond with the scene as it was described in the phrase or story. Three difficulty levels are presented; each corresponds to the number and complexity of relationships. The first two difficulty levels were used.

As mentioned previously, a system of prompts is also an integral part of PREP. There are three stages of prompting. During Prompting Stage 1, the instructor provides only a minimal amount of assistance and allows the student to acquire strategies and principles through experience. At Prompting Stage 2, the instructor's goal is to encourage the student through questioning to find his/her own unique way of completing the task. For example, with word identification tasks, the instructor may ask, "Have you seen this word before?", or "Do you know any of the sounds in this word?" In the final prompting stage, Prompting Stage 3, the instructor demonstrates the task and asks the student to attempt to explain the strategies that were used.

3.2.4.2. Meaning-based program

The meaning-based program emphasized the philosophy of the whole-language approach to teaching reading. Although there is considerable disagreement among theorists about what the whole language approach entails (see e.g., Chall, 1996 for the great debate), Pressley (1994) suggests that there are two essential characteristics. First, learning to read will occur naturally as long as opportunities are provided; in other words, direct, systematic instruction is not always necessary (Spiegel, 1996). Second, learning to read should be purposeful for students and should involve real examples of language. That is, the whole language approach should be child-centered and literature-based. On the same lines, Strickland and Cullinan (1990) have clearly argued that "current naturalistic research strongly suggests that phonics is best learned in the context of reading and writing" (p. 428) and that "the evidence supports a whole language and integrated language arts approach with some direct instruction, in a context, on spelling-to-sound correspondences" (p.433). Clay (1985), the proponent of the Reading Recovery Program, has also placed great emphasis on teaching word recognition skills in context:

> Whenever possible the child will read and write text. He will not be diverted from printed texts...but will be taught what he needs to learn in the context of continuous text. The learning of details such as the sounds of letters or a list of words is completed through text reading and text writing, and his interactions with his teacher (p.52).

This is certainly a top-down theoretical orientation to fluent reading, according to which, minimal word-level information is used to confirm language predictions.

In designing the present study we considered the argument which states that many poor readers simply lack reading experience and instruction. Consequently, we exposed half of our sample to such a reading environment by providing a 'meaning-based' reading intervention as an alternative to PREP. However, the 'meaning-based' intervention was by no means a fully developed whole-language teaching program. It would not be possible to fully adopt a developed program and administer it within the short time equivalent to the length of the PREP program. Nevertheless, we included such an intervention in lieu of a no-treatment control. We reasoned that some children may improve in reading simply by being exposed to written stories with pictures, accompanied by a discussion of the stories' contents.

Accordingly, the meaning-based program in our study was designed as follows. In order to provide opportunities for learning to read in a natural way, children were read stories they selected from the instructor's collection of quality children's literature. The stories, which were rich in language, covered a wide range of topics. No direct, systematic reading instruction was provided especially in terms of spelling-to-sound correspondences, although the children were being given the chance to read and recognize words that were included in the passages. Moreover, the children participated in discussions about events and pictures in the stories as they related to their own personal experience. The overall objective of the meaning-based program was to encourage children to derive meaning from print by reconstructing the author's message, based on their own experiences (Froese, 1990).

3.3. Remediation in Grade 2 (year 3)

The main objectives of the third year of the study were four-fold:

(a) To examine the long-term effects of the remediation offered in Grade 1. For this analysis the sample was divided retrospectively into three groups: (i) Low Gainers (LG) and (ii) Average Gainers (AG), based on their long-term remediation effects as revealed in the follow-up testing session in the winter of Grade 2, and (iii) Never-Remediated (NRE) group who needed no remediation since the group's Grade 1 reading scores exceeded the 26th percentile criterion (on both reading subtests, the Word Identification and Word Attack). Such a grouping enabled us to plot the trajectories of growth for proximal (phonological) and distal (cognitive) processes from Grade 1 pre-testing to follow-up testing eight months later (in Grade 2).

(b) To compare the efficacy of the PREP program in contrast to the competing program of Meaning-based intervention in terms of their long-term effects.

(c) To offer further remedial training to the group of participants who still experienced reading difficulties despite having already attended either a PREP or Meaning-based remedial program and having gone through almost two years of formal reading instruction. This time, only PREP remediation was provided as it had been shown in Grade 1 to be more efficient in improving the reading skills of the participants, especially with regard to word decoding.

(d) To examine the immediate post-results of this intensive course of remediation by post-testing the participating children on phonological (Rhyme Production, Phoneme Elision, and Sound Isolation) and reading measures (Word Identification, Word Attack, and Passage Comprehension).

3.3.1. Participants

Due to attrition, only 40 of the 58 children of the remediation groups participated in the follow-up Grade 2 testing as well, along with the remaining 18 children who had not participated in the Grade 1 remediation. The mean age of this new group of 58 children (18 female; 31%) was 89.55 months (SD = 3.35), while the age of the group of the 27 participants (6 females) who still needed remediation was 89.37 months (SD = 3.78). Moreover, of the 58 participants, 51 (87.9%) were Caucasian, 4 (6.9%) were Native Canadian, and the remaining 3 (1.7% each) were Asian, Indian, and African-Canadian, respectively. Thirty-six (62.07%) of these participants came from middle-to upper-middle income families and 22 (37.93%) came from lower-middle income families. None of the missing cases from the remediation groups explicitly withdrew because of significant progress in reading. In the majority of cases, the participants had either changed schools without providing information on their new location (6 participants), or had moved out of the city of Edmonton (7 participants) and, therefore, it was not possible for them to continue in our research. Furthermore, one school withdrew (3 participants) and two parents did not provide further consent for their children (2 participants) to participate in the Grade 2 study because of the testing-load requirements of the research. This attrition affected both the PREP and meaning-based groups, reducing the participants' number by 6 and 12 participants, respectively, in Grade 2.

3.3.2. Measures

The same set of the 14 tasks (nine cognitive, three phonological, and two reading tasks) that were used in the Grade 1 testing were administered again to all participating children in the winter of Grade 2 at follow-up testing. The passage comprehension test, from the Woodcock Reading Mastery Test-Revised (Woodcock, 1987), was also added in the reading measures.

Post-remediation scores were obtained on phonological and reading measures for the children who fully participated in remediation in spring of Grade 2.

3.3.3. PREP remediation

The second remediation began in April of 1997 and was administered again during school hours by graduate research assistants who were thoroughly trained in the administration of the PREP program. The remediation provided this year was varied slightly from that of the previous year in terms of length, intensity, and timing; PREP was provided for a period of four weeks or 20 daily sessions, each lasting 30 minutes. Moreover, all participating children worked individually, as opposed to the first year's design, where some of the children had to work in groups of two or three, due to the number of students receiving remediation in their schools.

CHAPTER IV

RESULTS

Section I

4.1.1. Fall 1995 in Kindergarten: Confirmation of sample selection

As has already been mentioned in the method section, the sample of this study was identified as being 'at-risk' based on the judgment of Kindergarten teachers who followed a screening form of inclusionary and exclusionary criteria. The judgments made by the teachers about the children's reading ability were generally confirmed by the subsequent cognitive profiles of these children, as the following results demonstrate.

To confirm sample selection, the mean scores on cognitive measures obtained by the sample of this study in Kindergarten were compared to the norm scores of the CAS battery (Das & Naglieri, 1993). Moreover, the scores on Phoneme Elision and Sound Isolation were compared to the respective scores provided by Wagner et al. (1993). In their study, a same-age Kindergarten sample was tested, but at the age of 5 years and 11 months, as opposed to the 5 year and 6 month old sample in our study. Finally, it should be mentioned that the Rhyming Production task was not included in these calculations due to the lack of comparable data of children at this age. In terms of unit of analysis, Planned Search, Planned Connections (only item 4), Expressive Attention (Item 3), Receptive Attention (Item 4), and Speech Rate were latency measures. In contrast, Figure Memory, Simultaneous Verbal, Word Series, Sentence Repetition and Questions, Phoneme Elision, and Sound Isolation were accuracy measures. Effect sizes[1] (d) were calculated for all the comparisons

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[1] Following formula $d = |Mean_1 - Mean_2| / [(Sd_1^2 - Sd_2^2) / 2]^{.5}$ (Cohen, 1969)

due to the availability only of means and standard deviations in the norming data. Table 1-1 presents the means, standard deviations, and effect sizes for initial present sample and norming group on cognitive and phonological measures. Similarly, Figure 1-1 displays graphically the standing of the sample compared to the norming group. The X-axis represents the norming group performance and the Y-axis shows the standardized distance between the present sample and the norming group. In terms of interpreting the effect sizes, Cohen (1969) suggests that effects sizes smaller than .5 should be regarded as small, .5 to .8 as medium, and .8 and above as large. Conceptually the effect sizes can be interpreted as an approximation of group differences in standard units. Thus, an effect size of .5 would indicate that the difference between the groups was about half a standard deviation unit.

The performance of the present sample on all the cognitive and the two phonological tasks appeared to be lower than the norming group's performance. The larger group differences were observed on Planned Search, Figure Memory, Speech Rate, and Sound Isolation. Medium group differences were observed on Simultaneous Verbal and Word Series tasks, whereas small differences were obtained on the Planned Connections, the two attention tasks, the Sentence Repetition and Questions, and Phoneme Elision tasks.

These results indicate that at the very beginning of this study, the present sample exhibited cognitive deficits, especially on measures of successive processing, simultaneous processing, and planning. The differences in the successive and simultaneous processing tests between the present sample and the norming group were expected to a certain extent from previous studies, in which significant differences between good and poor readers on these cognitive tasks have been reported (Das, Mensink, & Mishra, 1990; Das, Mishra, & Kirby, 1994). Moreover, in a study on Planning and its contribution to reading disability (Naglieri & Reardon, 1993) the Planned Search subtest accounted for a significant proportion of variance in reading scores. In addition to these cognitive tasks, the present

Table 1-1.

Means, Standard Deviations, and Effect Sizes for Initial Present Sample and Norming Group on Cognitive and Phonological Measures

	Initial Present Sample (n = 101)		Norming Group (n = 70)		
	Mean	(SD)	Mean	(SD)	d
Planned Search	418.90	(158.31)	265.59	(84.34)	-1.21
Planned Connections	30.40	(16.25)	25.37	(16.19)	-0.31
Expressive Attention	89.47	(24.98)	82.92	(27.79)	-0.24
Receptive Attention	99.99	(25.15)	89.55	(20.66)	-0.45
Simultaneous Verbal	10.41	(3.07)	12.83	(3.38)	-0.75
Figure Memory	3.76	(2.49)	5.86	(2.42)	-0.86
Word Series	6.49	(2.36)	8.50	(3.24)	-0.71
Sentence Rep. & Ques	7.39	(3.97)	9.33	(4.99)	-0.43
Speech Rate	193.29	(59.07)	148.88	(41.73)	-0.87
Phoneme Elision	1.70	(2.00)	2.70	(3.10)	-0.38
Sound Isolation	1.26	(1.65)	4.00	(4.30)	-0.84

Note: small effect = $.2 \leq d < .5$; medium effect = $.5 \leq d < .8$; large effect = $.8 \leq d < \infty$

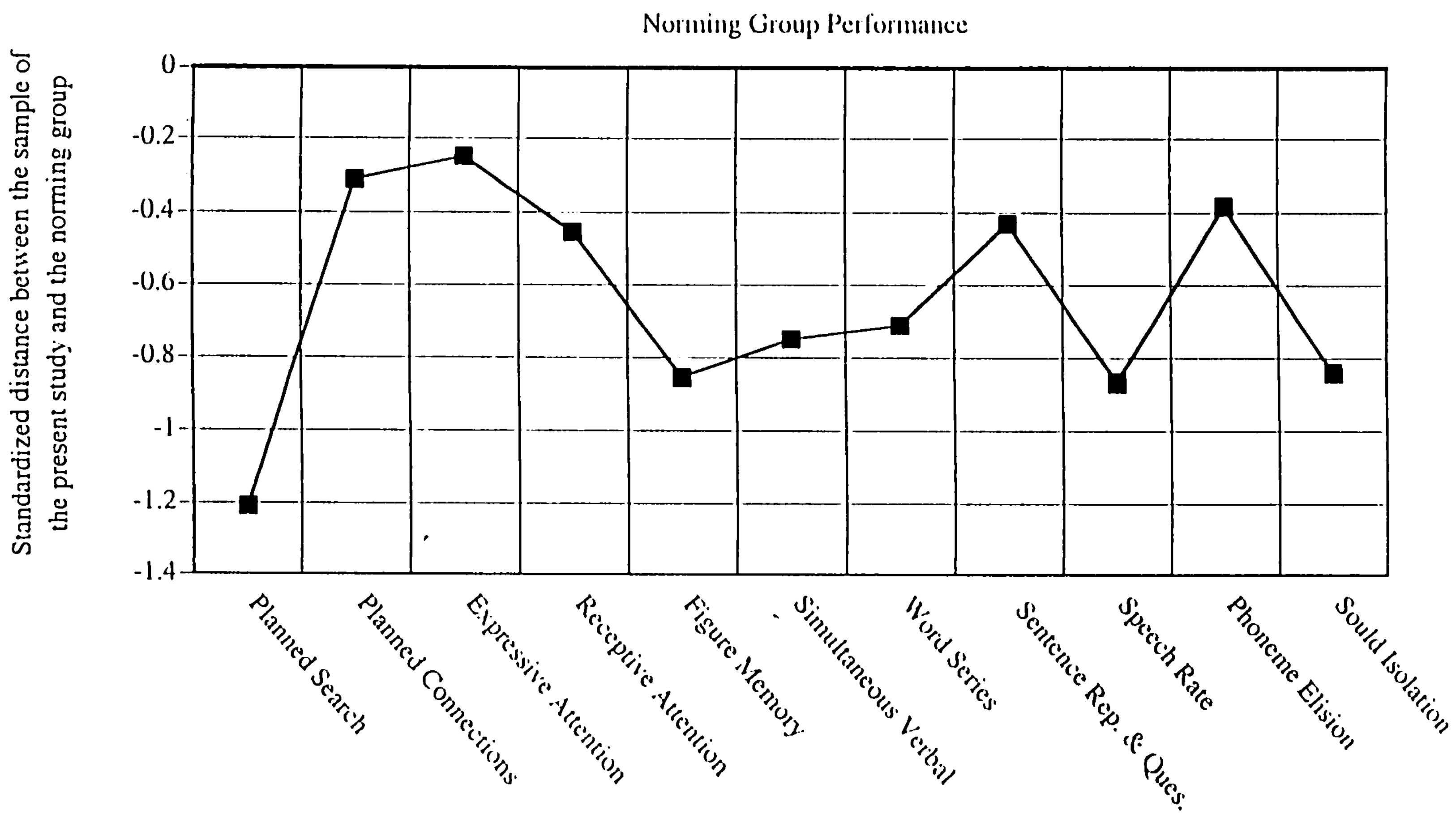


Figure 1-1. Effect Sizes for the Mean Differences in Cognitive and Phonological Tasks in Kindergarten for the Present Sample and the Norming Group (DN-CAS, 1993).

sample was observed to perform poorly in only one of the phonological tasks, Sound Isolation, a finding that supports the research implicating a basic phonological deficit at the core of reading difficulties in word recognition level (Ball & Blachman, 1988; Ehri, 1987; Lundberg, Frost, & Petersen, 1988; Torgesen, Wagner, & Rashotte, 1994). Considering these results together, it appears that the present group exhibited deficits in cognitive processes that went beyond phonological coding.

4.1.2. From Kindergarten to Grade 1: Predicting Grade 1 reading scores from Kindergarten phonological and cognitive scores

The main question asked in the present section is: What cognitive and phonological skills in Kindergarten predict reading in Grade 1 in an 'at-risk' sample of children? As would be expected with a sample of at-risk children, neither of the reading measures, Word Identification (WI) and Word Attack (WA), were normally distributed in Grade 1. For this reason, the main dependent variable was a categorical variable formed on the basis of the participants' reading scores. The first group consisted of "nonreaders" (NR: 28 participants [7 females]) who obtained very low raw scores on both reading tasks (WI M = .82, SD = .94, and WA M = 0; mean percentile scores 1.28 and 0, respectively). The second group, "poor readers" (PR), consisted of those 31 participants (15 females) who showed some, albeit rudimentary, reading skills. Their WI mean score was 6.35 (SD = 3.46) and the WA mean score .26 (SD = .44). The mean percentile scores for this group were 13.33 and 3.30, respectively. Finally, the third group, "low average readers" (LAR), consisted of participants who had one or both reading scores above the 30th percentile (WI M = 12.77, SD = 7.21, and WA M = 5.35, SD = 3.21; mean percentile score 30.23 and 33.13, respectively). These participants would generally not be considered as reading disabled.

First, Kruskall-Wallis nonparametric ANOVAs comparing the three different reading groups (NR, PR and LAR groups) on cognitive and phonological tests are reported. In doing this, I am particularly interested in examining whether these groups can be distinguished on the basis of their performance on successive and phonological tests. Since neither the cognitive nor the phonological scores in Kindergarten were normally distributed, only the results of nonparametric statistics are reported below. Table 1-2 presents the means, standard deviations, and Chi Square values from nonparametric ANOVA for the main effect of group on all cognitive and phonological tasks. ANOVA was not calculated for Speech Rate because 23 participants had missing values (they could not complete all eight series of three words). In addition, for Planned Connections, only the sum of items 1 to 4 was included in the analysis due to the low success rate on items 5 and 6. Moreover, for the two attention tasks, the measure of analysis was defined by the division of time by the number of correct responses obtained by the participants. This ratio score is more likely to provide more accurate information compared to the latency values used in the norming data.

