Cognitive Differences and Their Predictive Ability on Reading Performance in Skilled and Unskilled Readers.

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COGNITIVE DIFFERENCES AND THEIR PREDICTIVE ABILITY ON READING PERFORMANCE IN SKILLED AND UNSKILLED READERS

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

The Department of Curriculum and Instruction

By

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B.A., University of New Orleans, 1979
M.Ed., Southeastern Louisiana University, 1993
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Dedication

This dissertation is dedicated to the memory of Marcelle Philippi Carter without whose love and support, it would not have been possible.
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The completion of this project would not have been possible without the contribution and encouragement of several individuals. I wish to extend my appreciation to Dr. Earl Cheek, Jr., who served as my dissertation chairperson, for his excellent leadership, encouragement, and support throughout my graduate training, and to Dr. Tom Hosie, who served as my minor professor, for his support and encouragement. I would also like to thank the other members of my dissertation committee Dr. Gary E. Rice who introduced me to the diversity of the reading literature, and Dr. R. Kenton Denny who provided feedback on this project, both of whom gave me much encouragement and support throughout this endeavor.

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Abstract

The present study examined the relationships among short-term memory, working memory, phonological awareness, and reading performance as measured by an informal reading inventory. Relationships between and among the tasks, their predictive importance with regard to word recognition, accuracy, fluency, and comprehension, and their ability to discriminate among groups of readers were investigated. A battery of tests comprising 14 cognitive variables and 24 reading variables was individually administered to 105 fourth and fifth grade normally achieving readers, unidentified unskilled readers, and school identified unskilled readers.

Results revealed that working memory, phonological awareness, and syntactic awareness tasks were significantly intercorrelated among themselves, and had significant correlations with the reading tasks. A linear combination of cognitive tasks correctly classified 88% of the original normally achieving group. A second linear combination of the cognitive tasks performed upon the two groups of unskilled readers correctly classified 66% of the original below average group and 57% of the original project read group. The cognitive variables were most effective in predicting word recognition, fluency, and reading grade level. Individual reading measures of word recognition, accuracy, and fluency significantly discriminated between the normally achieving group and the
two groups of unskilled readers. Overall comprehension and oral retelling of setting/background significantly discriminated between the project read group and the below average group. A linear combination of cognitive and reading variables correctly classified 94% of the original normally achieving group. A second linear combination of cognitive and reading variables performed on the two groups of unskilled readers correctly classified 74% of the original below average and project read groups. These findings suggest that a combination of cognitive and reading tasks is most effective in discriminating among groups of readers, and that cognitive tasks appear to be effective predictors of reading performance.
Introduction

Over the past thirty years literacy requirements have increased dramatically, individuals are encountering situations and materials that require literacy and reasoning at levels of sophistication not previously required of earlier generations (Herber & Herber, 1993). The integration and information processing degree of literacy required in the workforce far surpasses the levels of literacy produced by our educational system (Brown, 1991). Thus, there is little doubt that to meet the changing needs in the workforce, the ability to read and comprehend written language is one of the most fundamental functions of our educational system.

Reading is a complex, cognitive activity that is neither completely understood nor has a single agreed upon definition. For this research, reading is interpreted as the complex process of integrating memory, phonological, and syntactic skills for the comprehension of written text (Siegel & Ryan, 1988). To obtain the intended meaning of a sentence, a reader must recognize most of the words, recode those words into their phonological form in memory, and draw upon syntactical knowledge to complete comprehension of that sentence (Harris & Sipay, 1990). Thus, it seems that if a deficit exists in syntactic, phonological, memory, or word recognition skills reading comprehension can be compromised, ultimately resulting in the development of a problem reader.
From the first day of school, students are evaluated to assess their ability to perform pre-reading and reading skills. Even with this attention given to the early stages of reading development, approximately 10 to 15 percent of American students will have reading disabilities (National Advisory Committee on Dyslexia and Related Disorders, 1969). Thus, in any elementary classroom there exists a group of students that do not acquire the ability to read or read fluently.

In order to receive special services in a public school setting, children who have problems reading and/or learning to read must be able to meet a particular set of criteria enabling them to be identified. However, due to the variation in interpretation and operationalism of the federal and state guidelines in setting the local criteria, there is question as to what differences really exist between identified and unidentified problem readers (Fletcher, Espy, Francis, Davidson, Rourke, & Shaywitz, 1989). Controversy exists over whether this group of readers who have difficulty reading and/or learning to read form a homogenous group or constitute distinct groups such as learning disabled, reading disabled, or dyslexic.

The most common way of identifying a student as having a reading disability is through use of a discrepancy definition, a difference between achievement and cognitive ability.

Stanovich and Siegel (1994) suggest that phonological processing ability rather than cognitive ability best differentiates between individuals.
with reading problems. Phonological processing ability is believed to have the same coherence and stability characteristic of other cognitive abilities rather than being a pure measure of reading-related knowledge (Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993).

Brady (1986) found a positive relationship between short-term memory tasks and reading ability, indicating that poor readers have specific difficulty with verbal short-term memory tasks. Swanson (1993a) differentiates between problems occurring in short-term memory versus problems in working memory. He found individuals identified as having learning disabilities, according to a discrepancy definition, to have less working memory capacity available for performing reading and nonreading tasks (Swanson, 1993a; 1993b).

Wiig and Roach (1975) found deficits in language processing in students with learning disabilities, suggesting that the language system for these individuals is not internalized. Weinstein and Rabinovitch (1971) discovered that syntactic structure facilitated retention in good readers but did not have the same facilitative effect in poor readers.

In summary, it seems that short-term memory, working memory, phonological awareness, and syntactic awareness are all integral components of reading achievement, and are very much aligned with Siegel and Ryan's (1988) definition of reading as a complex process of integrating grammatical, phonological, and memory skills. Most often the
criterion for designation of an individual into a particular group is determined according to a discrepancy definition.

**Definition of Terms**

Many terms are used in the present study depicting groups of readers. An understanding of these terms and how the groups are defined will facilitate reading of this dissertation:

**Discrepancy Definition**

Most discrepancy definitions of learning disabilities and dyslexia are based upon the existence of a difference between actual school achievement and intellectual ability (Harris & Sipay, 1990; Merrell & Shinn, 1990; Stanovich, 1991). However, there is no one operational definition of the discrepancy formula, and no guarantee that the same individual would be identified across states, between districts, and possibly even within districts. Thus, the erratic and inconsistent application of the discrepancy formula calls into question its reliability (Merrell & Shinn, 1990; Valus, 1986).

Controversy exists over using intellectual ability as a predictor of reading performance (Fletcher, Espy, Francis, Davidson, Rourke, & Shaywitz, 1989; Siegel, 1989a; Stanovich, 1988, 1991; Stanovich & Siegel, 1994). One complication is that performance on intelligence tests can be influenced not only by situational factors, but also by past learning and genetic endowment (Bortner & Birch, 1970; Estes, 1981). Intelligence
tests measure a limited range of skills affected by learning experiences and environmental influences, and individuals with reading disabilities of all intelligence levels demonstrate difficulties in reading, spelling, phonological processing, syntax, and memory (Siegel, 1989b). Furthermore, although IQ scores are correlated with school achievement, they have not been shown to be particularly predictive of achievement in children with reading disabilities (Fletcher et al., 1989). It is also not clear whether children with discrepancies between IQ and achievement have more specific disabilities than do poor achievers whose intelligence scores are not discrepant with achievement.

**Reading Disability**

The terms reading disability, specific reading disability, and dyslexia are frequently interchanged and imply that these individuals’ difficulty in learning to read is of neurological and/or genetic origin. Although there are no definitive criteria to distinguish between constitutional versus experiential causes of reading disability, an exclusionary definition is frequently used to separate individuals whose reading problems result from low intelligence, sensory deficits, emotional disorders and/or sociocultural deficits from those whose reading problems cannot be attributed to any of these factors (Barr, Kamil, Mosenthal, Pearson, 1991). Most current definitions of reading disability are based upon a significant discrepancy
between general aptitude and actual reading achievement (Harris & Sipay, 1990).

**Dyslexia**

The population of individuals identified as having dyslexia has also been referred to as having a specific reading disability, reading disability, or specific reading retardation. Dyslexia has been defined as “a neurologically based disorder in which there is an unexpected failure to read” (Shaywitz, Escobar, Bennett, Shaywitz, Fletcher, & Makuch, 1992, p. 145). The term is intended to identify individuals whose reading ability is markedly below what would be expected by their intellectual ability. Thus, in distinguishing students with dyslexia from other individuals with reading problems (Just & Carpenter, 1987), there is no consensus among professionals as to the meaning of dyslexia. The medical community regards dyslexia as a severe reading-language disability that is inherited; educational psychologists regard it as a severe reading disability; and educators vacillate between these two positions (Harris & Sipay, 1990).

To distinguish reading failure from general learning failure, dyslexia has been qualified as specific. Also, the terms developmental dyslexia and acquired dyslexia are used to contrast between individuals who have had poor reading ability all along versus individuals who have lost previously acquired reading skills as a result of some type of trauma to the brain (Harris & Sipay, 1990; Just & Carpenter, 1987). Overall, students with
dyslexia have extreme difficulty in reading and learning to read which would not be expected from their intellectual ability. Their reading problems tend to appear early in their school career and seem to become exacerbated beyond third grade. Many of these individuals have difficulty mastering symbol-sound relationships, spelling, and handwriting (Just & Carpenter, 1987) along with slowness of reading, confusions of letters such as “b” and “d” and “p” and “q”, omissions of short words, pluralization of singular nouns, and over reliance on initial letter cues (Critchley, 1981).

Learning Disability

The term learning disability is a global concept encompassing a number of specific disabilities in children, and is the fastest growing category of students with exceptionalities in the school systems (Merrell & Shinn, 1990). It comprises a heterogeneous group of individuals with developmental learning delays that include disorders of language, thinking, attention, memory, discrimination, spatial orientation, and academics. Learning disability began as a neurological area of study and has now become an area addressed by professionals in education (Kirk, 1981). There is no agreement among professionals as to the variable most critical in the conception of learning disability, and no consensus on whether learning disability is a neurologically-based processing difficulty (Bakker, 1992; Cruickshank, 1983; Galaburda, 1989), a significant discrepancy in
ability versus achievement, low academic achievement, or a social policy program (Merrell & Shinn, 1990).


Garden Variety Readers

This group of readers has also been referred to as poor readers or reading backward (Rutter & Yule, 1975). This group of readers’ lack of reading ability is not characterized by a discrepancy between intelligence and reading achievement. Rather, their below average reading performance is considered predictable from their general cognitive abilities (Stanovich, 1991). These individuals tend to have below average intelligence and generally low achievement. The term “garden variety” (Gough & Tunmer, 1986) was used to indicate that these readers tended to be more numerous than the discrepancy-defined below average readers.
Project Read

Bulletin 1903 contains the regulations for the implementation of R.S. 17:7(11), the Louisiana Dyslexia Law. In an effort for the state of Louisiana to provide an opportunity for all students to reach their maximum potential, the state has enacted Act 854 of the 1990 Regular Legislative Session R.S. 17.7(11). This Act requires that the State Board of Elementary and Secondary Education provide for the screening of certain students for dyslexia and related disorders, and that they also provide remediation of any student determined to have tendencies toward dyslexia or a related disorder. Act 854 defines dyslexia as a "language processing disorder which may be manifested by difficulty processing expressive or receptive oral or written language despite adequate intelligence, educational exposure, and cultural opportunity" (Louisiana Department of Education, 1991, p. 2).

There is a five-step process that local education agencies must adhere to for evaluation and placement of students suspected of being dyslexic. Among the criteria, the individual must be of adequate intelligence and demonstrate a discrepancy between achievement and cognitive ability. Once a student has met the set criteria, the student is then eligible for an alternative multi-sensory reading program within the regular classroom.
Project Read is a mainstream, multi-sensory alternative language arts program selected by the parish to fulfill the instructional obligation to the Louisiana Law for the Education of Dyslexic Students R.S. 17.7(11). It is designed to be delivered in the regular classroom by the regular education teacher who delivers instruction to a small group of students during guided reading. Project Read claims to be designed for the bottom 25% of the children who do not process information well verbally, and/or who would benefit from a kinesthetic instructional approach. Its direct instructional approach emphasizes phonics in Grades 1 through 3 and shifts emphasis to comprehension and writing in Grades 4 through 6. The multi-sensory techniques are thought to compensate for memory problems that these students might have (Greene & Enfield, 1993). The program is designed for students who do not acquire oral and written language automatically.

The students termed "project read" in this study were identified through Bulletin 1903, and placed in Project Read. This placement evidences that their primary disability is reading related.

**Below Average**

Below average readers were identified for the purpose of this research as having obtained a national stanine score of three or below on the vocabulary reading subtest of the California Achievement Test. Although a vocabulary score was established for each member of this group, not every student had a cognitive skills index score in their
cumulative folder. The cognitive skills index score is derived from the administration of the Test of Cognitive Skills. This test is administered to students in specific grades to ascertain an estimate of intellectual functioning. To ensure the similarity of the project read and below average populations in intellectual functioning and in reading ability, all the participating students were administered the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981), the reading subtest of the Wide Range Achievement Test (Jastak & Jastak, 1988), and their scores were compared for significant differences.

Normally Achieving

Achieving readers were identified for the purpose of this research as having obtained a national stanine score of six or above on the vocabulary subtest of the California Achievement Test. The scores of these students on the reading subtest of the Wide Range Achievement Test were compared with the two low reading ability groups to ensure they were drawn from a different population of readers, that of normally achieving readers.

Significance of the Study

Reading has become one of the most frequently discussed topics in learning disabilities research with a large portion of the literature concerned with the causes and treatment of reading disabilities. However, the percentage of literature in the field of reading concerned with the
treatment and causes of reading disabilities has remained constant, about 10 percent. It appears that the field of reading is abdicating the area of reading disabilities to the field of special education (Chall & Curtis, 1992). Most of the research in the field of reading has relied heavily on good-poor reader research (Barr, et al., 1991) rather than comparing similar groups of identified and unidentified unskilled readers.

The current method used in the diagnosing of reading disabilities has been questioned and considered unreliable (Vinsonhaler, Weinshank, Wagner, & Polin, 1983). There is little agreement among researchers as to an exact definition of what constitutes the difference in the discrepancy definition and the types of assessment instruments and techniques most appropriate to use in identifying these individuals (Chall & Curtis, 1992). Assessment of reading using standardized tests has come under fire (Johnston, 1987; Valencia & Pearson, 1987) and it has been suggested that the use of an informal reading inventory may give more accurate information (Harris & Sipay, 1985). There has been little research utilizing informal reading inventories and standardized tests (Chall & Curtis, 1992).

For individuals with reading problems to be eligible for services in a public school setting, they must be identified. In the majority of cases, a discrepancy definition is used as a basis of identifying individuals with reading problems and in determining whether or not they are eligible for services. However, it seems that whether these readers are identified
using a discrepancy definition or not, they have similar cognitive deficits in memory, phonological awareness, and syntactic knowledge. If this is the case, how do these groups of unskilled readers differ on the above mentioned cognitive domains, and could reading performance be predicted by cognitive ability?

Most of the research in this area has been good-poor reader research. Few studies have investigated school identified and unidentified groups of unskilled readers comparing their performance to good readers. Although there has been a wealth of research investigating the cognitive areas of short-term memory, working memory, phonological awareness, and syntactic awareness, there has been no one study that has examined all of these variables at the same time on differing groups of unskilled readers, measured against an informal reading inventory.

What are the cognitive differences and reading differences between a group of low achieving readers identified according to the guidelines in Bulletin 1903, and a group of low achieving readers regarded as normal learners, both groups with regular education placement? Information on cognitive differences and similarities between these two groups and predictions on reading performance can help to better inform future instructional approaches which can benefit both groups of readers.

Cognitive differences between short-term memory, working memory, phonological awareness, syntactic awareness, and their predictive ability
on word recognition, reading accuracy, fluency, and reading comprehension assessed through an informal reading inventory has not previously been studied. If underlying sources of reading-related individual differences can be identified, this may allow educators to predict children at-risk for reading failure before instruction begins and/or be able to identify potential targets for remediation (Wagner, et al., 1993).

**Research Questions**

1. Do the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness differ among a group of unskilled readers identified by the school system as having dyslexic tendencies, a similarly functioning group of unidentified unskilled readers, and a group of normally achieving readers?

2. Do the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness predict reading word recognition, accuracy, fluency, or comprehension?

3. What differences in performance exist on individual reading measures among a group of unskilled readers identified by the school system as having dyslexic tendencies, a similarly functioning group of unidentified unskilled readers, and a group of normally achieving readers as measured by an informal reading inventory?

4. How will a combination of cognitive and reading variables differentiate among a group of unskilled readers identified by the school
system as having dyslexic tendencies, a similarly functioning group of unidentified unskilled readers, and a group of normally achieving readers?
Review of Pertinent Literature and Related Research

Due to the specificity of the reading disabled population defined by the discrepancy formula, intellectual ability versus reading achievement, there has been a wealth of research performed on this population, most frequently identified as having learning disabilities, reading disabilities, or dyslexia. A major portion of this research has focused on white middle class male children as the population of study (Fletcher, et al., 1989). Characteristics exhibited by these individuals identified as having dyslexia, although not specific to them, include slow reading with little intonation, pronunciation errors, poor comprehension, poor word attack skills, and poor spelling ability (Aaron, 1985; Just & Carpenter, 1987). Identified students with dyslexia tend to be older and have additional strategies and skills not found in their younger normally achieving peers reading at the same level (Stanovich & Siegel, 1994). Students with dyslexia experience difficulty with verbal short-term memory, and have difficulty articulating multi-syllabic words, presumably due to a phonological impairment (Ackerman, Dykman & Gardner, 1990; Rack, Snowling & Olson, 1992).

