The Relation between Oral Reading

and

Silent Reading Comprehension Skill

by

Barbara T. Schmidt

A dissertation submitted to the Graduate Faculty in Speech and Hearing Sciences
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy, The City University of New York.

2003

UMI Number: 3083708

UMI

UMI Microform 3083708

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

This manuscript has been read and accepted for the Graduate Faculty in Speech and Hearing Sciences in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

April 20, 2003
Date

K Obler
Loraine K. Obler, Ph.D.
Chair of Examining Committee

4/30/03
Date

Robert Goldfarb, Ph.D.
Executive Officer

Linnea Ehri, Ph.D.

Martin Chodorow, Ph.D.

Supervisory Committee

Martin Gitterman, Ph.D.

Outside Reader

THE CITY UNIVERSITY OF NEW YORK

Abstract

THE RELATION BETWEEN ORAL READING

AND

SILENT READING COMPREHENSION SKILL

by

Barbara T. Schmidt

Advisor: Professor Loraine K. Obler

First, this study was intended to determine if it is possible for individuals who are slow inaccurate oral readers to have good reading comprehension with good semantic access while demonstrating poor oral reading skill. Second, this study questions if there is a correlation between cognitive factors (working memory, speed of access, and IQ) and efficient lexical access. And finally, this study examines if there is a correlation between spelling and oral reading skill.

In order to answer these questions, 41 native English-speaking young adults, 11 with a self-reported history of learning differences, participated in the following tasks: 1.the Nelson Denny Reading Test, 2.the Wide Range Achievement Test-Reading, 3. oral reading of text, 4. nonword reading, 5.the Single-Word Silent Reading Test, 6.theWeschler Adult Intelligence Scale III 7. Reading Span Test, 8. RAN (letters and colors), 9. the Wide Range Achievement Test-Spelling and 10. the Experimental Spelling Test (Fischer, ct al., 1984).

Correlation coefficients were calculated among the measures. Significant overall correlations were found between oral reading skill and reading comprehension, reading skill and cognitive factors, silent reading comprehension and Full scale IQ, as well as oral reading skill and spelling skill, oral reading and the Experimental Spelling Test. However, there were individuals who participated in this study who provide evidence of dissociations in component skills. Nevertheless, no individual in this study exhibited dissociation between reading skill and spelling skill. A regression analysis was performed with oral reading rate as the dependent variable; spelling and processing speed were the best predictors of oral reading skill.

Additionally, an analysis of the oral reading errors produced during text reading was performed. This analysis revealed that both fast, fluent oral readers and slow, dysfluent oral readers may make reading errors. However, the slow dysfluent readers made real word substitution errors and the fast fluent readers did not. Both fast, fluent readers and slow, dysfluent readers reading errors' included the production of nonword errors. Since the production of nonword errors and word substitution errors occurred while reading a passage of text (in context), the production of these errors suggests that oral reading is capable of being performed without complete semantic mediation.

Acknowledgements

This dissertation is tangible evidence of my personal and professional evolution. The seeds for that growth were planted many years before my doctoral study began and there are numerous people to thank for nurturing my progress.

I offer my thanks and appreciation to Loraine K. Obler, my advisor and mentor, who has provided me with encouragement, and most importantly, stimulating insights and wisdom. I will be forever grateful to her for being an extraordinary teacher who challenged me to exceed the expectations I had of myself.

Additionally, I have been fortunate to work with inspirational faculty. I would like to thank Linnea Ehri for guiding my work. Her years of research experience and expertise have added enormously to this study. I am appreciative for the opportunity to have learned from her. To Martin Chodorow I extend a heartfelt thank you. He has made himself available for theoretical discussions and explicit instruction. Often, his brief, seemingly simple statements motivated me to look at my work in a different way. It was a privilege to have Martin Gitterman as my outside reader. His comments and perspective were most valuable.

My association with my colleagues and friends at the Graduate Center has fortified my growth. A special thank you to Dr. Jim Jenkins who was helpful in the development of my dissertation proposal and to Mira Goral who encouraged me throughout my doctoral work. I also thank Peggy Jacobson who was of great support and made every effort to assist me in recruiting participants. And, I thank Elizabeth Galletta, Anita Haravon, Elizabeth Iljalba, Hia Datta, Pam Matthews, Yael Neumen, Inge Anema who were a source of encouragement and constructive criticism.

The faculty at Molloy College has also contributed to my evolution and I thank them as well. In particular, Alice Byrnes, Mary Pat Neylon and Margaret Kavanagh, my colleagues and friends, who have been ever-present cheerleaders, helping me remain focused when the rigors of work became intense. Alice graciously allowed me to recruit participants from her classes. Merritta Cullinan and Joan Harnett made time to look at my data and talk about my work. Kathy Conway and I shared "tragedies" and "triumphs." Lillian Bozak-Deleo and Tom Catania offered support and wisdom in difficult times enabling me to endure. Finally, the late Kay Kilkelly, whose vibrant and tenacious spirit permeated me, feeding my growth.

I would be remiss if I did not thank my students who kept me inspired. Their curiosity and enthusiasm has helped me to grow personally as well as intellectually. Particularly, Jennifer Nadler-Franz challenged me in ways no other student had previously done and unwittingly encouraged me to explore new territories. Many thanks as well to Christine Gangi and Stephanie Pagnozzi who both worked with me in examining these data and to all the students who participated in this study.

However, it is unquestionably my family who have contributed the most to this evolution. My parents, Warren and Alberta Weisberg, taught me about perseverance and fortitude. They stressed the value of knowledge and remain my role models. Most importantly, I thank my husband, Martin, my daughter, Holly and my son-in-law, James Redmond who were patient and selfless. I would especially like to thank my son, Eric, who questioned my questions and questioned my answers. I love you all.

Table of Contents

Page

Abstract iv

Acknowledgements vi

Table of Contents viii

List of Tables xi

List of Figures xii

List of Appendices xiii

I. Introduction

A. Overview 1

B. Theoretical Models of Reading 2

C. Reading and Spelling 7

Word Decoding and Phonological Skill 7

Correlation Between Reading Skill and Spelling Skill 12

Dyslexia and Spelling Patterns 16

D. Fluency and Reading Comprehension 19

E. Linguistic Factors Influencing Reader Performance 27

F. Cognitive Factors Influencing Reader Performance 31

Intelligence 32

Working memory 35

G. Dissociation Between Oral Reading and Silent Reading Skill 40

H. Research Questions 44

Predictions 45

II. Method 49

A. Participants 49

B. Materials 50

Reading Skill 50

Reading Comprehension 50

Oral Text Reading 51

Decoding and Single Word Reading Aloud 53

Silent Single-Word Reading 56

Spelling Skill 58

Cognitive Skills 59

Wechsler Adult Intelligence Scale III 59

Working Memory Capacity 60

Rapid Automatized Naming 62

C. Procedure 63

III. Results 65

A. Reading Measures 65

Speed 65

Reading Errors and Accuracy 66

Decoding and Word Reading 69

Silent Single-Word Reading 70

B. Cognitive Measures 71

C. Rapid Automatized Naming 72

D. Relation Among Oral Reading, Silent Reading and Predictor Variables 73

	E. Spelling Measures	74
	F. Variance in Fluency	75
	G. Individual Differences	76
	History of Learning Differences	81
IV.	Discussion	83
	A. Relation Between Oral Reading Fluency and Reading Comprehension	83
	B. Decoding and Phonological Skill	84
	C. Linguistic Access	85
	D. Spelling Skill and Reading Skill	87
	E. Cognitive Factors Influencing Reading Performance	87
	Intelligence	88
	Working Memory	89
	F. Oral Reading Rate and Errors	91
	G. History of Learning Differences	96
	H. Theoretical Models of Reading	97
V.	Conclusion	101
	Future Research	102
	References	132

Tables

Table 1 Participants with a self-reported history of learning differences 104

Table 2 Speed (WPM), Accuracy of Reading (C-WPM), and Dysfluency for the Slow and Fast Readers 105

Table 3 Oral reading errors in slow, dysfluent, readers and fast, fluent readers 106

Table 4 Correlations between factors 107

Table 5 Mean performance scores of slow, fast, mid-paced oral readers and the group 108

Table 6 Multiple regression analysis 110

Table 7 Rank-ordered task performance for slow and fast readers 111

Table 8 Comparison of reading comprehension, WPM, nonword reading, word reading aloud, cognitive measures and SWSRT for participants 4 and 8 112

Table 9 Task performance rank ordered for mid-paced readers 113

Table 10 Silent reading, oral reading and processing speed differences in individuals 16 and 21 114

Table 11 Participants with a dissociation in ranked scores meeting the stringent requirements set forth of a ranked score of 1-5 in one measure and 36-41 in the other measure 115

Table 12 Scores for the fluent participant who reported a history of learning difference as compared to the group mean 116