Nonparametric Kruskal-Wallis tests showed that the main effect of reading group was significant for Planned Search, $F\ (2, 87) = 3.43$, $p < .05$, Figure Memory, $F\ (2, 87) = 3.44$, $p < .05$, Word Series, $F\ (2, 87) = 3.34$, $p < .05$, Sentence Repetition and Questions, $F\ (2, 87) = 3.87$, $p < .05$, Rhyme Production, $F\ (2, 87) = 4.74$, $p < .01$, Phoneme Elision, $F\ (2, 87) = 6.53$, $p < .001$, and Sound Isolation, $F\ (2, 87) = 6.44$, $p < .001$.

Post hoc pairwise comparisons (Mann-Whitney test, $p < .05$) indicated that the NR group performed at a significantly lower level than the PR group on Word Series, Sentence Repetition and Questions, Rhyme Production, and Sound Isolation. Differences between the NR and the LAR groups were significant for all seven tasks that showed the significant main effect of group. In contrast, only one of the pairwise comparisons — Phoneme Elision — revealed significant differences between the PR and the LAR groups. In sum, children

Table 1-2.

Means, SDs, Chi-square values and Kruskal Wallis Tests on Cognitive and Phonological Tasks for Nonreaders, Poor readers, and Low-Average Readers for Kindergarten Scores

Tasks		Reading Groups			c^{2}†
		Non-readers (n = 28)	Poor readers (n = 31)	Low Average readers (n = 31)	
Planned Search	M	454.07^{3}	418.97	360.71	6.47*
	(SD)	(127.60)	(174.31)	(103.80)	
Planned Connections‡	M	72.48	77.17	78.83	0.96
	(SD)	(49.23)	(34.57)	(48.90)	
Expressive Attention	M	4.04	3.59	3.03	2.28
	(SD)	(4.33)	(2.95)	(2.02)	
Receptive Attention	M	14.43	14.57	11.80	2.76
	(SD)	(6.89)	(7.53)	(3.32)	
Simultaneous Verbal	M	9.71	10.68	10.87	2.77
	(SD)	(3.15)	(2.96)	(3.06)	
Figure Memory	M	3.00^{3}	3.87	4.58	6.34*
	(SD)	(2.78)	(2.01)	(2.60)	
Word Series	M	$5.50^{2,3}$	6.81	6.82	7.67*
	(SD)	(2.33)	(2.04)	(2.29)	
Sentence Repetition & Questions	M	$5.96^{2,3}$	8.60	7.93	8.57*
	(SD)	(4.50)	(3.86)	(2.73)	
Rhyme Production	M	$1.25^{2,3}$	2.48	2.77	9.91**
	(SD)	(1.86)	(2.06)	(2.06)	
Sound Isolation	M	$0.50^{2,3}$	1.26	1.97	11.28**
	(SD)	(0.92)	(1.44)	(2.07)	
Phoneme Elision	M	0.89^{3}	1.74^{3}	2.71	13.87**
	(SD)	(1.81)	(2.02)	(1.95)	

Note. $^{2, 3}$: indicate group differences (corresponding to second and third groups) after performing Mann-Whitney Post-hoc pairwise comparisons; † Kruskal Wallis values, df = 2; ‡ n = 21, 30, 30 for NR, PR, and LAR groups, respectively; * $p \leq .05$; ** $p \leq .01$

who were essentially nonreaders in January of Grade 1 performed significantly poorer than a group of low average readers on both phonological and successive tasks in Kindergarten.

Next, in order to examine which cognitive skills in Kindergarten are associated with reading performance in Grade 1, correlations (Kendall's tau-b Bivariate; appropriate for bimodal or quartiled distributions) between Kindergarten cognitive and phonological tasks and the reading groups in Grade 1 were calculated first. For these analyses, cognitive and phonological variables were recoded either into four or two categories, the latter being used only if the distribution was clearly bimodal, as was the case with the three phonological tasks. For most of the variables, four categories were formed by dividing the sample into quartiles and then assigning 1 to the lowest quartile, 2 to the second lowest quartile and so on. Two exceptions to the rule were Planned Connections and Speech Rate. In these two tasks, the quartiles were based on performance time with the exception that the participants who could not complete the task, nine in Planned Connections and 23 in Speech Rate, were all assigned to the lowest quartile. For Speech Rate, the lowest quartile consisted only of children who could not complete the task.

Table 1-3 displays the inter-correlations (non-parametric Kendall's Tau-b) among cognitive and phonological measures in Kindergarten. Although the main focus of this analysis is the variables that predict reading group membership (see next), inter-correlations are provided before cross-lag correlations in order to test for collinearity among the predicting variables. The correlations are presented separately for all 90 participants (above diagonal) and only 59 participants of Non-readers and Poor-readers groups (below diagonal).

Although there are significant correlations between the cognitive and phonological variables, all the correlations are lower than .5, which means that there is not threat a of collinearity among the predicting variables. There are some significant correlations, however, that we should pay attention to: when all 90 participants were included in the

Table 1-3.

Inter-correlations Among Cognitive and Phonological Variables in Kindergarten

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1—Planned Search		.01	.17	.31**	.10	.28**	.13	.05	.15	.06	.20*	.16
2—Planned Connect.	.08		.05	.03	.02	-.02	.06	.03	-.03	.04	.17	.19*
3—Expressive Attent.	.19	.08		.24**	.05	.20*	.09	.17	.15	-.02	.27**	.24*
4—Receptive Attention	.29**	.02	.14		.33*	.22*	.04	.20*	.02	.05	.24*	.13
5—Simultan. Verbal	.21	.08	.04	.38**		.18*	.03	.17	.16	.07	.18	.07
6—Figure Memory	.28*	-.07	.13	.15	.06		-.08	.18*	-.01	-.01	.15	.06
7—Word Series	.13	.07	.16	.03	.06	-.07		.35**	.24**	.21*	.03	.12
8—Sent. Rep. & Ques.	.07	.01	.22*	.21	.15	.15	.38**		.18*	.32**	.17	.34*
9—Speech Rate	.17	.01	.14	.02	.20	.06	.31**	.18		.16	.02	.06
10—Rhyme Production	.01	-.04	.15	.09	.18	.10	.24	.39**	.16		.31**	.22*
11—Sound Isolation	.12	.13	.19	.23	.18	.22	.09	.31*	.08	.32*		.46**
12—Phoneme Elision	.03	.26*	.29*	.01	.03	.08	.17	.42**	.05	.17	.47**	

Note: Correlations for all 90 participants are above the diagonal and correlations with the 59 participants (Non-readers and Poor Readers Groups are below the diagonal)

* $p \leq .05$; ** $p \leq .01$

analysis, significant correlations were observed between attention tasks, simultaneous processing tasks, successive processing tasks, as well as phonological processing tasks. These correlations were expected based on the results of several past studies, as well as on the theory associated with the use of them (Das, Naglieri, & Kirby, 1994; Wagner et al., 1993). Also, Planned Search was highly correlated with Figure Memory. This result may imply that for this young age a prerequisite of Planned Search, a visual matching skill, may have assumed more importance than strategies for locating a target in a field of distracters. For kindergarten children, the test probably involves target identification rather than search strategies and may therefore tap more into simultaneous processing than into planning. Also, Phoneme Elision is significantly correlated with Sentence Repetition and Questions may have some theoretical importance in terms of explaining reading skills (or difficulties) through both phonological and successive processing. The connection between the two, however, needs to be replicated before any definite conclusions can be drawn.

Similar trends were observed when only the weak readers were included in the analysis (NR and PR groups). Successive processing tasks continued to correlate significantly with each other, the only exception being of the correlation between Speech Rate and Sentence Repetition and Questions. The same level of significance was also observed with the phonological tasks, although this is not a surprise. Weak readers seemed to experience overall difficulties in both groups of tasks (Successive and Phonological processing tasks). The Sentence Repetition and Questions task was again, significantly correlated with the Phoneme Elision task, while a significant correlation was obtained with the Sound Isolation task as well. Finally, Planned Search and Figure Memory were again, significantly correlated.

Next, Table 1-4 displays only the significant cross-lag non-parametric correlations (Kendall's Tau-b) between Kindergarten scores on cognitive (categorical) and phonological (bimodal) and Grade 1 reading group membership. In the first column, all ninety

Table 1-4.
Significant Ordinal Correlations of Both Cognitive and Phonological Tasks in Kindergarten with Reading Groups in Grade 1

Non-disabled vs. Disabled Readers (LAR vs. PR & NR combined)	Kendall's tau-b	Disabled Readers only (NR vs. PR)	Kendall's tau-b
Phoneme Elision[a]	.402**	Word Series[b]	.312**
Sound Isolation[a]	.292**	Sound Isolation	.305*
Planned Search[b]	.243**	Speech Rate	.294*
Rhyme Production[a]	.243*	Phoneme Elision	.281*
Sentence Repetition and Quest[b]	.230*	Rhyme Production	.260*
Speech Rate[b]	.191*		

Note:

Correlations are presented in the order of significance

[a] binary data: participants who could perform the task and participants who could not

[b] categorical data based on quartiles

* $p \leq .05$; ** $p \leq .01$

participants are divided into two groups: 'non-disabled readers' (or Low Average Readers: LAR group) and 'disabled readers' [Poor Readers (PR) and Non-Readers (NR) groups combined]. In contrast, the second column only includes the 59 disabled readers and compares the PR group to NR group.

All three phonological tasks, and at least two of the successive processing tasks, appeared to be highly correlated with both outcome variables. In addition, Planned Search correlated with the division of non-disabled vs. disabled readers (LAR vs. PR & NR combined). Considering that Planned Search contains four items in which the participant has to locate a letter among letters as well as four items in which numbers have to be located among numbers, one could argue that poor performance on this task may reflect a lack of letter and/or number knowledge on the part of the combined PR and NR groups as compared to the LAR group. However, consequent nonparametric Kruskal-Wallis tests showed that the main effect of reading group (PR & NR vs. LAR group) was not significant in any of the following cases: (a) when groups were compared on items containing only letters, $\chi^2(1, \underline{n} = 90) = .203$, $\underline{p} > .05$, (b) when groups were compared on items containing only numbers, $\chi^2(1, \underline{n} = 90) = 1.475$, $\underline{p} > .05$, and (c) when groups were compared on items containing both letters and numbers, $\chi^2(1, \underline{n} = 90) = .047$, $\underline{p} > .05$. These latter results indicate that individual differences in reading are also related to the planning component.

To examine whether different variables correlated significantly with word decoding skills (Word Attack subtest) and word-recognition skills (Word Identification subtest), another set of correlations (Kendall's tau-$\underline{b}$) was calculated. The Word Attack scores were divided into a binary form, consisting of those participants who could perform the task ($\underline{n}$ = 36) and those participants who could not ($\underline{n}$ = 54), whereas the Word Identification scores were divided into quartiles with the lower quartile indicating the lower performance ($\underline{n}$s = 20, 23, 23, and 24, for quartiles 1 to 4, respectively).

Table 1-5 reports the respective correlations separately for Word Attack (binary) and Word Identification (quartiles) scores in Grade 1. In sum, Phoneme Elision, Rhyme Production, Planned Search and Speech Rate correlated significantly with Word Attack (WAT) scores in Grade 1. On the other hand, Phoneme Elision, Sentence Repetition and Questions, Figure Memory, Sound Isolation, Planned Search, Rhyme Production and Simultaneous Verbal correlated significantly with Word Identification (WID) scores.

Taken together, Tables 1-4 and 1-5 indicate that both successive processing and phonological processing skills in Kindergarten correlate significantly with reading skills one year later in our sample of 'at risk' children — with the Phoneme Elision task revealing the highest correlations. Moreover, the tasks that correlated significantly with pseudoword reading (WAT) were partially different from the tasks that correlated significantly with the ability to read familiar words (WID). The significant correlation between Kindergarten Figure Memory scores and Grade 1 Word Identification scores suggests that some of our participants may have relied extensively on sight reading strategies in this task.

Next, two separate regression analyses were computed in order to examine what variables in Kindergarten predict reading performance in Grade 1. Because linear regression analysis cannot be used when dependent variables are categorical, logistic regression analysis was used instead (Wright, 1995). The predictor variables remained in the same format as in the correlational analyses and were entered in the regression equation following a forward stepwise procedure.

The first question was: What predicts subsequent reading disability in an at-risk sample of Kindergarten children? For these analyses, NR and PR groups were again combined to form the disabled readers group and then compared with the LAR group (non-disabled poor readers). Logistic regression analyses (using Likelihood-Ratio Statistics[2])

[2] The Likelihood-Ratio Statistic has a chi-square distribution with r degrees of freedom, where r is the difference between the number of terms in the full model and the reduced model

Table 1-5.

Significant Correlations of Both Cognitive and Phonological Tasks in Kindergarten with Word Attack and Word Identification Scores

Word Attack Scores[a]	Kendall's tau-b	Word Identification Scores[b]	Kendall's tau-b
Phoneme Elision[a]	.381**	Phoneme Elision	.350**
Rhyme Production[a]	.236*	Sentence Rep. & Quest.[b]	.305**
Planned Search[b]	.220*	Figure Memory[b]	.302**
Speech Rate[b]	.214*	Sound Isolation[a]	.291**
		Planned Search	.271**
		Rhyme Production[a]	.225*
		Simultaneous Verbal[b]	.175*

Note:

Correlations are presenting in the order of significance

[a] binary data: participants who could perform the task and participants who could not

[b] categorical data based on quartiles

* $p \leq .05$; ** $p \leq .01$

Ns: Word Attack scores = 54 participants were assigned 0, not being able to perform the task and 36 participants were assigned 1 for being able to perform the task
Word Identification scores = 20, 23, 23, and 24 participants, in quartiles 1-4, respectively

indicated that three variables were significant predictors of this division (in the order of enter into the equation): Phoneme Elision, LR = 6.56, $p \leq .05$ (percent correct 67.78%), Figure Memory, LR = 6.05, $p \leq .05$ (percent correct 75.56%), and Speech Rate, LR = 5.57, $p \leq .05$. Together, these three variables correctly predicted the reading status of 76% of the participants with only seven "false negatives" (children who belonged to the NR/PR group although they were predicted to belong to the LAR group).

A second set of logistic regression analyses examined which variables predict "subtypes" (NR or PR) of reading disability. In other words, which variables differentiate those children who have no reading skills from those who have some, albeit rudimentary, reading skills in Grade 1. Logistic regression indicated that Word Series, LR = 6.84, $p \leq .01$, (percent correct 67.80%), and Sound Isolation, LR = 5.17, $p \leq .05$ were the only significant predictors of the NR versus PR division. Together, these two tasks correctly classified 71% of the participants. This accuracy is quite remarkable given the highly selective nature of the sample.

To summarize, the results of this first section indicate that the present sample was logically identified by Kindergarten teachers as being 'at-risk', exhibiting weaknesses on both cognitive and phonological processing tasks. Yet, three distinctly different groups emerged from this sample, with the two lower groups performing significantly poorer than the higher group (LAR group) on both successive and phonological tasks in Kindergarten. These differences, in turn, were confirmed when the Kindergarten cognitive and phonological measures were used as predictors of the word recognition and word decoding performance in Grade 1. More specifically, the correlational results indicated that being a poor reader, and therefore, participating in the remediation, was defined by both successive and phonological processing tasks, along with one planning task, the Planned Search. Similarly, being a poor reader, as compared to a non-reader, was only defined by successive and phonological processing tasks. In addition, it is important to note that different tasks were significantly correlated with word decoding and word recognition skills. Simultaneous processing seemed to play a significant role in the latter case of word recognition skills, implying that for this 'at-risk' readers group, sight word reading can be an efficient strategy for successful word-reading. Finally, regression analyses confirmed that all three phonological awareness, successive processing, and simultaneous processing tasks are primarily responsible for differentiating, first the disabled readers from the low average readers, and then the nonreaders from the poor readers within the disabled group.

The analysis performed in this section needs to be replicated with another population with the same characteristics to confirm the results obtained here. However, the argument can be made up to this point that the above results coincide with our hypothesis that both successive and simultaneous processing, along with the phonological measures do predict reading difficulties.

The next section of the results deals with the remediation effects. Two subsections are presented: the first subsection focuses primarily on the differential effects of PREP versus Meaning-Based programs after the remediation provided in the spring of Grade 1, and the second subsection investigates the long-term benefits of the remediation examining the participants' performance on all cognitive, phonological, and reading tasks in Grade 2. Finally, the results of the second round of the PREP remediation in Grade 2 are also reported.

Section II-I

4.2.1. Remediation in the spring of Grade 1

As mentioned in the methodology section, in January 1996, the same set of phonological and cognitive measures, which had been administered to participants in

Kindergarten, were re-administered to them in Grade 1, along with two reading measures from the Woodcock Reading Mastery battery (Word Identification and Word Attack subtests). Following this testing, two groups were formed based on the participants' reading measures. The first group consisted of those 29 participants (12 females) who, although they had been identified as being 'at-risk' while they were in Kindergarten, obtained reading scores above the 26th percentile (in average on WAT and WID measures) and therefore did not need remediation. The second group consisted of 61 children (22 females) who needed remediation, scoring below the 26th percentile on both reading measures in January of Grade 1. In this group, there was an attrition of three participants during remediation. The mean age for this group was 76.6 months ($\underline{SD} = 3.8$). Next, two remediation groups matched on 14 variables were formed from the latter group. One group attended the PREP remediation program and the other attended the meaning-based program.