Stanovich (1988, 1991; Stanovich & Siegel, 1994) proposed deficient phonological processing as the primary cause of reading disabilities, as discrepant below average readers tend to evidence a greater phonological deficiency than non-discrepant below average readers (Fletcher et al., 1989). He suggests that reading failure during the initial
stages of reading development affect general aspects of verbal intelligence. Thus, reading disabled children may begin with a high degree of specificity in deficient phonological processing upon entering school, but due to the "Matthew Effect," that specificity becomes more generalized. The Matthew Effect (Stanovich, 1986), refers to children whose difficulty in learning to read leads to lack of motivation to engage in print related activities. Thus, their reading problems increase as their experience with print decreases. These young dyslexic readers are thought to have the potential of turning into "garden variety" (Gough & Tunmer, 1986) readers whose poor academic performance would be predictable from their poor performance on tests of intellectual ability.

Accordingly, Stanovich (1988, 1991; Stanovich & Siegel, 1994) posits that the majority of poor readers in school populations are not characterized by severe intelligence and reading achievement discrepancies. Rather, he believes garden variety readers (poor academic achievement and poor intellectual performance) are more numerous in our school populations. He indicates that not only is it difficult to demonstrate empirical differences among poor readers of differing IQ’s, there is also no evidence of differing rates in reading growth for students with dyslexia versus garden variety readers.

It appears to be reading skill, and not intellectual ability, which separates subject groups more strongly on such variables as visual
processing, phonological processing, sentence tasks, and short-term memory. There is no solid data available to indicate that discrepancy-defined students with dyslexia respond differently to various educational treatments than do garden variety readers of the same age or than younger nondyslexic children at the same reading level. It is listening comprehension rather than full scale or verbal IQ that has a higher correlation with reading comprehension (Stanovich, 1991). Accordingly, children simultaneously low in reading and listening comprehension would not have an "unexplained" reading problem, nor would children who have difficulty comprehending spoken language be expected to read well.

In summary, it is difficult to distinguish between the reading performance of individuals identified through a discrepancy formula versus those who have no discrepancy between reading achievement and ability. It seems that cognitive variables such as memory, phonological knowledge, and syntactic knowledge, rather than intellectual ability, more strongly separate groups of readers.

Cognitive Domain

Short-term Memory

Memory is active in acquiring, storing, and retrieving information necessary for reading and reading comprehension. It does not occupy a discrete area of the brain, rather memory is represented diffusely throughout the higher cortical regions (Levine, 1987). The three
processes of encoding, storage, and retrieval constitute memory (Torgesen, 1985). Encoding is the process through which sensory information is translated into a representational form that can be stored in memory. Storage refers to the permanence of the coded information. Memory codes are available for varying amounts of time in short-term memory, working memory, and long-term memory. Retrieval is the process of extracting information stored in memory (Harris & Sipay, 1990). The present discussion on memory will be limited to the processes of short-term and working memory.

Short-term memory is a passive and highly transient storage area for verbatim information (Shankweiler & Crain, 1986). It is a limited-capacity system holding a small amount of information, up to seven or eight items, for less than 15 seconds before it decays (Torgesen, 1985). Propositions are encoded into abstract symbolic representations in short-term memory, only a few of which can be held at any one time. This encoded information is only available for a second or two while the thought unit or sentence is being processed for meaning. As new propositions enter, previously assembled ones are vulnerable to memory loss (Harris & Sipay, 1990).

Chi (1976) questioned whether short-term memory loss and capacity were different between age groups, and whether short-term memory increased with age. He found no evidence directly suggesting that
capacity and rate of information loss was significantly different between age groups, rather there was evidence suggesting that rate of information loss is invariant across age. He concluded what appears to be short-term memory limitation in children is actually a deficit in processing strategies and speed and that it is the development of strategy use and speed of processing that increases with age.

Research has shown that children of average intelligence who have difficulties learning basic reading skills are less able to recall series of sequentially presented digits (Senf & Freundl, 1972). Memory span tests have traditionally been used as measures of short-term memory (Jorm, 1983; Torgesen, 1988). Reduced memory span has been found to be related to reading retardation in that these students with dyslexia performed significantly poorer than their normally achieving peers (Byrne & Arnold, 1981; Rizzo, 1939; Rugel, 1974; Spring, 1976).

In contrast, Torgesen and Houck (1980) conducted a series of experiments to determine what could account for poor performance of some learning disabled children on tests of short-term memory like the Digit Span subtest of the Wechsler Intelligence Scale for Children - Revised. They concluded that rather than reduced memory span, these individuals have a processing deficit in that their system for coding highly familiar stimuli was inefficient. In other words, they differed from the
other groups in their ability to develop efficient and easily accessible memory codes for stimuli to which they were repeatedly exposed.

Payne and Holzman (1983) investigated the relationship between reading comprehension, digit span, and short-term memory. They found that performance on digit span tasks discriminated between good and poor fifth-grade readers. Performance on the forward digit span correlated significantly in the poor reader group whereas total digit span correlated significantly in the normal reader group. They concluded that normal readers may differ from some poor readers in their ability to maintain information in short-term memory.

Brady (1986) found a significant relationship between phonetic processes and verbal memory span but not between phonetic processes and nonverbal memory span. Brady, Mann, and Schmidt (1987) examined 28 second grade and 24 third grade readers’ performance on recall tasks with differing sets of consonant-vowel syllables. The poor readers were found to recall significantly less information than the good readers. Interestingly, however, the poor readers made the same systematic processing errors as good readers but they occurred at a higher rate.

In order to discover whether there was a difference between encoding of semantic and phonemic information, Shulman (1970) utilized a probe recognition task in which the probe item might be either a synonym or a homonym of a presented word. Sixty right-handed male college
students participated in the research. He found that encoding of both semantic and phonemic information can occur in short-term storage, and that semantic encoding takes more time than phonemic encoding.

In summary, a positive relationship appears to exist between reading ability and short-term memory tasks. Poor readers have been shown to have specific difficulty with verbal short-term memory tasks regardless of whether presentation is verbal or auditory. However, it does not appear to be a limitation in short-term memory capacity, but rather a deficit in processing strategies and speed of processing which creates these differences among readers. Processing of information is considered an attribute of working memory rather than short-term memory, and will be considered next.

**Working Memory**

According to Swanson (1994), working memory and short-term memory are independent constructs, and problems in short-term memory appear to be independent of problems in working memory (Swanson, 1993a). Working memory is an active processing system which includes a storage component. It has the properties attributed to short-term memory along with a control mechanism which allows integration of phonological, syntactic, and semantic information. The control mechanism is responsible for processing and storage of information such as translating unrelated speech sounds into real words (Baddeley, 1979), and is involved in the on-
line regulation of syntactic and semantic analyses after orthographic decoding and phonological processing have begun (Shankweiler & Crain, 1986). The greater the memory load imposed upon this system, however, the less processing space is available for decoding, blending, and comprehending (Baddeley, 1979). Working memory is considered an important aspect of reading comprehension (Engle, Nations, & Cantor, 1990), especially in grasping the gist and complexities of reading comprehension (Engle, Cantor, & Carullo, 1992).

Baddeley (1986) defines working memory tasks as those tasks which involve concurrent processing and storage of information. Tasks used to measure working memory require a person to hold a small amount of material in mind for a short time while at the same time carrying out further operations on this information. Intercorrelations among working memory tasks tend to be high which would indicate that persons who score high on a particular working memory measure will also score high on other working memory measures (Swanson, 1992).

Daneman and Carpenter (1983) view working memory as a limited capacity system which does not differ across individuals. Processes that are more demanding would consume more of the available capacity, and individual differences would reflect differences in processing efficiency. They suggest that poor readers devote more capacity to executing the reading process leaving less capacity for storage and maintenance of that
information in working memory. In contrast, skilled readers whose reading skills are more efficient would have more available working memory resources. They also believe working memory to be instrumental in the processing and integration of new information with prior knowledge.

A competing view (Engle, Nations, & Cantor, 1990; Turner & Engle, 1989) suggests that individuals are poor readers because their working memory capacity is small, and that this capacity is independent of reading. That is, differences between skilled and unskilled readers are not a consequence of poor reading skills but rather poor readers have less working memory capacity available for performing reading and nonreading tasks. This view is based on findings which suggest that visual-spatial and verbal working memory tasks tap the same underlying processes (Turner & Engle, 1989), indicating that working memory functions independent of academic domain, its measures reflect independent operations, and it is not dependent upon a particular strategy to accomplish the task (Swanson, 1993b; Turner & Engle, 1989). Thus, working memory appears to operate as a generalized system independent of reading skill.

Mann, Liberman, and Shankweiler (1980) tested recall of phonetically controlled sentences and word strings in second-grade good and poor readers. They found good readers performed better than poor readers when the material to be recalled contained no phonetically confusable words. They concluded that poor readers may have difficulty
comprehending some types of sentences when working memory is stressed.

Swanson (1993a; 1993b) further suggests that learning disabled individuals tend to have less working capacity available for performing reading and nonreading tasks than do skilled readers. He found subjects with and without learning disabilities to be statistically comparable on most visual-spatial working memory and short-term memory measures, but to vary considerably across the majority of verbal working memory measures. Swanson (1994) found working memory rather than short-term memory to be significantly related to academic performance in children and adults without learning disabilities. In children and adults with learning disabilities, however, he found both short-term memory and working memory to be related to achievement.

Just and Carpenter (1992) view working memory capacity as the maximum amount of activation available in working memory to support both storage and processing of language comprehension. In a study using college students, they found working memory to store intermediate and final products of information as readers constructed and integrated ideas from successive words in the text, and that language comprehension demands extensive storage of partial and final products in service of complex information processing. They also found syntactic processes to play an important role in working memory capacity, and comprehension to
deteriorate when demand on working memory capacity increased. They imply that individual differences in reading ability are associated with a variety of different component processes of comprehension which may be fast or slow due to an overall capacity difference.

Kyllonen and Christal (1990) studied the relationship between reasoning ability and working memory capacity in four separate studies using military recruits, and agree with Baddeley (1986) that working memory is domain-independent. They found a consistent and high correlation between working memory and reasoning ability, concluding that reasoning ability and working memory are similar, if not identical, constructs. Reasoning ability is interpreted as reflecting general ability, and general ability is considered to reflect availability of attentional resources. They suggest that general ability is more predictive of learning performance in the earliest stages of learning, because it is at this point that working memory capacity limitations are most critical.

Leather and Henry (1994) investigated the relationship between working memory, short-term memory and beginning reading in 7-year-olds to determine if they contributed in the same or separate ways to the variance in reading accuracy and comprehension. They found that the phonological awareness tasks were highly correlated with the complex memory tasks, and that the simple and complex memory tasks were not
highly related, and identified phonological awareness as an effective
predictor of reading accuracy and reading comprehension.

In summary, it appears that working memory effectively
discriminates between skilled and unskilled readers. However, it is unclear
as to whether these differences in individual readers are due to inefficient
processing ability or differences in working memory capacity. Working
memory tasks were found to be highly correlated with phonological
awareness tasks.

**Phonological Awareness**

Phonological awareness is an awareness of and access to the sound
structure of one’s language (Mattingly, 1972), and is directly related to
understanding the pronunciation clues of written language. In order to
develop fluency in utilizing the alphabetic principles of written language,
there must be conscious, analytic knowledge of how phonetic elements
map out onto phonemes (Barr, et al., 1991). Phonological processing is
the use of phonological information of one’s oral language in processing
written and oral information (Jorm & Share, 1983; Wagner & Torgesen,
1987). Normal primary language processing of storing, indexing, and
retrieving lexical information is carried out by means of a phonetic code
(Shankweiler & Crain, 1986). Phonological coding refers to the
acquisition of the rules which dictate the relationship between morphemes
and phonemes and the ability to apply these rules in ordering the
phonemes that constitute words. Printed words are thought to be coded in terms of their phonological features, and phonological coding is believed to be important in the retention of verbal information in short-term memory (Harris & Sipay, 1990; Shankweiler & Crain, 1986).

In working memory, phonological coding occurs in a sound-based representational system for efficient storage during ongoing processing of information (Baddeley, 1982, 1986; Conrad, 1964; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). Efficient phonological coding provides readers with an accurate set of phonemes or sounds to blend, leaving free a maximum amount of cognitive resources for the blending of those sounds into words (Baddeley, 1982; Jorm, 1983; Torgesen, Kistner & Morgan, 1987). Thus, the proficiency with which individuals are able to retrieve phonological codes associated with individual phonemes, word segments, or entire words should affect the degree to which phonological information is useful in the ability to decode (Baddeley, 1986).

A primary task of beginning readers is to construct a link between speech and print. Alphabetic orthographies place demands on the beginning reader to discover the relationship between the internal structure of the printed word and the internal structure of the spoken word (Shankweiler & Crain, 1986). Beginning readers tend to show more errors on final rather than initial consonants, suggesting available processing space is being used up as they work through words (Liberman,
Shankweiler, Liberman, Fowler, & Fischer, 1977). However, it is not merely a matter of acquiring letter-to-sound correspondences, since such correspondences are not fully reflective of phonetic facts in the English orthographies of our language (Shankweiler & Liberman, 1976). Rather, readers need to establish a phonetic base from which meaningful understanding of orthographic representations can be extracted.

Children who have facility for generating verbal labels and phoneme segmentation are more likely to be among the better readers at the end of first grade (Blachman, 1983). Beginning readers who fall behind in reading at the onset of first grade tend to stay behind. This is probably due to a combination of deficient decoding skills and a lack of practice with on-level materials, which tends to result in less involvement with reading-related activities. This is similar to what Stanovich describes in his "Matthew Effect". Thus, these readers become deficient in areas which facilitate reading comprehension such as general knowledge, vocabulary, and syntactic knowledge, which are normally developed through reading (Stanovich, 1988).

Good and poor readers differ in their use of phonetic coding in working memory for both visual and auditory presentation of information. Phonetic similarity appears to exert a more powerful effect on good readers than poor readers in that good readers are more strongly affected by phonetic confusability. Young good readers are better than their poor
reading peers at recalling items that are phonetically dissimilar. However, these good readers are nearly indistinguishable from poor readers in their recall of items which are phonetically similar or confusing (Mann, Liberman, & Shankweiler, 1980; Shankweiler & Liberman, 1976; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979; Siegel & Linder, 1984).

Stanovich and Siegel (1994) used a regression-based test to study the phonological-core variable-difference model in children who have reading problems with and without an aptitude-achievement discrepancy. The phonological-core variable-difference model suggests that the basic cause of reading disability is a deficiency in processing the phonological features of language. They found that children with and without a discrepancy performed similarly with regard to the subskills of phonological and orthographic coding that determine word recognition, and that cognitive differences between these two groups resided outside the word-recognition module. There were differences between these two groups on short-term memory and working memory tasks, and on language tasks in which the discrepant group significantly outperformed the nondiscrepant group.

McDougall, Hulme, Ellis, and Monk (1994) investigated the relationship between reading, short-term memory, and phonological skills in seven to 9-year-old low, average, and high ability readers. They found
speech rate to be significantly associated with single word reading performance, and to account for variance not tapped by a measure of short-term memory. They also found phoneme deletion to account for a significant amount of variance once speech rate had been accounted for, concluding that phoneme deletion and speech rate make independent contributions to predicting reading performance.

Siegel and Ryan (1988) examined the development of phonological, grammatical, and short-term memory skills in three groups of 7- to 14-year-old children who were normally achieving, reading-disabled, arithmetic-disabled, or had an attention deficit disorder. The reading disabled children were found to perform significantly more poorly than children in any of the other groups on the oral-cloze and error-correction tasks, except at the 13- to 14-year ages. The reading-disabled group also had significantly lower scores for reading accuracy, comprehension, and reading speed. The reading-disabled children were found not only to have significant deficits in phonics and phonological processing, but to lag behind in developing sensitivity to basic grammatical structures of language.

In summary, unskilled readers appear to have a language problem in the phonological domain, and are generally lacking in metalinguistic awareness of phonological structure. They appear deficient in their conscious ability to segment words into phonemes and to manipulate
phonemes. This inefficiency appears to interfere with development in awareness of syntactic structures.

**Syntactic Awareness**

Syntactic awareness is knowledge of the rules governing word order in clauses, phrases, and sentences. This knowledge allows readers to organize information into chunks larger than single words, facilitating the ability to chunk words into larger meaningful units. Syntactic awareness allows prediction of what type of words are likely to follow in a sentence, especially when combined with lexical and prior knowledge (Harris & Sipay, 1990).

Knowledge of syntactic structure helps to bridge the gap between the levels of linguistic information, from the initial sensory perception to its final form in long term storage (Liberman, Mattingly, & Turvey, 1972). This awareness of the characteristics of language can facilitate the efficient use of memory for linguistic information. The different levels of linguistic information can be recoded from one linguistic level to another through governing grammatical rules called codes.

Syntactic coding is the ability to apply these acquired rules for ordering words in a language and for representing and understanding structural differences in sentences. Syntactic codes are abstract representations which conform with rules of order, and grammatical codes are representations of the class of a word such as noun, verb, etc. To
comprehend sentences, a reader must learn to apply the syntactic rules in segmenting sentences into their grammatical elements, and determine how these elements are related to one another (Barr et al., 1991).

Weinstein and Rabinovitch (1971) studied syntactic structure in good and poor fourth-grade readers. They found syntactically structured lists to facilitate learning in good readers, but to have no effect on poor readers, with both groups of readers having similar difficulty in learning syntactically unstructured lists (Epstein, 1961, 1962). Thus, the syntactic cues implicit in the structured lists facilitated learning in the good readers.