Figures

Figure 1	Predicted correlations between variables	117
Figure 2	Oral reading errors of fluent and dysfluent readers by error type	118
Figure 3	Oral reading rate and reading errors	119
Figure 4	Reading model	120

Appendices

Appendix A Nonword Reading 121

Appendix B Single-Word Silent Reading Test (SWSRT) 122

Appendix C Experimental Spelling Test 123

Appendix D Questionnaire 124

Appendix E General Demographic Information 128

Appendix F Rank-ordered performance for slow dysfluent readers with no history of learning differences and slow dysfluent readers with a reported history of learning differences, and mid-paced readers with a history of learning differences and the fast reader with a history of learning differences 129

Appendix G Scores for the four dysfluent participants with no history of learning difference as compared to the group means 130

Appendix H Scores for slow dysfluent readers with no history of learning differences and with a reported history of learning differences 131

Chapter I: Introduction

A. Overview

Reading is a complex task relying on multiple cognitive and linguistic skills. The reader must be capable of adequately perceiving the orthographic symbols, encoding, storing, retrieving, integrating information and drawing inferences. The process by which a skilled reader is able to automatically engage in these operations is an area of considerable investigation. The literature suggests that individual differences in linguistic and cognitive abilities have the potential to influence reading skill. Furthermore, while it is well known that some individuals have difficulty learning to read, there is evidence that the eventual development of good reading comprehension is possible for at least some of these people.

The present study attempts to answer four questions. First, is it possible for individuals who are slow, inaccurate oral readers to have compensatory skills that result in their having good reading comprehension with good semantic access? Second, what would be the implications of such a dissociation between oral reading skill and silent reading comprehension for theoretical models of reading? Third, is there a correlation between cognitive factors and efficient lexical access? And finally, do unresolved spelling difficulties provide evidence of processing deficits?

This chapter will summarize the theoretical models of reading, discuss the relation between reading skill and spelling skill, review the linguistic and cognitive factors posited to influence reading performance, and explain the established association between fluency in oral reading and reading comprehension.

B. Theoretical Models of Reading

The literature includes two widely accepted models by which one can explain skilled reading. The first, the dual route model, suggests that we have the potential to access words in the mental lexicon via two routes: 1) the phonological route (based on grapheme-phoneme conversion) and 2) the word form mechanism (based on visual-orthographic representation) (e.g. Coltheart, Patterson and Marshall, 1980; Coltheart, Curtis, Atkins and Haller, 1993, Coltheart, 2003).

Evidence in support of the dual route model comes largely from studies investigating individuals with acquired reading disorders (alexia). Based on the reports of individuals with alexia, also termed "acquired dyslexia," impaired access to the lexicon via either of the two routes is possible. Surface dyslexia, for example, is a disorder wherein the individual appears to rely on the phonological route for reading. Individuals with surface dyslexia tend to make errors that are based on the orthographic characteristics of the word, often described as visual errors. Additionally, individuals with surface dyslexia make "regularization errors." A regularization error is an error whereby the individual uses the more frequent pronunciation of a phonemic unit in a situation where the less frequent form should be used (e.g. reading the word "**pint**" with a short "**i**" as in "**hint**") (Caplan, 1987). These individuals have also been noted to mistake pseudohomophones (e.g. **blud**, **kat**) for real words during lexical decision tasks. This type of error prompts speculation that these individuals access the lexicon based on the perceived sound of the word. The evidence suggests that people with surface dyslexia have an intact phonological route, which relies on the most common grapheme-phoneme correspondences, and they do not have access to the whole-word recognition route.

A second type of acquired dyslexia, deep dyslexia, is, by contrast, a disorder characterized by an inability to access words via the phonological route (e.g. Coltheart, 1980; Shallice and Warrington, 1975; Patterson and Marcel, 1977; Newton and Barry, 1997). A deficit in the phonological route commonly results in an inability to read nonwords and unfamiliar words, since these units are not represented in the mental lexicon and therefore cannot be activated. Individuals with deep dyslexia are best known for making semantic errors (e.g. they read the target word "pot" with an error word "pan"). Such semantic errors suggest access to the intended meaning (lexical access), despite errors in word accuracy and the inability to decode unfamiliar words.

While the dual route model appears tenable when we consider the evidence from disordered populations, there are those who challenge the interpretations of the evidence. For example, Marcel (1980) challenges the claim that the phonological route is used for grapheme-phoneme conversion during nonword reading tasks. Instead, he proposes that nonword reading is based on familiarity with known words, and that the reader uses the activation of the lexical entry of an analogous known word to stimulate the phonological representation of a nonword.

The second theoretical model used to explain reading, the connectionist theory, proposes that there are separate mechanisms for phonological and orthographic processing, but that these mechanisms are connected (Seidenberg and McClelland, 1989). The connections between the mechanisms are strengthened by increased use, resulting in efficient retrieval of the information (e.g. word access during reading or grapheme access during spelling). Evidence in support of the connectionist model is derived from computer simulations. These simulations are intended to mimic normal processing behaviors, as well as provide evidence based on patterns of breakdown ("lesioned" simulations). Early simulations were less capable of replicating the range of observed reading disabilities. However, more recently these simulations have become more comprehensive. Harms and Seidenberg (2001) report findings from a computer simulation to support the notion that phonological dyslexia, a disorder characterized by an inability to accurately read nonwords, has a phonological basis. In this study Harms et al. examine pseudohomophone reading in undergraduate students as well as by computer simulation in order to explore the contribution of orthographic and phonological deficits in phonological dyslexia. The authors found that simulating a lesion in the phonological mechanism impedes pseudohomophone reading. For both normal readers and during computer simulation nonwords become more difficult as the orthography becomes more opaque (e.g. "phocks" provides greater difficulty than "kat"). The authors suggest that for normal readers orthographic differences in words are not independent of phonology and have phonological ramifications

In their examination of the evidence for the connectionist model, Coltheart et al. (1993) point out the usefulness of a computational model, which is capable of learning. During these computer simulations the model is able to slowly learn to "read," demonstrating normal human behaviors. However, these computer simulations have been criticized for failing to accurately account for the varieties of behavioral characteristics noted in acquired and developmental dyslexia (Coltheart et al., 1993). For instance, Seidenberg and McClelland suggest that their computational model is capable of reading regular words, nonwords and exception words, all tasks used to support the dual route model. Yet, Coltheart et al. (1993) point out that the model was only able to read nonwords with limited success (using three different sets of stimuli the model read correctly 65%, 59% and 51%). In contrast, skilled readers perform significantly better (94% and 89%) (Coltheart et al., 1993). More recently, computer simulations have been better able of providing evidence of deficits that emulate adults and children with various component skill reading disabilities. However, it remains questionable whether scientists are currently capable of simulating the requisite sub skills that humans use to develop a wide range of reading behaviors (e.g. reading unfamiliar, irregular letter combinations), and additionally explain the scope of disabilities.

The dual route theory and connectionism both have their strengths and weaknesses. Proponents of connectionism would argue against the modular nature of the dual route model. Connectionists argue that the linguistic functions of reading are likely to be interrelated, and their computer simulations have supported this notion. However, in addition to the failure of connectionism to fully account for human variability in reading, neither reading model can fully account for the linguistic factors that influence individual reading performance (e.g. morphology) (Berninger, Abbott, Brooksher, Lemos, Ogier, Zook, and Mostafapour, 2000; Obler and Gjerlow, 1999). As previously noted, this study will examine variability among readers in order to find evidence supporting connectionism and/or the dual route theory.

Dual route theory suggests distinct routes for phonological access and lexical access. Connectionism proposes interconnected phonological and orthographic mechanisms with increased capability resulting from increased use. Examination of readers' lexical and phonological access during reading should supply us with evidence supporting a theoretical model of reading. It is commonly argued that reading words and nonwords aloud is dependent on phonological access. In contrast, silent reading of words and text relies on lexical and semantic access in a skilled reader. If individuals have access to two reading routes, phonological and lexical, it will be possible for individuals to have good silent reading comprehension (good lexical access), despite poor oral reading skill (phonological access). Such individuals have been reported in the literature on adult alexia (e.g. Newton and Barry, 1997), however, they have not been discussed in the developmental literature. Therefore, this study will address the question of whether there is a correlation between silent reading comprehension and oral reading accuracy and rate (a measure of word decoding and therefore of access to the phonological route in skilled readers). If the answer is "yes," there is a correlation, we can hypothesize that connections are made between phonological and lexical representations, and that a weakness in the access via the phonological route will inhibit the development of connections with the lexical route, resulting in a correlation between grapheme-phoneme access and whole word lexical access. This finding will support the notion of connectionism. However, if the answer is "no," and oral reading rate and silent reading comprehension are not correlated, this supports the notion of distinct reading routes. One reading route is available for direct lexical access (likely to be used during silent reading comprehension), and one for grapheme-phoneme conversion (likely to be used when confronted with oral reading situations such as reading aloud passages and familiar and less familiar words).