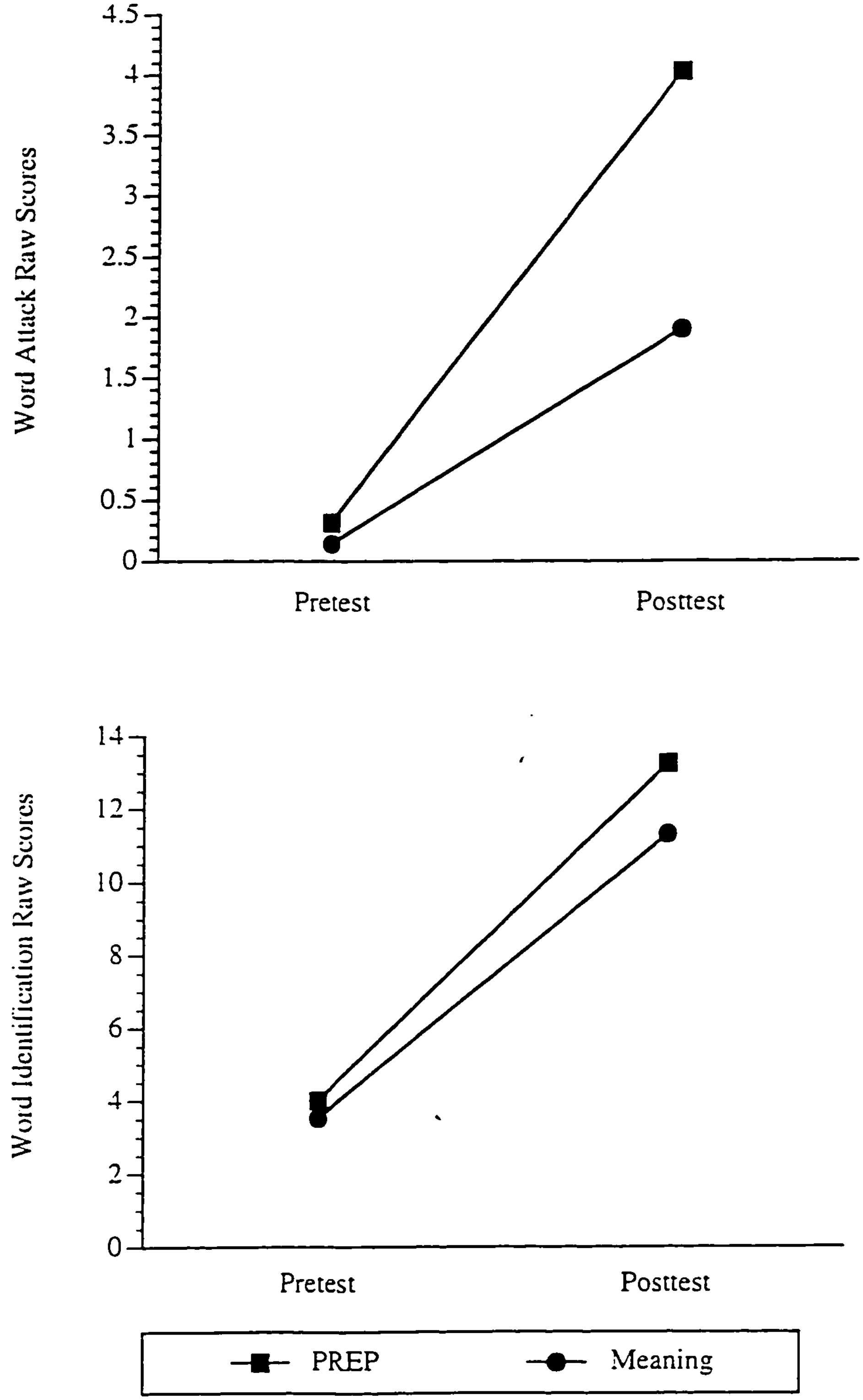
Table 2-1 presents the means and standard deviations (in parenthesis) for the pre- and post-test Word Attack and Word Identification scores for the two remediation groups. The data were subjected to Testing Time (2) X Remediation Group (2) repeated measures ANOVA separately for Word Attack and Word Identification. The main effect of Testing Time was significant in both analyses, indicating that over the three month period the participants had advanced in their basic reading skills. For Word Attack, the Remediation Group X Testing Time interaction was also significant, $\underline{F}\ (1, 56) = 4.90$, $\underline{p} = .031$. This result indicates that the PREP group improved significantly more than the meaning-based group in pseudoword reading. The interaction is shown in Figure 2-1. The interaction was not significant for Word Identification ($\underline{p} > .10$), despite the fact that the PREP group showed a slightly higher benefit from the remediation, as shown in Figure 2-2.

A detailed examination of individual word attack performances showed that 14 out of the 29 children from the PREP group gained 15 percentile points or more during the remediation, exhibiting gains relative to the norm sample. Eleven of these 14 participants

Table 2-1.

Word Attack and Word Identification Scores as a Function of Remediation and Testing Time.

	Word Attack		Word Identification	
	Pretest	Posttest	Pretest	Posttest
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
PREP (n = 29)	.31 (.66)	4.03 (4.30)	4.00 (3.81)	13.24 (8.30)
Meaning (n = 29)	.14 (.35)	1.93 (2.46)	3.52 (3.50)	11.31 (8.82)



<u>Figures 2-1 & 2-2.</u>
Pre- and Post-test Scores (in Grade 1) for Word Attack and Word Identification Subtests for PREP and Meaning-Based Remediation Groups

were at the 2nd percentile before remediation, one was at the 7th percentile and two were at the 15th percentile. Moreover, eight of these 14 children scored at the 30th percentile or higher on the Word Attack post-test. In the meaning-based group, seven out of the 29 participants gained 15 percentile points or more (with five of them being at the 2nd percentile and two being at the 7th percentile before remediation), and two participants scored at the 30th percentile or higher in post-testing. On Word Identification, similar gains were made by four participants from the PREP group (with two being at the 3rd percentile, one at the 17th percentile, and one at the 21st percentile at pre-testing) and by two participants from the meaning-based group (both being at the 19th percentile before remediation). Combining the results from both Word Attack and Word Identification subtests, it appears that nine participants included in the PREP remediation group would not have qualified as having early reading problems if they had been tested after the remediation. In contrast, only three participants from the meaning-based remediation group exhibited similar progress.

In sum, these results indicate that while both programs were effective in producing small gains on a word recognition task, PREP produced significantly higher gains on the pseudoword reading task. This results was expected based on the theoretical framework of the PASS Reading Enhancement Program.

4.2.2. Cognitive profiles of participants in PREP and Meaning-based remediation programs

The above analysis of percentile scores showed that some children gained substantially from the remediation, while others did not. This is also reflected in the large post-test standard deviations presented in Table 2-1. An interesting question arises from these results: Are there differences in the cognitive profiles of participants who benefited from the remedial treatment and participants who did not?

In order to examine this question, participants in both remediation groups were divided into "Gainers" and "No-Gainers" on the basis of the Grade equivalent gain they showed from pre- to post-testing. Consequently, for Word Attack, Gainers in both PREP (PREP G) and meaning (MNG G) groups were those participants who showed a Grade equivalent gain of more than one-half grade, ranging from .70 to 1.30 (ns = 13 and 7, respectively). Similarly, on Word Identification, Gainers in both PREP and meaning groups were those participants who demonstrated a Grade equivalent gain from .50 to .80 (ns = 9 and 6 respectively). In contrast, participants who showed no improvement in terms of Grade equivalent in Word Attack in either group, were considered No Gainers (PREP NG and MNG NG groups; ns = 11 and 12 respectively). On the other hand, participants who showed an increment in their performance up to .20 in Grade equivalent were considered No-Gainers in Word Identification (ns = 6 for the PREP NG group and 10 participants for the MNG NG group). These criteria of gain were selected based on three distinct clusters of performance: a cluster of children in each group who show almost no improvement, a cluster of children who showed a relative gain, and a cluster of children who showed a considerable gain after remediation.

Table 2-2 displays the pre-test means and standard deviations for all cognitive, phonological, and reading tasks for the four Word Attack groups (Gainers and No-Gainers of PREP and Meaning-based groups) before remediation, and Table 2-3 displays all the corresponding scores for the four Word Identification groups.

In order to test the significance of potential group differences, two separate Gain group (2) x Remediation (2) MANOVAs were calculated for planning, attention, simultaneous processing, successive processing, phonological processing, and pre-test reading scores. The first analysis included the groups that showed gain on word attack, and the second analysis included the groups that showed gain on word identification.

Table 2-2.

Pre-test Means and Standard Deviations for the Word Attack Gainers and No-Gainers Groups in Cognitive, Phonological, and Reading Tasks.

	Remediation Groups							
	PREP				Meaning			
	Gainers (n = 13)		No-Gainers (n = 11)		Gainers (n = 7)		No-Gainers (n = 12)	
Variables	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Planned Search	269.78	(114.72)	260.46	(67.58)	224.57	(89.47)	252.75	(68.62)
Planned Connections	61.00	(22.81)	78.00	(36.17)	53.00	(16.57)	82.89	(29.61)
Expressive Attention	3.00	(4.26)	2.48	(1.84)	1.67	(0.52)	3.05	(1.57)
Receptive Attention	7.93	(1.67)	8.94	(3.45)	7.54	(1.23)	10.14	(3.01)
Simultaneous Verbal	14.31	(2.17)	11.18	(3.28)	13.28	(2.36)	10.33	(3.58)
Figure Memory	5.77	(2.55)	5.45	(3.36)	5.43	(1.72)	5.25	(2.86)
Word Series	7.77	(2.83)	6.27	(3.29)	7.00	(1.53)	5.92	(2.15)
Sentence Rep. & Ques.	12.54	(5.28)	5.63	(3.20)	9.43	(3.60)	8.67	(5.61)
Speech Rate	143.54	(24.40)	154.80	(35.81)	140.43	(20.47)	174.40	(68.21)
Rhyme Production	2.61	(2.40)	1.73	(1.85)	2.86	(2.11)	1.67	(1.87)
Phoneme Elision	2.46	(2.40)	0.64	(0.92)	2.14	(3.34)	1.58	(2.91)
Sound Isolation	3.38	(3.35)	0.64	(1.21)	5.00	(4.47)	2.17	(2.98)
Word Identification	5.15	(3.60)	2.18	(3.43)	6.00	(3.70)	1.58	(2.87)
Word Attack	0.23	(0.60)	0.18	(0.40)	0.28	(0.49)	0.08	(0.29)

Table 2-3.

Pre-test Means and Standard Deviations for the Word Identification Gainers and No-Gainers Groups in Cognitive, Phonological, and Reading Tasks.

	Remediation Groups							
	PREP				Meaning			
	Gainers (n = 13)		No-Gainers (n = 11)		Gainers (n = 7)		No-Gainers (n = 12)	
Variables	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Planned Search	240.23	(63.98)	257.02	(84.26)	193.83	(27.18)	275.70	(87.50)
Planned Connections	63.11	(32.72)	58.80	(37.26)	62.33	(21.70)	82.56	(26.41)
Expressive Attention	1.83	(0.84)	1.90	(0.71)	1.96	(1.01)	2.79	(1.27)
Receptive Attention	8.14	(2.12)	8.90	(3.91)	9.08	(4.57)	9.85	(3.46)
Simultaneous Verbal	12.00	(4.64)	12.67	(3.98)	10.50	(3.94)	10.40	(2.95)
Figure Memory	5.67	(3.46)	7.17	(3.19)	7.17	(2.23)	4.30	(2.83)
Word Series	6.89	(3.44)	8.17	(3.82)	6.00	(1.67)	5.30	(1.64)
Sentence Rep. & Ques.	11.11	(7.85)	9.33	(5.05)	7.83	(4.67)	7.90	(3.98)
Speech Rate	138.56	(18.24)	158.50	(43.25)	170.67	(63.10)	151.00	(51.89)
Rhyme Production	3.00	(2.24)	2.50	(1.87)	2.00	(2.28)	2.10	(2.02)
Phoneme Elision	1.89	(2.47)	0.67	(1.03)	4.17	(4.75)	0.80	(1.32)
Sound Isolation	3.00	(3.90)	1.67	(1.50)	4.83	(5.27)	1.10	(1.73)
Word Identification	2.33	(2.34)	4.67	(5.43)	3.50	(3.15)	1.90	(2.81)
Word Attack	0.33	(0.71)	—	—	0.33	(0.52)	0.08	(0.29)

In terms of word attack gaining groups, the multivariate Wilks L was not significant for any of the three effects (i.e., Gain group, Treatment group, and Interaction effects). Subsequent univariate results indicated that the main effect of Gain group was significant for Planned Connections, F (1, 32) = 4.36, p = .045, Simultaneous Verbal, F (1, 32) = 7.61, p = .010, Sentence Repetition and Questions, F (1, 32) = 6.90, p = .013, Sound Isolation, F (1, 32) = 4.22, p = .048, and Word Identification, F (1, 32) = 9.71, p = .004, and marginally significant for Word Series. However, neither significant main effects of treatment nor significant interactions were observed.

When the Gainers and No-Gainers within each remediation condition were compared using post hoc pairwise comparisons (Joint-Univariate Bonferroni test with a significance level of .05), the differences for Planned Connections, Receptive Attention, Expressive Attention, and Word Identification were significant only within the meaning-based group. In contrast, differences in Simultaneous Verbal, Sentence Repetition and Questions, Phoneme Elision, and Sound Isolation were evident in the PREP groups comparisons.

In sum, these results indicate that children whose word decoding skills (as indicated by Word Attack gain scores) benefited most from PREP had somewhat better initial successive, simultaneous, and phonological skills. In contrast, children whose word decoding skills benefited most from the meaning-based intervention program were those who had somewhat better initial planning, attention, and word recognition skills.

Running the same MANOVA analysis (based on scores of Table 2-3) using the Word Identification groupings, none of the three multivariate Wilks L revealed significant results, although the Gain group (2) x Remediation (2) multivariate interaction effect approached significance (p = .081). The main effect of Gain group approached significance only for Planned Search, F (1, 24) = 3.78, p = .064, and Phoneme Elision, F (1, 24) = 3.99, p = .057. However, a significant Gain group x Remediation interaction was obtained for the Figure Memory task. Children in the meaning-based program who gained considerably in their word recognition scores had higher initial Figure Memory scores than did children who did not show gains, whereas no differences were observed between the participants of the PREP program. This result suggests that some of the children in the meaning-based program may have developed their sight vocabulary during the remediation period. While this method of reading can lead to better test outcomes at this level of performance, in the long term, it can be regarded as an inadequate reading strategy if used exclusively (see e.g., Share, 1995, for a convincing argument against sight reading). Finally, Planned Search, and Phoneme Elision revealed significant differences between MNG G and MNG NG groups, as post-hoc Joint Bonferroni t-tests shown.

We should also note that all 10 of the 11 children in the PREP NG group obtained scores of zero on the pre-test Word Attack test (one obtained a score of 2). Thus, it is possible that a complete absence of initial word decoding skills was hindering their progress in word recognition. The same number of children (all 11 of them) also obtained scores of zero on the Word Attack post-test, indicating that they, together with the 11 children in the meaning-based remediation who scored zero on both the pre-test and post-test Word Attack, have severe decoding problems. A more intensive form of PREP remediation than the one reported here would likely be necessary for these children.

Section II-II

4.3. Follow-up scores after remediation in Grade 1

This section of results focuses on the long-term benefits of the remediation offered by the end of Grade 1. Eight months following remediation of Grade 1 readers, the remaining participating children in the study were retested on the cognitive, phonological, and reading measures. This analysis was run after attrition was taken into account. This meant that only the 58 children still participating in the research in Grade 2 were included in the analysis.

Results from the analysis involving these data are reported in two sections. The first section focuses on the pattern of changes in the performance of the three groups: (a) Never Remediated group (NRE) of 18 children (six females) who did not receive remediation; (b) Average Gainers group (AG) of 13 children (six females) who overcame their reading problems after one remedial program, exceeding the criterion of reading performance of the 26th percentile on both reading measures (Word Identification and Word Attack); and (c) Low Gainers group (LG) of 27 children (six females) who still scored lower than the 26th percentile on both reading measures after remediation. The latter two groups of AG and LG consisted of participants from both PREP and Meaning-based intervention programs. Such a retrospective classification and grouping was considered necessary in order to plot the trajectories of growth for proximal (phonological) and distal (cognitive) processes for these three groups.

In order to fulfill the purpose of the analysis, the scores obtained for the 58 remaining participants in Grade 1 were included in the analysis again. Thus, MANOVAs and ANOVAs, as described below, were performed on three classes of scores obtained during the winter of Grade 1 and follow-up testing during the winter in Grade 2: reading measures (Word Identification and Word Attack), phonological measures (Phoneme Elision, Sound Isolation, & Rhyme Production), and the cognitive scores (planning, attention, simultaneous, and successive processing). These results are reported below (section 4.3.1.) and focus on the trajectories of development of the three groups mentioned above (NRE, AG, and LG groups). Subsequently, results of the comparison between the PREP and Meaning-Based interventions are presented in the following section (section 4.3.3).

4.3.1. <u>Initial differences in Grade 1 prior to remediation</u>

Table 2-4 presents the group means and standard deviations in Grade 1 for the two reading, nine cognitive, and three phonological tasks for the 58 children participating in the second year of the study. Reading tasks are presented first since they were used as the selection variables for assignment to remediation. Thus, before remediation, the three reading groups obtained the following percentile reading scores, converted from raw scores: On Word Identification, the mean obtained by the NRE group was 32.50 (SD = 16.79), the mean of the AG group was 11.43 (SD = 9.68), and the mean of the LG group was 5.70 (SD = 7.24). Similarly, on Word Attack, the NRE group had a mean percentile score of 32.44 (SD = 17.93), the AG group had a mean of 4.38 (SD = 4.91), and the LG group had a mean of 3.04 (SD = 2.88).

Based on Table 2-4, three separate one-way MANOVAs were computed, each one comparing two of the groups in the 14 variables: the first included the NRE and AG groups, the second involved the NRE and LG groups, whereas the third involved the AG and LG groups. The results showed that, before remediation, the NRE group was significantly different from both the AG group, Wilks $L = .217$, $F(14, 15) = 3.87$, $p < .01$, and the LG group, Wilks $L = .281$, $F(14, 26) = 4.74$, $p < .001$, whereas the differences in test scores between the AG and LG groups were not significant. Subsequent ANOVAs targeting the NRE and AG groups confirmed significant differences between the two groups in phonological and reading measures (Table 2-5). NRE and LG groups also differed significantly in the Planned Search and Simultaneous Verbal cognitive tests, as well as in the phonological and reading measures (Table 2-5). Finally, the AG and LG groups were significantly different in Simultaneous Verbal and approached significance in Planned Search; $F(1, 33) = 3.50$, $p = .07$. In contrast, the AG and LG groups did not differ in

Table 2-4.