Slobin (1971) found an interaction between grammatical structure and semantic aspects of memory for sentences in that meaning and form can be stored independently, with meaning more persistent in memory than form. Wiig and Roach (1975) investigated immediate recall of semantically and syntactically varied sentences in adolescent learning disabled and achieving readers. They found the learning disabled adolescents to exhibit significantly poorer immediate recall of semantically and syntactically varied sentences, to depend more heavily upon semantic aspects of sentences for language processing, and to experience sequencing problems for modifier-strings. Their responses were characterized by word omissions, substitutions, and interfering perseverative responses. Thus, the learning disabled group did not seem to have the ability to code information in terms of linguistic structure.
Corley (1988) further suggests that poor readers’ reliance on semantic information hinders maintenance of surface syntactic information.

Syntactic development can limit the number of words an individual can speak in a single sentence. An individual cannot accurately repeat a sentence that is more syntactically advanced than the ones they can produce spontaneously (Gillet & Temple, 1994). There is evidence that poor readers have more difficulty than good readers in comprehending spoken sentences (Shankweiler & Crain, 1986). Thus, having an individual repeat sentences, gives an idea of the limits of complexity of the sentences they will be able to understand in written text.

Failure to comprehend sentences in print that could be understood orally is diagnostic of specific reading disability (Shankweiler & Crain, 1986). Willows & Ryan (1986) found young children to show a developmental increase across Grades 1 through 3 in sensitivity to semantic and syntactic information in both oral-language and reading, and that this developmental increase lessens beyond Grade 4 or 5.

In support of this research, Siegel and Ryan (1988) found children age 7 to 14 with a reading disability to perform significantly poorer on error-correction and oral-cloze tasks than other learning disabled or normally achieving children. They conclude that reading disabled children demonstrate sensitivity to basic grammatical structure of language.
significantly later than normally achieving children, and that this developmental lag is present throughout middle childhood.

John and Rattan (1991) found learning disabled individuals to show a reduced ability to recall sentences, evidence perseverative responses, and demonstrate sequencing deficits resulting in increased dependence upon semantic aspects when processing language. These findings lend support to the findings of Wiig and Roach (1975). Based upon their results, they suggest that sentence memory tasks are good predictors of reading performance.

In summary, syntactic awareness was found to show a developmental increase across Grades 1 through 3, leveling off in Grades 4 and 5. Syntactic awareness facilitates learning in skilled readers while unskilled readers appear to rely more on semantic rather than syntactic aspects when processing language. Unskilled readers seem to lag behind in their awareness to syntactic structure. This deficit in syntactic awareness appears to interfere with comprehension ability.

**Reading Domain**

**Word Recognition and Accuracy/Decoding**

The concept of word is the realization that language comes in units of individual words, and it is the "benchmark" that advances children's acquisition of conventional literacy (Templeton & Bear, 1992). Word recognition initially begins through use of a letter-by-letter process, with
the length of the visual unit increasing beyond single letters until the entire word becomes the unit of recognition (Samuels, Schermer, & Reinking, 1992), resulting in the ability to associate the printed word with its spoken counterpart (Harris & Sipay, 1990). As proficiency develops in matching spoken words to print, the reader begins to recognize written words as individual entities. Words seen repeatedly begin to appear obvious and become recognizable with very little examination. A word so familiar that it is recognized instantly is called a sight word. Sight words are necessary for all reading. In general, recognizing words and the ability to understand text are closely related (Gillet & Temple, 1986); word recognition is the basic process upon which all other reading processes are predicated (Besner & Humphreys, 1991).

Decoding is the ability to approximate the spoken form of a printed word through the use of various skill areas such as visual analysis, symbol-sound association, and visual blending; however, readers appear to place the most reliance on symbol-sound associations. In our alphabetic writing system, the grapheme-phoneme relationships are consistent enough to make knowledge of them useful in decoding printed words. Thus, the ability to decode printed words allows one to pronounce many words that are not recognized at sight. Research suggests that there is a wide range of decoding ability at various grade levels, and that decoding ability seems to increase with reading ability (Harris & Sipay, 1990).
Slow decoding ability interferes with integration of incoming information, and thus inhibits reading comprehension (Perfetti & Lesgold, 1977). Brady, Mann, and Schmidt (1987) found both poor readers and good readers to make the same systematic decoding errors, however, poor readers' errors occurred at a higher frequency. Thus, it seems that poor readers attempt to apply the same strategies as good readers, but are less efficient in their application of these strategies. Poor readers' pattern of errors was demonstrated by significantly more order confusions between adjacent consonants, suggesting that these transpositions might be due to deficient phonetic processing ability.

Phonological coding and orthographic coding were found to be weakly related in reading disabled individuals, but to have a significantly higher correlation in nonreading disabled individuals (Olson, Wise, Conners, Rack & Fulker, 1989). This is further suggestive of a phonological coding deficit in some reading disabled individuals. This deficit in grapheme-phoneme conversion can interfere not only with comprehension but also with reading rate (Aaron, 1985). Goodman (1965), who suggests that readers predict as they read using cues from their reading to confirm or disconfirm their predictions, developed a procedure for analyzing oral reading errors. This procedure is referred to as an analysis of oral reading miscues, and includes substitutions, mispronunciations, omissions, and insertions identified as miscues. Beginning readers tend to make more...
substitutions (Wixson, 1979) and miscues that are graphically similar to the word. Proficient readers tend to make a higher percentage of omissions while reading. Thus, readers tend to make "positive" and "negative" miscues, and analysis of a reader's miscues will provide useful information about the strategies that reader is using (Cheek, Flippo, & Lindsey, 1989).

In summary, word recognition is the basis upon which all other reading processes are built. It begins as a letter-by-letter strategy and develops into the ability to recognize spoken words in print. Words seen repeatedly become recognizable with very little scrutiny. Children who do not develop the ability to read words accurately and quickly encounter difficulty because their attention is directed toward identification of individual words. Analysis of the miscues a reader makes while reading can identify the particular strategies a reader is utilizing, and which strategies facilitate or interfere with comprehension ability. Thus, concentration on individual words can reduce the ability to efficiently access and integrate word and sentence meanings, ultimately interfering with comprehension ability. Accurate word recognition is the beginning of fluent word identification, and fluent word recognition is crucial to reading comprehension.

Fluency

A fluent reader has the ability to read smoothly, easily, and readily without the interference of word recognition and identification problems.
According to Allington (1983), lack of fluency is commonly noted as a characteristic of a poor reader, and usually results in hesitations, word-by-word reading, repetitions, and inadequate use of voice. In general, most of these problems are caused by inaccurate word recognition and decoding ability (Harris & Sipay, 1990).

Slow articulation can be linked to phonological impairment. Achievement-ability discrepant readers demonstrate slow articulation and naming rates, and tend to articulate word sequences more slowly than normally achieving readers (Ackerman, Dykman, & Gardner, 1990). Research suggests that speech rate is significantly associated with single word reading performance and is a strong predictor of individual differences in reading ability. Measures of reading ability, phonological ability and short-term memory span for words are highly intercorrelated, with speech rate being significantly associated with single word reading ability (McDougal, Hulme, Ellis, & Monk, 1994). Therefore, both reading rate as measured in words per minute and automaticity of single word reading should be good predictors of reading fluency.

In summary, fluency is the ability to read smoothly and easily without interference of word recognition and identification problems. The less attention that is directed toward problems at the word level, the more available will be resources for comprehension of written text.
Comprehension

“Reading is the meaningful interpretation of written language. In short, reading is comprehending” (p.10). In order to comprehend, a reader must integrate information available not only in the written text, but also within the mind of the reader. Reading comprehension is a reader’s ability to integrate graphic symbols used to represent language, linguistic information, cognitive skills, and general world knowledge (Harris & Sipay, 1990).

Reading disability comprehension research commonly studies poor readers identified as dyslexic, specific reading disability (Leong, 1989), or specific reading retardation (Aaron, 1987; Aaron, Kuchta, & Grapenthin, 1988) through the use of an achievement-ability discrepancy definition, versus individuals identified as garden variety or general reading backwards (Aaron, 1987; Aaron, Kuchta, & Grapenthin, 1988) readers who are considered to have a general cognitive deficit and whose poor reading achievement would be predictable by their cognitive ability.

Leong (1989) suggests that it is the verbal inefficiency of dyslexic readers which accounts for their poor comprehension ability. He concludes it is their inefficient ability to process phonological information that interferes with their ability to develop rapid, automatic activation of word recognition, thus, reducing comprehension ability.
Sawyer (1992) suggests that comprehension is initially influenced by word recognition with word recognition progressing to influence comprehension, and the two ultimately becoming independent of one another. Thus, an inability to automatize verbal labels would be exacerbated by a deficit in short-term memory (Blachman, 1983), interfering with the ability to comprehend at the sentence level (Corley, 1988) resulting in a lack of persistence to continue processing problematic text and a general deficit in comprehension ability (Zabrucky & Ratner, 1989).

Abrahamsen and Shelton (1989) believe listening comprehension develops before reading comprehension, and suggest that learning disabled students demonstrate language deficits which affect listening comprehension. Aaron, Kuchta, and Grapenthin (1988) propose that students with dyslexia are deficient in decoding but not necessarily in comprehension, and that listening comprehension is a way of differentiating between students with dyslexia and other poor readers. They found that poor readers with normal listening comprehension were deficient on tasks which required decoding, however, when tested on tasks which minimized decoding, their reading comprehension was comparable to normal readers. The poor readers who had inadequate listening comprehension continued to evidence inferior performance on comprehension tasks even when decoding emphasis was minimized.
Cawley, Miller, and Carr (1990) found learning disabled students, identified using an achievement-ability discrepancy, to read at a more rapid rate with a higher number achieving an independent reading level when compared to mildly educationally handicapped children who were defined as being significantly below average in all academic areas. However, there was little difference in word recognition performance between the two groups.

**Summary**

In summary, it is difficult to distinguish between the reading performance of individuals identified through a discrepancy formula versus those who have no discrepancy in reading and achievement. It seems that cognitive variables such as memory, phonologic knowledge, and syntactic knowledge rather than intellectual ability more strongly separate groups of readers.

Poor readers have been shown to have specific difficulty with verbal short-term memory tasks, regardless of whether presentation is verbal or auditory. However, it does not appear to be a limitation in short-term memory capacity, but rather a deficit in processing strategies and speed of processing, creating these differences among readers. Processing of information is considered an attribute of working memory rather than short-term memory. Working memory appears to more effectively discriminate between skilled and unskilled readers than short-term memory.
It is unclear as to whether these differences in individual readers are due to inefficient processing ability or differences in working memory capacity. Working memory tasks were found to be highly correlated with phonological awareness tasks.

Unskilled readers appear to be generally lacking in metalinguistic awareness of phonological structure. They appear deficient in their conscious ability to segment words into phonemes and to manipulate phonemes. This inefficiency seems to interfere with development in awareness of syntactic knowledge. Syntactic awareness was found to facilitate learning in skilled readers; whereas, unskilled readers appeared to rely more on semantic than syntactic aspects when processing language, seeming to lag behind in their awareness to syntactic structure.

In considering the reading measures, it appears that children who do not develop the ability to read words accurately and quickly encounter difficulty because their attention is directed toward identifying individual words. This concentration on individual words reduces the ability to efficiently access and integrate word and sentence meanings ultimately interfering with comprehension ability. Analysis of a reader's miscues can give information as to strategies that need to be developed to facilitate comprehension. The ability to read smoothly and easily without interference of word recognition and identification problems allows more available resources for comprehension. Poor sight vocabulary appears to
affect comprehension for all individuals with reading problems, but
students with dyslexia seem to have better listening comprehension, and
quite possibly better overall comprehension than poor readers without an
achievement-ability discrepancy. However, there appears to be little
difference in reading performance at the word level by different groups of
unskilled readers.
Methodology

Participants

Participating in the study was a total of 105 fourth and fifth grade students from a local school district. Of these students, 35 were readers identified for Project Read, 35 were below average readers, and 35 were normally achieving readers. All groups had a regular education placement.

The three groups were identified according to the following criteria: (1) below average students were identified as having a score at or below the third national stanine on the reading vocabulary subtest of the California Achievement Test; (2) project read students were identified by the school system according to the guidelines of Bulletin 1903, for participation in the Project Read instructional program; (3) normally achieving students were identified as having a score at or above the sixth national stanine on the reading vocabulary subtest of the California Achievement Test.

Procedure

Permission slips were distributed by classroom teachers to all fourth and fifth grade regular education students in four different local public schools. Students were given an incentive to return the permission slips. Those students who returned consensual permission slips, and met a particular group criteria were selected for participation in the study.
The researcher introduced herself to the student and explained they would be working together for approximately an hour and a half doing a variety of tasks: some easy, some hard, there was no good/bad or pass/fail on anything they did, and for them to try and do their best on each task presented. The battery of tests was individually administered by the researcher in one session. Morning and afternoon administrations were dependent upon the schedule in a particular school and when a particular grade level went to lunch.

Tests were presented in random order to prevent any type of order effect. The tests were administered according to one of nine previously determined random orderings of the tests. A table of random numbers was utilized to determine the nine random orderings. The researcher began with the first random ordering of tests and went through to the ninth before starting over with the first ordering. Tests were administered either in a library, classroom, or testing room depending upon which was available at the time of testing. Students were chosen for testing each day according to who was present and available to be tested. Usually, the classroom teacher chose among the possible students and selected which students would be tested that day.

The researcher has course work, training, and experience in psychological assessment. She has over 15 years experience as a
psychometrician, and is presently employed as a part-time psychometrician in the neuropsychology department at Tulane Medical Center.

**Materials**

**General Measures**

The Peabody Picture Vocabulary Test-Revised (PPVT-R) (Dunn & Dunn, 1981) and the Wide Range Achievement Test (WRAT) reading subtest (Jastak & Jastak, 1978) were administered to all students participating in the study. Scores were compared for the two groups of low achieving readers to verify that they were not significantly different in intellectual ability (Craig & Olson, 1991) or reading achievement. Scores were further compared to verify that the normally achieving group was significantly different in reading performance from the two groups of low achieving readers.

The PPVT-R measures single word receptive auditory vocabulary. The student was asked to choose from a plate of four picture choices which picture best fit the word read to the student. Practice trials were given and testing was discontinued after six errors were made within eight consecutive items. The standard score yielded from the PPVT-R was utilized in the analysis of data. Correlation coefficients with the Weschler Intelligence Scale for Children-Revised full scale score range from -.16 to .91 with a median of .64. Reliability coefficients range between .67 and .88.
The WRAT reading subtest measures recognizing and naming letters and pronouncing words out of context. The student was presented with a list of words and required to pronounce each word within ten seconds. Testing was discontinued after 12 consecutive failures. The standard score from the WRAT was utilized in the analysis of data. Validity coefficients range from .74 to .80 and reliability coefficients range from .90 to .95.

**Short-term Memory Tasks.**

In the administration of the forward digit span (Wechsler, 1974), the researcher read aloud sequences of numbers to the student and the student was required to repeat them exactly as read. The number sequences ranged from three to nine digits, and were presented at one second intervals. There were two trials at each span level, and testing was stopped when a student missed both trials at the same level. The forward digit span raw score was used in the analysis of data. The reliability coefficients of the Weschler Intelligence Scale for Children-Revised (Wechsler, 1974) Digit Span subtest range from .71 to .84 with an average of .78.

In the forward visual memory span (Wechsler, 1987), the researcher touched a series of red colored squares in a predetermined order. The student was required to touch the same colored squares in the exact order demonstrated by the researcher. The number of squares touched
increased with each level. There were two trials at each level with testing discontinued when the student missed both trials on one level. The raw score yielded from the forward visual memory span was used in the analysis of data. Validity coefficients for the Wechsler Memory Scale-Revised Visual Memory subtest (Wechsler, 1987) range between .51 and .68, and the reliability coefficients of the forward visual memory span range between .53 and .68.

In number/letter memory (Sheslow & Adams, 1990), the researcher read aloud a random mix of both letters and numbers and the student was required to repeat them exactly as read. The items within each trial were presented at one second intervals. There were 28 possible trials ranging from 2 to 10 items. Testing was discontinued after errors were made on three consecutive trials. The number/letter memory raw score was used in the analysis of data. The validity and reliability coefficients of the Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990) Number/letter Memory subtest range from .67 to .90 and from .83 to .90, respectively.

Working Memory Tasks.

In the Paced Auditory Serial Addition Test (PASAT) (Zezak, 1983), the student was required to add a series of 60 random digits presented one every three seconds. A previously recorded auditory cassette was used in order to control for presentation rate. A practice trial was administered to
make sure the student understood the task. The raw score yielded from the PASAT was used in the analysis of data. Gronwall and Wrightson (1981) found the PASAT to be significantly correlated with the Wechsler Memory scale ($p < .01$).

To administer the backward digit span (Wechsler, 1974), the researcher read aloud number sequences to the student and the student was required to repeat them exactly in reverse order. The number sequences ranged from 2 to 8 digits, and were presented at one second intervals. There were two trials at each span level, and testing was discontinued when a student missed both trials at the same level. A practice trial was given. The backward digit span raw score was used in the analysis of data. The reliability coefficients of the Weschler Intelligence Scale for Children-Revised Digit Span subtest (Wechsler, 1974) range from .71 to .84 with an average of .78.

In the administration of the backward visual memory span (Wechsler, 1987), the researcher touched a series of green colored squares in a predetermined order. The student was required to touch the same colored squares in the exact reverse order of that demonstrated by the researcher. The number of squares touched increased with each level. There were two trials at each level with testing discontinued when a student missed both trials at the same level. The raw score yielded from the backward visual memory span was used in the analysis of data.
Validity coefficients for the Wechsler Memory Scale-Revised Visual Memory subtest (Wechsler, 1987) range between .51 and .68 with the reliability coefficients of the backward visual memory span ranging between .62 and .66.

Phonological Awareness Tasks.