C. Reading and Spelling

Word Decoding and Phonological Skill

Proponents of both the dual route model and the connectionist model would agree that skilled readers have the ability to access the mental lexicon via whole words, without overtly converting the graphemes (alphabetic representation of speech sounds) to phonemes (speech sounds). Beginning readers, however, must go through the process of learning grapheme-phoneme conversion. They must acquire word-decoding strategies while simultaneously relying on their knowledge of the spoken language to integrate the visual representation with units in their mental lexicon.

The process of learning to read may result in frustration and failure. Children who demonstrate a weakness in learning to read are sometimes identified as being dyslexic. This descriptor is most often used for children who have marked difficulty learning to read despite adequate capabilities (i.e. they have no known cognitive or neurological deficits).

In order to learn to read, a child must become proficient at a series of tasks. Initially, the child must have knowledge of the alphabet. Differentiation of the visual characteristics of letters enables the child to progress to the second task, which is the ability to associate speech sounds (phonemes) with letters and letter groups (graphemes). The knowledge that speech sounds may be comprised of alphabetic groupings, and that these graphemes may vary (e.g. The phoneme **/k/** may be represented by a variety of graphemes including **c**, **k**, or **ck**), is of considerable importance in learning to decode English words. Often, the basis of the initial problem is the readers' inability to accurately convert graphemes to phonemes. This results in poor word decoding skill.

Researchers have explored the deficits of children who have difficulty learning to read and have generally agreed that poor readers have poor phonological awareness (recognition of the structural components of the sound system of language). Reading disabled children have been found to be unable to segment sounds in words or manipulate sounds in words as well as better readers. This deficit in phonological awareness is hypothesized to be the basis for their poor word decoding skills (e.g. Scarborough, 1990). Furthermore, there is evidence to suggest that these phonological deficits persist into adulthood (Bruck, 1992) and recent evidence suggests that even in Finnish, a language with a transparent orthography, there is evidence of word decoding deficits in adults with dyslexia (Leinonen, Muller, Leppanen, Aro, Ahonen, and, Lyytinen, 2001).

Much of the evidence that deficient phonological awareness is the basis of poor reading skill is found in the developmental literature. Investigating the interaction between the phonological system and word form access, Snowling (1980) used a cross-modal task involving the matching of an auditory nonword with a written representation. Snowling was able to demonstrate that dyslexic children (age range 9yr.2m.-15yr.) appeared to have a basic weakness in the phonemic access route to lexical information. While these children were able to match pairs of auditory nonwords and pairs of written nonwords, they lacked the grapheme-phoneme conversion skills to match a visual nonword with an auditory nonword. The inefficient use of this conversion mechanism in children with reading disorders suggests a possible link between the phonological system and access to word forms as well.

Also exploring decoding in elementary school children, Perfetti and Hogaboam (1975) found that both words and pseudowords were read with greater speed by skilled readers (standardized test scored > 75 percentile) than less skilled readers (standardized test scores< 26 percentile). Based on the premise that oral reading is a reflection of decoding capability, and that decoding is a prerequisite for comprehension, their participants were asked to read aloud words and pseudowords. Using vocalization latencies, they concluded that skilled readers possess more rapid decoding capability. They conclude that the skilled readers have more automatic decoding skills than the less skilled readers do. However, in this particular study Perfetti et al. (1975) go a step further, underscoring the importance of grapheme-phoneme conversion skills to skilled reading. They argue that the less skilled readers must put more effort into the decoding of words (and pseudowords), even for more familiar words. They suggest the “shared limited capacity hypothesis,” that the increased effort required for decoding by less skilled readers might limit the capacity available for the more complex integrative functions used for reading comprehension. Thus, less skilled readers deplete their capacity on word decoding and do not then have the capacity required for integration of information during reading, a notion to be further pursued in my study.

It must be noted that while the Perfetti and Hogaboam (1975) study confirms that poorer readers are less skilled at oral word decoding, the authors acknowledge that this study did not attempt to separate production (vocalization) from decoding (transformation of written language). In their study the focus was on having participants see a written word and uttering that word as quickly as possible. Perfetti et al. found that despite word familiarity, the less skilled reader was slower at word recognition.

Given the evidence that more skilled readers are able to read words aloud faster than less skilled readers, despite word familiarity, this indicates that during production tasks less skilled readers perform slower. Vocalization, or oral production of the written word, is a component skill used in oral reading. Oral reading relies heavily on access to the phonological representation of words. However, for some individuals access to the phonological representation of words may be deficient, and yet they may possess the component skills needed for integration of the orthographic representation with the lexical representation. The ability to integrate the orthographic representation with the lexical representation facilitates the ability to glean meaning from written words. Nonetheless, these words may be difficult for the reader to read aloud quickly. Therefore, in this study I attempt to separate the components of oral production and silent reading.

Perfetti and Hogaboam hypothesize that there is a theoretical relationship between oral decoding and reading comprehension. This position contradicts my hypothesis that adults with early decoding difficulty may rely on compensatory skills that result in their having good reading comprehension with poor oral reading skill. This study will examine whether it is possible for the individual to have poor access to the phonological representation of the written word, as demonstrated by poor oral reading, but to nonetheless develop good access to the semantic representation of the word, which would be demonstrated by good silent reading comprehension. This distinction in skill would suggest the influence of cognitive skill, an issue to be discussed further in a subsequent section of this chapter.

Dissociation between oral reading skill and silent reading comprehension may provide evidence for the dual route model of reading. Poor oral word decoding suggests poor access via the phonological route. Good silent reading comprehension implies good lexical access via the whole word lexical route. The relation of decoding to reading fluency and reading comprehension is, of course, essential to this discussion. Therefore, decoding, reading fluency, and reading comprehension will be addressed at greater length in a subsequent section of this paper.

As the literature suggests, poor oral word decoding indicates poor access via the phonological route with underlying phonological awareness deficits. While word decoding during reading relies on phonological access in order to convert graphemes to phonemes, similarly word encoding, or spelling, relies on the phonological route for phoneme to grapheme conversion. Reliance on the phonological route for both reading and spelling suggests that the two should be interlinked.

Correlation between Reading Skill and Spelling Skill

During the early stage of learning to read, the beginning reader is simultaneously learning to decode printed words and to take phonemes (speech sounds) and convert them into grapheme units (word spellings). The literature suggests that for children there is a correlation between reading skill and spelling skill (Ehri, 1980). Furthermore, children acquire spelling skills in a sequence of stages (Ehri, 1986; Moats, 1995) and normally developing children provide evidence of the use of phonemic strategies and rules when spelling (e.g. Marsh, Friedman, Welch, and Desberg, 1980; Treiman, 1984).

English orthography, of course, must be considered variable with some irregularities. While some words maintain a close phoneme-grapheme correspondence (e.g. **bar**, **pen**, **cup**), other words do not (e.g. **yacht**, **sign**, **colonel**). Additionally, while consonant sounds may be represented with various graphemes (/k/, as **c**, **ck** or **k**), vowels too have multiple graphemic representations. Treiman, Kessler and Bick (in press) suggest that for normal adults the difficult task of vowel spelling in English, (e.g /ɛ̆/, **ea** as in **head** or **e** as in **hell**), is governed by the consonant context in which the vowel occurs. Moreover, in addition to the rules concerning phoneme-grapheme correspondences, there are also strictly orthographic rules (Moats, 1995). For example, when adding a suffix beginning with a vowel to a monosyllabic word ending in a single consonant, that final consonant is doubled (e.g. **cut/cutting**). However, when a word is multisyllabic and the final syllable has one vowel and ends in a consonant, but the stress is on the initial syllable of the word, the final consonant is not doubled when a suffix beginning with a vowel is added (e.g. **open/opening**). The inconsistency in English spellings implies that different strategies must be employed in order to learn to convert these varied patterns of graphemes to phonemes for reading and phonemes to graphemes for spelling.

Individuals with reading difficulty typically have difficulties in spelling, though there are some good readers who are poor spellers (Frith 1980). In a study pertinent to the current study, Fischer, Shankweiler, and Liberman (1985) examined whether adults with different spelling capabilities differ in their linguistic sensitivity. They define linguistic sensitivity as, "… the ability to apprehend the inherent regularities at various levels of linguistic representation and the ability to exploit this knowledge in reading and writing words" (p. 424). Testing undergraduate students (mean age 20) in two groups (good spellers and poor spellers), they were able to demonstrate that the poorer spellers appeared to have significantly less linguistic sensitivity. The good spellers were selected because they performed at or above grade level on the spelling subtest of the Wide Range Achievement Test (WRAT) (mean spelling grade level 14.4). The poor spellers performed on average 4 years below grade level on the WRAT (mean spelling grade level 10.2).