Initial Scores (Winter in Grade 1) for Cognitive, Phonological, and Reading Tasks for Never-Remediated, Average Gainers and Low Gainers Groups.

	Reading Groups					
	Never Remediated (n = 18)		Average Gainers (n = 13)		Low Gainers (n = 27)	
Variables	Mean	(SD)	Mean	(SD)	Mean	(SD)
Word Identification	13.56	(6.31)	5.38	(4.15)	2.89	(3.23)
Word Attack	5.28	(3.48)	0.38	(0.77)	0.18	(0.48)
Planned Search†	227.50	(96.66)	239.50	(85.50)	287.80	(81.67)
Planned Connections†	57.76	(24.64)	67.00	(24.46)	64.39	(25.77)
Expressive Attention†	1.97	(0.47)	2.80	(4.28)	2.44	(1.35)
Receptive Attention†	7.85	(2.20)	7.50	(1.70)	9.51	(3.30)
Simultaneous Verbal	13.35	(1.83)	14.38	(1.94)	11.56	(2.68)
Figure Memory	6.94	(2.75)	6.00	(1.87)	5.30	(2.98)
Word Series	7.41	(2.45)	8.00	(2.27)	7.15	(3.07)
Sentence Rep. & Ques.	11.59	(4.36)	11.92	(5.42)	9.63	(5.30)
Speech Rate†	142.20	(35.10)	137.80	(33.69)	153.50	(37.81)
Rhyme Production	3.89	(1.41)	2.23	(2.38)	2.07	(2.04)
Phoneme Elision	8.65	(3.72)	2.08	(1.80)	2.33	(3.11)
Sound Isolation	8.59	(3.32)	2.77	(2.89)	2.37	(2.92)

Note: † Latency measures

Table 2-5.

Univariate F-tests on Cognitive, Phonological, and Reading Measures as a Function of Initial Group Differences

	Comparison Groups								
	NRE vs. AG groups			NRE vs. LG groups			AG vs LG groups		
Variable[†]	df	MS Error	F	df	MS Error	F	df	MS Error	F
Initial scores in winter of grade 1									
Planned Search				1, 39	8418.29	4.38*			
Simultaneous Verbal				1, 39	5.35	4.04*	1, 33	6.05	8.46**
Rhyme Production	1, 28	3.35	7.67**	1, 39	3.21	7.05**			
Phoneme Elision	1, 28	9.33	33.16**	1, 39	11.54	31.32**			
Sound Isolation	1, 28	10.92	20.14**	1, 39	10.29	29.62**			
Word Identification	1, 28	30.73	17.15**	1, 39	23.33	44.71**			
Word Attack	1, 28	7.59	22.41**	1, 39	5.41	48.64**			

Note: * $p < .05$; ** $p < .01$

[†] only the variables that significantly differentiated the groups are presented

either word reading measure. The results show that prior to remediation the two groups of children had the same low performance in phonological processing and word decoding.

4.3.2. Follow-up testing in Grade 2

In this section, all three groups of participants (NRE, AG, and LG groups) are compared in the reading, phonological and cognitive tasks. The remediated groups had received remediation eight months prior to this follow-up testing. The purpose of this analysis was to examine the group performances in the three classes of tasks as a function of time. First, a series of 2-way Group (3) X Time (2) repeated measures MANOVAs were performed, with the reading, phonological, and cognitive variables in separate analyses. Only initial (Grade 1) and follow-up (Grade 2) scores were included in this analysis because the NRE group did not receive the tests immediately following remediation, as mentioned in the previous section. Table 2-6 presents the means and standard deviations of the scores obtained in all tasks by the three groups in Grade 2, and the repeated measures analysis results are presented in Table 2-7.

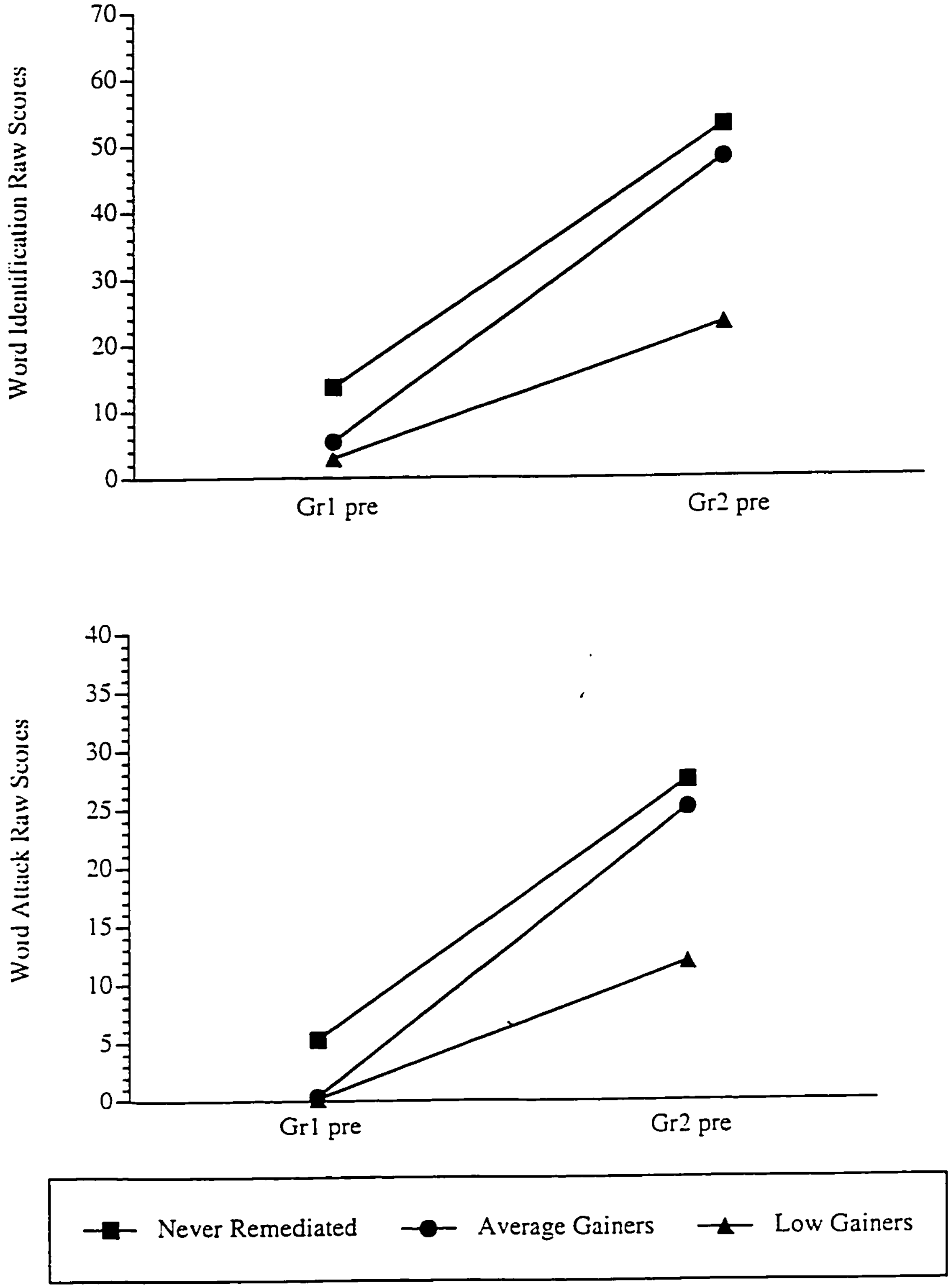
For the reading measures, the main effect of group was significant for both Word Identification, F (2, 55) = 62.52, MSe = 4726.30, $p < .001$, and Word Attack, F (2, 55) = 43.89, MSe = 1211.84, $p < .001$. Moreover, the main effect of time was significant for both measures: for Word Identification, F (1, 55) = 1101.75, MSe = 31039.86, $p < .001$, and for Word Attack, F (1, 55) = 463.50, MSe = 10096.66, $p < .001$. The Group (3) X Time (2) interactions were also significant for both measures, F (2, 55) = 54.39, MSe = 1532.34, $p < .001$, for Word Identification, and F (2, 55) = 22.44, MSe = 488.86, $p < .001$, for Word Attack, indicating that each group improved across time in terms of reading skills, but not all to the same extent. Figures 2-3 and 2-4 depict the three groups' reading performance from Grade 1 to Grade 2 follow-up testing.

Table 2-6.

Follow-up Scores (Winter in Grade 2) for Cognitive, Phonological, and Reading Tasks for Never-Remediated, Average Gainers and Low Gainers Groups.

	Reading Groups					
	Never Remediated (n = 18)		Average Gainers (n = 13)		Low Gainers (n = 27)	
Variables	Mean	(SD)	Mean	(SD)	Mean	(SD)
Word Identification	53.00	(48.15)	48.15	(6.42)	23.26	(9.71)
Word Attack	27.39	(6.84)	25.08	(7.63)	11.89	(6.21)
Planned Search[†]	158.90	(44.99)	137.00	(37.90)	173.60	(46.86)
Planned Connections[†]	40.76	(15.78)	34.75	(13.59)	40.11	(15.82)
Expressive Attention[†]	2.28	(0.63)	2.04	(0.42)	2.05	(0.61)
Receptive Attention[†]	4.45	(0.77)	4.67	(0.70)	5.35	(1.10)
Simultaneous Verbal	18.41	(2.53)	17.62	(3.33)	16.11	(2.55)
Figure Memory	10.65	(2.03)	9.38	(2.32)	9.18	(2.62)
Word Series	11.82	(1.91)	11.85	(2.76)	11.63	(2.44)
Sentence Rep. & Ques.	19.59	(3.50)	19.23	(4.24)	16.78	(4.49)
Speech Rate[†]	98.53	(14.55)	92.15	(14.23)	101.90	(16.16)
Rhyme Production	4.94	(0.23)	4.61	(0.87)	4.59	(0.89)
Phoneme Elision	13.32	(1.50)	12.38	(1.90)	10.26	(2.77)
Sound Isolation	12.65	(1.87)	11.23	(2.05)	9.67	(2.95)

Note: [†] Latency measures



Figures 2-3 & 2-4.

Reading Performance (Word Identification and Word Attack Subtests) for Never-Remediated, Average Gainers, and Low Gainers Groups from Pre-test (Grade 1) to Follow-up Testing (Grade 2).

Similar results were obtained when the phonological measures were included in the analysis (Table 2-7). The main effects of group were significant for all three measures (all $\underline{p}$s < .01): Phoneme Elision, $\underline{F}$ (2, 55) = 26.14, $\underline{MSe}$ = 257.18, Sound Isolation, $\underline{F}$ (2, 55) = 21.15, $\underline{MSe}$ = 226.42, and Rhyme Production, $\underline{F}$ (2, 55) = 5.05, $\underline{MSe}$ = 13.87. In addition, the main effects of time were significant (all $\underline{p}$s < .01): Phoneme Elision, $\underline{F}$ (1, 55) = 336.42, $\underline{MSe}$ = 1554.34, Sound Isolation, $\underline{F}$ (1, 55) = 232.23, $\underline{MSe}$ = 1210.45, and Rhyme Production, $\underline{F}$ (1, 55) = 64.43, $\underline{MSe}$ = 104.73. Finally, the interactions Group (3) X Time (2) were also significant for all three measures, Phoneme Elision, $\underline{F}$ (1, 55) = 13.32, $\underline{MSe}$ = 61.55, $\underline{p}$ < .001, Sound Isolation, $\underline{F}$ (1, 55) = 6.57, $\underline{MSe}$ = 34.26, $\underline{p}$ < .001, and Rhyme Production, $\underline{F}$ (1, 55) = 3.87, $\underline{MSe}$ = 6.29, $\underline{p}$ < .05, implying a similar type of improvement (as compared to reading improvement) in phonological skills for all the children across time. Figures 2-5 (for Rhyme Production), 2-6 (for Sound Isolation), and 2-7 (for Phoneme Elision) show graphically the group performances in the phonological measures from the Grade 1 pre-test to the Grade 2 follow-up testing.

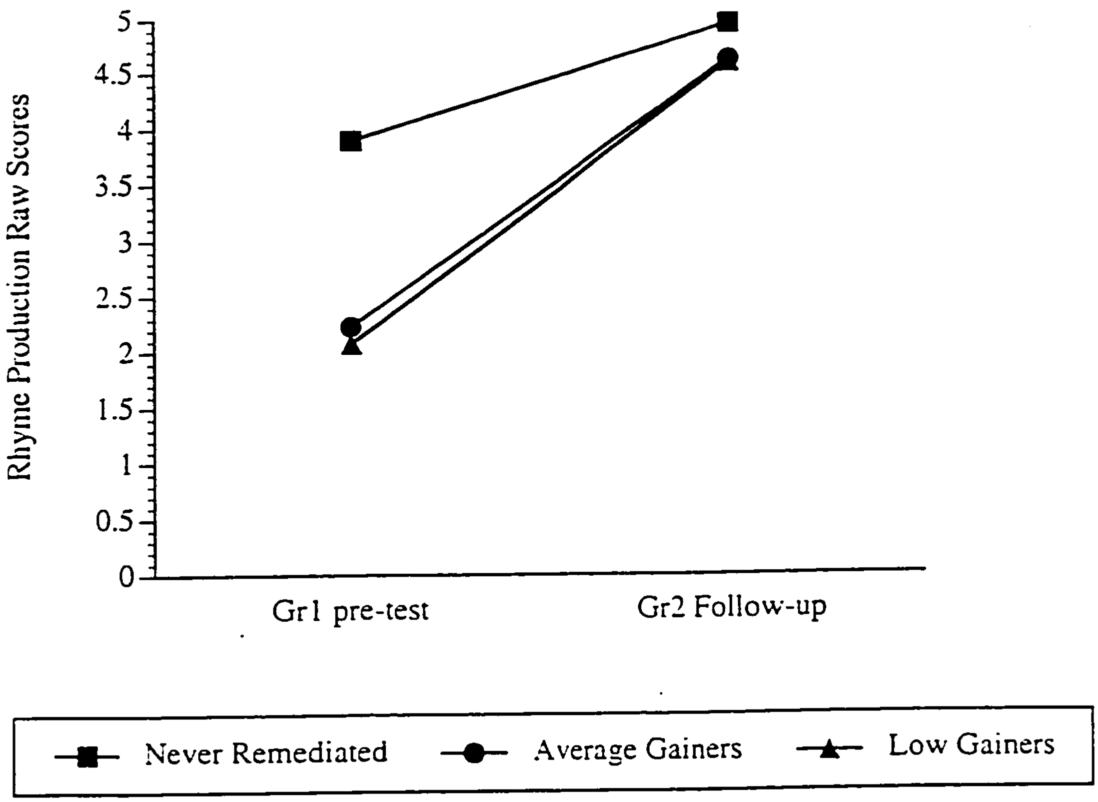
Finally, when the seven cognitive measures were included in the analysis (attention tasks were excluded, due to the different content they presented from Grade 1 to Grade 2), the main effects of time revealed significant results for all the tests (all $\underline{p}$s < .01; Table 2-7): Planned Search, $\underline{F}$ (1, 55) = 76.79, $\underline{MSe}$ = 24011.59, Planned Connections, $\underline{F}$ (1, 55) = 178.41, $\underline{MSe}$ = 135983.99, Simultaneous Verbal, $\underline{F}$ (1, 55) = 82.33, $\underline{MSe}$ = 465.61, Figure Memory, $\underline{F}$ (1, 55) = 85.34, $\underline{MSe}$ = 331.84, Word Series, $\underline{F}$ (1, 55) = 133.55, $\underline{MSe}$ = 468.68, Sentence Repetition and Question, $\underline{F}$ (1, 55) = 263.87, $\underline{MSe}$ = 1494.74, and Speech Rate, $\underline{F}$ (1, 55) = 116.73, $\underline{MSe}$ = 57056.14. However, the main effect of group was significant only in the case of Planned Search, $\underline{F}$ (2, 55) = 3.51, $\underline{MSe}$ = 22767.99, $\underline{p}$ < .05 and Simultaneous Verbal, $\underline{F}$ (2, 55) = 7.94, $\underline{MSe}$ = 58.62, $\underline{p}$ < .001. None of the interactions were significant. These results indicate that for most of the cognitive tasks, the

Table 2-7.