According to Stanovich, Cunningham, and Cramer (1984), phonological awareness tasks are reliable predictors of reading. Leather and Henry (1994) modeled their tasks closely after those used by Stanovich, Cunningham, and Cramer (1984), and the tasks developed by Leather and Henry (1994) were used in this study. The reliability coefficients of the phonological awareness tasks (strip initial consonant, strip final consonant, phoneme tapping) ranged between .76 and .89 with an average of .84.

The strip initial consonant task required the student to delete the initial phoneme of a word and to pronounce the embedded word that remained. The task consisted of 12 trials and the student was instructed to listen carefully to the target word, saying the first sound of the word silently in their head and the rest of the word out loud. Practice trials were given to make sure the student understood the task. The raw score yielded from the strip initial consonant task was used in the analysis of data.
The strip final consonant task required each student to delete the final sound or phoneme from a word and pronounce the embedded word that remained. The task consisted of 12 trials, and the student was instructed to listen carefully to the target word, saying the word out loud leaving off the final sound of the word. Practice trials were given to make sure the student understood the task. The raw score yielded from the strip final consonant task was used in the analysis of data.

Phoneme tapping required the student to tap out the number of sounds making up a target word presented orally by the researcher. The student was encouraged to “sound out” the word as they would an unfamiliar word, and then tap out each sound they heard in the word. The student was reminded not to “spell” the words, or tap out the number of letters, but to tap the number of sounds heard in the word. Since the number of sounds in a word does not always correspond to the number of letters, knowledge of spelling sequences did not necessarily aid performance. The experimental words were made up of two, three, and four phonemes presented in random order. Practice trials were given to make sure the student understood the task. The raw score yielded from the phoneme tapping task was used in the analysis of data.

In the phoneme deletion task (McDougal et al., 1994), the researcher said a monosyllabic nonword to the student, and the student was required to “take away” a sound, specified by the researcher, making
the nonword into a word. A true word was always formed as a result of
the deletion of the sound. Practice trials were given to make sure the
student understood the task. The raw score yielded from the phoneme
deletion task was used in the analysis of data. Although there was no
reported reliability information on this task, McDougal et al. (1994) found it
to significantly differentiate between reading groups (p < .001).

In administering the word attack task (Woodcock, 1973), the
student was asked to pronounce words that were not “real” words. The
task contained 50 items which measured the child’s ability to identify
nonsense words through the application of phonic and structural analysis
skills. Items were arranged in order of difficulty. Interpretation of the raw
score was based upon grade placement; the percentile score from the
word attack was used in the analysis of data. The validity and reliability
coefficients for the Woodcock Johnson Reading Mastery Word Attack
subtest (Woodcock, 1973) range from .85 to .90 and from .94 to .97,
respectively.

**Syntactic Awareness Tasks.**

The error-correction and oral-cloze tasks were taken from the ones
used by Siegel and Ryan (1988). The sentence-repetition task they
administered was replaced with Spreen and Benton’s (1963) Sentence
Repetition Test, due to the latter’s increase in sentence length and
complexity. The Sentence Repetition Test was considered to better
differentiate individual language ability rather than those sentences used by Siegel and Ryan (1988) which were all of a specific length. Syntactic development can limit the number of words a child can speak in a single sentence, "children cannot accurately repeat a sentence that is more syntactically advanced than one they can produce spontaneously" (Gillet & Temple, 1994, p. 63). Shewan and Kertesz (1980) found a correlation of .88 between the Sentence Repetition Test and the repetition of words, phrases, and sentences of the Western Aphasia Battery.

In the administration of the error-correction task, the student was read a sentence (Siegel & Ryan, 1988; Willows & Ryan, 1986) that contained an error. The student was initially informed that each sentence contained an error, and was instructed to correct each sentence. There was a total of 21 sentences presented, and the errors ranged across parts of speech and meaning. Repetition of the sentence was allowed. The raw score from the error-correction test was used in the analysis of data. Although there was no validity data available, Siegel and Ryan (1988) found this task to significantly differentiate between groups of reading disabled and normally achieving readers (p < .0001).

In the administration of the oral-cloze task (Siegel & Ryan, 1988; Willows & Ryan, 1986), the researcher read each sentence aloud saying "blank" for the missing word. The student was instructed to supply a word that fit into the sentence. The class of the missing word varied across
parts of speech (nouns, verbs, adjectives, etc.). Due to the confusability of one of the sentences, the task was reduced from the original 15 to 14 sentences each containing one missing word. The raw score from the oral-cloze task was used in the analysis of data. Siegel and Ryan found this task to significantly differentiate between groups of reading disabled and normally achieving readers (p < .0001).

Reading Measures

The Qualitative Reading Inventory-II (QRI-II) (Leslie & Caldwell, 1995), an informal reading inventory, was administered to assess oral reading level, word recognition, reading accuracy, oral reading fluency, and reading comprehension. The QRI-II consists of graded word lists and narrative and expository texts ranging in level from pre-primer to junior high. Inter-scorer reliability estimates were .99 for total miscues, .99 for meaning change miscues, .98 for explicit comprehension, and .98 for implicit comprehension. Reliability coefficients for instructional level decisions based upon comprehension scores ranged from .80 to .90. Criterion-related validity coefficients ranged between .65 and .86.

The student was administered the graded word lists until the highest instructional word recognition level was determined. Administration began with the word recognition list at or below grade level, and the researcher proceeded either up or down in grade levels until an instructional level and a frustration level (identification of 13 words or less) was reached. The
instructional word recognition level was determined as the highest level below the frustration level.

The researcher began administering the oral reading passages at the grade level identified by the word recognition level. The researcher proceeded either up or down in grade levels until an instructional level and a frustration level [correctly answering between 0 and 3-6 (depending upon grade level) comprehension questions] was reached. The instructional grade level was determined as the highest instructional level below the frustration level.

The word recognition measures were derived from three different tests and used in the analysis of data. From the Qualitative Reading Inventory-II, the highest instructional word recognition level was established for each student, and the total number of words recognized at that level was recorded. Standardized scores from the Peabody Picture Vocabulary Test-Revised (PPVT-R) and The Wide Range Achievement Reading subtest (WRAT) were also used as measures of word recognition.

Reading accuracy was determined by examining how the student's oral reading deviated from the written text. Accuracy measures used in the analysis of the data consist of percent scores for the following oral miscues (Flynt & Cooter, 1993; Leslie & Caldwell, 1995) evidenced by the student at their highest instructional grade level: initial consonant similarity (graphically similar on initial sound), final consonant similarity (graphically...
similar on final sound), mispronunciation (word incorrectly pronounced, can be nonword), substitution (real word substituted for word in the text), omission (no word is given), insertion (word not in text is added), self-correction (miscue spontaneously corrected), semantic acceptability (no meaning disruption), and a total miscue raw score.

The fluency measures consist of oral reading rate and automaticity of word recognition. Reading rate was measured in words per minute, and was determined by the number of words in the passage multiplied by 60 and divided by the number of seconds it took to read the passage. Reading rate at the student's highest instructional level passage was recorded and used in the analysis of data. Automaticity of word recognition was determined by the number of words automatically recognized within one second at the students' highest instructional word recognition level.

The comprehension measures were determined through prior knowledge questions, an oral retelling, and comprehension questions. The student was asked three or four prior knowledge questions prior to their reading of the passage which elicited one prior knowledge percent score used in the analysis of data. The student was then asked to retell the passage after reading the selection. Four areas of retelling were assessed and elicited the following percent scores used in the analysis of the data: setting, events, goal, and results. Following the retelling, the student was
asked direct questions about the text in which the answers were either explicitly stated in the text or needed to be inferred from the information in the text. Three comprehension percent scores were obtained and used in the analysis of the data: explicit comprehension, implicit comprehension, and overall comprehension.

**Purpose**

The use of a discrepancy definition, the difference between intellectual ability and reading achievement, has been a frequently used method of separating groups of readers, however, controversy exists over using an ability versus achievement discrepancy in understanding reading performance (Fletcher, et al., 1989; Siegel, 1989a; Stanovich, 1988, 1991; Stanovich & Siegel, 1994). The use of a discrepancy formula is often used in school systems to identify students with reading problems and place them in special programs. However, there seems to be little difference in reading performance evidenced by identified and unidentified groups of unskilled readers in that they both share the inability of being successful readers (Simmons, 1992). Also, due to the proliferation of operational definitions of the discrepancy formula and the way it is applied, there is little guarantee that the same individual will be identified across states or even between districts (Fletcher, et al., 1989; Merrel & Shinn, 1990).
Identification of dimensions relative to the reading process may provide for better classification definitions. The present review identified the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness as important in the reading process. These cognitive domains have been shown to distinguish among groups of readers. Investigators have primarily employed two or three of these cognitive domains within a study, but none have examined the relationship among all within the same study.

Currently, the emphasis in reading education has been toward the use of authentic assessment of children’s abilities, from emergent readers to advanced readers. Authentic assessment efforts focus on assessing literacy abilities using authentic tasks, in contexts that closely resemble actual situations of use. Informal reading inventories, which allow distinction between a student’s independent, instructional and frustration reading levels, have been used as authentic measures of reading assessment and have a long history of use in education (Hiebert, Valenica, & Afflerbach, 1994). This form of reading assessment is rich in information on reading performance. Informal reading inventories can give qualitative and quantitative information on word recognition, accuracy, fluency, and comprehension measures. Standardized instruments tend to assess reading ability from a limited perspective, under a limited set of conditions, and within a limited set of responses (Farr & Carey, 1986).
Research has yet to study the relationship of the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness on the diverse areas of reading performance as measured by an informal reading inventory.

Most of the research in understanding reading ability has been good-poor reader research. More research is needed on identified and unidentified groups of unskilled readers to understand the dimensions of reading that set apart these groups of readers, rather than relying on a discrepancy formula that gives little information toward tailoring instruction to the diverse needs of these readers.

An initial step in this determination will be to explore the relationship among the variables within each of the cognitive domains to ascertain if they are measuring the same or different components. If the variables within each domain load on the same component, this will suggest that the combination of tasks chosen provides effective measures of the particular domain. These measures then will be analyzed to discern how the cognitive tasks differentiate among the three groups of readers to determine if the cognitive tasks are effective in predicting reading performance as measured by word recognition, accuracy, fluency, and comprehension.

The cognitive variables will be explored along with the reading variables to determine whether they aid in the understanding of differences
among groups of readers. In particular, how do different groups of readers perform along the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness, and are they effective in predicting reading performance? How do different groups of readers perform along specific dimensions of the reading process as measured by word recognition, accuracy, fluency, and comprehension? Are these measures effective in discriminating among normally achieving readers, identified unskilled readers, and unidentified unskilled readers all with placement in the regular education classroom?

**Hypotheses**

**Hypothesis 1**

The cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness do not differ among a group of unskilled readers identified by the school system as having dyslexic tendencies, a similarly functioning group of unidentified unskilled readers, and a group of normally achieving readers.

**Hypothesis 2**

The cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness do not predict reading word recognition, accuracy, fluency, or comprehension.
Hypothesis 3

There is no difference in performance on individual reading measures among a group of unskilled readers identified by the school system as having dyslexic tendencies, a similarly functioning group of unidentified unskilled readers, and a group of normally achieving readers on any of the reading variables.

Hypothesis 4

No combination of cognitive and reading variables differentiates among a group of unskilled readers identified by the school system as having dyslexic tendencies, a similarly functioning group of unidentified unskilled readers, and a group of normally achieving readers.

Overview of Analyses

Initial analyses provided calculation of the descriptive statistics. Correlation analysis and principal components analysis were performed to examine the interrelationships among the cognitive variables. One-way ANOVAs were employed to examine between-group differences for individual cognitive variables. Discriminant analyses were performed on the cognitive variables to identify linear combinations of cognitive variables that discriminated among the three groups of readers.

Correlations among and between cognitive and reading variables were examined. Regression analyses, with the reading measures as dependent variables, were performed to determine the effectiveness of the
cognitive variables in predicting performance in reading. Correlation analyses were conducted to examine the interrelationships among the reading variables, and a series of one-way ANOVAs was conducted to determine if there were differences in performance among the groups as measured by an informal reading inventory. Canonical correlation analyses were performed to examine the correlation structure between the cognitive variables, on the one hand, and the reading variables on the other. Finally, a discriminant analysis was performed to see whether a combination of cognitive and reading variables provided more effective discriminators among the groups of readers.

Determining appropriate sample size is an important element in establishing statistical power and detecting statistically significant effects (Cohen, 1992). Cohen (1988) provides power estimates and explains that 35 subjects per group will be required for the present study, if having an effect size at .30, power set at .79 and alpha level at .05.
Results

Results of the statistical analyses are delineated through narrative text along with the use of tables. This investigation examined the ability of the cognitive domains short-term memory, working memory, phonological awareness, and syntactic awareness to discriminate among an unidentified and identified group of unskilled readers as compared with a group of skilled readers. Next, it examined the effectiveness of the cognitive domains in predicting reading performance in the areas of word recognition, reading accuracy, fluency, and comprehension as measured by an informal reading inventory. Then, the effectiveness of the above areas of reading in discriminating between an unidentified and identified group of unskilled readers as compared with a group of skilled readers was examined. Finally, the study investigated the effectiveness of using a combination of cognitive and reading measures in discriminating among an unidentified and identified group of unskilled readers as compared to a group of skilled readers.

All data analyses were conducted using the SAS System for Microsoft Windows 6.10 (1993). The sample consisted of 105 fourth and fifth grade students ranging in age from 9 to 12 years (see Table 1). A Chi-Square was computed to examine relative frequencies of the nominal variables of gender and race. In the normally achieving group, there was a substantially greater proportion of nonminority students (whites = 33,
Table 1

**Student Sample Descriptive Statistics**

<table>
<thead>
<tr>
<th>Age</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
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<tr>
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<td>M</td>
<td>F</td>
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<tr>
<td>Grade</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minority</td>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>NA</th>
<th>BA</th>
<th>PR</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normally Achieving (NA)</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>105</td>
</tr>
<tr>
<td>Below Average (BA)</td>
<td>35</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Read (PR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>NA</th>
<th>BA</th>
<th>PR</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>105</td>
</tr>
<tr>
<td>Sex</td>
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<tr>
<td></td>
<td>22</td>
<td>15</td>
<td>21</td>
<td>58</td>
</tr>
<tr>
<td>Minority</td>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>19</td>
<td>21</td>
<td>73</td>
</tr>
<tr>
<td>Age</td>
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<td>10</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>20</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>9</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Grade</td>
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<td>13</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>22</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

blacks = 2) than in the below average group (whites = 19, blacks = 16) or the project read group (whites = 21, blacks = 14), \( X^2 (2, N = 105) = 15.462, p < .001 \). No significant gender distribution differences were found across groups (normally achieving: females = 22, males = 13; below average: females = 15, males = 20; project read: females = 21, males = 14) \( X^2 (2, N = 105) = 3.313, p < .191 \).
The data for this study consists of 38 scores for each of the 105 subjects. The scores are reported in several forms: raw scores for the measures that could be scored as number correct, percents for the measures in which percent correct facilitated interpretation due to the variability in the total number of responses, and standard scores and percentile for measures which depended upon an age or grade information for interpretation (see Table 2).

In order to verify that there were no ability/achievement differences between the two groups of unskilled readers, an ANOVA was performed on the PPVT-R scores used as an estimate of ability (Craig & Olson, 1991) and on the WRAT scores. No significant differences were found between the two groups of unskilled readers. However, statistically significant differences were found between the normally achieving group and the two groups of unskilled readers. As shown in Table 11, p. 90 average PPVT-R and WRAT differed significantly between the normally achieving group and the below average group, and differed significantly between the normally achieving group and the project read group, but did not differ significantly between the below average group and the project read group.

First, the ability of the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness to discriminate among the below average group, the project read group, and the normally achieving group was examined. A principal components
Table 2

**Measures of Study**

**Cognitive Measures**

<table>
<thead>
<tr>
<th>Short-term Memory</th>
<th>Working Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward digit span</td>
<td>Backward digit span</td>
</tr>
<tr>
<td>Forward visual memory</td>
<td>Backward visual memory</td>
</tr>
<tr>
<td>Number/letter Memory</td>
<td>PASAT</td>
</tr>
</tbody>
</table>

**Phonological Awareness**

<table>
<thead>
<tr>
<th>Phoneme deletion</th>
<th>Syntactic Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip initial consonant</td>
<td>Sentence error correction</td>
</tr>
<tr>
<td>Strip final consonant</td>
<td>Oral-cloze</td>
</tr>
<tr>
<td>Phoneme tapping</td>
<td>Sentence Repetition</td>
</tr>
<tr>
<td>Word attack***</td>
<td></td>
</tr>
</tbody>
</table>

**Reading Measures**

<table>
<thead>
<tr>
<th>Comprehension</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior knowledge*</td>
<td>Initial similarity*</td>
</tr>
<tr>
<td>Events*</td>
<td>Final similarity*</td>
</tr>
<tr>
<td>Setting*</td>
<td>Insertion*</td>
</tr>
<tr>
<td>Goal*</td>
<td>Misproununciation*</td>
</tr>
<tr>
<td>Results*</td>
<td>Omission*</td>
</tr>
<tr>
<td>Explicit*</td>
<td>Self-correction*</td>
</tr>
<tr>
<td>Implicit*</td>
<td>Semantic acceptability*</td>
</tr>
<tr>
<td>Overall*</td>
<td>Substitution*</td>
</tr>
<tr>
<td></td>
<td>Total number of miscues</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Word Recognition</th>
<th>Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word recognition grade level</td>
<td>Words per minute****</td>
</tr>
<tr>
<td>Total word recognition</td>
<td>Automatic word recognition</td>
</tr>
<tr>
<td>PPVT-R**</td>
<td></td>
</tr>
<tr>
<td>WRAT**</td>
<td></td>
</tr>
</tbody>
</table>

**Instructional Reading Level**

| Reading grade level               |                                 |
|-----------------------------------|                                 |

**Note.** Scores reported as raw scores unless otherwise noted. *percent; **standard score; ***percentile; ****# words in passage(60)/# of seconds.
analysis was utilized to determine the relationship of the cognitive tasks within each of the four cognitive domains to ascertain if they are measuring the same or different components. If the variables within each domain load on the same component, this suggests that the combination of tasks chosen provides effective measures of the particular domain (see Table 3).