In order to assess linguistic sensitivity, Fischer et al. (1985) asked participants to engage in a series of tasks, spelling being one of the tasks. Criticizing standard measures of spelling skill for not considering word frequency and the morphophonemic structure of English, Fischer et al. developed their own spelling test. This test, the *Experimental Spelling Test*, was comprised of three parts with a total of 120 words. Each part consisted of 40 words that differed in their degree of orthographic transparency. The first level consists of transparent words considered to have high frequency spelling patterns (e.g. **yam, inflate**). The second level was divided into two different types of words, all containing ambiguous portions. The first 20 words in level two require knowledge of the rule-based nature of spelling (e.g. **sobbing, omitted** [where doubling of the final consonant is required]). The remaining 20 items require morphophonemic knowledge in order to spell (e.g. **indigestible).** Items in the third level of words were low orthographic frequency words (e.g. **Fahrenheit, gnaw**). They report that the three lists were balanced for syllable length (mean = 2.8) and the frequency of occurrence in written English (mean = 6.1) according to Kucera and Francis (1967) (See Fischer et al. for a complete description of the test construction).

In addition to administering this spelling test, Fischer et al. (1985) had their participants engage in a variety of tasks designed to explore their metalinguistic abilities related to spelling. These tasks included: a) prefixation (participants wrote a word from dictation, detaching any prefixation), b) suffixation (participants were required to attach a suffix to a pseudoword), c) the reading recognition subtest of the Wide Range Achievement Test and d) the Kimura Recurring Figures Test (a nonverbal test of visual memory involving figure recognition) (Kimura, 1963). As mentioned above, their findings suggested poor spellers as a group have a deficit in linguistic sensitivity (recognizing linguistic regularity). Their findings include the evidence that the poor spellers made significantly more errors than the good spellers did: a) while identifying consonant and vowel patterns when responding "yes" or "no" as to whether a written spelling corresponded with an uttered word (Participant heard a word and saw it in written form. The task demanded that they respond "yes" if the written form matched the uttered form.), b) by making phonologically plausible substitutions during spelling from dictation, c) in accuracy of spelling when suffixation was involved, and d) in detaching prefixation.

Additionally, their data supplied some interesting evidence with regard to language skill. In particular, the poorer spellers, though described as having "college level proficiency in reading English" had mean oral reading grade equivalents that were 2 years below those of the good spellers (based on performance on the WRAT-Reading subtest). The good spellers' had a mean reading grade of 15.3 (SD 1.3), while the poor spellers' mean reading grade was 13.3 (SD 1.7), despite no significant group differences on the vocabulary subtest of the Wechsler Adult Intelligence Scale (Wechsler, 1958). The authors explain the results of the vocabulary measure, suggesting that vocabulary is not a factor of importance to the ability to ascertain the internal structure of words. Additionally, group differences were noted on the verbal aptitude score of the Scholastic Aptitude Test (SAT): good spellers had a mean score of 534 (SD 75.8) and poor spellers had a mean score of 465 (SD 66.7) (t (28) = 2.57, $p < .01$).

In summary, while there was no significant difference between the good spellers and poor spellers on a measure of vocabulary, the groups differed on various measures of reading and spelling skill. The authors propose that the consistent differences in performance between the two groups are related to the underlying linguistic abilities of the good and poor spellers. Therefore, it would appear that despite their good reading ability, their poor spelling ability may provide evidence of processing differences.

Dyslexia and Spelling Patterns

Recognizing the relation between reading and spelling, as well as the individual differences among developmental dyslexics, Boder (1973) investigated reading and spelling skills in children with reading difficulty. Based on documentation of distinctive reading-spelling patterns she identified three subtypes of developmental dyslexia. The first subtype, dysphonetic dyslexia, includes those children who have grapheme-phoneme conversion difficulties. This is sometimes referred to as developmental phonological dyslexia (Castles, Datta, Gayan, and Olsen, 1999). Children with developmental phonological dyslexia characteristically learn words in their sight vocabulary, but cannot decode words due to their poor phoneme-grapheme awareness. Boder proposes that their word spelling is based on visualization and is not likely to represent the phonological shape of the word.

The second subtype of children with dyslexia that Boder identified are dyseidetic dyslexic children. These individuals slowly develop letter recognition skill and tend to decode phonetically. The cognitive psychological literature sometimes refers to this group of individuals as having developmental surface dyslexia (Castle, Datta, Gayan, and Olsen). Boder noted that children in this group spell poorly, but their spellings tend to be "phonetic."

The third category Boder identifies is mixed dysphonetic-dyseidetic dyslexia. These individuals are considered the most severely impaired; displaying a poor sight vocabulary and poor grapheme-phoneme conversion skills. Flynn and Deering (1989) provided electrophysiological evidence supporting the Boder system of classification of dyslexia and proposed that the deficits of reading disabled children are based on different neurolinguistic processing mechanisms, arguing that the deficit is indeed language based.

For some dyslexic children reading skills improve with time, however, spelling problems persist (Bruck, 1993; Moats 1995; Pennington, McCabe, Smith, Lelfy, Bookman, Kimberling, and Lubs, 1986). It is speculated that these persistently poor spellers have deficits in their phonological mechanism. Pennington et al., using familial adult dyslexics matched with normal adults for age (dyslexic mean = 33.8, SD 13.4; normal mean = 36.7, SD 12.2), and level of education (dyslexic mean = 14.1, SD 2.4; normal mean = 14.7, SD 2.1), report measures of IQ, mathematics, general information, reading and spelling. Their dyslexic adults differed from normal adults only in measures of reading and spelling, with no significant differences in their mathematical ability, general information, verbal, performance, or full-scale IQ scores.

The authors did a detailed analysis of the spelling errors made by the participants. The spelling errors made by the dyslexic adults demonstrated that the dyslexic adults were significantly different from normal adults on a variety of spelling skills including, “simple phonological accuracy,” i.e. the accurate use of consonants in the correct order without consideration of vowel spelling. Based on an analysis of such errors, Pennington et al. (1986) propose that the dyslexic adults in this study have a deficit in the phonological route.

It should be noted that the individuals Pennington et al. studied were identified as being dyslexic based on self-report and test performance. Moreover, in order to meet the criteria established for inclusion, the dyslexic participants had been previously identified in a genetic linkage study. At the time of testing they all had a Reading Quotient (RQ) of less than .80. (The RQ is a derived score based on IQ, an oral reading test, academic grade achieved and a spelling test (Finucci, Isaacs, Whitehouse and Childs, 1982). Finucci et al. recommend that a RQ of less than .80 is indicative of a reading disability. People who have compensated for dyslexia are defined as individuals with a positive history but a RQ of greater than .80 were excluded from this study).

Examination of their data reveals some interesting findings. First, as mentioned earlier, the normal and dyslexic groups had been matched for level of education (dyslexic mean = 14.1, SD 2.4; normal mean = 14.7, SD 2.1) and age (dyslexic mean = 33.8, SD 13.4; normal mean = 36.7, SD 12.2). The fact that both groups were equally educated and those with dyslexia had functioned in an academic environment beyond high school, in and of itself suggests that they may have “compensated” to some degree for their deficit in reading. Since the RQ is determined by a calculation including IQ, spelling, oral reading, and academic grade achieved, it would appear that Pennington et al. (1986) could have potentially included individuals who have compensated for dyslexia and who received low scores because they were poor readers and spellers. Using decoding and encoding skill in a formula to determine reading skill, in the absence of including a measure of reading comprehension skill, implies a single available route for spelling and reading and ignores the possibility of dissociation. The present study will attempt to determine the extent to which spelling skill, oral reading skill and silent reading comprehension are interlinked or dissociable in skilled readers.

D. Fluency and Reading Comprehension

Reading comprehension, or the ability to understand and learn from what has been read, is the ultimate goal for the reader. Fluency during reading (the ability to accurately and automatically read words and move smoothly through text) implies less overt emphasis on decoding and greater attention to the meaning of the material. As previously mentioned in the section on word decoding skill, poor readers tend to have less automatic decoding skill than good readers and slower word recognition. Slow word recognition is a notion used to explain dysfluent reading (LaBerge and Samuels, 1974). In this section the components contributing to fluent reading, and the proposed correlation between the development of fluency and reading comprehension will be examined.

It has been proposed that there is a correlation between fluency and reading comprehension, especially through the eighth grade when reading skill is stabilized (Dowhower, 1994; Shinn, Good, Knutson, and Tilly, 1992; Tan and Nicholson, 1997). However, Fleisher, Jenkins and Pany (1979) found that training fourth and fifth grade children to decode faster did not improve their reading comprehension.