Repeated Measures ANOVAs in Reading, Phonological, and Reading Measures as a Function of Reading Group and Testing Time

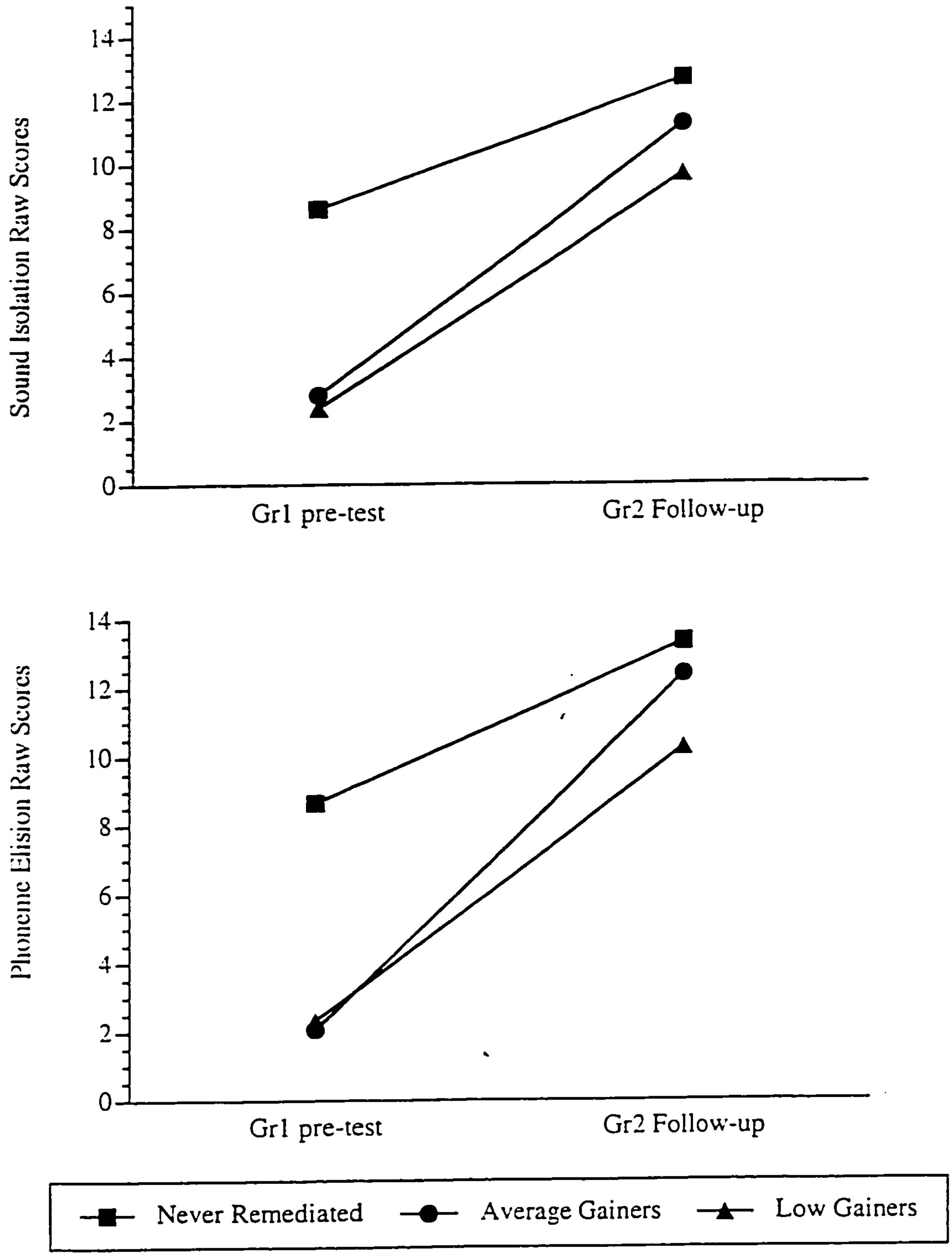
	F-values		
Measures[†]	Group	Time	Group X Time
Reading Measures			
Word Identification	62.52**	1101.75**	54.39**
Word Attack	43.89**	463.50**	22.44**
Phonological Measures			
Phoneme Elision	26.14**	336.42**	13.32**
Sound Isolation	21.15**	232.23**	6.57**
Rhyme Production	5.05**	64.43**	3.87 *
Cognitive Measures			
Planned Search	3.51*	76.79**	1.84
Planned Connections	1.18	178.41**	0.92
Simultaneous Verbal	7.94**	82.33**	0.91
Figure Memory	2.11	85.34**	0.27
Word Series	0.31	133.55**	0.25
Sentence Rep. & Questions	2.16	263.87**	0.41
Speech Rate	1.44	116.73**	0.42

Note: [†] Time df = 1, 55; * $p < .05$; ** $p < .01$



Figures 2-5.

Performance on the Rhyme Production Task for Never-Remediated, Average Gainers, and Low Gainers Groups from Pre-test (Grade 1) to Follow-up Testing (Grade 2).



Figures 2-6 & 2-7.

Performance on the Sound Isolation and Phoneme Elision Phonological Tasks for Never-Remediated, Average Gainers, and Low Gainers Groups from Pre-test (Grade 1) to Follow-up Testing (Grade 2).

growth shown by all the participants followed a linear trend from pre-testing to follow-up testing.

In order to clarify the group differences, the three groups, NRE, AG, and LG, were taken and compared two at a time, using separate ANOVAs, as presented in Table 2-8. The results showed that eight months after remediation, the AG group did not significantly differ from the NRE group except in one test (the Sound Isolation task). The AG group was almost as competent as the NRE group. These results indicate that the participants who gained from remediation demonstrated improvement not only in reading but also in both proximal (phonological) and distal (cognitive) processes which are related to reading.

In contrast, the NRE group was still significantly superior to the LG group in three cognitive (Receptive Attention, Simultaneous Verbal, and Sentence Repetition and Questions), two phonological (Phoneme Elision and Sound Isolation), and the two reading (Word Identification and Word Attack) tasks as the subsequent ANOVAs indicated (Table 2-8). The planning tasks had no further supporting role for successful reading. In contrast, successive processing and attention played a prominent role in differentiating the normal readers from the poor readers. Finally, of the three phonological tasks, Rhyme Production did not differentiate NRE from LG readers at follow-up testing because of a ceiling effect on this task.

In the next comparison between the AG and LG group, univariate analysis showed significant differences between AG and LG groups on Planned Search, Receptive Attention, Speech Rate, Phoneme Elision, Word Identification, and Word Attack (Table 2-8). These group differences occurred despite the fact that at the time of initial testing, the two groups were not significantly different in any of the tasks in our battery with the exception of Simultaneous Verbal. In sum, the results indicate that the participants in the AG group were characterized by somewhat better planning, attention, articulation, and phonological processing skills, as compared to the LG group, which coincided with their enhanced

Table 2-8.

Univariate F-tests in Cognitive, Phonological, and Reading Measures as a Function of Follow-up Group Differences

Variable[†]	Comparison Groups								
	NRE vs. AG groups			NRE vs. LG groups			AG vs LG groups		
	df	MS Error	F	df	MS Error	F	df	MS Error	F
	Follow-up scores in winter of grade 2								
Planned Search							1, 38	1955.80	6.00*
Receptive Attention				1, 43	0.96	8.93**	1, 38	0.98	4.06*
Simultaneous Verbal				1, 43	6.94	6.22*			
Sent. Rep. & Quest.				1, 43	16.77	4.97*			
Speech Rate							1, 38	322.06	4.57*
Phoneme Elision				1, 43	5.53	19.83**	1, 38	6.37	6.22*
Sound Isolation	1, 29	3.84	4.70*	1, 43	6.68	15.66**			
Word Identification				1, 43	94.31	101.29**	1, 38	77.60	70.08**
Word Attack				1, 43	41.83	62.02**	1, 38	44.78	34.08**

Note: * $p < .05$; ** $p < .01$

[†] only the variables that significantly differentiated the groups are presented

reading performance. When considering all the results, support is provided for the argument that some of the distal cognitive processes were improved along with the proximal phonological processes of reading (Kirby et al., 1996).

In sum, although the present analysis was conducted with only the 58 remaining participants in Grade 2, using a retrospective classification we were able to plot the trajectories of growth for proximal (phonological) and distal (cognitive) processes of the three distinct clusters of children of NRE, AG, and LG groups. The Average Gainers showed a significant improvement on both proximal and distal processes which eliminated the observed Grade 1 differences between this group and the NRE group on the above tasks. In contrast, the differences between AG and LG groups grew larger as the follow-up scores indicated. The next section examines the differences between the AG and LG groups within each remediation program offered a year earlier (in Grade 1).

4.3.3. PREP and Meaning-based remediation

One of the major objectives was to examine the relative efficacy of PREP and Meaning-Based (MNG) intervention programs in enhancing Grade 1 children's reading performance. Since no other tests besides the reading measures were administered immediately following remediation, the appropriate statistical analysis was a repeated measures ANOVA for Word Identification and Word Attack scores. Two separate ANOVAs on PREP AG and MNG AG as well as PREP LG and MNG LG based on Word Identification and Word Attack scores at initial, post-remediation, and follow-up testing were carried out (Table 2-9). The analysis was performed with two fewer participants since no post-remediation scores were obtained for them.

The main-effect for the testing times in both reading measures was significant indicating, as expected, an improvement in performance. But in the case of Word Attack,

Table 2-9.
Repeated Measures ANOVAs on Reading Measures as a Function of Remediation and Testing Time

	Comparison Groups					
	PREP AG vs. MNG AG			PREP LG vs. MNG LG		
Source	df	MS	F	df	MS	F
Word Identification						
Group	1	308.62	3.58	1	38.59	0.35
Testing Time	2	6375.99	366.79**	2	2894.54	118.66**
Group X Time	2	25.84	1.49	2	64.45	2.64
Within-group Error	22	17.38		50	24.39	
Word Attack						
Group	1	324.45	14.58	1	0.99	0.05
Testing Time	2	2299.47	203.89**	2	1036.47	69.93**
Group X Time	2	66.70	5.91**	2	31.41	2.12
Within-group Error	22			50	14.82	

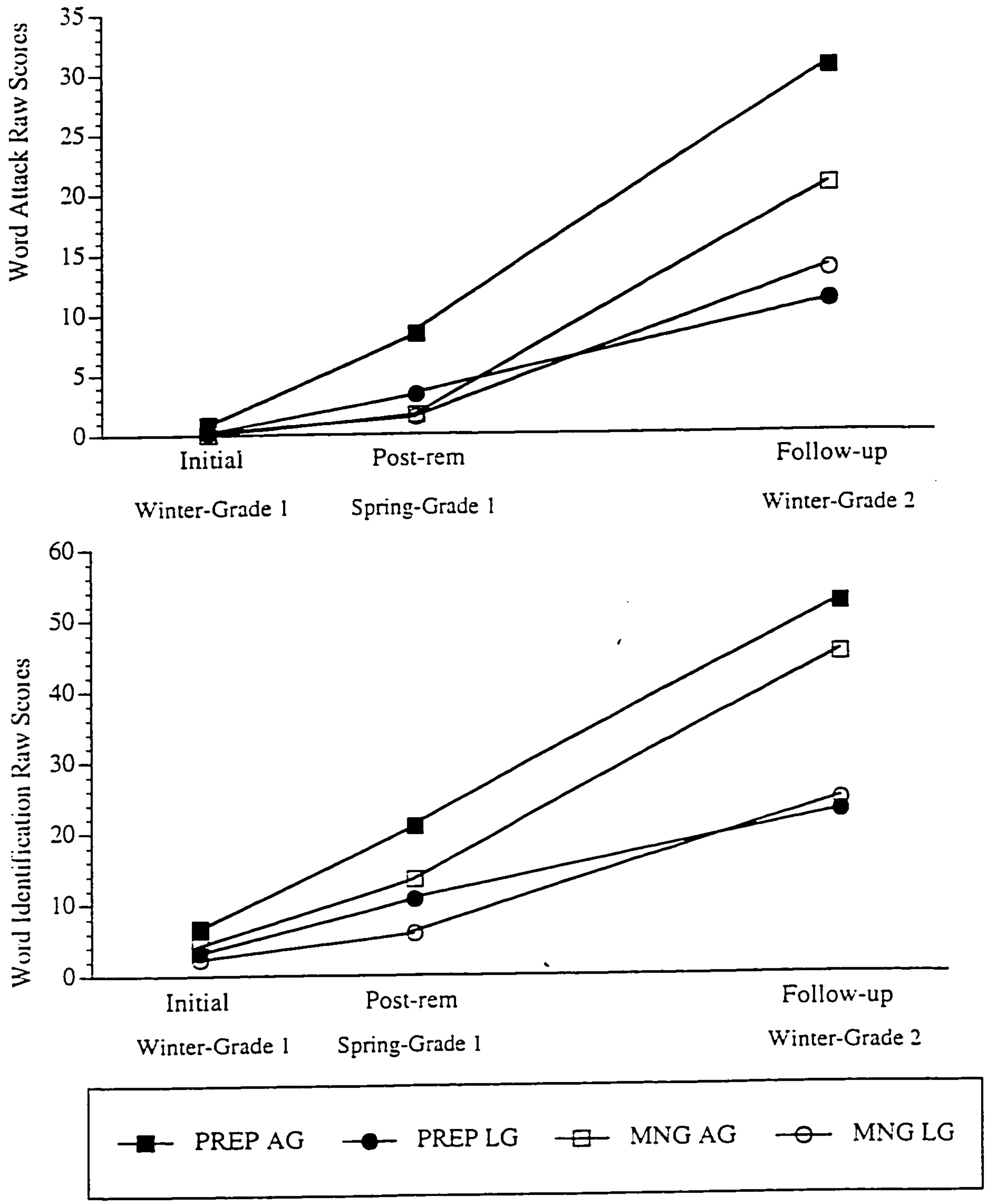
Note: ** $p < .01$; ns: 6 PREP AG, 7 MNG AG, 17 PREP LG, and 10 MNG LG the main effect of group was significant as was the Remediation Groups (2) X Testing Time (3) interaction, $F\ (2, 22) = 5.91$, $p < .01$, for the Average Gainers groups. The PREP AG gained significantly more than the MNG AG group following remediation — the Remediation Groups (2) X Testing Time (2) interaction (pre- to post-testing) was also significant, $F\ (1, 11) = 15.01$, $p < .01$ — a gain that was also maintained at follow-up testing, indicating that the former group had improved significantly more than the latter group in pseudoword reading across time. However, the interaction of the Remediation Group (2) X Testing Time (3) was not significant for the Word Identification subtest ($p > .05$). Finally, the interactions were not significant for either of the reading tasks when Low Gainers were compared. Figures 2-8 and 2-9 depict these trends clearly.

Section III

4.4.1. Remediation in spring of Grade 2

As we saw in the previous section of the results, 27 children (the LG group) were still experiencing reading difficulties, despite the fact that they had already attended either a PREP or Meaning-based remedial program and had gone through almost two years of formal reading instruction. This group of children (with the exception of one child who moved from the City of Edmonton before remediation began) participated in a second remediation in the spring of Grade 2. At this final remediation, all the children participated in the PREP program which had been shown to be more effective than the Meaning-based remedial program, especially in regard to improving word decoding skills.

The remediation provided this year was slightly different from that of the previous year in terms of length, intensity, and timing; PREP was provided for a period of four



<u>Figure 2-8 & 2-9.</u>
Initial, Post-remediation, and Follow-up Scores for Word Attack and Word Identification for Average Gainers and Low Gainers in each Remediation Group.

weeks or 20 daily sessions, each lasting 30 minutes. Moreover, all participating children worked individually, as opposed to the first year's design, where some of the children worked in groups of two or three, due to the large number of students receiving remediation in their schools.

Post-remediation scores were obtained on phonological and reading measures for 24 children who fully participated in remediation in the spring of Grade 2. Two participants withdrew after attending very few of the remediation sessions. Table 3-1 presents the pre- and post-remediation means and standard deviations (in parenthesis) for the above measures for the 24 remediated children. Mean percentile scores are also displayed as they were used as the criterion for inclusion in the remediation (as before the cut-off point was the 26th percentile). Paired sample t-tests and effect sizes are also presented as a function of improvement from pre- to post testing.

Significant results from pre- to post-testing were obtained for all the reading and phonological tasks except the Rhyme Production which almost approached ceiling (the maximum possible score on this task was 5). The vast majority of the effect sizes were also large, as shown in Table 3-1. Phoneme Elision produced a medium effect, although the t-test was also significant. The most important finding is that the group reached average performance on Word Attack (47.89 percentile), obtaining a score that was twice as large as the pre-test score (23.11 percentile) and clearly above the criterion for inclusion in remediation (i.e., the 26th percentile). In addition, the largest improvement, as indicated by the effect sizes, was shown in the Word Attack and the Passage Comprehension tests. These results indicate that PREP remediation was shown again as a program appropriate to strengthen participants' word decoding skills.

Two of the participants in this remediated group showed no improvement on reading and phonological scores across time (since initial testing in Grade 1). More specifically, their reading skills remained at a very weak level as demonstrated in all three reading tasks,

Table 3-1.

Pre- and Post Means and Standard Deviations, t-values and Effect Sizes for the Remediated Group on Phonological and Reading Measures

	Remediated Group					
	Pre-test		Post-test			
Tasks	M	(SD)	M	(SD)	t-value	d
Phonological Tasks						
Rhyme Production	4.67	(0.76)	4.96	(0.20)	2.07	0.52
Phoneme Elision	10.42	(2.76)	12.29	(3.07)	4.19**	0.64
Sound Isolation	9.62	(3.08)	12.17	(3.16)	5.80**	0.82
Reading Tasks						
Word ID Raw	23.83	(9.86)	34.08	(12.23)	8.05**	0.92
Word AT Raw	12.62	(6.00)	21.92	(8.57)	9.06**	1.26
Pass CR Raw	13.09	(4.54)	19.17	(4.81)	8.99**	1.30

Note: small effect = $.2 \leq d < .5$; medium effect = $.5 \leq d < .8$; large effect = $.8 \leq d < \infty$

** $p < .001$; df = 23

where they scored ≤ 1% even after the second remediation by the end of Grade 2. Similarly, the two participants' phonological skills showed improvement only on Rhyme Production, whereas their scores on Phoneme Elision and Sound Isolation remained at least 1 1/2 standard deviations below the average performance of same age peers. Moreover, similarities were observed in the cognitive profiles of these two participants at the pre-testing stage in Grade 2: their overall performance on the CAS tasks was within the weak (below 1 SD compared to the mean) to average level with weaker performances on planning, attention, and simultaneous tasks. On successive tasks their performance approached the low average to average levels, indicating that at least successive processing skills had improved slightly as a result of the remediation the first year. However, the considerable weaknesses evident in all the other cognitive and phonological tasks may have hindered them from improving in reading. These participants were also not very eager, especially when they were confronted with demanding tasks; they seemed to quit rather quickly, regardless of the task's content.

When these two participants were excluded from the analysis, as expected the results from the pre- to post-testing comparisons appeared to be more promising for PREP remediation. Improvement in all reading and phonological tasks reached a very high level of significance ($p < .001$, for all tasks) as indicated also from the large effect sizes ($d > 1.00$, for all tasks). Table 3-2 presents in detail the new mean scores for the remediated group with the two outliers excluded.