Principal components analysis of the three short-term memory measures evidence two principal components. The first component has an eigenvalue of 1.59 accounting for 53 percent of the variance, and the second component has an eigenvalue of 1.02 accounting for 34 percent of the variance, with a total of 87 percent of the variance accounted for with these two components. The tasks most highly correlated with the first principal component are forward digit span and number/letter memory with forward visual memory span being poorly correlated. Forward visual memory span is most highly correlated with the second principal component. This finding clearly separates the visual component from the auditory/verbal component of short-term memory. Visual short-term memory is understood as a limited-capacity system which maintains recently presented visual information (Hitch, Brandimonte, & Walker, 1995) and should not be interpreted as measuring the same construct as short-term auditory memory (McGhee & Liberman, 1994).
Table 3

**Principal Components Analysis**

**Short-term Memory Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDS</td>
<td>0.667</td>
<td>-0.351</td>
<td>0.657</td>
</tr>
<tr>
<td>FVMS</td>
<td>0.213</td>
<td>0.935</td>
<td>0.283</td>
</tr>
<tr>
<td>Num/Let</td>
<td>0.714</td>
<td>0.049</td>
<td>-0.699</td>
</tr>
</tbody>
</table>

Eigenvalue 1.591 1.025 0.383
Cum. Pro. 0.530 0.872 1.000

**Working Memory Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
<th>Component 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDS</td>
<td>0.598</td>
<td>-0.301</td>
<td>-0.743</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BVMS</td>
<td>0.587</td>
<td>-0.466</td>
<td>0.661</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASAT</td>
<td>0.545</td>
<td>0.832</td>
<td>0.102</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eigenvalue 1.716 0.698 0.585
Cum. Pro. 0.572 0.804 1.000

**Phonological Awareness Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
<th>Component 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phon. Del</td>
<td>0.525</td>
<td>-0.064</td>
<td>-0.388</td>
<td>0.036</td>
<td>-0.753</td>
</tr>
<tr>
<td>Strip Fi</td>
<td>0.468</td>
<td>0.027</td>
<td>0.473</td>
<td>-0.744</td>
<td>0.044</td>
</tr>
<tr>
<td>Strip In</td>
<td>0.455</td>
<td>-0.195</td>
<td>0.574</td>
<td>0.648</td>
<td>0.069</td>
</tr>
<tr>
<td>Tapping</td>
<td>0.228</td>
<td>0.954</td>
<td>-0.044</td>
<td>0.156</td>
<td>0.108</td>
</tr>
<tr>
<td>Word Attack</td>
<td>0.496</td>
<td>-0.216</td>
<td>-0.541</td>
<td>-0.002</td>
<td>0.643</td>
</tr>
</tbody>
</table>

Eigenvalue 2.759 0.924 0.586 0.474 0.256
Cum. Pro. 0.551 0.737 0.853 0.949 1.000

**Syntactic Awareness Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Err Corr</td>
<td>0.584</td>
<td>-0.097</td>
<td>-0.806</td>
</tr>
<tr>
<td>Oral-Cloze</td>
<td>0.575</td>
<td>-0.650</td>
<td>0.495</td>
</tr>
<tr>
<td>Sen Rep</td>
<td>0.572</td>
<td>0.753</td>
<td>0.324</td>
</tr>
</tbody>
</table>

Eigenvalue 2.129 0.456 0.415
Cum. Pro. 0.709 0.861 1.000

**Note.** FDS = forward digit span; FVMS = forward visual memory span; Num/Let = number/letter memory; BDS = backward digit span; BVMS = backward visual memory span; PASAT = paced auditory serial addition; Phon. Del = phoneme deletion; Strip Fi = strip final consonant; Strip In = strip initial consonant; Err Corr = sentence error correction; Sen Rep = sentence repetition; Cum. Pro. = cumulative proportion.

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The working memory measures evidence one principal component with an eigenvalue of 1.72 accounting for 57 percent of the variance. All of the working memory measures were moderately correlated with the first principal component. This finding concurs with Baddeley's (1986) conclusion that working memory tasks tend to be intercorrelated.

Principal components analysis of the phonological awareness measures evidenced two principal components. The first component has an eigenvalue of 2.76 accounting for 55 percent of the variance, and the second component has an eigenvalue of .92 accounting for 18 percent of the variance with a total of 74 percent of the variance accounted for. Four of the phonological awareness measures (phoneme deletion, strip final consonant, strip initial consonant, and word attack) are moderately correlated with the first component with one measure (phoneme tapping) being poorly correlated (Leather & Henry, 1994). Phoneme tapping is highly correlated with the second principal component. This suggests that phoneme tapping, which involves not only phonological knowledge but also motor skills, is measuring an aspect of phonological awareness independent of the other phonological awareness measures.

The syntactic awareness measures evidence one principal component with an eigenvalue of 2.13 accounting for 71 percent of the variance. All of the syntactic awareness measures are moderately correlated with the first principal component. This suggests that all of the
syntactic awareness measures are measuring a latent characteristic of syntactic awareness.

Principal components analysis of the cognitive domains resulted in identifying six components. The short-term memory measures demonstrated a distinct auditory/verbal and a visual memory component. The working memory and syntactic measures loaded on one component each. The phonological measures demonstrated a verbal component and a motor component.

A correlation analysis was performed to examine the interrelationships among the cognitive variables. Many of the correlations amongst the 38 variables, although low, were statistically significant. Such low correlations, though statistically significant, are of little practical significance due to higher levels of unexplained variance (McMillan & Schumacher, 1989). Only correlations in the moderate to high range (p < .0001) were considered as noteworthy and will be discussed in this investigation.

As reflected in Table 4, other than amongst themselves, the short-term memory measures were correlated only with sentence repetition and backward visual memory. A memory aspect is involved in the successful performance of sentence repetition which explains this finding. Forward visual memory, identified as measuring a separate visual component, is correlated with backward visual memory span. These two tasks comprise
Table 4

**Correlation Analysis of Cognitive Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>FVMS</th>
<th>NUM/LET</th>
<th>BVMS</th>
<th>SEN REP</th>
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</thead>
<tbody>
<tr>
<td>FDS</td>
<td>-.04</td>
<td>.56*</td>
<td>.09</td>
<td>.40*</td>
</tr>
<tr>
<td>FVMS</td>
<td>.21</td>
<td>.41*</td>
<td>.12</td>
<td></td>
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<tr>
<td>NUM/LET</td>
<td>.11</td>
<td>.44*</td>
<td></td>
<td></td>
</tr>
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</table>

**Working Memory with Phonological and Syntactic Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>BV</th>
<th>PA</th>
<th>PD</th>
<th>SF</th>
<th>WA</th>
<th>EC</th>
<th>OC</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD</td>
<td>.41*</td>
<td>.34</td>
<td>.49*</td>
<td>.41*</td>
<td>.50*</td>
<td>.50*</td>
<td>.31</td>
<td>.42*</td>
</tr>
<tr>
<td>BV</td>
<td>.32</td>
<td>.49*</td>
<td>.26</td>
<td>.43*</td>
<td>.30</td>
<td>.39*</td>
<td>.22</td>
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<tr>
<td>PA</td>
<td>.41*</td>
<td>.25</td>
<td>.49*</td>
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<td>.30</td>
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</table>

**Phonological Awareness and Syntactic Measures**

<table>
<thead>
<tr>
<th>Variable</th>
<th>SF</th>
<th>SI</th>
<th>Tap</th>
<th>WA</th>
<th>EC</th>
<th>OC</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pdel</td>
<td>.55*</td>
<td>.53*</td>
<td>.26</td>
<td>.73*</td>
<td>.61*</td>
<td>.49*</td>
<td>.39*</td>
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<tr>
<td>SF</td>
<td>.51*</td>
<td>.25</td>
<td>.49*</td>
<td>.44*</td>
<td>.39*</td>
<td>.26</td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>.14</td>
<td>.49*</td>
<td>.40*</td>
<td>.27</td>
<td>.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap</td>
<td>.15</td>
<td>.26</td>
<td>.04</td>
<td>.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WA</td>
<td>.52*</td>
<td>.48*</td>
<td>.40*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>.58*</td>
<td>.57*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC</td>
<td>.54*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. FDS = forward digit span; FVMS = forward visual memory span; NUM/LET = number/letter memory; BV = backward visual memory span; SEN REP = sentence repetition; BD = backward digit span; BV = backward visual memory span; PA = paced auditory serial addition; PD = phoneme deletion; SF = strip final consonant; WA = word attack; EC = sentence error correction; OC = oral-cloze; SR = sentence repetition; Pdel = phoneme deletion; SI = strip initial consonant; Tap = phoneme tapping; *p < .0001.

The visual memory span subtest of the WMS-R, and are expected to correlate. It seems that the short-term memory tasks used in this study are relatively independent of phonological awareness, syntactic awareness, and reading ability.
Working memory phonological awareness, and syntactic awareness are all intercorrelated. Although the PASAT, the only working memory task that contained an element of speed, loaded on the same principal component, it is not well correlated with the other working memory tasks. Working memory is correlated with three of the five phonological awareness variables, and all three of the syntactic awareness variables. All of the working memory variables are correlated with phoneme deletion and word attack. Backward digit span is correlated with strip final consonant, error correction, and sentence repetition. Backward visual memory is correlated with oral-cloze. None of the syntactic awareness measures, however, are correlated with the PASAT.

As shown earlier, phoneme tapping was identified as measuring a characteristic of phonological awareness different from the other phonological awareness tasks. Except for phoneme tapping, all of the phonological awareness variables are correlated with the syntactic awareness variables, and the phonological awareness variables and syntactic awareness variables are correlated amongst themselves. Oral-cloze and sentence repetition are not correlated with strip initial consonant, however, sentence error correction is. These intercorrelations amongst the working memory, phonological awareness and syntactic awareness measures are expected and are further suggestive of the importance of phonemic ability to language ability.
To determine the level of difference between the normally achieving, below average, and project read groups on the individual cognitive variables, a series of univariate one-way ANOVAs was conducted (see Table 5). In the cognitive domain of short-term memory the normally achieving group differed significantly from the below average group, but not from the project read group. This suggests that the below average group has less available short-term memory than the normally achieving readers. Furthermore, it appears that the project read group possibly has a more efficient use of short-term memory than the below average group of readers.

The normally achieving group performed significantly better than the project read group and the below average group of readers on all working memory measures. The normally achieving group performed significantly better than both groups of unskilled readers on four of the five phonological awareness measures, and on all of the syntactic awareness measures. There are no significant differences amongst the groups on the phoneme tapping task. Except for phoneme tapping, the cognitive domains of working memory, phonological awareness, and syntactic awareness significantly discriminated between the normally achieving group and the two groups of unskilled readers. However, the individual cognitive variables were not as effective in discriminating between the below average and project read groups as there were no statistically
Table 5

**Analysis of Variance of Cognitive Measures**

**Short-term Memory and Working Memory**

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>FDS</th>
<th>FVS</th>
<th>NUM/LET</th>
<th>BDS</th>
<th>BVMS</th>
<th>PASAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA-PR</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>NA-BA</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>BA-PR</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
</tr>
</tbody>
</table>

Prob > F .001 .018 .009 .001 .001 .001

**Phonological and Syntactic Awareness Measures**

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>Pdel</th>
<th>StFi</th>
<th>StIn</th>
<th>Tap</th>
<th>WA</th>
<th>EC</th>
<th>OC</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA-PR</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>NS+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>NA-BA</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>NS+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>BA-PR</td>
<td>NS-</td>
<td>NS+</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
</tr>
</tbody>
</table>

Prob > F .001 .001 .001 .500 .001 .001 .001 .001

Note. FDS = forward digit span; FVS = forward visual memory span; NUM/LET = number/letter memory; BDS = backward digit span; BVMS = backward visual memory span; PASAT = paced auditory serial addition; Pdel = phoneme deletion; StFi = strip final consonant; StIn = strip initial consonant; Tap = phoneme tapping; WA = word attack; EC = sentence error correction; OC = oral-cloze; SR = sentence repetition; NA-PR = normally achieving - project read; NA-BA = normally achieving - below average; BA-PR = below average - project read. +/- = direction of difference; NS = non significant; *p < .05; df = 2, 102; Prob > F = significance level for testing that there are no differences among the three groups.

significant differences on any of the individual cognitive variables between these two groups of readers.

To further reveal differences on cognitive measures among the groups of readers, a stepwise discriminant analysis was performed on the cognitive variables, with a significance level of .1 to enter and a
significance level of .1 to remove. The following subset of variables was identified: word attack, oral-cloze, PASAT, and sentence error-correction. A cross-validation discriminant analysis based on the subset of variables identified in the stepwise analysis was performed to determine the linear discriminant function that would best classify the individuals. The linear discriminant function of the cognitive variables word attack, oral-cloze, PASAT, and sentence error-correction yielded an 85% correct classification into the normally achieving group. However, a cross-validation discriminant analysis based only on the word attack and oral-cloze variables yielded a higher correct classification of 88% into the normally achieving group with a 57% classification into the below average group and a 40% classification into the project read group (see Table 6).

A second stepwise discriminant analysis was conducted on the cognitive variables to further investigate differences between the two lower functioning reading groups on the cognitive measures, with a significance level of .3 to enter and a significance level of .3 to remove. A cross-validation discriminant analysis based on the subset of variables identified in this second stepwise analysis was performed to determine the linear discriminant function of cognitive variables that would best classify individuals. The linear discriminant function of the cognitive variables backward visual memory span, phoneme deletion, strip final consonant,
Table 6

Discriminant Analysis of Cognitive Variables
Number of Observations and Percent Classified into Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Achieving</th>
<th>Below Avg</th>
<th>Project Read</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieving</td>
<td>31</td>
<td>2</td>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>88.57</td>
<td>5.71</td>
<td>5.71</td>
<td>100</td>
</tr>
<tr>
<td>Below Avg</td>
<td>1</td>
<td>20</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>2.86</td>
<td>57.14</td>
<td>40.00</td>
<td>100</td>
</tr>
<tr>
<td>Project Read</td>
<td>4</td>
<td>14</td>
<td>24</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>11.43</td>
<td>48.57</td>
<td>40.00</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>39</td>
<td>30</td>
<td>105</td>
</tr>
<tr>
<td>Percent</td>
<td>34.29</td>
<td>37.14</td>
<td>28.57</td>
<td>100</td>
</tr>
</tbody>
</table>

Error Count Estimate

<table>
<thead>
<tr>
<th></th>
<th>Rate</th>
<th>Priors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.1143</td>
<td>.3333</td>
</tr>
<tr>
<td></td>
<td>.4286</td>
<td>.3333</td>
</tr>
<tr>
<td></td>
<td>.6000</td>
<td>.3333</td>
</tr>
<tr>
<td></td>
<td>.3810</td>
<td></td>
</tr>
</tbody>
</table>

and number/letter memory correctly classified only 66% of the below average group and 57% of the project read group (see Table 7).

In summary, the majority of cognitive tasks used in this investigation appeared appropriate to their particular domain. Except for short-term memory, the cognitive domains were intercorrelated amongst themselves, and discriminated the skilled from the unskilled groups of readers. The phonological awareness variable of word attack was significantly correlated with all of the working memory, phonological awareness, and syntactic awareness variables, except for phoneme tapping. The domains of phonological and syntactic awareness were most effective in
discriminating skilled from unskilled readers. The domains of memory and phonological awareness were the most effective discriminators between the unskilled groups of readers, although classification was not much better than chance. It is evident from these results that the cognitive variables are better at discriminating the normally achieving readers from the unskilled readers rather than between the two groups of unskilled readers.

Next, the effectiveness of the cognitive domains in predicting reading performance in the areas of word recognition, reading accuracy, fluency, and comprehension as measured by an informal reading inventory was examined. A correlation analysis was performed to investigate the

<table>
<thead>
<tr>
<th>Group</th>
<th>Below Average</th>
<th>Project Read</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Average</td>
<td>23</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>65.71</td>
<td>34.29</td>
<td>100</td>
</tr>
<tr>
<td>Project Read</td>
<td>15</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>42.86</td>
<td>57.14</td>
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<tr>
<td>Total</td>
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<td>70</td>
</tr>
<tr>
<td>Percent</td>
<td>54.29</td>
<td>45.71</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Error Count Estimates for Group

Rate .3429 .4286 .2571
Prior .50 .50 .2571
interrelationships among the cognitive variables and the reading variables (see Table 8). The short-term memory variables did not correlate with any of the reading variables. Only two of the reading accuracy measures are correlated with working memory, and both involve a visual facet. Backward visual memory is positively correlated with mispronunciation and negatively correlated with substitution. All of the working memory measures are correlated with reading grade level and PPVT-R. Word recognition level and the WRAT are correlated with backward digit span and the PASAT, but not backward visual memory. The working memory task that includes an element of speed (PASAT) is correlated with the fluency measure of words per minute.

Phoneme tapping, identified as measuring a different component than the other phonological awareness measures, is not correlated with any of the reading variables, and does not seem to contribute much in the understanding of reading ability. The accuracy measures of substitution and total number of miscues have significant negative correlations with the phonological awareness measures of word attack and phoneme deletion. Initial similarity is negatively correlated with word attack. Reading grade level and word recognition level are significantly correlated with all of phonological awareness measures except for tapping. Word attack is the only phonological variable correlated with reading fluency. PPVT-R and WRAT are significantly correlated with phoneme deletion and word attack.
PPVT-R is correlated with strip final consonant whereas WRAT is correlated with strip initial consonant.