Furthermore, Bruck (1990) indicates that many of her college-age participants were able to achieve good reading comprehension despite continued weak word recognition skill. Based on the premise that dyslexic readers rely on context to facilitate word recognition, Bruck included a context task in her study. Her data suggest that individuals with dyslexia read words more accurately in context than out of context, but their word-reading response times remain very slow. Moreover, Rubin and Johnson (2002) provide electrophysiological and behavioral evidence of lexical retrieval differences between college students identified as having a learning disability and students who do not have a learning disability. The lexical access task used in this study was the Test of Adolescent/Adult Word Finding (TAAWF) (German, 1990). The TAAWF requires word retrieval under different conditions (e.g. picture naming, sentence completion, naming by word classes and categories). Rubin et al. indicate that while all the participants in their study were equally accurate in their retrieval of the correct lexical information, the learning disabled required more time to accomplish the task.

Additionally, Jackson and Doellinger (2002) report on college students who, despite their poor word reading ability, had good reading comprehension. In their study, Jackson and Doellinger screened 194 undergraduate students and identified 6 individuals who possessed good comprehension, poor spelling, poor pseudoword reading and poor word reading skill. These individuals were identified as being "resilient readers." The resilient readers were differentiated from "nonresilient" readers, or those with poor reading comprehension. These 6 resilient readers were matched with "typical readers." The typical readers were students who demonstrated similar reading comprehension skill to the resilient readers, but unlike the resilient readers, the typical readers possessed good pseudoword reading skill. In addition to assessing reading comprehension (text comprehension was evaluated using a variety of measures and included both oral and silent tasks) and pseudoword reading, the participants engaged in measures of intelligence, phonological awareness, real word reading, spelling, listening comprehension, measure of working memory, rapid automatized naming (RAN), and speeded text reading. The resilient readers differed from the nonresilient readers on measures of phonological awareness and reading comprehension. The resilient readers performed better on the phonological awareness task. Most interestingly, while the resilient readers did not differ from the typical readers in reading comprehension, by nature of the design of the study, nor oral reading speed, the two groups differed on the number of oral reading errors produced during an oral text reading comprehension task. The resilient readers made more uncorrected errors, causing them to be less accurate. Despite their inaccuracy, as evidenced by their word reading errors, the resilient readers demonstrated good reading comprehension.

It is customary to measure reading comprehension throughout an individual's primary and secondary academic experience. Reading comprehension is typically assessed by having an individual silently read a passage of text and respond to multiple choice or fill-in-the-blank questions regarding the content of the passage. A variety of standardized assessment instruments are available to measure reading comprehension. Fluency, though not always formally assessed, can be examined using a variety of techniques. The first possible method is to determine the readers' rate (per minute) of reading text orally or silently. Oral reading rates beyond the fifth grade range from 120-150 wpm (Mercer and Campbell, 1998). According to the Nelson-Denny Reading Test revised (1993) the mean silent reading rate for high school is 200 wpm (± 20). Using readers' reading rate in words per minute as a measure of fluency considers only their speed of reading. A second technique for determining a readers' level of fluency is to quantify the pauses and errors produced by the reader (Shinn et al., 1996). Oral reading errors would include word omissions, substitutions, and mispronunciations. Additionally, pauses of 3 seconds or more during oral reading would also be tabulated as errors. Quantification of the errors made by a reader takes the accuracy of reading into consideration. Ideally, fluent reading should be adequately fast and accurate in order to facilitate comprehension.

Beginning readers are obliged to decode, which naturally slows down their word recognition and thwarts fluency. However, as decoding becomes more automatic, readers are capable of faster word recognition, and thus their reading is expected to become more fluent. LaBerge and Samuels (1974) point out that the development of "automaticity" in word recognition enables the reader to devote more attention to the content of the material. The phonological difficulties presumed to be at the basis of decoding deficits in the reading disabled are likely to result in slow word recognition, which hinders the development of fluent reading, and the capacity for comprehension.

Exploring the issue of slow word recognition, van der Leij and van Daal (1999) provide evidence confirming that Dutch dyslexic children perform word and letter group identification tasks (reading words, nonwords and morphemes [e.g., -**teur**]) at significantly slower speeds than chronological-age matched peers, even for very familiar words. They suggest that the skilled readers have developed "relative automaticity" or the ability to process words effortlessly, a notion previously introduced by LaBerge and Samuels. Those with dyslexia have not developed this ability and require increased time to read words. Additionally, as the task became more demanding (words of greater length and increasing complexity), van der Leij et al. found that dyslexic children performed relatively more poorly.

The literature suggests that naming speed, or Rapid Automatized Naming (RAN), is a predictor of word recognition and reading skill (Denckla and Rudel, 1976; Bowers 1993; Denckla and Cutting, 1999; Wolf, 1999). RAN can be administered using numbers, colors, letters and objects or a combination of any of these. Denckla and Rudel indicate that for normal readers, as well as dyslexic children, letters and numbers are relatively easy RAN tasks, while colors and objects are the more difficult RAN tasks. Bowers (1993) points out that naming speed may be an indicator of efficient lexical access. Testing children in grades 2, 3 and 4, she found that poor readers are slower at naming digits than good readers and improvement in oral reading fluency, as measured by words read per minute, was predicted by naming speed. Similarly, it has been noted that delayed naming speed is an indicator of a history of reading disability in adults (Felton, Naylor, Wood, 1990).

Naming capability was a component of a study that examined the literacy and cognitive skills of college students with dyslexia (Hatcher, Snowling, and Griffiths, 2002). In this study, Hatcher et al. report on 23 individuals with dyslexia (mean age 24.93) and 50 controls (mean age 21.8) who had similar verbal skills (as measured by the verbal subtest of the Wechsler Adult Intelligence Scale-Revised) and nonverbal ability (as measured by the Raven's Advanced Progressive Matrices). Each participant was administered a series of tasks in the areas of: 1. literacy (word reading, nonword reading, proof reading and spelling), 2.cognitive-processing skills (speed of processing, verbal short term memory, mental arithmetic), 3. fluency tasks (semantic fluency, phonemic fluency and rhyme fluency), 4. attention, and 5. writing (speed of writing and written summary skills).

Despite their similar verbal and nonverbal abilities, the two groups differed from each other in all assessed areas (literacy, cognitive processing, fluency, attention and writing), with the exception of one of the three fluency tasks, semantic fluency. The fluency tasks assessed fluency in three areas, semantic, phonemic and rhyme fluency. In the case of semantic fluency the individual was required to name as many items as possible in 30 seconds in the categories of "animals" and "food" (e.g. category-**animals**, response "**bear, dog, cat**..."). The phonemic fluency task allowed the same 30-second time limit, however, in this task the individual was required to provide as many words as possible beginning with a designated phoneme (e.g. /**m**/, response, " **milk, money, mud**..."). The rhyme fluency task required participants to name as many words as possible that rhymed with a target word in the 30-second time interval (e.g. target "**play,**" expected response "**say, day**..."). The dyslexic group did not differ significantly from the control group on the measure of semantic fluency, but differed significantly on the rhyme and phonemic tasks. This finding suggests that lexical access in general may not be challenging for the dyslexic, but that specifically the rapid retrieval of phonological information may be problematic for the dyslexic.

Although the issue of timing, or temporal processing, is hypothesized to be a critical factor in word retrieval and therefore, fluent reading, Berninger, Abbott, Thomson, and Raskind (2001b) remind researchers that reading fluency on different component tasks (e.g. nonword reading, real word reading and text reading) may be influenced differently by the variability of the underlying basis in temporal processing deficits. Berninger Abbott, Billingsley and Nagy (2001a) suggest that there are different component processes that may be at the basis of fluency. They suggest that efficiency (speed of temporal processing), automaticity (speed of lexical access and phonological output), and executive function (the ability to attend, coordinate and monitor reading, respectively) are all separate processes that may influence oral reading skill. Berninger et al. (2001a) propose that deficits in any of these components (efficiency, automaticity, or executive function) may interfere with oral reading and result in a variety of different types of dysfluency (e.g. slow accurate reading, repetitions with good monitoring, errors with poor monitoring). Therefore, reading fluency on nonword reading, real word reading and text may vary within and across individuals.

In a family genetics study using 102 reading disabled elementary school children (grades 1-6) and their parents, Berninger et al. (2001b) assessed a variety of behaviors including reading and writing fluency. Among the 23 psychometric measures administered, each of the children in this study engaged in a nonword reading, a real word reading and a text reading aloud task. Berninger et al., (2001a) report that only 16% of the participants in that study had deficits in all three of the reading fluency measures administered, concluding that timing deficits may result in individual performance differences across tasks.