Supplementary information regarding the progress made by the remediated group in reading skills is provided by the relative frequencies on percentile gains. More than 70.2% of the remediated children (17 out of 24 participants) showed a 20 point or larger percentile improvement on Word Attack from pre- to post-testing, among whom 37.5% (9 participants) showed a percentile gain equal or higher than 30 points. In actual percentile scores, these gains are interpreted as 19 out of 24 children (79.2%) going beyond the criterion of 26th

Table 3-2.

Pre- and Post Means and Standard Deviations, t-values and Effect Sizes for the Remediated Group on Phonological and Reading Measures (Outliers Excluded)

	Remediated Group					
	Pre-test		Post-test			
Tasks	M	(SD)	M	(SD)	t-value	d
Phonological Tasks						
Rhyme Production	4.68	(0.78)	4.95	(0.21)	1.82	0.47
Phoneme Elision	10.86	(2.42)	13.04	(1.78)	5.08**	1.03
Sound Isolation	10.09	(2.72)	12.82	(2.28)	5.97**	1.09
Reading Tasks						
Word ID Raw	25.73	(7.81)	36.41	(9.69)	7.96**	1.47
Word AT Raw	13.64	(5.16)	23.68	(6.42)	10.40**	1.72
Pass CR Raw	13.81	(3.97)	20.09	(3.90)	8.80**	1.59

Note: small effect = $.2 \leq d < .5$; medium effect = $.5 \leq d < .8$; large effect = $.8 \leq d < \infty$

** $p < .001$; df = 21

percentile on Word Attack. On the other hand, 29.2% of the participants (seven children) showed a gain of 11 or more percentile points, resulting in 8.3% of the participants (two children) overriding the 26th percentile in the Word Identification subtest. Finally, three participants (12.5%) exceeded the 26th percentile in passage comprehension, whereas seven (30.4%) showed an improvement of 10 percentile points or greater. In sum, when these results are interpreted in terms of defining the present sample, the vast majority of poor readers in this 'at-risk' group are likely to be classified as so-called 'garden-variety' or 'culturally disadvantaged readers' rather than 'dyslexics'. They are readers who show no further problems with phonological or word decoding tasks, but who perform at a weak or low average level on cognitive processing tasks (as shown in the previous section of results where LG group was compared to NRE and AG at pre-testing) and who might have substantially low motivation for reading primarily because of very little exposure to reading material in their home environment. Thus, borrowing Stanovich's definition (1993) of 'garden-variety readers', the present group cannot qualify as being 'dyslexic' as long as they exhibit cognitive deficits over time.

4.4.2. Never-Remediated, Average Gainers, and Low Gainers comparison

Although the scores obtained by the remediated group in the post-testing provides a positive picture of the remediation effects, a new analysis was conducted including the Never-Remediated and the Average Gainers groups (as defined in the previous section of analysis) so as to further challenge the results. Because neither of these two groups were post-tested after the second remediation, their anticipated reading scores were used to calculate the mean differences. The following formula was applied to obtain the expected scores:

$$\frac{R_{3a} - R_{2a}}{[(Age_{3a} - Age_{2a}) - 2]} \times (Time_{3b} - Time_{3a}) + (R_{3a})$$

where,

R_{3a} is the reading score obtained by the participant in Grade 2 pre-testing

R_{2a} is the reading score obtained by the participant in Grade 1 pre-testing

Age_{3a} is the chronological age of the participant in Grade 2 pre-testing

Age_{2a} is the chronological age of the participant in Grade 1 pre-testing

$Time_{3b}$ refers to the post-testing time in Grade 2

$Time_{3a}$ refers to the pre-testing time in Grade 1

Thus, in order to obtain the expected value, the reading progress that the participant showed within the period between the Grade 1 pre-testing and the Grade 2 pre-testing (minus the two summer months during which no reading instruction was provided) was multiplied by the number of months between pre- and post-testing in Grade 2. This ratio score was then added to the participants' Grade 2 pre-testing score.

Two analyses were conducted involving raw and age equivalent scores. Table 3-3 presents the results of the Groups (3) X Time (2) repeated measures MANOVAs, on the two reading measures involving raw and age equivalent scores.

As was expected, the main effect of time was significant for all comparisons. The main effect of group was also significant in all three cases, but not always in favor of the LG group. More specifically, the significant main effect of group was in favor of the LG group in the case of Word Attack scores, but not in the case of the Word Identification subtest. Consequently, the interactions on Word Attack were significant when raw scores were involved in the analysis, F (2, 50) = 25.96, $p < .05$, indicating that the LG group showed a remarkable improvement in word decoding skills, as opposed to the expected reading

Table 3-3.

Repeated Measures MANOVAs on Reading Measures as a Function of Remediation and Testing Time

	Comparison Groups					
	NRE, AG, & LG groups Raw scores			NRE, AG, & LG groups Age Equivalent scores		
Source	df	MS	F	df	MS	F
Word Identification						
Group	2	8901.41	54.56**	2	66.72	16.84**
Testing Time	1	3422.89	253.66**	1	84.86	33.02**
Group X Time	2	8.60	0.64	2	11.62	4.52*
Within-group Error	50			50		
Word Attack						
Group	2	1746.19	18.98**	2	102.93	6.74**
Testing Time	1	1694.62	252.45**	1	44.62	68.62**
Group X Time	2	25.96	3.87*	2	0.42	0.65
Within-group Error	50	6.71		50		

Note: * $p < .05$; ** $p < .01$

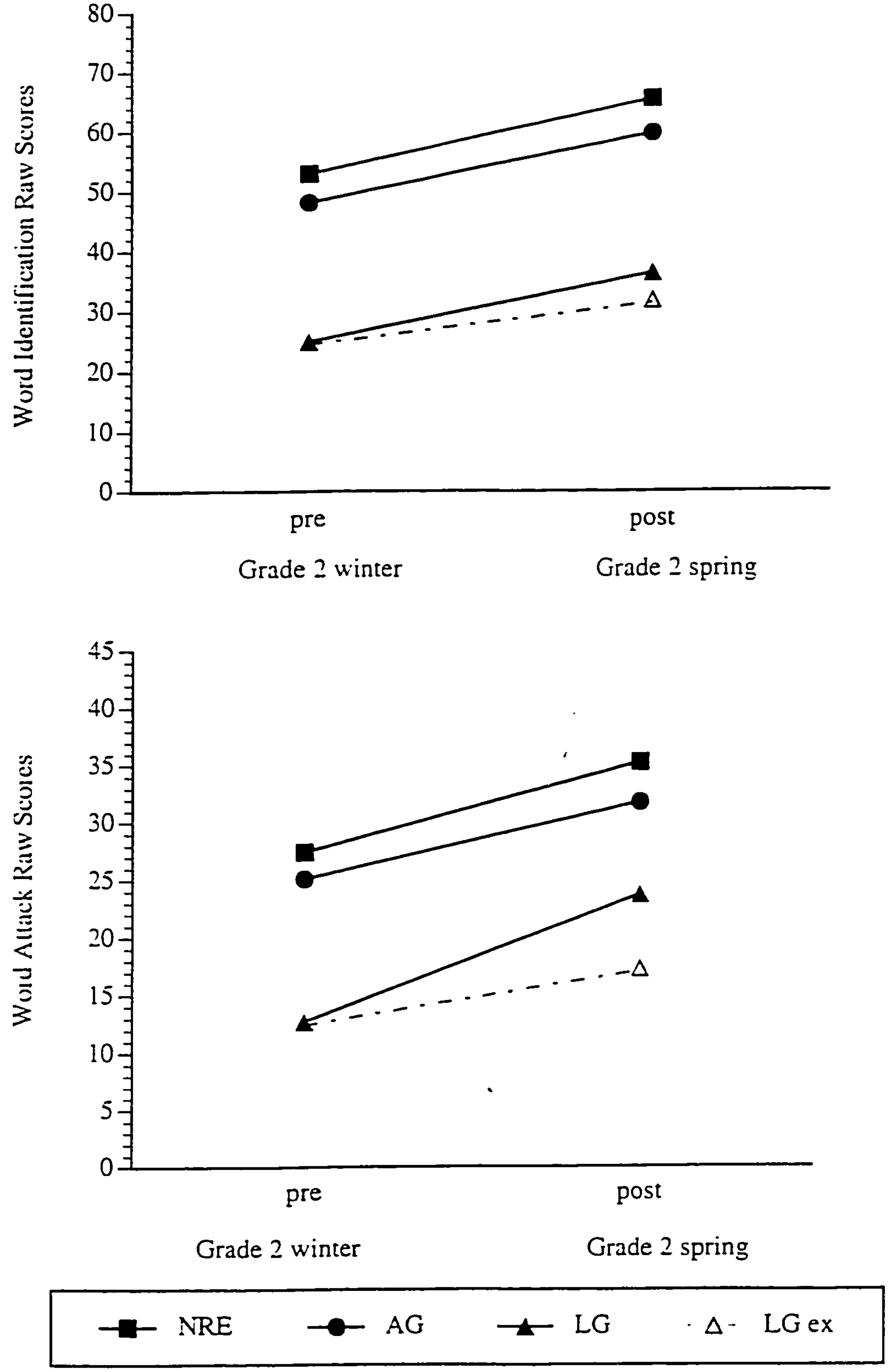
performance of the NRE and AG groups. However, the interaction was not significant in terms of age equivalent scores. In contrast, the Group (3) X Time (2) interaction was not significant for the Word Identification subtest, when raw scores were involved in the analysis. Only when age equivalent scores were used, a significant interaction was obtained, F (2, 50) = 4.52, $p < .01$, indicating that the progress showed by the LG group on word recognition skills was weaker as compared to the anticipated progress that the NRE and AG groups would show over time. Figures 3-1 (a & b) and 3-2 (a & b) present graphically these interactions for raw and age equivalent scores, respectively.

At the next step of analysis, a comparison between the observed and the expected post-remediation reading scores of the LG group was carried out using paired sample t-tests. Table 3-4 presents the observed and expected means on the reading measures along with the results of the comparisons of the two scores for the remediation group.

With the exception of age equivalent scores on the Word Identification subtest, the rest of the comparisons revealed significant differences between the observed and the expected values of the LG group. These results add supplementary evidence on the effectiveness of the PREP remediation program in a group of at-risk readers such as the one participating in this study.

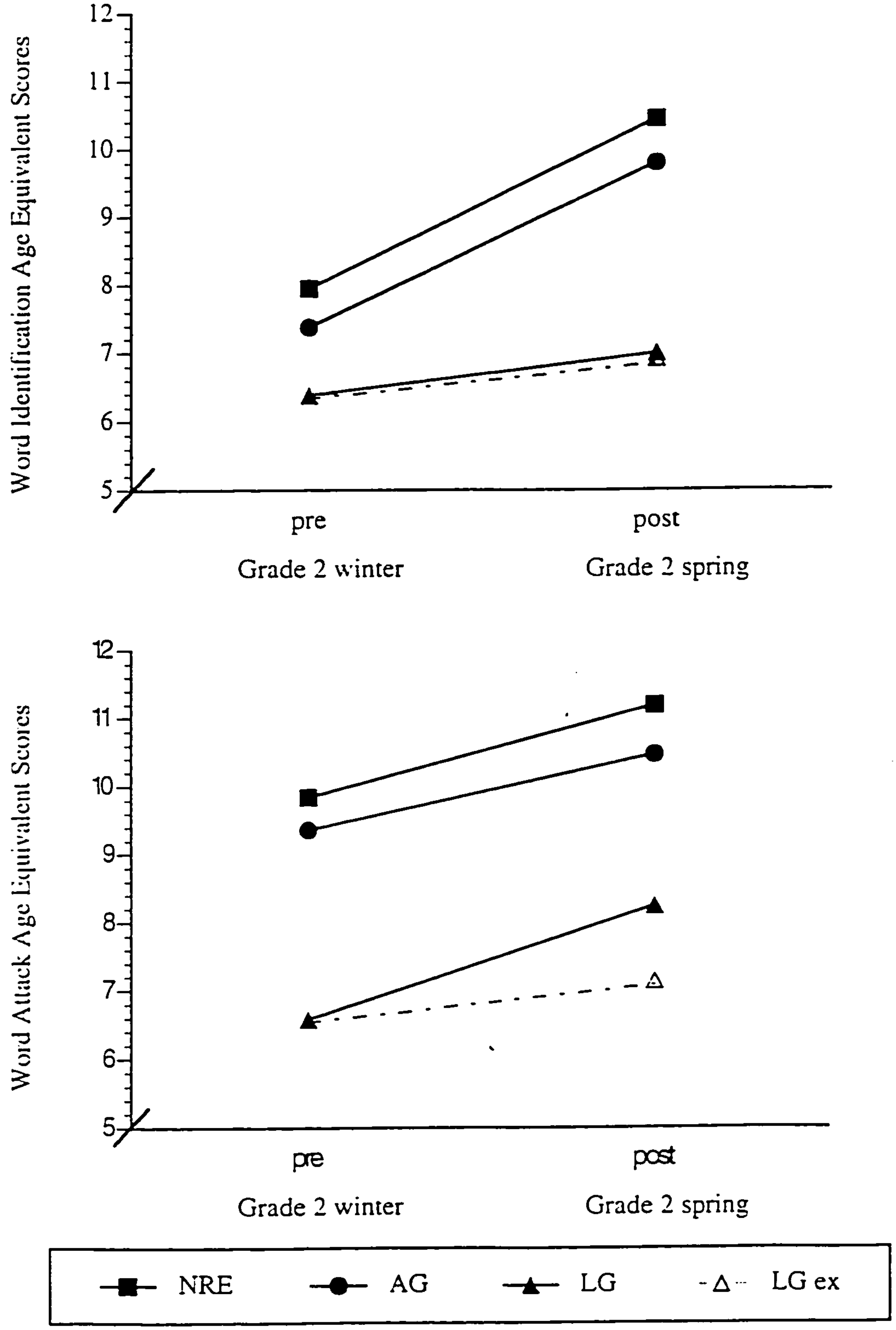
To summarize the results of this second remediation session, more intensive PREP remediation appeared to be beneficial for the vast majority (19 of the 24) of poor readers in this sample. It is noteworthy that as a group, these children reached an average mean performance on Word Attack (47.89 percentile), obtaining a score that was twice as large as the pre-testing score (23.11 percentile) and clearly above the criterion for inclusion in remediation (i.e., the 26th percentile).

Although there are certain limitations in terms of interpreting the results in favor of PREP due to the lack of a compelling control group, the progress that was made within a month of remediation was remarkable given the specific characteristics of the sample.



Figures 3-1-a & 3-1-b.

Pre to -Post Raw Scores on Word Identification and Word Attack for the NRE, AG, and LG Groups. (Expected values are presented for the NRE and AG groups, whereas both expected and observed values are presented for the LG group).



Figures 3-2-a & 3-2-b.
Pre to -Post Age Equivalent Scores on Word Identification and Word Attack for the NRE, AG, and LG Groups. (Expected values are presented for the NRE and AG groups, whereas both expected and observed values are presented for the LG group).

Table 3-4.

Post-Remediation Observed and Expected Means, Standard Deviations, and t-values for the Remediated Group on Reading Measures

	Remediated Group				
	Observed Reading Scores		Expected Reading Scores		
Reading Tasks	M	(SD)	M	(SD)	t-value
Word Identification					
Raw	36.41	(9.69)	31.80	(9.51)	3.82**
Percentile	15.05	(12.70)	5.52	(5.27)	2.93**
Age Equivalent	6.99	(0.37)	6.90	(0.63)	0.68
Word Attack					
Raw	23.68	(6.42)	17.21	(6.60)	5.88**
Percentile	52.18	(20.10)	28.72	(17.97)	6.98**
Age Equivalent	8.24	(1.60)	7.13	(0.74)	3.57**

Note: ** $p < .01$; df = 21

Scores on word decoding and passage comprehension showed the greatest improvement, while the scores on word recognition improved at a slower rate. These results were confirmed when the observed scores of the LG group were compared to the expected scores of the NRE and AG groups, where only the interactions on Word Attack revealed significant results in favor of the LG group.

CHAPTER V
DISCUSSION

5.1. Theoretical concerns

5.1.1. Longitudinal and intervention studies

In the introduction of this manuscript several intervention studies that relate to specific theoretical predictions were reviewed. At this stage, although the results of those studies look promising, we note that some problems also arise in this type of study. Experimental interventions show what *can* be done to alter the course of development but they do not show what *typically* happens in development. Bryant and Goswami (1986, 1987), however, have argued that combining longitudinal prediction studies with intervention studies can overcome this problem. Prediction studies show that a certain variable is associated with differences in reading ability, and intervention studies then allow for evaluation of the nature of the relationship between the variable and reading. On the same line, Rack, Hulme, and Snowling (1993) indicate that intervention studies are useful when one has a developmental theory to test, and such theories arise most securely from longitudinal prediction studies.

To a certain extent, these premises were met in the present research. The first prediction part of this research indicated that successive, simultaneous, and phonological abilities were valid predictors of differences in reading skills of the participating population. Moreover, the next two parts of the research allowed for the evaluation of the nature of the relationship between these predictors and the dependent variable by supporting that by offering remediation which targets the aforementioned variables will ameliorate reading difficulties. It would have been ideal to have the same number of participants in the third year of the study so that we could have drawn some conclusions about the stability of the correlations between successive, simultaneous, phonological, and reading variables. However, sample mortality, the most significant threat to longitudinal studies, did not allow me to attain this goal. Inevitably during the course of this long-term cohort study, participants dropped out or refused further co-operation. This limitation must be taken into account when interpreting the results of the study.

5.1.2. Phonological awareness and reading

Learning to read is a complex process requiring multiple capabilities. Although phonological awareness, as one of those capabilities, has been shown to be strongly related to reading achievement, it is not enough by itself to explain reading disability. Recent research on reading, however, has focused on the variance accounted for phonological awareness in the acquisition of early reading skills. Researchers seem to agree that, by discovering the importance of phonological awareness in literacy, we have made some significant steps in our understanding of literacy acquisition (Adams, 1990; Blachman, 1994; Shankweiler & Liberman, 1989; Wagner & Torgesen, 1987). Most theories of the development of reading skills consider phonological decoding as a central achievement. Preferring the language of cryptography, Gough and Hillinger (1980) refer to this as *cipher reading*, meaning the mastery of a system of rules by which letters and letter sequences map onto phonological forms.