Table 8

**Correlation Analysis of Cognitive and Reading Variables**

**Working Memory and Reading Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mp</th>
<th>Sb</th>
<th>RgL</th>
<th>Wpm</th>
<th>PP</th>
<th>WR</th>
<th>WrL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDS</td>
<td>.11</td>
<td>-.23</td>
<td>.42*</td>
<td>.26</td>
<td>.38*</td>
<td>.42*</td>
<td>.42*</td>
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<tr>
<td>BVMS</td>
<td>.43*</td>
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<td>.41*</td>
<td>.04</td>
<td>.37*</td>
<td>.32</td>
<td>.34</td>
</tr>
<tr>
<td>PASAT</td>
<td>.15</td>
<td>-.29</td>
<td>.52*</td>
<td>.40*</td>
<td>.43*</td>
<td>.45*</td>
<td>.40*</td>
</tr>
</tbody>
</table>

**Phonological and Reading Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Init</th>
<th>Sb</th>
<th>Total</th>
<th>RgL</th>
<th>Wpm</th>
<th>PP</th>
<th>WR</th>
<th>WrL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pdel</td>
<td>-.28</td>
<td>-.53*</td>
<td>-.37*</td>
<td>.57*</td>
<td>.35</td>
<td>.55*</td>
<td>.70*</td>
<td>.60*</td>
</tr>
<tr>
<td>StFi</td>
<td>-.33</td>
<td>-.32</td>
<td>-.27</td>
<td>.46*</td>
<td>.18</td>
<td>.42*</td>
<td>.51*</td>
<td>.55*</td>
</tr>
<tr>
<td>StIn</td>
<td>-.26</td>
<td>-.25</td>
<td>-.24</td>
<td>.36*</td>
<td>.19</td>
<td>.31</td>
<td>.45*</td>
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<td>WA</td>
<td>-.45*</td>
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<td>.67*</td>
<td>.57*</td>
<td>.53*</td>
<td>.85*</td>
<td>.77*</td>
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</tbody>
</table>

**Syntactic and Reading Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sb</th>
<th>RgL</th>
<th>PP</th>
<th>WR</th>
<th>WrL</th>
<th>Imp</th>
</tr>
</thead>
<tbody>
<tr>
<td>ErrCorr</td>
<td>-.38*</td>
<td>.51*</td>
<td>.65*</td>
<td>.56*</td>
<td>.49*</td>
<td>.23</td>
</tr>
<tr>
<td>Oral-Cloze</td>
<td>-.42*</td>
<td>.54*</td>
<td>.50*</td>
<td>.54*</td>
<td>.52*</td>
<td>.38*</td>
</tr>
<tr>
<td>Sen Rep</td>
<td>-.26</td>
<td>.46*</td>
<td>.41*</td>
<td>.36</td>
<td>.34</td>
<td>.28</td>
</tr>
</tbody>
</table>

**Note.** BDS = backward digit span; BVMS = backward visual memory span; PASAT = Paced Auditory Serial Addition; Mp = mispronunciation; Sb = substitution; RgL = reading grade level; Wpm = words per minute; PP = Peabody Picture Vocabulary Test-Revised; WR = Wide Range Achievement Test; WrL = word recognition level; Pdel = phoneme deletion; StFi = strip final consonant; StIn = strip initial consonant; WA = word attack; Init = initial similarity; Total = total miscues; ErrCorr = sentence error correction; Sen Rep = sentence repetition; Imp = implicit comprehension; *p < .0001.

All of the syntactic awareness measures are correlated with reading grade level and with the PPVT-R. Sentence error correction and oral-cloze...
are negatively correlated with the accuracy measure of substitution. Sentence error correction and oral-cloze are significantly correlated with WRAT, sentence error correction is correlated with word recognition level, and oral-cloze is significantly correlated with implicit comprehension.

A regression analysis was used to investigate the relative power of the cognitive tasks in predicting word recognition, reading accuracy, fluency, comprehension, and overall reading ability as measured by reading grade level. A stepwise regression analysis was performed to ascertain the subset of cognitive variables that were the best predictors of reading, with a significance level of .15 to enter and remove. Each of the reading variables was regressed on the subset of cognitive variables previously identified in the stepwise analysis (see Table 9). Although all of the models discussed are statistically significant, due to r-squared being low in some of the fitted models, other interpretations might explain the relations equally as well as the ones presented.

Of the nine reading accuracy measures, the cognitive variables had a significant effect on seven (p < .001). The cognitive domain most predictive of reading accuracy was phonological awareness, in particular, word attack ability. Word attack has negative coefficients for total miscues, initial similarity, substitution, and mispronunciation; positive coefficients for omission and insertion; and is the sole predictor for all of these variables except for mispronunciation. This seems to indicate that
reading accuracy is dependent upon readily available word attack skills. It appears that the less ability one has to decode words the more dependent one is upon initial sounds in word identification, resulting in an increase in substitution errors and total number of miscues.

The cognitive variables had a significant effect on overall reading ability reading \( (p < .001) \). The cognitive variables most predictive of reading grade level are word attack, PASAT, and oral-cloze. These results suggest that the cognitive domains of phonological awareness, syntactic awareness, and working memory are all involved in the reading process.

The cognitive variables had a significant effect on both of the fluency measures \( (p < .01) \). The only cognitive variable predictive of both reading fluency measures is the PASAT working memory variable. It appears that speed and efficient use of working memory capacity are necessary components of reading fluency. In the words per minute model, the coefficient of backward visual memory is negative, possibly indicating that the more one's visual memory is active the less fluent the reader. Word attack ability appears to play a role in reading fluency but not in automatic word recognition. Short-term memory and working memory seem to be active in automatic word recognition, and apparently the less dependent one is on using initial sounds to decode a word, the more automatic their word recognition.
### Table 9

**Regression Analysis**

**Reading Accuracy on Cognitive Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total Miscues</th>
<th>Total Similarity</th>
<th>Total Substitution</th>
<th>Total Mispronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>20.878(.01)</td>
<td>65.850(.01)</td>
<td>89.034(.01)</td>
<td>-38.586(.01)</td>
</tr>
<tr>
<td>Word Attack</td>
<td>-0.190(.01)</td>
<td>-0.430(.01)</td>
<td>-0.411(.01)</td>
<td>-0.352(.01)</td>
</tr>
<tr>
<td>Oral-Cloze</td>
<td>0</td>
<td>0</td>
<td>2.513(.01)</td>
<td></td>
</tr>
<tr>
<td>Phoneme Del</td>
<td>0</td>
<td>0</td>
<td>1.645(.01)</td>
<td></td>
</tr>
<tr>
<td>Prob&gt;F</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.191</td>
<td>0.197</td>
<td>0.356</td>
<td>0.288</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Omission</th>
<th>Insertion</th>
<th>Self-Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>9.250(.01)</td>
<td>5.756(.01)</td>
<td>0.481</td>
</tr>
<tr>
<td>Word Attack</td>
<td>0.213(.01)</td>
<td>0.212(.01)</td>
<td>0</td>
</tr>
<tr>
<td>Strip Initial</td>
<td>0</td>
<td>0</td>
<td>3.164(.01)</td>
</tr>
<tr>
<td>Prob&gt;F</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.087</td>
<td>0.149</td>
<td>0.102</td>
</tr>
</tbody>
</table>

**Reading Grade Level and Fluency on Cognitive Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>WPM</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-2.088(.01)</td>
<td>88.830(.01)</td>
<td>11.759(.01)</td>
</tr>
<tr>
<td>Word Attack</td>
<td>0.027(.01)</td>
<td>0.669(.01)</td>
<td>0</td>
</tr>
<tr>
<td>Oral-Cloze</td>
<td>0.262(.01)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PASAT</td>
<td>0.043(.01)</td>
<td>0.643(.03)</td>
<td>0.075(.05)</td>
</tr>
<tr>
<td>BVMS</td>
<td>0</td>
<td>-4.681(.01)</td>
<td>0</td>
</tr>
<tr>
<td>FDS</td>
<td>0</td>
<td>0</td>
<td>0.499(.02)</td>
</tr>
<tr>
<td>Strip Initial</td>
<td>0</td>
<td>0</td>
<td>-0.415(.02)</td>
</tr>
<tr>
<td>Prob&gt;F</td>
<td>0.001</td>
<td>0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.563</td>
<td>0.408</td>
<td>0.121</td>
</tr>
</tbody>
</table>

*(table cont’d.)*
Word Recognition on Cognitive Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>PPVT-R</th>
<th>WRAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.816(.32)</td>
<td>40.444(.01)</td>
<td>67.990(.01)</td>
</tr>
<tr>
<td>Word Attack</td>
<td>0.046(.01)</td>
<td>0</td>
<td>0.395(.01)</td>
</tr>
<tr>
<td>Strip Final</td>
<td>0.131(.01)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oral Cloze</td>
<td>0.188(.02)</td>
<td>0</td>
<td>1.495(.01)</td>
</tr>
<tr>
<td>Error Cor.</td>
<td>0</td>
<td>3.236(.01)</td>
<td>0</td>
</tr>
<tr>
<td>PASAT</td>
<td>0</td>
<td>0.601(.01)</td>
<td>0</td>
</tr>
<tr>
<td>FDS</td>
<td>0</td>
<td>-2.440(.01)</td>
<td>0</td>
</tr>
<tr>
<td>BVMS</td>
<td>0</td>
<td>0</td>
<td>-1.110(.01)</td>
</tr>
<tr>
<td>FVMS</td>
<td>0</td>
<td>0</td>
<td>1.107(.03)</td>
</tr>
<tr>
<td>Prob&gt;F</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.654</td>
<td>0.538</td>
<td>0.774</td>
</tr>
</tbody>
</table>

Comprehension Measures on Cognitive Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall</th>
<th>Implicit</th>
<th>Events</th>
<th>Results</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>63.72(.01)</td>
<td>-10.18(.54)</td>
<td>50.94(.01)</td>
<td>27.68(.23)</td>
<td>10.16(.46)</td>
</tr>
<tr>
<td>Oral-Cloze</td>
<td>1.37(.02)</td>
<td>5.10(.01)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strip Init.</td>
<td>-1.08(.04)</td>
<td>0</td>
<td>-2.13(.02)</td>
<td>-5.34(.01)</td>
<td>0</td>
</tr>
<tr>
<td>FVMS</td>
<td>1.50(.05)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.71(.03)</td>
</tr>
<tr>
<td>PASAT</td>
<td>0</td>
<td>0.69(.02)</td>
<td>0</td>
<td>0</td>
<td>4.20(.01)</td>
</tr>
<tr>
<td>Sen. Rep.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4.20(.01)</td>
</tr>
<tr>
<td>Strip Final</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-1.84(.01)</td>
</tr>
<tr>
<td>Number/let</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.51(.03)</td>
</tr>
<tr>
<td>Prob&gt;F</td>
<td>0.008</td>
<td>0.001</td>
<td>0.019</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.109</td>
<td>0.188</td>
<td>0.052</td>
<td>0.133</td>
<td>0.131</td>
</tr>
</tbody>
</table>

Note. Values = parameter estimates (p-values); Level = reading grade level; FDS = forward digit span; BVMS = backward visual memory; FVMS = forward visual memory span; Sen. Rep. = sentence repetition; 0 = nonsignificant predictor variable.

Of the four word recognition measures, the cognitive variables had a significant effect on PPVT-R, WRAT, and word recognition grade level (p < .001). It is interesting that the phonological awareness tasks most
predictive of word recognition level are word attack and strip final consonant. This suggests that the ability to manipulate final sounds in words is important in developing sight vocabulary. The cognitive domains of phonological awareness and syntactic awareness contributed to expressive vocabulary. Visual memory contributed to performance on the WRAT. It seems the more one was utilizing the visual component of working memory the lower the WRAT score, whereas, the use of short-term visual memory appears to facilitate performance on the WRAT. In receptive vocabulary, the cognitive domains of short-term memory, working memory and syntactic awareness appear to be facilitative.

The cognitive variables had a significant effect on five of the eight comprehension variables (values ranging between $p < .019$ to $p < .001$). These were measures of direct questioning and oral retelling of the passage. The cognitive domain of syntactic awareness is included in both of these approaches to comprehension. It also appears that the more involvement there is with the initial sounds of words, the less comprehension is available. The ability to efficiently utilize working memory capacity and knowledge of syntactic awareness seem important in developing implicit reading comprehension.

In summary, reading grade level is significantly correlated with all of the working memory, phonological awareness, and syntactic awareness variables, except phoneme tapping. The word recognition measures of
PPVT-R, WRAT, and word recognition level have significant correlations with working memory, phonological awareness, and syntactic awareness. The accuracy measure of substitution is consistently negatively correlated with working memory, phonological awareness, and syntactic awareness, in particular, backward visual memory, phoneme deletion, word attack, sentence error correction, and oral-cloze. The cognitive variables appear to be efficient predictors of reading performance. Although word attack did not contribute to any of the comprehension models, it contributed to 10 of the 18 models presented. The models with the strongest relations were word recognition level and WRAT, with phonological awareness and syntactic awareness significantly contributing to word recognition level. Working memory, phonological awareness, and syntactic awareness are not only significantly correlated with reading grade level, but are significant predictors of reading grade level.

Then, the effectiveness of reading performance, measured by an informal reading inventory, in discriminating among the normally achieving group, the project read group, and the below average group was examined. A correlation analysis was performed to examine the interrelationships among the reading variables. Correlation analysis of the reading variables (see Table 10) shows that initial similarity is negatively correlated with insertion and omission, but positively correlated with mispronunciation. It is also negatively correlated with word recognition as
measured by the WRAT and word recognition level. Substitution is negatively correlated with insertion, mispronunciation, omission, reading grade level, word recognition level, the WRAT, and the PPVT-R. Semantic acceptability is negatively correlated with self-correction. Total number of miscues is negatively correlated with reading words per minute, word recognition level, and the WRAT. Reading fluency as measured in words per minute was significantly correlated with the WRAT. Implicit comprehension has a higher correlation with overall comprehension than does explicit comprehension. Implicit comprehension is also correlated with reading grade level and with expressive word recognition.

The QRI-II measures of reading grade level and word recognition level were significantly correlated with the standardized measures of the WRAT and the PPVT-R. It is interesting to note that the variables correlating with the standardized measures contained the highest correlations. The reading subtest of Wide Range Achievement Test (WRAT) had the highest correlation with the most number of variables: QRI-II word recognition level (.87), word attack subtest (.85), QRI-II reading grade level (.73), reading words per minute (.65), and the phoneme deletion task (.70). Next, is the word attack subtest of the Woodcock Johnson Reading Mastery Test (WJRMT): QRI-II word recognition level (.77), phoneme deletion (.73), and QRI-II reading grade level (.67). Last, the Peabody Picture Vocabulary Test-Revised (PPVT-R)
was highly correlated with: sentence error-correction task (.65), and the
QRI-II reading grade level (.64). The reading measures produced more and

Table 10

**Correlation Analysis of Reading Variables**

<table>
<thead>
<tr>
<th>Accuracy Variables</th>
<th>In</th>
<th>Ins</th>
<th>Mp</th>
<th>Om</th>
<th>SC</th>
<th>SA</th>
<th>Sb</th>
<th>Tot</th>
<th>RgL</th>
<th>PP</th>
<th>WR</th>
<th>WrL</th>
<th>Wm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fluency and Word Knowledge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Wm</td>
<td>PPVT</td>
<td>WRAT</td>
<td>WrL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RgL</td>
<td>.47*</td>
<td>.64*</td>
<td>.73*</td>
<td>.75*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wm</td>
<td>.25</td>
<td>.65*</td>
<td>.65*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>PPVT</td>
<td></td>
<td>.61*</td>
<td></td>
<td>.47*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.87*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** In = initial similarity; Ins = insertion; Mp = mispronunciation; Om = omission; SC = self-correction; SA = semantic acceptability; Sb = substitution; Tot = total miscues; RgL = reading grade level; PP = Peabody Picture Vocabulary Test-Revised; WR = Wide Range Achievement Test; WrL = word recognition level; Wm = words per minute; Comp = overall comprehension; Exp = explicit comprehension; Imp = implicit comprehension; *p < .0001.
higher intercorrelations than the cognitive measures. The fact that the QRI-II reading grade level was so highly correlated with the WRAT, WJRMIT, and the PPVT-R lends support to the validity and reliability of the instrument.

Analysis of variance of the reading measures (see Table 11) shows that the normally achieving group differed significantly from the two groups of unskilled readers on five of the nine accuracy variables. The normally achieving readers made significantly less total miscues, less substitutions, and were significantly less dependent upon utilizing the initial consonant to decode a word than both groups of unskilled readers. However, the normally achieving group made significantly more omissions and insertions than the other two groups of readers. The types of miscues one makes while reading is reflective of one’s reading ability, and the reading strategies being used (Cheek, Flippo, & Lindsey, 1989).

The normally achieving group differed significantly from the two groups of unskilled readers on reading rate as measured in words per minute. In automatic word recognition, however, the normally achieving group significantly differed from the project read group but not the below average group. As expected, the normally achieving group differed significantly from both groups of unskilled readers on reading grade level.