In summary, rapid word recognition and lexical access are considered critical for the development of fluent reading. Fluent reading, judged by either rate of reading or the number of pauses and interruptions, is considered to indicate that a reader comprehends the text, certainly in children through grade 8. Generally as individuals get older (beyond 8th grade) one would expect fluent, automatic reading. Upon hearing a slow, inaccurate oral reader one is likely to judge that individual as being a "poor reader" who is thought to have inadequate comprehension. While this is a reasonable assumption, I hypothesize that it is possible for individuals with word recognition deficits during oral reading to use compensatory skills that result in their having good reading comprehension despite their persistent word recognition deficits. Bruck proposes that one explanation for a discrepancy between poor word recognition and apparently good reading comprehension may be that the measures of reading comprehension are poorly devised. An alternative possibility, is that poor oral reading fluency may reflect only the readers' inferior phonological representation, despite their adequate ability to access words via the whole word lexical representation. Furthermore, individuals who are able to access lexical representations, despite poor phoneme-grapheme representation, may have particularly strong cognitive mechanisms that enable efficient lexical access and linguistic manipulation in spite of weak access via the phonological mechanism.

E. Linguistic Factors Influencing Reading Performance

As previously mentioned, the ultimate goal of reading is to develop the ability to understand and learn from the written word, or comprehend text. I hypothesize that it is possible to have good silent reading comprehension with persistently poor decoding skill, or poor phonological awareness. Since reading is a linguistic task, comprehension of the written word may be facilitated by numerous linguistic variables. Furthermore, it could be assumed that individuals with good reading comprehension possess good linguistic knowledge. In this section I will explore the linguistic variables that may influence the development of reading comprehension.

There are five linguistic factors that clearly influence reading performance. The first, discussed in a previous section, is phonological skill, which has the potential to affect reading capability and ultimately reading comprehension.

Second, lexical access, or the ability to associate a visual representation (written word) with a semantic representation, is important. Skilled reading requires rapid lexical access of familiar words (e.g. high frequency words), unfamiliar words (e.g. low frequency, irregular words), and words with affixation or grammatical morphology (e.g. **-ing**, **-ed**, **-ly**, etc.). As previously stated, the reading disabled are found to have slow word recognition skills, which persist into adulthood (Bruck, 1990; Leij and van Daal, 1999). While it may be argued that the slowness is the result of poor decoding skill, it can also be argued that this slowness is the consequence of a deficit in lexical access (Rubin and Clinton, 2002).

The third factor of significance to reading is vocabulary or word knowledge (Stanovich, 1986). Swanson and Trahan (1996) found children (mean chronological age of 10.5 years) with reading difficulties perform poorly on vocabulary measures when compared to average readers. Additionally, Stanovich points out that good readers are apt to read more, thus expanding their vocabulary, while poor readers, who are less likely to read, fall increasingly behind in their vocabulary growth. The correlation noted between vocabulary and reading skill in children has been confirmed in skilled readers as well. Baddeley, Logie, and Nimmo-Smith (1985) reported a correlation between vocabulary and reading comprehension in a sample of adults ranging in age from 18-60. A strong knowledge of vocabulary suggests knowledge of varied word types and an understanding that words can be used in different contexts to mean different things. Lexical ambiguity may cause the reader to have difficulty deriving meaning from a sentence or text. This happens when words with multiple meanings are used, as in the sentence " The boy eagerly anticipated the hero." In this sentence the word "hero" could be referring to a large sandwich, or, a courageous individual. Stronger vocabulary skills enable the reader to more easily disambiguate words in text. Accurate understanding of varied semantic configurations requires that the reader have knowledge of the construction of language and the ability to manipulate that structure (MacDonald, Just, and Carpenter, 1992). This manipulation requires higher-level linguistic skill.

There are dissenting reports however. Recall the previously mentioned study of Fischer et al. (1985) who reported that the poor spellers in their study, though considered good readers (based on the Wide Range Achievement Test), had mean oral reading grade equivalents that were 2 years below those of the good spellers. There were no significant group differences between good and poor spellers on the vocabulary subtest of the Wechsler Adult Intelligence Scale, however. Important to note is the distinction between reading skill, as assessed by measures of word-reading aloud, and, reading comprehension, as measured by demonstrating an understanding of what has been read. While Fischer et al. report no group differences between skilled and less skilled readers on the vocabulary subtest of the Wechsler Adult Intelligence Scale, they did find group differences on their measure of skilled reading which was single-word reading aloud. In actuality, a single-word reading task provides information with regard to decoding and word recognition, of acknowledged import, but this does not assess an understanding of words read. Thus, I propose that we are likely to find a correlation between reading comprehension skill and vocabulary, or reading comprehension and word knowledge.

The fourth linguistic factor of importance is the ability to comprehend complex syntactic structures. Readers rely on their knowledge of word order and morphology in order to parse sentences. The skilled reader is expected to be capable of understanding simple sentences with one clause (e.g. "Michael assembled the newly acquired bicycle."), and more complex sentences with multiple clauses assembled in a variety of grammatical arrangements (e.g. "That the candidate from Arizona won the election amazed us." Or, "The ring he gave Mary was stolen by the intruder."). Moreover, some sentences are constructed in such a way as to create temporary ambiguity. For instance, the simple sentence "She read the letter to her cousin in Italy" could be interpreted to mean that the two were in Italy when she read the letter to her cousin, or, the cousin, who was in Italy, was read the letter. Understanding varied grammatical structures requires a sophisticated knowledge of language and higher-level manipulative skill, which may be related to cognitive factors discussed in the next section.

The fifth influential linguistic factor is the ability to derive implied information, or draw inferences, from text. McKoon and Ratcliff (1981) describe a model for the mechanism used in drawing inferences. This model is proposed to consist of three steps: a) the inferred facts must be retrieved from memory (which implies a prior knowledge of these facts) b) these inferred facts must be held actively in memory and c) the initial notion that activated the inferred facts must be associated with the current thought and subsequently transferred to storage in order to understand the intended message of the text. Skilled reading requires inference-generation (e.g. Fisher and Peters, 1981). Klin, Guzman, and Levine (1999) investigated readers' ability to formulate predictive (forward) inferences, or inferences about things that are presumably going to happen. They found that readers do draw forward inferences, particularly when the text is highly predictive or constrained. Evidence suggests that the ability to draw inferences is dependent upon "underlying cognitive capability" (King and Just, 1991; Masson and Miller, 1984; McKoon and Ratcliff, 1981).

In conclusion, there are clearly at least five linguistic factors that have the potential to influence reading performance; phonological skill, lexical access, vocabulary, syntactic skill, and inferencing skill being among them. If skilled readers have two available reading routes (lexical and phonological), I hypothesize that individuals who develop good reading comprehension in spite of poor decoding skills are likely to demonstrate a distinctness in linguistic skill development. The individual with poor phonological access who is able to develop good reading comprehension is apt to have strengths in other linguistic domains that enable the development of good reading comprehension. In addition to exploring the phonological skills of able silent readers, the present study will assess the efficiency and accuracy of lexical access. Since inferencing and vocabulary skill are proposed to be correlated with cognitive skills, these linguistic components will be examined in this study through measurement of cognitive factors believed to influence reading performance.

F. Cognitive Factors Influencing Reading Performance

As previously established, there are a variety of linguistic factors that influence reading performance. And, because reading is a complex task relying on linguistic and cognitive skills, it is important to this investigation to consider the cognitive factors that are likely to influence reading performance. Therefore, this section of the paper will review the influence of intelligence and working memory on reading skill.

Intelligence

Intelligence, or cognitive capability, is generally conceptualized as the innate competency of an individual to learn and manipulate information. Intelligence measurements, reported in the form of an intelligence quotient (IQ), are presumed by many to be indicators of cognitive capability. Generally speaking, IQ is often used as a predictor of performance and academic success. Despite the expectation that IQ be a predictor of performance, there are individuals who have average or above average IQ, and yet fail to develop linguistic skills in the anticipated manner. Most notably, this is the case in children with specific language impairment (SLI) and individuals with dyslexia.

Specific language Impairment (SLI) is a developmental language disorder in children who have no cognitive, frank neurological, or psychosocial deficits (Watkins and Rice, 1994). However, despite their cognitive potential for learning, they are deficient in their ability to effectively acquire language.

Likewise, dyslexia may be defined as a disorder of reading (presumed to be a linguistic skill) in individuals who have average or above average IQ. For many, this IQ-achievement discrepancy is a prerequisite for the diagnosis of dyslexia (Catts and Kamhi, 1999). Poor readers with a low IQ have been labeled with a variety of descriptors including "garden variety poor readers" (Stanovich, 1991).

Let us consider, then, the relation between IQ and the numerous linguistic factors discussed in the prior section (including phonological skill, speed of lexical access, vocabulary and the ability to understand complex syntactic structures that have been previously cited to influence reading performance and the development of fluency). Evidence suggests that there is no correlation between naming speed, a factor linked to the development of fluency, and IQ (Biemiller, 1977). It has been hypothesized that there is the possibility of a link between intelligence and reading proficiency (deJong and deJong, 1996; Swanson and Alexander, 1997).