Thus, based on the outcomes of the related research, for many poor readers, difficulties in word decoding seem to stem from a lack of awareness that speech can be segmented into phonological units that are more or less represented in an alphabetic script (Iversen & Tunmer, 1993; Juel, 1988; Stanovich, 1988). Subsequently, it is argued that respective remedial training on phonological skills may ameliorate the reading difficulties encountered by some children early on in their school career. This, however, is only partly true. Despite both well-designed longitudinal — primary correlational — studies that attempt to predict and to outline the progress of early reading and good remediation studies that target the improvement of phonological skills of young poor readers, many questions still remain unanswered. Why some children still fail to acquire the necessary phonological skills has not been adequately addressed. Moreover, the phonological awareness literature does not provide clear evidence on what factors the deficiencies may be attributed to. Can we assume that both word-reading difficulty and phonological coding deficit among children can be related to fundamental problems in cognitive processing as measured by tasks that do not require reading?

Wagner and Torgesen (1987) have noted that few studies have attempted to determine which component processes of reading are differentially affected by the various phonological processes abilities. Most researchers have been content simply to show significant relationships between performance on phonological processing tasks and overall scores on standardized reading measures. Although the available evidence suggests that phonological processing is most strongly related to word recognition, even this general conclusion lacks a firm research foundation.

In understanding phonological processes in reading, it is important to differentiate levels of processing. Virtually most of the reading theorists agree that phonological codes in working memory play some role in supporting comprehension processes (Baddeley, 1986; Perfetti, 1985; Rayner & Pollatsek, 1989). The major debate has centered around the role of word reading at the word recognition level — specifically, whether or not phonological coding is implicated in lexical access. However, a strong form of the phonological coding hypothesis — that phonological coding precedes lexical access for all words was quickly abandoned based on the outcomes of earlier research (Carr & Pollatsek, 1985; Vellutino, 1982). Much attention was then paid to developing versions of what came to be called dual-route models.

According to the dual-route theory, readers form connections between the visual configuration of written words and their meanings in memory. Dual-route theory reflects (a) the traditional non-phonological view of sight word reading, which does not involve phonological mediation in any way, and (b) an indirect route through phonology that utilizes stored spelling-to-sound correspondences. The problem with this view is that it ignores the matter of access — that is, how readers find one particular word in memory when they look at its spelling.

To summarize, individual differences in reading can be explained partially by prelexical phonological processes because they are assumed to mediate lexical access and, hence, word recognition. However, do differences in phonological coding account for all individual differences in reading? The answer is no, as proven with the at-risk readers in the present research who began in Kindergarten. In addition, there is also general agreement with regards to the limitations of phonological awareness training studies. Torgesen (1995), for example, commenting on the success of those studies with specific reference to children who exhibit 'phonologically-based reading disabilities' (p. 91), recognized the existence of studies that report treatment failures with explicit phonological instruction and suggests that "we still have much to learn about word level reading instruction with these children" (p. 93). Moreover, Wagner, Torgesen, Laughon, Simmons, and Rashotte (1993) concluded, after considering the results of phonological training studies, that "highly intensive and sustained phonological awareness training by itself provides, at best, limited improvement in subsequent reading" (p. 100). Similarly, Blachman (1994) suggested that phonological awareness training is necessary but not sufficient for enhancement of word-decoding skills: Only when combined with training in letter and/or letter-sound knowledge has training in phonological awareness been successful. Variables such as length, intensity, and timing of the treatment program have also been specifically addressed as factors that endanger the outcome of phonological training. This explanation, however, leaves a number of questions still unanswered. How can we remediate the reading problems of children who exhibit not only phonological processing deficits but also other cognitive deficits (the so called 'garden variety' poor readers), or of children who still fail to read despite explicit phonological instruction? It is a fact that the population exhibiting reading difficulties is heterogeneous (Hurford et al., 1994; Papadopoulos & Parrila, 1997). We also know that processing and performance training programs may have a differing impact on various populations as defined by age, reading ability, and general intellectual ability (Lovett, Warren-Chaplin, Ransby, & Borden, 1990; Lyon, 1985). Thus, an examination of other non-phonological cognitive factors that influence treatment effectiveness is necessary (Blachman, 1994).

The point of this discussion is that we need to recognize the role of other non-phonological cognitive processes in separating good and poor readers, processes which may explain the variance in reading disability beyond phonological coding deficits. These processes could be called 'distal' in contrast to 'proximal' (e.g., phonological coding processes) and are closely associated to reading. More specifically, we need to not only examine the relationship between distal cognitive processes and word-decoding, but to practically design remedial programs that provide training in the underlying processes that support reading.

With this in mind, a cognitive remediation training program (PASS Reading Enhancement Program, PREP) that incorporates both 'higher-order' distal processes and the instantiation of these in proximal phonological coding was used in this study. The efficacy of PREP has been a topic of previous investigation (Das, Mishra & Pool, 1995; Carlson & Das, 1997). The results of the present study coincide with those of previous PREP studies, showing that PREP training was successful in improving word-decoding, especially pseudo-word decoding performance.

5.1.3. Cognitive processes and reading

Thus, the question still remains: What other processes are critical for word-reading aside from phonological coding? According to some researchers , phonological skills may not tell the whole story, and deficient phonological skills are themselves an outcome of difficulties experienced with more fundamental cognitive processes. For example, Siegel (1993) suggested recently that one "cognitive" aspect, working memory, is directly related to reading, along with phonological processing and syntactic awareness. Similarly, Rack, Hulme, and Snowling (1993), in examining the cognitive bases of phonological skills and reading, refer to working memory and to Seidenberg's and McClelland's (1989) connectionist model of word recognition. While working memory, and particularly the articulatory (phonological) loop, certainly seems to play a role in reading difficulties, its influence may be too broadly interpreted. Thus, while the construct of working memory may prove very useful to build theories of why individuals differ in their ability to perform complex cognitive tasks such as reading, there is a danger of it becoming a "vacuous catch-all concept" (Baddeley, 1981, p. 18) if it is used without discrimination as a label for all performance differences. For example, not all reading disabled children exhibit working memory problems (Torgesen et al., 1989). Moreover, working memory deficit may be specific to tasks requiring phonological coding (Share, 1994). Also, the way in which the development of working memory and reading acquisition are specifically connected is not fully understood or explained.

What makes working memory (as well as knowledge base) attractive candidates to account for individual differences in reading ability is that they are not localized into a single process but are resources shared by many component processes. In a recent article, Swanson and Alexander (1997) argued that working memory problems characterize and may explain word-reading deficiency in the majority of poor readers. However, they further suggested that, while phonological coding ability determines normal readers' scores on pseudo-word reading, 'higher-order' cognitive components, including working memory and metacognition, fill that role for poor readers.

In light of these shortcomings, it is legitimate to suggest that the search for relevant cognitive processes needs to include working memory and to go beyond the traditional working memory paradigm. PASS theory and its tool, the Cognitive Assessment System, meet the needs of the current call for research. Both theory and practice have gone beyond the working memory paradigm by digging deeper into the cognitive processes that underlie reading as the results of the present study illustrate. The next sections integrate these theoretical issues and the findings of the present research.

5.2. Predicting reading difficulties

The purpose of the first part of the analysis in the present study was to examine whether phonological and nonphonological cognitive tasks predict reading acquisition in a group of at-risk children. The results clearly show that phonological, successive, and simultaneous processing tasks are important predictors of both success and failure in learning to read. Thus, these results are consistent with earlier findings from longitudinal studies with children who do not experience reading difficulties and cross-sectional studies with poor readers. With the exception of Felton and Brown (1990), who included an intervention in their design prior to second testing, this is the first study that examines the relationship between several cognitive variables and reading acquisition with at-risk children from Kindergarten to Grade 1. What makes these results even more impressive is that a clear relationship between reading in Grade 1 and phonological, successive, and simultaneous tasks in Kindergarten emerged in spite of the limited variability and conservative statistical methods employed.

Table 1-2 showed that the three reading groups could be distinguished in terms of their performance on three phonological coding tasks and three nonphonological cognitive tasks. Looking at the results in more detail, we showed in Table 1-5 that the two phonological tasks, Phoneme Elision and Rhyme Production, as well as one successive processing task, Speech Rate, and a planning task, Planned Search, successfully discriminated between those children who could read some pseudo-words and those who could not. The Word Attack test has been frequently identified as being the closest reading test to phonological coding and thus, it is no wonder that the two phonological tasks emerged as discriminators between the two levels of performance in Word Attack. Similarly, the Speech Rate task, although not typically used as a measure of phonological coding, distinguished between those two groups. This is less surprising, however, if we note that in the existing literature verbal working memory tasks — of which Speech Rate can be thought of as an example — together with phonological coding ability have predicted reading (e.g., Snowling, 1980; Siegel, 1993).

The second reading test was Word Identification which involves recognition of highly familiar whole words. Since the word can be recognized as one unit in contrast to being read phonetically, as in the case of pseudo-words, it is not surprising that both simultaneous processing tasks, Figure Memory and Simultaneous Verbal, correlated significantly with the Word Identification quartiles. Sight reading is one of the earliest strategies for children but it clearly is not a generalizable one and several studies have indicated that children who rely on this strategy will fall behind their peers who rely more on the phonological coding strategy (Freebody & Byrne, 1988). The phonological coding strategy was also evident in our sample, as is indicated by the fact that one successive test, Sentence Repetition and Questions, and all three phonological coding tasks correlated significantly with the Word Identification quartiles. Planned Search was also highly correlated with the reading of familiar words.

The study also examined what cognitive processes differentiate between those at-risk children who were diagnosed as reading disabled a year later and those who were not. We expect from previous research that phonological awareness and auditory STM are influential in determining whether or not the child will develop reading disabilities (e.g., Ellis & Large, 1988). The importance of phonological knowledge has been repeatedly demonstrated. For example, Juel (1988) found that poor readers at the end of Grade 4 had entered Grade 1 with little phonemic awareness. Three variables were identified in the current research: phonological (Phoneme Elision), successive (Speech Rate), and visual-spatial (Figure Memory) processing. In view of the past research on PASS and, even prior to that, with simultaneous and successive processing (Kirby & Das, 1977), it would be expected that the predictors of reading disability would have components from both simultaneous and successive processing strategies, as indeed the present results indicate. Figure Memory, a simultaneous processing task, and Speech Rate, a successive processing task, clearly contribute to the distinction between disabled and non-disabled readers and roughly to an equal extent as Phoneme Elision.

We also saw from the correlational analysis that being a poor reader and consequently participating in the remediation was predicted by both successive and phonological processing tasks, along with one planning task, Planned Search. Planned Search in older age groups involves strategies for locating a target in a field of distracters. However, at this very young age a prerequisite of Planned Search, visual matching skill, may have assumed more importance. For Kindergarten children, the test probably involves target identification rather than search strategies and may therefore tap more into simultaneous processing than into planning. The relation between Word Series and Speech Rate is much more familiar as in several past studies reviewed by Das, Naglieri, and Kirby (1994). Speech Rate and Word Series are systematically related: the rate of articulation of a word apparently provides a causal link to the span of short term memory for words. Also, that Phoneme Elision is largely predicted by the other relatively similar phonological coding task of Sound Isolation is no surprise. Phoneme Elision was also found to be predicted by Sentence Questions and Repetition, which it was not necessarily expected. The connection between the two has to be replicated before any conclusions can be made.

Finally, I examined which tests could best predict who will be the poor readers and the nonreaders after half a year of instruction. Interestingly, the cognitive tasks that distinguished between the two groups of disabled readers were not the same as the tasks that distinguished between disabled and non-disabled readers. Only two variables were identified: successive (Word Series) and phonological (Sound Isolation) processing. The disappearance of the simultaneous processing variable at this level is understandable if we keep in mind that it probably reflected sight reading and that at this level, very few children were able to read by using any means. The phonological system was represented by Sound Isolation, which in turn was highly correlated (based on the correlational Table 1-3) with Phoneme Elision and, to a lesser extent, with Rhyme Production and Sentence Repetition and Questions. This last point raises an interesting possibility that needs to be studied further. Considering the regression analyses and the correlational results and looking at the variables that are highly correlated with the predictors of the division of Low Average Readers (LAR) vs. Non-readers (NR) and Poor Readers (PR) groups as well as of the division of NR vs. PR groups, the question can be stated as follows: If relatively good phonological processing (at the division of LAR vs. NR & PR groups) is highly correlated with successive processing, planning, and other phonological tasks and relatively poor phonological processing (at the division of NR vs. PR groups) is highly correlated with successive processing task and phonological tasks, is the phonological processing itself a qualitatively different activity at these two levels?

A successive variable was represented in the second level of analysis (NR vs. PR group) by Word Series which was then highly correlated with the other two successive processing tasks, Sentence Repetition and Questions and Speech Rate. Group means presented in Table 1-2 indicate that in Word Series and Sentence Repetition tasks, children with some skills could not be differentiated (poor readers versus low average readers), whereas nonreaders were significantly poorer than either of the "reader" groups. The same is only true for Sound Isolation and Rhyme Production tasks. Thus, it seems that an extremely poor level of functioning on these four tasks in Kindergarten could be used as an indicator of a need for special attention in order to prevent later reading problems. Similarly, training of phonological and successive processes in Kindergarten could effectively prevent further reading problems, as shown by the next step of our research, when remediation was provided.

To conclude, the first part of the current research began with a hypothesis that an answer to reading improvement could be found in terms of the cognitive mechanisms that are related to word recognition. The present results essentially confirmed the earlier findings which showed that phonological processing is an important predictor of reading. Of the other cognitive processes the only consistent one (and generic one) was working memory. This study has gone beyond the working memory paradigm by looking deeper into the cognitive processes within the framework of the PASS model. It has also gone beyond the predictors whose connection to word and pseudoword reading is transparent. Thus, an addition has been made to the results of the longitudinal development study by Scarborough (1990), who found that reading disabled children may have significant difficulty in sound awareness and letter-sound knowledge. The cognitive processes that either underlie phonological coding, or are required for the application of phonological coding to reading (Kirby, Booth, & Das, 1996), have been identified in the present study at an early age. That knowledge is useful in designing remedial programs for the amelioration of these processes in children that are beginning to show difficulties as early as the Kindergarten level.

Finally, I would like to comment on the decision made to include only word-reading measures to assess reading ability. In the first volume of the Handbook of Reading Research, Gough (1984) began his review on word recognition by noting that "Word recognition is the foundation of the reading process" (p. 225). It would be indeed surprising if such a fundamental conclusion was not true any more. Research shows that word recognition is the foundational process of reading. It is now generally acknowledged that to emphasize the centrality of word recognition is not to deny that the ultimate purpose of reading is comprehension (Daneman, 1996). This also implies that skill at the word recognition level is so central to the total reading process that it can serve as a proxy diagnostic for instructional methods. That is, while it is possible for adequate word recognition skill to be accompanied by poor comprehension abilities, the converse virtually never occurs. It has never been theoretically stated, nor empirically demonstrated, that some instructional innovation could result in good reading comprehension without the presence of at least adequate word recognition ability.

The results of the present study proved that reading at the word-level can lead to the division of low average readers from poor readers and non-readers. In addition, examining group differences at the word-reading level enhanced the association of certain cognitive and phonological abilities with the ability of word decoding and word recognition. This finding is particularly important as it translates into instructional practices.

5.3. The outcomes of cognitive remediation in year 2 (Grade 1)

The second aim of the present study was to attempt to demonstrate the efficacy of the cognitive remediation program, PREP, by showing its advantage over a meaning-based reading program that was received by a carefully matched control group. As expected, both groups improved during the nine weeks of remediation. Also expected was the fact that children in the PREP group exhibited greater improvement, particularly in their ability to decode pseudo-words. As we saw in the previous section, the ability to decode pseudo-words is a clear indicator of increased phonological coding ability, and is necessary for fluent reading (Share, 1995).

Perhaps the most important contribution this current study made was in the manner in which this gain was obtained: Rather than directly teaching phonological coding skills, PREP training allowed children to develop their own strategies for cognitive processing. In the previous section of this discussion I appealed for the examination of fundamental cognitive processes, wherein a weakness may be causally linked to the acquisition of reading skills (see also Das, 1995). Within this context, the success of PREP in improving pseudo-word reading, and not familiar word reading to the same extent, speaks to the merit of this program. These results can be interpreted as indicating that phonological coding was enhanced by the amelioration of the associated cognitive processes — particularly successive and simultaneous processes. Global cognitive process training tasks, when combined with curriculum-related process training tasks (bridging tasks), have previously been shown to be an effective approach for remediating reading problems with children in Grades 3, 4, 5, and 6 (Boden & Kirby, 1995; Carlson, 1996; Carlson & Das, 1997; Das, Mishra, & Pool, 1995). The current study demonstrates that PREP is also effective with younger children, thus raising the possibility of preventing the development of reading disabilities.

The treatment programs reviewed in the introduction of this manuscript merely rely on phonological awareness teaching for their effectiveness. In these programs, transfer in word decoding from treatment to post-test is therefore a small step — a case of *near transfer*. The aim of phonological training is not to ameliorate the underlying cognitive deficit(s). In contrast, PREP's global process training tasks and bridging tasks that were mapped onto these training tasks aim at *far transfer*, which is based on improving the underlying, and more pervasive, cognitive processes. In this sense, the "rocky road" (Salomon & Perkins,

1989) to transfer has been chosen which is the only road that can possibly result in a more fundamental expression of the child's potential.