Significant differences were found between the normally achieving group and the unskilled readers on three of the word recognition measures.
Table 11

**Analysis of Variance of Individual Reading Measures**

### Accuracy Measures

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>Fi</th>
<th>In</th>
<th>Ins</th>
<th>Mp</th>
<th>Om</th>
<th>SC</th>
<th>SA</th>
<th>Sb</th>
<th>Tot</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA-PR</td>
<td>NS</td>
<td>*+</td>
<td>*+</td>
<td>NS</td>
<td>*+</td>
<td>NS</td>
<td>NS</td>
<td>*+</td>
<td>NS</td>
</tr>
<tr>
<td>NA-BA</td>
<td>NS</td>
<td>*+</td>
<td>*+</td>
<td>NS</td>
<td>*+</td>
<td>NS</td>
<td>NS</td>
<td>*+</td>
<td>NS</td>
</tr>
<tr>
<td>BA-PR</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Prob>F .853 .001 .001 .763 .003 .062 .112 .001 .008

### Fluency and Reading Level Measures

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>Wpm</th>
<th>WrA</th>
<th>RgL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA-PR</td>
<td>*+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>NA-BA</td>
<td>*+</td>
<td>NS+</td>
<td>*+</td>
</tr>
<tr>
<td>BA-PR</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
</tr>
</tbody>
</table>

Prob>F .001 .055 .001

### Word Recognition Measures

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>WrL</th>
<th>WrT</th>
<th>PPVT</th>
<th>WRAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA-PR</td>
<td>*+</td>
<td>NS+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>NA-BA</td>
<td>*+</td>
<td>NS+</td>
<td>*+</td>
<td>*+</td>
</tr>
<tr>
<td>BA-PR</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
</tr>
</tbody>
</table>

Prob>F .001 .170 .001 .001

### Comprehension Measures

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>PK</th>
<th>Ev</th>
<th>Goal</th>
<th>Rslt</th>
<th>Set</th>
<th>Expl</th>
<th>Impl</th>
<th>Comp</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA-PR</td>
<td>NS</td>
<td>NS</td>
<td>NS-</td>
<td>NS-</td>
<td>NS+</td>
<td>NS+</td>
<td>*+</td>
<td>*+</td>
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<tr>
<td>NA-BA</td>
<td>NS</td>
<td>NS</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
<td>NS-</td>
<td>NS+</td>
<td>NS+</td>
</tr>
<tr>
<td>BA-PR</td>
<td>NS</td>
<td>NS</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
<td>NS+</td>
</tr>
</tbody>
</table>

Prob>F .705 .461 .713 .448 .062 .929 .001 .015

**Note.** Fi = final similarity; In = initial similarity; Ins = insertion; Mp = mispronunciation; Om = omission; SC = self-correction; SA = semantic acceptability; Sb = substitution; Tot = total word recognition; Wpm = words per minute; WrA = automatic word recognition; RgL = reading grade level; WrL = word recognition level; WrT = word recognition total; PK = prior knowledge; Ev = events; Rslt = result; Set = setting; Expl = explicit comprehension; Impl = implicit comprehension; Comp = overall comprehension; NA = normally achieving; BA = below average; PR = project read. +/- = direction of difference; NS = non significant; *p < .05.
A possible reason for no differences among groups on total word recognition is because the score contained a ceiling. The score was derived from the instructional word recognition level, and to meet the criteria for instructional level the number of words recognized had to be within a certain range. A cumulative score inclusive of all the words recognized across grade levels might have been a better measure.

The normally achieving group significantly differed from the project read group but not the below average group on implicit comprehension and overall comprehension ability. Oral retellings and prior knowledge, as measured in this study, did not appear to lend much information to the understanding of reading comprehension, with only the knowledge of setting variable approaching significance.

To further explore any differences that might exist between the two groups of unskilled readers, a second series of univariate one-way ANOVAs was conducted on the individual reading variables. The below average group performed significantly better than the project read group on the reading variables of setting \( (F(1,68) = 5.32, p < .02) \) and overall comprehension \( (F(1, 68) = 5.27, p < .02) \). This demonstrates that the below average group answered a higher percentage of both the setting/background questions and comprehension questions than the project read group suggesting better comprehension ability for the below average group.
In summary, the accuracy miscue of substitution is negatively correlated with variables that appear to facilitate reading ability. Reading grade level, word recognition level, PPVT-R, and WRAT are all negatively correlated with substitution. The reading accuracy measures of insertion and omission and mispronunciation are also negatively correlated with substitution.

Implicit comprehension is correlated with reading grade level, word recognition level and WRAT. The QRI-II reading grade level and word recognition level are highly correlated with the standardized measures of PPVT-R and WRAT. Reading fluency, measured by the QRI-II, is also highly correlated with the WRAT. The normally achieving group performed significantly better than both groups of unskilled readers on the majority of the reading measures. The normally achieving group significantly outperformed the project read group on automatic word recognition and overall comprehension. The below average group performed significantly better than the project read group on two comprehension measures.

Finally, the effectiveness of using a combination of cognitive and reading measures in discriminating among the normally achieving group, the below average group, and the project read group was examined. A stepwise discriminant analysis was performed on all 38 variables, to discern if a combination of both cognitive and reading measures might further reveal information of measures which best discriminate among the
three groups of readers. A significance level of .2 was used to enter and to remove. The following subset of variables was identified as being best able to discriminate among the three groups of readers: word attack, reading grade level, initial similarity, setting, semantic acceptability, sentence repetition, words per minute, backward visual memory span, forward visual memory span, PPVT-R, and forward digit span.

A cross-validation analysis based on the subset of variables identified in the stepwise analysis was performed to determine the linear discriminant function that would best classify individuals into the different groups of readers. The linear discriminant function based on word attack, reading grade level, initial similarity, setting, semantic acceptability, sentence repetition, words per minute, backward visual memory span, forward visual memory span, PPVT, and forward digit span variables correctly classified 94% of the original normally achieving group, 66% of the original the below average group, and 57% of the original project read group (see Table 12).

A canonical discriminant analysis was computed from the subset of variables identified in the stepwise discriminant analysis to describe two linear scores that best discriminate among the three groups. As can be seen in Figure 1, the plot of CAN1 vs. CAN2, CAN1 distinguishes the normally achieving group from the below average and project read groups, while CAN2 further distinguishes between the below average and project
read groups. The class means of the first canonical structure are: normally achieving (2.39856), below average (-1.14458), and project read.

Table 12

Discriminant Analysis of All Variables

<table>
<thead>
<tr>
<th>Group</th>
<th>Achieving</th>
<th>Below Avg</th>
<th>Project Read</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieving</td>
<td>33</td>
<td>2</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>94.29</td>
<td>5.71</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Below Avg</td>
<td>2</td>
<td>23</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>5.71</td>
<td>65.71</td>
<td>28.57</td>
<td>100</td>
</tr>
<tr>
<td>Project Read</td>
<td>1</td>
<td>14</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>2.86</td>
<td>40.00</td>
<td>57.14</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>40</td>
<td>29</td>
<td>105</td>
</tr>
<tr>
<td>Percent</td>
<td>34.29</td>
<td>38.10</td>
<td>27.62</td>
<td>100</td>
</tr>
</tbody>
</table>

Error Count Estimates for Group

Rate .0286 .2286 .3714 .2095
Priors .3333 .3333 .3333

(-1.25397). The variables that have the largest coefficients and contribute most to the first canonical structure are reading grade level (.70229) and words per minute (.61315). The class means for the second canonical structure are: normally achieving (-0.01961), below average (0.65469), and project read (-0.63508). The variables that have the largest coefficients and contribute most to the second canonical structure are reading grade level (.81355) and setting (.71812). Again, the below
Plot by Group of Canonical Discriminant Analysis

Note. 1 = normally achieving; 2 = below average; 3 = project read
average group appears to have slightly better skills than the project read group.

A canonical correlation analysis was performed to analyze the relationship between the cognitive variables (word attack, sentence repetition, forward visual memory span, and forward digit span) and the reading variables (reading grade level, setting, semantic acceptability, words per minute, PPVT-R) identified in the stepwise discriminant analysis. The results yielded a canonical variable (V1) for the cognitive variables and a canonical variable (W1) for the reading variables that have the maximum possible correlation between the two sets of variables (F = 6.86, p < .0001). The cognitive variables that most highly correlated with the cognitive V1 canonical variable were word attack (.95) and sentence repetition (.63). The reading variables that most highly correlated with the reading W1 canonical variable were reading grade level (.90), PPVT-R (.75), and words per minute (.71). Word attack (.76) was the cognitive variable most highly correlated with the reading canonical variable and reading grade level (.72) was the reading variable that was most highly correlated with the cognitive canonical variable. Phonological awareness and syntactic awareness appear consistent in their ability to discriminate skilled from unskilled readers. In particular, word attack ability seems to stand out as being a steady contributor to reading ability.
To further investigate differences between the two lower functioning groups of readers, a stepwise discriminant analysis was conducted on all 38 variables with a significance level of .3 to enter and a significance level of .3 to remove. The following subset of variables was identified as discriminating most between the two groups of readers: number/letter memory, backward visual memory span, phoneme deletion, strip final consonant, word attack, overall comprehension, explicit comprehension, semantic acceptability, words per minute, events, setting, PPVT-R, WRAT, automatic word recognition, and total word recognition.

A cross-validation analysis based on the subset of variables identified in this second stepwise analysis was performed to determine the linear discriminant function that would best classify individuals into the project read group. The linear discriminant function of the variables number/letter memory, backward visual memory span, phoneme deletion, strip final consonant, word attack, overall comprehension, explicit comprehension, semantic acceptability, words per minute, events, setting, PPVT-R, WRAT, automatic word recognition, and total word recognition yielded a 74% correct classification into the project read group and a 74% correct classification into the below average group (see Table 13).

A canonical correlation analysis was performed to analyze the relationship between the cognitive variables and the reading variables identified in the second stepwise analysis. The results yielded a canonical
variable (V1) for the cognitive variables and a canonical variable (W1) for the reading variables that have the maximum possible correlation.

Table 13

**Discriminant Analysis of All Variables: Unskilled Readers**

<table>
<thead>
<tr>
<th>Group</th>
<th>Below Average</th>
<th>Project Read</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below Average</td>
<td>26</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>74.29</td>
<td>25.71</td>
<td>100</td>
</tr>
<tr>
<td>Project Read</td>
<td>9</td>
<td>26</td>
<td>35</td>
</tr>
<tr>
<td>Percent</td>
<td>25.71</td>
<td>74.29</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>35</td>
<td>70</td>
</tr>
<tr>
<td>Percent</td>
<td>50.00</td>
<td>50.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**Error Count Estimates for Group**

- Rate: .2571, .2571, .2571
- Priors: .5000, .5000

(F = 2.54, p < .0001). The cognitive variables most highly correlated with the V1 cognitive variable are phoneme deletion (.71) and word attack (.83). The reading variable most highly correlated with the W1 reading variables was the WRAT variable. The cognitive variables most highly correlated with the W1 reading canonical variable were: word attack (.64), phoneme deletion (.55), and strip final consonant (.44). The only reading variable that was correlated with the cognitive canonical variable V1 was the WRAT (.65). Phonological awareness seems to
make the most important contribution in discriminating between the below average group and the project read group.

In summary, a combination of cognitive and reading variables appears to be more effective in discriminating among groups of readers. Similar to using cognitive variables alone, the combination of cognitive and reading variables is better in discriminating skilled from unskilled readers. However, combining reading variables along with cognitive variables increases the percentage of correct classification between the two groups of unskilled readers. The below average group appears to have better comprehension than the project read group. This lends some, albeit weak, support to the identification of these readers as separate from the below average group.
Discussion

The purpose of the present investigation was fourfold. First, the ability of the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness to discriminate among an unidentified and identified group of unskilled readers as compared with a group of skilled readers was examined. Next, the effectiveness of the cognitive domains short-term memory, working memory, phonological awareness, and syntactic awareness predicting reading performance in the areas of word recognition, accuracy, fluency, and comprehension as measured by an informal reading inventory was investigated. Then, the effectiveness of the above areas of reading in discriminating among an unidentified and identified group of unskilled readers as compared with a group of skilled readers was examined. Finally, the effectiveness of combining cognitive and reading variables in discriminating among an unidentified and identified group of unskilled readers as compared to a group of skilled readers was investigated.

First, the ability of the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness to discriminate among an unidentified and identified group of unskilled readers as compared with a group of skilled readers was examined. Results suggest that the cognitive variables were better able to differentiate between skilled and unskilled readers rather than between
groups of unskilled readers. In general, the cognitive tasks chosen for use in this investigation appear appropriate to their particular domain. All of the working memory measures loaded on one component and all of the syntactic awareness measures loaded on one component. However, the short-term memory measures demonstrated an auditory/verbal and a visual memory component, and the phonological awareness measures demonstrated a verbal and a motor component.

All of the working memory, phonological awareness, and syntactic awareness variables were significantly intercorrelated, except for phoneme tapping. The phoneme tapping task was the only phonological awareness task that did not significantly differentiate among groups of readers or correlate with any of the other cognitive variables. Leather and Henry (1994) also found intercorrelations between working memory and phonological awareness tasks, but no intercorrelations with phoneme tapping. The short-term memory tasks did not show the same intercorrelations as the other cognitive tasks, supporting Daneman and Carpenter's (1980) conclusion that short-term memory tasks do not correlate highly with working memory or reading tasks because they take into account storage rather than processing functions.

The individual cognitive variables working memory, phonological awareness (except phoneme tapping), and syntactic awareness were able to significantly discriminate among the normally achieving group of
readers and the two groups of unskilled readers. The short-term memory variables were able to significantly discriminate between the normally achieving group and the below average group, but not between the normally achieving and the project read group. This is consistent with Cermak, Goldberg, Cermack, Drake (1980) who concluded that there are no “pure” short-term memory deficits. Rather, it is a processing deficit (Chi, 1976; Torgesen & Houck, 1980), in particular, processing speed (Chi, 1976; Payne & Holzman, 1983) that best differentiates among groups of skilled and unskilled readers.

A discriminant analysis revealed a small subset of cognitive variables (word attack and oral-cloze) that correctly classified 88% of the original normally achieving readers. Results suggest that phonological awareness and syntactic awareness are the cognitive areas that best discriminate skilled from unskilled readers (Siegel & Ryan, 1988). Although the individual cognitive variables did not significantly discriminate between the below average and project read groups, cross-validation of a subset of cognitive variables (backward visual memory, phoneme deletion, strip final consonant, and number/letter memory) correctly classified 66% of the original below average readers. The cognitive variables seem more effective in their ability to discriminate skilled from unskilled readers. It appears that the cognitive domains of short-term memory, working memory, and phonological awareness best discriminate between the two
groups of unskilled readers. The ability to manipulate phonemes throughout words and maintain this information for processing are abilities which appear to be more developed in the below average group. This deficiency in the project read group’s ability suggests that their phonological ability is similar to that of beginning readers (Liberman, et al., 1977).

Syntactic awareness was a discriminator between skilled and unskilled readers but not between the groups of unskilled readers. The normally achieving group appears to have an awareness of language not yet developed in either the project read group or the below average group of readers supporting the supposition that unskilled readers lag behind in their knowledge of syntactic awareness (Siegel & Ryan, 1988).

Next, the effectiveness of the cognitive domains of short-term memory, working memory, phonological awareness, and syntactic awareness in predicting reading performance in the areas of accuracy, fluency, word recognition, and comprehension as measured by an informal reading inventory was examined. Results suggest that cognitive variables are effective predictors of reading performance. Working memory, phonological awareness, and syntactic awareness were all significantly correlated with reading grade level and word recognition level, and were all significantly negatively correlated with the accuracy measure of substitution. This suggests that readers who make high numbers of
substitution miscues are deficit in their ability to make sound symbol associations, and this paucity in an accurate set of phonemes or sounds to blend places heavier demands on working memory resources (Baddeley, 1982; Jorm, 1983; Torgesen et al., 1987). The PASAT was significantly correlated with phoneme deletion, word attack, words per minute, reading grade level, and word recognition level suggesting that these variables all share an element of processing speed, again supporting speed of processing as a factor important to reading ability. The most efficient predictor of reading accuracy was phonological awareness (Bradley & Bryant, 1983; Leather & Henry, 1994). Specifically, it was the word attack task that was the best predictor of reading performance. It appears that the better word attack skills an individual has the less dependent one is on initial sounds in decoding the word, resulting in less substitutions and total number of miscues while reading.

Syntactic structure has been found to facilitate learning in skilled readers but not in unskilled readers (Slobin, 1971; Weinstein & Rabinovitch, 1971; Wiig & Roach, 1975), and unskilled readers are thought to lag behind in their knowledge of awareness to syntactic structure (Shankweiler & Crain, 1986; Siegel & Ryan, 1988), all of which is consistent with the present findings. Syntactic awareness tasks significantly discriminated between the normally achieving group and the two groups of unskilled readers. The oral-cloze and the PASAT were
predictors of implicit comprehension. Oral-cloze, strip initial consonant, and forward visual memory span were predictors of overall comprehension. Explicitly, the oral-cloze task appears to be the syntactic measure that is most effective in predicting reading comprehension. The oral-cloze task is based upon the ability to predict the class of word (noun, adjective, verb, etc.). Thus, it appears that syntactic awareness of word class facilitates comprehension in reading. Syntactic awareness facilitates learning (Slobin, 1971; Weinstein, & Rabinovitch, 1971; Wiig & Roach, 1975), is predictive of comprehension, and discriminates between skilled and unskilled readers (Shankweiler & Crain, 1986). The project read and below average groups appear to be deficient in their awareness of syntactic structure.

Word attack and PASAT were predictors of reading words per minute along with backward visual memory span. Word attack and oral-cloze were predictors of word recognition level and reading grade level. Since, the PASAT was a predictor in reading grade level, word recognition level, words per minute, automatic word recognition, and implicit comprehension these findings would suggest that fast and efficient processing is necessary to becoming a skilled reader.