Examining the link between cognitive factors and reading skill, Swanson and Alexander compared a group of reading disabled elementary school children with a group of skilled readers (age of the children ranged from 8-12) of similar intelligence. The reading disabled group had full scale IQ scores on the Wechsler Intelligence Scale for Children of over 90 (scores ranged from 90-105). IQ scores were not reported for the skilled readers, who had average percentile scores on the Colored Progressive Matrices Test (as did the reading disabled group). The study included tasks designed to assess phonological awareness (e.g. phoneme blending, phoneme deletion), orthographic awareness (e.g. identifying words from nonwords), word knowledge (e.g. vocabulary), working memory (e.g. reading span), a metacognitive questionnaire, nonverbal IQ (as measured by the Colored Progressive Matrices Test), and assessment of reading skill (e.g. cloze task, standardized assessment of comprehension). While their participants were all considered of average intelligence, the less skilled readers performed more poorly than the skilled readers on all of the other cognitive measures. Based on their analysis of the findings, Swanson et al. argue that reading skill is dependent on the integration of cognitive and linguistic factors, and the less skilled readers rely relatively more on their metacognitive skills.

Also exploring the relation between cognitive skill and reading in a sample of elementary school children, de Jong and de Jong (1996) included two tests in their protocol that they identified as "reasoning tests." The first test, the *Figural Analogical Reasoning Test,* required the participants to draw conclusions on figure alterations based on a picture analogy ("Figure A" transforms into "Figure B", therefore, "Figure 1" transforms into "____"). The second test, the *Categorical Thinking Test,* required participants to examine pictures and determine which of the pictures shared similar features (e.g. similar physical characteristics, "glass objects"). These two tests were sections of a standardized measure of nonverbal intelligence, Snijders-Oomen NonVerbal Intelligence Test –Revised (as cited in de Jong and de Jong)). These reasoning tests were found to have a stronger correlation with reading comprehension (.53) than the correlation between working memory capacity and reading comprehension (.20). This finding of a weak correlation between working memory and reading comprehension is atypical of the larger literature, which will be discussed in the subsequent section.

Furthermore, it should be noted that the authors selected nonverbal intelligence tests involving visual tasks. While these nonverbal tasks may be adequate for exploring the reasoning abilities of individuals, verbal IQ measures would appear more closely linked to a linguistic task such as reading. If there were a correlation between IQ and reading comprehension skill, verbal IQ measures would be likely to reveal that correlation. This is in keeping with the suggestion of Stanovich (1991) who argues that verbal IQ provides greater insight into reading capability than nonverbal IQ.

If IQ is a measure of higher-level capability that is important to the development of reading comprehension, individuals with a higher IQ may be capable of developing good semantic access for written words, despite their inability to efficiently decode words (poor oral reading). If there is no relation between IQ and the dissociation between poor oral reading fluency and good reading comprehension, it could be concluded that compensatory capabilities are based on other cognitive factors.

Working-memory

Working-memory, the term used to describe the cognitive mechanism available for temporary storage and information processing, has been theorized to be an integral component of reading comprehension skill. The notion of working-memory as a mechanism used for information processing and information storage is a departure from the previously accepted multistore model of memory (Craik and Lockhart, 1972). Multistore models of memory proposed that information was transferred from limited capacity storage mechanisms, through transient mechanisms, to large-capacity permanent-storage mechanisms. The limited-capacity mechanism, previously referred to as short-term memory, was hypothesized only to store information, not to process information. While working-memory is still believed to have a limited capacity, it is now widely accepted that both encoding and information processing occur while information is in working-memory (Daneman, M., and Carpenter, P.A., 1980; Masson and Miller, 1983).

Daneman and Carpenter (1980) suggest that working-memory efficiency and capacity may explain differences in reading comprehension skills. They developed a measure of working-memory that involved sentence comprehension as well as retention of word information, in the hopes of imposing greater processing demands than the previously accepted serial recall tasks. They argued that serial recall tasks (e.g. recalling a series of digits), customarily used to measure memory, imposed storage demands, but neglected to impose processing demands. Their measure, the Reading Span Test, was developed based on the assumption that reading comprehension requires encoding, storage, and information retrieval (See Daneman et al., 1980, for a complete description of the test protocol). The measure derived is used to quantify an individuals' capacity for information storage and information processing.

Administering the Reading Span Test to 20 college students, Daneman and Carpenter (1980) found a significant correlation between working-memory capacity and standard measures of reading comprehension (i.e. SAT scores). This finding of a correlation between the reading span test and measures of reading comprehension (e.g. Nelson Denny Test of Reading Comprehension and experimental tasks devised to measure an understanding of written text) has been replicated by researchers using somewhat larger set of individuals (Masson and Miller, 1983; Baddeley, Logie, and Nimmo-Smith, 1985). Thus, the correlation between the reading span test and reading comprehension suggests that working-memory capacity may account for differences in reading comprehension skill.

Masson and Miller (1983) argue, however, that working-memory capacity correlates with measures of reading comprehension due to the crucial requirement of the reader to integrate information in text, to infer notions from text, and to encode information into long-term memory for later retrieval. They maintain that these processing components are integral to reading comprehension.

Masson and Miller collected data from 29 college students on six tasks: (a) a serial recall task (letter strings ranging from 4-10 units), (b) the Reading Span Test (Daneman and Carpenter, 1980), (c) an explicit reading comprehension test (a fact test based on information explicitly stated in text; based on Walker and Meyer, 1980), (d) an inferential reading comprehension test (information derived from explicitly stated facts; based on Walker and Meyer, 1980), (e) a Cloze Test (used as a measure of reading processing during the Reading Span Test), and (f) the Nelson-Denny Reading Test (a standardized measure of reading comprehension). They were able to confirm the previous finding of Daneman and Carpenter of a correlation between the Reading Span Test and measures of reading comprehension. Additionally, Masson and Miller found a strong correlation between reading span scores and the comprehension of both explicit and implicit information. The authors argue that these findings strongly suggest that working-memory capacity is directly related to the ability to integrate information and draw inferences from written text. As previously discussed, the ability to draw inferences is an important component of reading comprehension. Masson and Miller speculate that individual differences in working-memory capacity explain the variability in reading comprehension skills, however, such capacity differences are also important in the formation of long-term representations of comprehended material for later use in drawing conclusions.

In addition to the evidence suggesting that working-memory capacity correlates with reading comprehension skill and the ability to draw inferences, it has also been argued that differences in working-memory capacity affect processing of more complex syntactic structures (MacDonald, Just and Carpenter 1992; King and Just, 1991). As previously mentioned, the ability to parse complex syntactic structure is an important linguistic component for skilled reading comprehension.

In summary, it has been hypothesized that the larger the working-memory capacity of individuals, the more material (or concepts) are likely to be stored and available for use during their reading. A larger working-memory capacity enables the reader to have access to previously read information in order to arrive at conclusions. The research suggests that reading comprehension skill (Daneman et al., 1980; Baddeley et al., 1985), inferencing skill (Masson and Miller), and the ability to comprehend complex syntactic structures (MacDonald et al., 1992; Just et al., 1992; King et al., 1991) all correlate with an individuals' working-memory capacity. It is argued that the larger the capacity of working-memory, the more skilled is the reader at storage and information processing. Therefore, individuals with larger working-memory capacity are predicted to have superior reading comprehension skills.

While there is substantial evidence to argue that working-memory capacity may indeed influence reading comprehension skill, there are issues in this research that should not be ignored. The most commonly used measure of working-memory capacity is undoubtedly the measure devised by Daneman and Carpenter. While this measure of working-memory capacity has repeatedly been found to correlate with measures of reading comprehension, there are methodological concerns associated with determining an individual's working-memory capacity (Caplan and Waters, 1999).

Waters and Caplan (1996) explored some of those concerns when they investigated the correlation between the Reading Span Test and other measures of working-memory capacity. They indeed found a correlation between various working-memory measures, however, they indicate that the test-retest reliability of Daneman and Carpenter's task was not high ($r = .41$). Due to the instability of this measure, Caplan and Waters suggest using a composite measure of working-memory. Therefore, for this study working memory capacity will be measured using the Daneman and Carpenter protocol, but additionally, each individual will be administered the working memory subtest of the Wechsler Adult Intelligence Test III (a derived score of recall tasks).

If the ability to engage in complex information processing correlates with working-memory capacity, and it appears to, it would seem that working-memory capacity is integral to skilled reading. If individuals with decoding deficits possess a large working-memory capacity, they may have a mechanism available to them that enables compensation for their deficits. If this is the case, one might expect to find that individuals who have a large working-memory capacity and poor oral reading skills, could in fact have good reading comprehension. If, however, there is no relation between working-memory capacity and the dissociation between poor oral reading fluency and good reading comprehension, one would conclude that compensatory capabilities are based on other cognitive factors.