"Aptitude-treatment interaction" was also examined in both remediation programs. The question here concerned whether or not individuals who gained from remediation could be distinguished from those who did not on the basis of their cognitive processing performance prior to intervention. Aptitude-treatment interaction analyses indicated that different initial characteristics were associated with a more favorable outcome in PREP than in the meaning-based program. This preliminary finding emphasizes the importance of this line of research: If children with specific cognitive strengths and weaknesses are to benefit from a particular intervention program, then identifying their cognitive profiles prior to assigning them to specific remediation programs becomes a necessary prerequisite. The prediction part of the study makes similar contributions. If we know what variables are associated with reading failure in the early ages then we can make the right selection in terms of matching the remediation program with the child's specific strengths and weaknesses producing positive results with less frustration on the child's part (Papadopoulos, Parrila, Das, & Kirby, 1997).

But an aptitude-treatment interaction also requires that we identify the "right" aptitudes; those that contribute to poor performance and are malleable. Previous studies have shown that successive processing, for example, meets both of these requirements; it is important for early reading development and can be trained. The present study suggests that an initial level of successive processing may also be beneficial for successful remediation, a result that requires further validation. Not all children who experience early reading problems, however, struggle with successive processing or phonological tasks. Parrila, Das, Kirby, and Papadopoulos (1998), for example, identified three diagnostic categories of poor readers. These categories were based on cognitive profiles of students' performance on PASS and phonological processing tasks and include children who (a) are predominantly poor in successive processing and phonological coding, (b) are weak in nearly all PASS processes, as well as in phonological coding tasks, and (c) display few or no processing deficits that could be detected using PASS or phonological tests. The first category of readers is consistent with "true dyslexics" with their major difficulty being word decoding. The second category represents the so-called "garden-variety" poor readers who are experiencing difficulty in most school subjects. The third category is interesting in that these children show no deficits in phonological coding, which is the most commonly referred to predictor of early reading level.

Two conditions, however, should be addressed in future research before we can draw definite conclusions about aptitude-treatment interactions in the area of reading remediation. First, in terms of remediation, aptitude may be better described as a within-person process of adaptation to treatment (Snow, 1989) — or the participant's potential for change under the treatment conditions — rather than the degree to which the participant possesses certain characteristics at the outset. In its emphasis on nondirective intervention, PREP training focuses specifically on eliciting the within-person adaptation process or, more specifically, the self-generation of functional strategies. To predict the outcome of this adaptation process more accurately, we will first require a theoretical model of the process and prerequisites of early reading acquisition ("initial state aptitude complexes" [Snow, 1989]), followed by theoretically-derived dynamic assessment methods in order to capture the within-person potential for change. I believe that these issues should be given high priority in future research on reading.

The second, and not unrelated, shortcoming involves the dearth of analyses of reading activities and processes within treatments. As defined by Parrila, Das, Kendrick, Papadopoulos, and Kirby (1997), when we go beyond static and molar descriptions of aptitudes, we also need to describe how these interact with specific instructional methods. For example, a microgenetic analysis of the learning situation and the participant's responses during each PREP session is necessary if we are to establish a causal link between the theory of cognitive functions that provides the rationale for PREP and the changes in strategies that occur during PREP training. A pre-test-post-test improvement, as shown in this study, is a good start; how the improvement is produced in the participant-treatment interaction should be the next step of investigation. In future research on remediation — involving any remedial program — analyses of how a child completes the various tasks during training will be useful not only in terms of establishing causal pathways for reading improvement but also in designing practical methods of instruction. Why some children may fail to benefit from remedial training while others benefit from such training, when their cognitive profiles are known, will be an issue to investigate in future research involving remediation. Not only is this possible and cost-effective, but it will also have theoretical benefits.

5.4. Follow-up testing in year 3 (Grade 2)

In this section of analysis, I would first like to discuss the performance of participants grouped on the basis of their remediation outcome. In regard to their distal (cognitive) and proximal (phonological) test profiles, the NRE, AG, and LG groups were found to be distinguishable. The group of participants who were poor readers to start with during initial testing but who gained significantly following remedial intervention (AG group) did not show any deficit in cognitive tasks compared to the NRE group, although they did have poor phonological processing skills. The gap between the two groups, however, was minimized as the AG group gained from remediation and maintained this gain at follow-up testing. In contrast, the difference between the NRE and the LG participants was observed in two cognitive tasks, as well as in all of the phonological tasks at initial testing. Also, a significant gap remained between the two groups at follow-up testing: the LG group was found to be weaker in all phonological and three cognitive tasks.

Consequently, when the LG group was compared to the AG group at follow-up testing, they were also found to be weaker in two cognitive tasks and two of the phonological tasks. Generally, then, it appears that the AG participants were only temporarily behind NRE participants, but improved over time due to the combined effect of remediation and school instruction. On the other hand, the LG participants were found to have a relatively stable deficit.

Discussing the performance of the LG group in further detail in the follow-up testing, we note that the group was lower than the NRE group on measures such as Receptive Attention, Simultaneous Verbal, Sentence Repetition and Questions, and the two demanding phonological tasks (Phoneme Elision and Sound Isolation; Table 2-8). In comparison to the AG group, the LG group performed significantly lower on the cognitive tasks of Planned Search, Receptive Attention, and Speech Rate. The differences in cognitive test performance between the AG and LG groups were expected to a certain extent from previous studies — significant differences between good and poor readers on Speech Rate and Receptive Attention have been reported (Das, Mensink, & Mishra, 1990; Das, Mishra, & Kirby, 1994). Moreover, in a study on Planning and its contribution to reading disability (Naglieri & Reardon, 1993), the Planned Search test accounted for a significant proportion of variance in reading scores. In addition to these cognitive tasks, the LG group was observed to perform poorly at follow-up testing in one of the phonological tasks, Phoneme Elision. These differences in test performance with the AG group and the more numerous ones with the NRE group suggest that the LG group experienced a basic phonological deficit (Ball & Blachman, 1991; Ehri, 1987; Lundberg, Frost, & Petersen, 1988; Torgesen, Wagner, & Rashotte, 1994) as well as cognitive deficits.

Next, the effects of PREP and Meaning-based interventions were discussed. It is clear from the previous discussion that the Meaning-based intervention program, which meant to challenge the effectiveness of PREP remediation, was not as intensive a tutorial program as in other similar types of studies (e.g., Vellutino et al., 1996). Nevertheless, it did work as a brief and well-designed program which was comparable in duration to PREP. As the results showed (Figure 2-9), the Meaning-based group gained as much in word identification as children in the PREP group. However, the major difference between the two remediation groups was revealed once again in comparing word-attack scores (Figure 2-8). Although the average gainers in both groups combined showed significant progress on both word attack and word identification scores compared to the NRE group, as post-remediation results demonstrate, the PREP AG group improved significantly more than the MNG AG group on the word attack measure (pseudo-word reading). These results were maintained at follow-up testing eight months later and thus are indicative of the positive impact of the PREP remediation program on word attack.

Once again, the additional advantage of PREP over meaning-based intervention was anticipated on the basis of the theoretical rationale underlying PREP. PREP's global tasks focus on training the cognitive strategies that underlie reading (mainly, but not only, successive and simultaneous processing) whereas the bridging tasks offer the possibility of using these strategies in reading both pseudowords and familiar words. Thus, without directly teaching phonological skills, but by providing training in successive processing, subsequent improvement of the basic-word reading skills of the participants in the PREP group was achieved. In contrast, Meaning-Based intervention entailed more of a whole language reading approach. This intervention resulted in an improvement of reading familiar words (word identification) for the MNG AG group by simply encouraging exposure to printed material as a supplement to classroom instruction.

To summarize the results from the first remediation, one of the most notable findings concerns the demonstration that poor word attack and word identification skills can be improved as early as the ages of six and seven, with appropriate remediation focusing on strengthening of the cognitive processes underlying reading, and in conjunction with exposure to reading instruction in school.

5.5. PREP remediation in year 3 (Grade 2)

The results of the remediation of the previous year (in Grade 1) were indeed promising for the proponents of cognitive remediation. Even in a short remediation program of 18 twenty-minute sessions, significant improvements were witnessed in word-reading skills and especially in terms of pseudoword reading on the part of the PREP group.

Building on this premise, the PREP remediation was slightly prolonged in the subsequent treatment, in Grade 2, to better secure the results of remedial training. It was assumed that these 27 children who had not responded readily to remediation may have been the "hard core" organically impaired readers. Clay (1987) makes a similar point quite compellingly. She reports results which indicate that 80 to 90 percent of a population of beginning readers, who were identified as significantly impaired in reading, were brought up to Grade level reading after 14 to 20 weeks of daily tutoring. This is, however, a financially taxing proposition. Thus, we are left with an additional question: Would a shorter intervention be as effective when emphasis is given to those cognitive processes which underlie reading?

The post remediation scores obtained on the three reading (a passage comprehension task was also included) and the three phonological tasks indicated that, indeed, the performance of the participating children was remarkably improved from pre- to post-testing in Grade 2 after only four weeks of daily remediation. With the exception of Rhyme Production, which approached ceiling, all the other tasks revealed medium to large effect sizes when all 24 participants were included in the analysis, and only large effects when two outliers were not included in the analysis. In the latter comparisons, the pre- to post-gain on

Word Attack again revealed the larger effect size (d = 1.72), with Passage Comprehension (d = 1.59) and Word Identification improving to a lesser extent (d = 1.47). The t-values were also significant for all the tasks with the exception again of Rhyme Production. But a legitimate question arises with regard to the significance of these results: How significant is the relative gain shown by the 24 participants in this second remediation?

Unfortunately, time and financial resources did not allow us to collect post-remediation data for the NRE and AG groups as well. To compensate, the pre-testing scores of the participants in these two groups were extrapolated by adding in them the monthly increment they were expected to show within the two months of remediation. The expected monthly increment was calculated on the basis of the development they had shown between the time they were pre-tested in Grade 1 and again in Grade 2. Results confirmed the pattern of development that had been observed during the remediation in Grade 1. PREP remediation significantly improved the word decoding skills of the participants when they were compared to the NRE and AG groups. However, the post-hoc tests did not reveal a significant difference in favor of the LG group in terms of word reading skills.

These results indicate that although cognitive remediation is an effective way to ameliorate the reading difficulties of an at-risk population, it is not a panacea. The vast majority of the participants in the present sample appeared to overcome their initial reading difficulties by adequately developing the necessary skills for successful word decoding. The fact that similar transfer did not occur in the word recognition task may not be surprising, first, because of the disproportionally high number of irregular spelling words in the Word Identification test, and second, because the purpose of PREP is to enhance the cognitive processes on which phonological decoding is based (Das, Parrila, & Papadopoulos, 1997).

5.6. Conclusions

Terms such as *reading disability*, *specific reading disability*, and *dyslexia* (which have been used in this manuscript interchangeably) currently carry the implication that children who encounter difficulties in learning to read are primarily impaired by *constitutional* factors which adversely affect the cognitive abilities that underlie reading (see also Vellutino et al., 1996). They also imply that *experiential factors* which are based on the effects of inadequate prereading experience, inadequate instruction, or both may also be responsible for the reading problems that some children experience. Yet, the fact remains that there are currently no definitive criteria that allow one to distinguish between constitutionally and experientially based causes of developmental reading disability. Commonly used definitions of reading disability attempt to distinguish between these two etiologies through the use of exclusionary criteria designed to separate those children whose reading problems are due to such factors as low intelligence, sensory deficits, emotional disorders, and/or sociocultural deficits on the one hand, from those whose reading problems cannot be attributed to any of these factors on the other. Unfortunately, such definitions have not made the constitutional-experiential distinction any clearer.

Regrettably, neurological assessment does not always distinguish between poor readers who are identified on the basis of these criteria, and the so-called "garden-variety" poor readers who do not meet these criteria, since many of the children from this latter group have also been found to be neurologically impaired (Rutter, Tizard, & Whitmore, 1969). More importantly is the fact that virtually all of the research available failed to evaluate or adequately control for the environmental and/or educational deficits that may cause a reading disorder, and until recently, it has been difficult to separate the two. The reason for this difficulty is that any level of reading achievement can be the result of a complex interaction between one's cognitive abilities and the quality of one's literacy experience and instruction.

Therefore, the child who is better able to make use of a balance of cognitive abilities is more likely to profit from reading experience and instruction than the child who is not as endowed with these same abilities. The latter was proven in the present sample with both the group of children who were never remediated as well as with the group of children who showed remarkable improvement after the first remediation. The first group did not experience any difficulties in reading in Grade 1 although these children had been identified as being at-risk for developing reading difficulties in Kindergarten. On the same line, the second group overcame their reading difficulties after remediation targeting the cognitive skills necessary for successful reading was provided. The most successful children of the group, those who gained from the first remediation, were more able to profit from less than optimal experience and instruction, than the inadequately equipped children in the group who went through a second remediation; the latter group even had some difficulty benefiting from additional experience and instruction.

To conclude, PREP remediation was shown to enhance reading skills in an at-risk population. Moreover, the present experiment showed that it is possible to ameliorate reading difficulties as early as the age of six or seven, when a theoretical approach to remedial training is applied. Encouraging further the children's motivation toward reading should be an integral part of enhancing reading improvement, as positive self-efficacy and self-esteem are also key components in the process of learning (Mulcahy & Papadopoulos, 1997; Mulcahy & Wiles, 1996).

Throughout this research, it was demonstrated that the fundamentals of reading play a central role in the PASS model and the PASS Reading Enhancement Program (PREP). Also, both the model and the remedial program were shown to consist of useful tools for studying the development of reading as well as for understanding and remediating the reading difficulties of young at-risk readers.

5.7. Epilogue

In the area of cognitive psychology, reading research holds a paramount position. Research in this area of inquiry has produced numerous works with many different perspectives. Yet, solving the riddle of reading difficulties is not an easy task for researchers, teachers or other members of the general academic community. Accordingly, I believe that this research does not necessarily answer all the questions regarding the diagnosis and remediation of reading difficulties. It would be an exaggeration, if not naive, to suggest that the present findings define *knowledge* as the term is eloquently defined by Plato. Rather, the findings in this cognitive approach to reading enhance our knowledge and help us to understand and find ways to remediate reading difficulties. Our conclusions, therefore, consist mainly of belief. Only when our beliefs lead us to acquire the knowledge necessary to deduce the reasons behind reading difficulties and to develop universal definitions, will we approach the true definition of 'science' or 'episteme' as defined by the ultimate of philosophers, Socrates.

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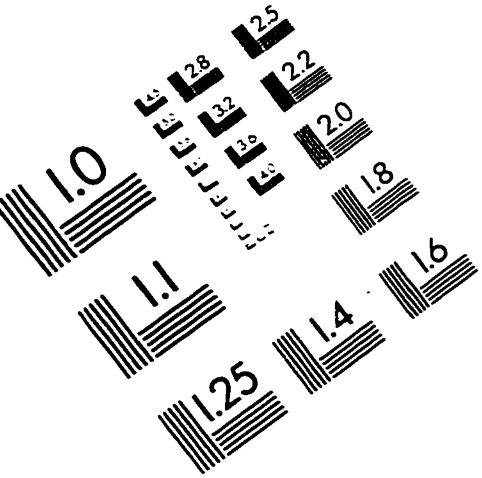
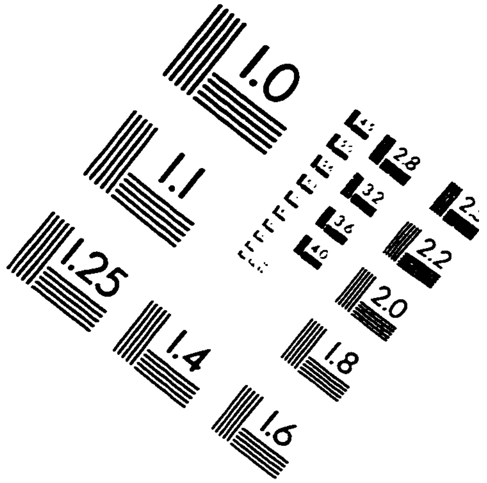
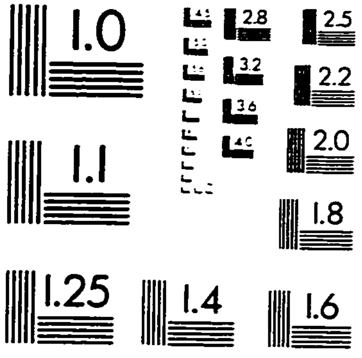
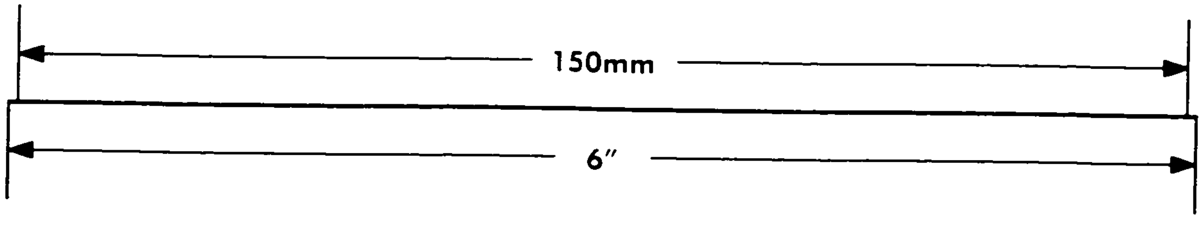
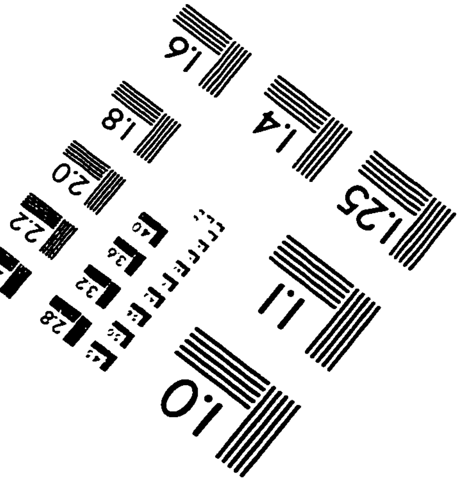
IMAGE EVALUATION TEST TARGET (QA-3)











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