Then, the effectiveness of reading word recognition, accuracy, fluency, and comprehension in discriminating among an unidentified and identified group of unskilled readers as compared with a group of skilled readers was examined. The reading measures of word recognition,
accuracy, fluency, and comprehension were able to significantly
differentiate among the readers. The word recognition measures of word
recognition level, WRAT and PPVT-R significantly discriminated among the
normally achieving and the project read and below average groups of
readers as would be expected. Initial similarity, insertion, omission, and
substitution, and total number of miscues significantly discriminated
between the skilled and unskilled readers. Similarly, Wixson (1979) found
novice readers to make more substitutions, and proficient readers to make
more omissions. Initial similarity, substitution, and total number of miscues
were negatively correlated with word attack, whereas mispronunciation,
insertion, and omission were positively correlated with word attack. Word
attack ability seems crucial to development of reading accuracy. It
appears that dependence upon the initial sounds of words in decoding
leads to a "glance and guess" (Gillet & Temple, 1994) approach to
decoding resulting in substitution miscues and a higher number of total
miscues. Since mispronunciation is positively correlated with word attack
ability, it is possible that this is a "transitional" type of miscue that is made
by a reader who has a more developed ability to manipulate phonemes
throughout words. It is possible that differences in word attack ability
create these variations in reading accuracy among readers, and thus, these
readers would require differing instructional approaches. Therefore,
analysis of the type of miscue students make can provide useful
information about their strengths and weaknesses and reading strategies (Cheek, Flippo, & Lindsey, 1989).

The comprehension measures of overall comprehension and implicit comprehension significantly discriminated between the normally achieving and the project read group, but not between the normally achieving and the below average groups. The comprehension variables, overall comprehension and oral retelling of setting, significantly differentiated between the below average group and the project read group. The areas of reading word recognition, accuracy, and fluency significantly discriminated between skilled and unskilled readers. Siegel and Ryan (1988) also found accuracy measures to differentiate between skilled and unskilled readers. Reading comprehension, however, appears more effective in discriminating between groups of unskilled readers than between skilled and unskilled readers. This finding is consistent with Stanovich and Siegel (1994) who suggest that differences between groups of unskilled readers will be found beyond the level of word recognition. These findings suggest a possible hierarchy of the groups: normally achieving, below average, and project read.

Finally, the effectiveness of a combination of cognitive and reading variables in discriminating among an unidentified and identified group of unskilled readers as compared to a group of skilled readers was examined. A subset of cognitive and reading variables (word attack, reading grade
level, initial similarity, setting, semantic acceptability, sentence repetition, words per minute, backward visual memory span, forward visual memory span, PPVT-R and forward digit span) was able to correctly classify 94% of the normally achieving readers. A subset of cognitive and reading variables (number-letter memory, backward visual memory span, phoneme deletion, strip final consonant, word attack, overall comprehension, explicit comprehension, semantic acceptability, words per minute, events, setting, PPVT-R, WRAT, automatic word recognition, and total word recognition) was able to correctly classify 74% of the students into the project read group and into the below average group. It appears that a combination of both cognitive and reading variables are better at discriminating between groups of readers than cognitive variables alone. The normally achieving group seems to have better defined abilities, thus making it easier to identify and classify these readers. The subset of variables used to classify the normally achieving group was almost equal in number of cognitive and reading variables. Correct classification of the project read group and the below average group took a larger number of variables, and twice as many reading as cognitive variables.

In summary, cognitive variables were most effective in discriminating between groups of skilled and unskilled readers. The cognitive domains of working memory, phonological awareness, and syntactic awareness seem to be effective predictors of reading performance. Cognitive measures
alone were not as effective in classifying groups of readers as was a combination of reading and cognitive variables.

The below average and project read groups demonstrated deficits in the areas of working memory, phonological awareness, and syntactic awareness. Specifically, it appears that for these groups of readers, deficiency in word attack skills creates deficits in their reading performance. However, the below average group appeared to demonstrate better comprehension than the project read group. The development of word attack skills is not in itself adequate for development of a reader, also necessary, it seems, is fast and efficient processing in the ability to decode words. Consistent with the present findings, lack of fluency is a characteristic of a poor reader (Allington, 1983), and slow articulation is linked to phonological impairment (Ackerman, Dykman, & Gardner, 1990). Present findings suggest that a deficit in processing speed in working memory can result in deficits in phonological awareness and fluency, and is consistent with Leong's (1989) conclusion that unskilled readers are deficient in their ability to develop rapid, automatic activation of word recognition.

In discriminating among the normally achieving group and the project read and below average groups of readers, there was always a syntactic awareness variable present. However, syntactic awareness was not a discriminator between the project read group and the below average
group. The below average and project read groups appear to be operating within the domain of phonological awareness, and have yet to approach efficient functioning within the domain of syntactic awareness.

Some limitations of the current investigation should be kept in mind when interpreting its results. Although adequate, the rather modest sample size of 35 students in each group. The students were drawn from intact preexisting groups and consequently there was no random assignment of students into groups. The students, although drawn from four different schools, were all from one school district and although the school districts are required to follow the guidelines in Bulletin 1903 in identifying students with dyslexic tendencies, there is no standard practice that is used throughout the district (Valus, 1986). Each school has flexibility in deciding how the students will be evaluated. Students identified at one school would not necessarily be identified at another. Although a discrepancy factor is one of the requirements in Bulletin 1903 guidelines, the majority of the project read students in this investigation did not meet that criteria. Thus, there is room for considerable doubt as to whether the below average and project read students are genuinely distinct populations. The most critical variable in the classification decision appeared to be low academic achievement level (Algozzine, 1985; Algozzine & Ysseldyke, 1983; Ysseldyke, Algozzine, Richey, & Graden, 1982).


**Instructional and Research Implications**

Based on the findings of this research, it appears that the cognitive domains phonological awareness and syntactic awareness best classified normally achieving readers. The cognitive domains short-term memory, working memory, and phonological awareness, although much less efficient, best classified the below average and project read groups. In particular, the tasks of word attack and oral-cloze best discriminated between skilled and unskilled readers. Word attack correlated with the reading domains of word recognition, accuracy, and fluency. Oral-cloze correlated with the reading domains of accuracy, word recognition, and comprehension. Word attack and/or oral-cloze were predictors of reading accuracy, fluency, word recognition, comprehension, and reading grade level. These same areas discriminated between the normally achieving and the unskilled readers, except for comprehension which was able to significantly discriminate between the below average and project read groups. Tasks drawn from all of the cognitive and reading domains best classified the normally achieving group. Tasks from all of the cognitive, except syntactic awareness, and reading domains best classified the below average and project read groups. Both groups of unskilled readers appear to be lacking in their knowledge of syntactic awareness.

These below average and project read readers could benefit from specific instruction in the areas of reading accuracy, fluency, word
recognition, and comprehension. They, in general, are reading below grade level, have a slow reading rate, a limited sight vocabulary, and, in particular, the project read group, inadequate comprehension ability. Readers whose primary oral reading accuracy miscue is substitution demonstrate deficient word attack skills, appear to have difficulty being able to phonemically manipulate the entire word, and tend to over rely on initial word sounds. Explicit phonics instruction in letter-sound correspondences, especially of medial and final word sounds, and blending sounds of letters in identifying isolated words, improves word calling ability; these analysis skills can transfer to the reading of unknown words (Johnson & Bauman, 1984). Students whose primary accuracy miscue is mispronunciation would benefit from instruction in metacognitive and self-monitoring strategies emphasizing reinspection of text and reading for meaning. Mispronunciation miscues are often nonwords. Reading for meaning would cue the student that the sentence did not make sense, and reinspection of the sentence would encourage reading for meaning and aid the reader in identifying the correct word.

Repeated reading, having a student reread a passage of about 100 words until it can be read in one minute, facilitates fluency, automatic decoding, and can improve comprehension (Samuels, Schermer, & Reinking, 1992). Echo reading in which the teacher reads a sentence or two aloud and the student immediately repeats it, is a support measure
which aids fluency (Gillet & Temple, 1994). The most important benefit of echo reading is that it allows the teacher to model fluent reading and the student to practice it. Also, allowing these students to read aloud books at their independent reading level to younger students gives practice in fluent reading and “saves face” for the older student reading books below grade level.

Rereading and repeated reading are strategies that also develop word recognition. Rereading of the stories increases self-confidence, permits individual words to be seen repeatedly in meaningful context, and allows students to recognize familiar words at sight. Incidental learning of new vocabulary is increased when rereading includes explanation and discussion of unfamiliar words (Elley, 1989). Instruction in completing cloze-procedures and word sorting can help readers develop word recognition, sensitivity to semantic and syntactic clues, and use of these clues while reading (Gillet & Temple, 1994). A cloze passage can be used in which a particular class of word is deleted. Students complete the passage, and then discuss their choices. Discussion of choices is important in using a cloze procedure because it demonstrates how different choices can lead to subtle changes in meaning. Using word banks and sorting for grammatical features can also help students learn the way words function in sentences. Closed sorts can be used in which the student is directed to sort words according to their particular class.
Discussion of choices should also follow word sorting. Once a student becomes proficient in closed sorting for grammatical features, open sorts can be used to test for generalization of learning these features.

All of the recommended strategies should take place within a setting in which these students are immersed in a rich oral and written language environment and where active engagement in oral discussions and conversations is encouraged. Directed listening-thinking activity (DLTA) and directed reading-thinking activity (DRTA) can be used to develop comprehension abilities (Gillet & Temple, 1994). Both of these activities encourage development in prediction, summarization, and evaluation abilities. Instruction in comprehension monitoring (Pearson, Roehler, Dole, & Duffy, 1992) can help foster comprehension ability. These readers should be taught to search for connections between what they know and new information encountered in texts; to monitor text meaning while reading taking steps to correct comprehension; to distinguish important from less important ideas; synthesize information; and ask questions of themselves and the author while reading.

Reading is a process of building meaning. What changes in this process is the student's level of expertise and the support the teacher needs to provide. Instructional strategies have been identified that research has shown to be effective. These strategies represent a start for teachers to use until their own emerging and dynamic understanding of the
students' instructional situation causes them to assess and adapt their instructional goals and strategies (Pearson, et. al, 1992).

There has been no solid data that discrepancy-defined unskilled readers respond differently to various educational treatments and controversy exists over the discrepancy-definition being used to predict reading performance (Fletcher et al., 1989; Siegel, 1989a; Stanovich, 1988, 1991; Stanovich & Siegel, 1994) and its use in identification of unskilled readers for services. Discriminant analysis provided a linear combination of variables that were effective in discriminating readers into groups. Further research into developing a reliable and valid instrument using both cognitive and reading tasks could more effectively identify readers and use of such an instrument would ensure that the same readers were being identified across states and districts. Also, awareness of the types of tasks that discriminate among groups of poor readers could be used to help drive instructional strategies for these students.

There is debate as to whether it is more demanding processes that take up available working memory capacity (Daneman & Carpenter, 1983) or whether unskilled readers have smaller working memories (Engle, Nations, & Cantor, 1990). Findings in the present study support Daneman and Carpenter (1983). Processing speed appeared to be an element shared by working memory, phonological, syntactic, and reading measures. Unskilled readers seem to be deficient in the speed in which
they can process information (Chi, 1976; Payne & Holzman, 1983).

Investigation into whether practice with automaticity and fluency tasks can increase processing speed in unskilled readers appears warranted, and if so does this increase in processing speed generalize to reading ability. Or, does the practice in automaticity and fluency have to be in the specific domain of reading to have an effect on reading ability.
References


Strip Initial Consonant Task

What is the beginning sound of kit? I am going to say some words to you. Listen carefully to the word as I say it. As you sound the word out, say the first sound of the word in your head and say the rest of the word out loud. For example, if I say the word "kit" what sound would you say in your head? Then you would say ____ out loud? ball

  told    old
  pink    ink
  plate   late
  man     an
  nice    ice
  train   rain
  slow    low
  win     in
  bus     us
  pitch   itch
  car     are
  fruit   root
Strip Final Consonant Task

What is the ending sound of "plant"? I am going to say some words to you. Listen carefully as I say the word, then say the word out loud leaving off the ending sound of the word. For example, if I say the word "plant", you would leave off the _ sound and say __. surf, nose.

<table>
<thead>
<tr>
<th>band</th>
<th>ban</th>
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<tbody>
<tr>
<td>throat</td>
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<td>been</td>
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<td>damp</td>
<td>dam</td>
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<tr>
<td>team</td>
<td>tea</td>
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</tbody>
</table>
Phoneme Deletion Task

I am going to say some words to you that are not real words. I will tell you a sound to take away from it to make it into a real word. I want you to say the word out loud taking away the sound to make it into a real word. For example, if you take the "f" sound from "penf" it makes the word _____. spipe

(b)ice ice s(p)low slow
toa(b) toe (s)trail trail
(b)arch arch (b)eei eei
tea(p) tea cloo(f) clue
(k)elm elm
bloo(t) blue
jar(l) jar
(g)lamp lamp
(b)rock rock
s(t)ip sip
hi(f)t hit
star(p) star
c(r)oal coal
(f)rip rip
hil(f) hill
cro(t)s crows
c(l)art cart
bir(l)d bird
Phoneme Tapping Task

I am going to say a word. I want you to "sound out" the word the way you would an unfamiliar word, and then tap out each sound you hear in the word. Tell me the number of sounds you hear in the word. Remember not to "spell" the word it is not the number of letters, it is the number of sounds in each word that you are to tell me. How many sounds do you hear in the word kite:

- Cat
- Chin
- Belt
- Trip
- So
- Drive
- Out
- Red
- My
- Heat
- Crash
- Up
- Bread
- To
- Pack
- He
- Hold
- Book
Error Correction

I am going to read you some sentences. Each sentence has something wrong with it. I want you to correct each sentence.

1. The puppy swam into its basket.
2. In the summer it snows.
3. At night everyone goes at sleep.
4. Jim was as quickly as a bunny.
5. Animal are kept in zoos.
6. It was very cold outside tomorrow.
7. The baby hold a spoon in her hand
8. Can you read them book?
9. They are cutting the grass when it got dark.
10. The lion and tiger lives in the jungle.
11. The king had a silver coins.
12. Mr. Jones signed his name from the bottom of the paper.
13. We goed to the playground at recess.
14. There are flowers flying in the garden.
15. Bill cried when he caught their finger in the door.
16. James have locked up his house.
17. The moon is very big and bright in the morning.
18. The police caught the baby climbing the wall.
19. Don picked up some stones and threwed them into the water.
20. The mailman should have take the letter today.
Oral-cloze Task

I am going to read you some sentences in which there is a word missing. You are to fill in the blank with a word that makes sense in the sentence.

1. The pretty little___________put on their dresses.
2. The_______________little pigs ate corn.
3. "_______________is at the door?" he asked.
4. John buys candy at the ______________.
5. They___________raking leaves when it got dark.
6. She baked chocolate______________.
7. The boy___________down and hurt his knees.
8. The mean little_____________scared little Red Riding Hood.
9. Jack___________his sister ran up the hill.
10. "_______________is wrong with you?" the doctor asked.
11. It____________very cold outside yesterday.
12. Because of the rain, the children___________inside the house.
13. The puppy jumped______________his basket.
14. It was a sunny day with a pretty______________sky.
Dear Parents:

My name is Mary Carter and I am a reading education doctoral candidate at Louisiana State University. For my dissertation, I have developed a research project to see if a particular set of tests can predict reading performance. The tests that I will administer give information on strengths and weaknesses in knowledge of syntax, phonetic knowledge, reading fluency, ability to sound out words, and reading comprehension. I am interested in testing children who read below grade level and children who read on or above grade level.

I am seeking fourth and fifth grade students to participate in my study. Students who participate will be individually administered a battery of tests. It will take approximately an hour and a half for me to administer the tests to your child. The individual child's scores will be known only to myself, the researcher. I am interested in group trends rather than individual scores. I am hoping to be able to identify trends within the different groups which would lead to suggestions of effective instructional strategies for these groups of children. However, individual test information can be shared with you and/or your child's teacher, if you would like.

I am drawing a population to participate in my study from several different schools in the Jefferson Parish School System, so not everyone who wishes to participate can be selected. To group students according to research criteria and determine eligibility for participation, I need to access standardized test scores in the cumulative record. I am asking your permission to include your child in this study. I will be available at your child's school on _______________ from ____________ to meet with you and answer any questions, you might have. Or, you can call me at ____________ during the above time.

Thanking you in advance for this opportunity.

Mary E. Carter, M.Ed.
Please fill in below and return to your child’s teacher tomorrow.

___________________________ has my permission to participate in the above mentioned research project, and Mary Carter has permission to view the cumulative record. I understand that I may withdraw my permission through written request at any time.

___________________________ (Parent’s Signature)

I do [] do not [] request assessment results.

I do [] do not [] give permission for assessment results to be shared with my son/daughter’s teacher.

[] I do not wish my child to participate at this time.

___________________________    __________________________
parent’s signature                  date

___________________________    __________________________
student’s signature                date

Approved: ______________________
Vita

Mary Elizabeth Carter was born in New Orleans, Louisiana, on October 22, 1952. Mary received her Bachelor of Arts degree in psychology from the University of New Orleans, New Orleans, Louisiana, in May, 1979. She received her Master of Education degree in counseling and guidance from Southeastern Louisiana State University, Hammond, Louisiana, in December, 1993. Mary has worked in a clinical psychology environment providing various counseling and psychometric duties. Her most recent position before beginning her doctoral training was that of Director of the Irlen Clinic where she assessed and provided instructional recommendations for individuals with reading problems. After earning her master’s degree, she immediately began her doctoral studies at Louisiana State University in curriculum and instruction, with an emphasis in reading education. During her doctoral training, she taught an undergraduate prescriptive and diagnostic course in reading, and worked as a part-time psychometrician in the neuropsychology department at Tulane Medical Center.
DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Mary Elizabeth Carter

Major Field: Curriculum and Instruction

Title of Dissertation: Cognitive Differences and their Predictive Ability on Reading Performance in Skilled and Unskilled Readers

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination: June 11, 1996