G. Dissociation Between Oral and Silent Reading Skill

As mentioned above, oral reading fluency may be considered an indicator of reading comprehension. The evidence would suggest that fluency is dependent upon rapid word decoding and fast word retrieval skills. However, there are special groups of individuals who fail to show an association between word recognition, oral fluency, and reading comprehension. Direct dyslexia and hyperlexia are two of the disorders that most elegantly illustrate the dissociation between oral reading and reading comprehension.

Direct dyslexia is an acquired reading disorder characterized by the readers' ability to read aloud words that they are unable to comprehend (Rayner and Pollatsek, 1989). This is often observed in adults who are in the earlier stages of dementia. Schwartz, Saffran, and Marin (1980) report on an individual with dementia who was able to read regular and irregular words aloud, but was unable to match pictures and words. In these situations, the reader appears unable to access the semantic representation of written words, but retains access to the visual and phonological representations.

Individuals with hyperlexia, a developmental disorder, similarly display good oral reading skills, and yet are often unable to comprehend the words they read. Aram and Healy (1988) point out that hyperlexic children often have low IQ's, slow speech development, and poor expressive language skills. According to Aram et al., these children generally begin reading during preschool. The age of initiation of reading behaviors (indeed, the compulsion to attend to written material) has been reported in these children as early as one year old (Goodman, 1972). And, despite the ability of individuals with hyperlexia to read both words and nonwords, their decoding strategies do not appear to be related to reading comprehension, or phonological awareness (Sparks, 2001). In a longitudinal study, Sparks examined three hyperlexic children, first in 1990 and again in 1998. Each child participated in a series of tasks including measures of oral word-reading, oral paragraph reading, IQ, oral word knowledge and phonemic awareness. Among the reported data, is evidence that these three readers display phonological awareness skills that do not correspond with decoding skill. Therefore, individuals with hyperlexia appear to be capable of decoding words efficiently and reading fluently, in spite of being significantly deficient in spoken communication and reading comprehension.

In addition to the evidence of dissociation in individuals with hyperlexia and direct dyslexia, reports of individuals with acute neurological episodes additionally demonstrate this phenomenon. The case of JA, a 59 year old with deep dyslexia reported on by Katz and Lanzoni (1997), is such an instance. JA, an individual who had a sudden neurological episode, had poor scores on oral reading and writing. However, his ability to access meaning from words was relatively good. When presented with three semanticly related words (e.g. **knife, fork, spoon**) JA was able to point to the target word on 20/24 trials. Despite this ability to recognize the printed word, JA read aloud correctly only 29/60 object names on this task. He was noted to make a variety of reading-aloud errors including semantic errors (e.g. **bed/pillow**), derivational errors (e.g. **dart/darts**), and phonetic errors (e.g. **noose/loose**). In a condition where JA was supplied a phonetic cue, to stimulate word access, correct reading improved. Interestingly, in an additional reading condition where JA was supplied 21 trials of a miscue (e.g. target word "cigar", miscue /pai/) the researchers were able to provoke a semanticly related error 5 times (error word "pipe"). While miscues were used to produce semantic error responses in only 5/21 trials, this evidence suggests semantic and phonological activation of words. Katz et al. propose that, "...oral reading depends on activating the appropriate representation and inhibiting competing representations" (p.56). They argue that the printed word activates multiple semantically related targets and poor inhibition of competing representations causes semantic errors. Hence, the visual representation may provoke semantic access, with incomplete access to the correct phonological representation, rendering such a brain injured person likely to make semantic oral reading errors.

In summary, the disordered populations provide evidence of a variety of dissociations in reading skill. Direct dyslexia provides evidence for an intact phonological mechanism with a deficient semantic mechanism. Acquired deficits such as deep dyslexia and surface dyslexia provide support for the notion that either the whole word lexical route or the phonological route may be impaired. Likewise, the heterogeneity of developmental dyslexia suggests the potential for deficits via either the phonological or lexical route. And, despite the literature suggesting that efficient decoding and rapid word recognition are prerequisites for fluency and reading comprehension, individuals with hyperlexia provide evidence that, in fact, fluency and rapid word recognition are possible without understanding. Individuals with hyperlexia provide evidence of a possible dissociation between oral reading capability and reading comprehension skill. Consequently, we might expect to find people with no frank neurological damage who possess the ability to access semantic representations efficiently, despite persistently poor access via the phonological mechanism. These individuals would likely demonstrate poor oral word decoding, poor spelling, good semantic access and good reading comprehension. They may have experienced trouble in the earlier stages of learning to read, but were not necessarily individuals who were identified as having a reading disorder.

H. Research Questions

To summarize, previous reading research suggests skilled reading requires the integration of various linguistic and cognitive capabilities. Skilled readers must possess a good knowledge of vocabulary with rapid lexical access. They must demonstrate sophisticated syntactic skill, have good inferencing ability, and the cognitive proficiency to integrate all of these components. Efficient decoding and word retrieval, with proficient integration of information, enables skilled fluent reading with good reading comprehension.

As previously mentioned, the disordered populations provide evidence of a variety of dissociations in reading skill. Dissociation in reading skill supplies us with information regarding individual strength and weakness. Improved awareness of these strengths and weaknesses facilitates our ability to understand the capabilities that may enhance reading performance when underlying constituent skill deficits exist.

A review of the pertinent literature and consideration of the models of reading, then, led to a pilot study intended to explore the relation between oral reading fluency and reading comprehension. This study, using 12 young adult readers, examined the relation between silent reading comprehension and oral reading fluency. Indeed, the pilot data on fluent and dysfluent young adult readers suggested that some individuals are able to have good semantic access, for both single words and text, while simultaneously demonstrating poor oral word reading and poor spelling (Schmidt, Obler, Ehri, Chodorow, 2002). Therefore, the study reported here was intended to find significant factors linked to the variance in reading fluency. The following questions were posed: First, is it possible for individuals who are slow, inaccurate oral readers to possess compensatory skills that result in their having good reading comprehension? Second, is there a correlation between cognitive factors (working memory, speed of access, and IQ) and efficient lexical access? Third, is there a correlation between spelling and oral reading skill? And finally, despite group correlations across variables, are there individuals who show interesting dissociations?

Predictions

Research Question 1

Is it possible for individuals who are slow, inaccurate oral readers to possess compensatory skills that result in their having good reading comprehension?

Prediction

It is expected that silent reading comprehension and oral reading rate will not be correlated in young adults. This is expected based on previous reports in the literature and the pilot data providing evidence of individuals who were slow inaccurate readers with good reading comprehension. Furthermore, it is expected that since oral reading requires obligatory rapid access to grapheme-phoneme information, oral reading rate will be correlated with single-word reading aloud, nonword reading, and processing speed (see Figure 1). The correlations between oral reading and nonword reading, and oral reading and single-word reading, are expected based on the assumption that word reading and nonword reading both require knowledge of grapheme-phoneme correspondence. Processing speed and oral reading rate are expected to be correlated based on the assumption that the speed with which visual information is processed will influence the rapidity of phonological output.

Moreover, since reading comprehension relies on semantic access, it is predicted that the Nelson Denny Test and semantic-judgment (Single-Word Silent Reading) will be correlated with each other.

Therefore, it is hypothesized that there will be individuals who possess adequate ability to access semantic information directly (good reading comprehension), but who lack the ability to efficiently and fluently utter text during oral reading.

Research Question 2

Is there a correlation between cognitive factors (working memory, speed of access, and IQ) and efficient lexical access?

Prediction

There will be a significant correlation between efficient lexical access, as measured by reading comprehension, and cognitive factors, particularly working memory capacity and verbal IQ. It is presumed that the greater one's working memory capacity, the greater one's ability will be to manipulate and store information, thereby improving comprehension. Furthermore, the better an individual's Verbal IQ, the more likely that individual is to have a strong knowledge of vocabulary and linguistic structure, both important components associated with stronger reading comprehension.

Research Question 3

Is there a correlation between spelling and oral reading skill?

Prediction

There will be a significant correlation between spelling and oral reading skill. This is expected based on the previous research and the assumption that spelling relies on knowledge of grapheme-phoneme relations and morphophonological structure, skills that are also necessary for oral reading.

Research Question 4

Despite group correlations across variables, are there individuals who show dissociations of interest?

Predictions

It is expected that there will be individuals who show dissociations of interest. As an example, the stronger an individual's cognitive skill (e.g. working memory capacity, verbal IQ) the more likely that individual is to have good reading comprehension, even in the absence of proficient decoding skill. Additionally, as a result of individual differences in visual recognition and grapheme-phoneme knowledge the dysfluent readers will produce more overall real word substitutions, morphological substitutions, and pauses due to explicit decoding deficits.

Chapter II: Method

A. Participants

Forty-one individuals ranging in age from 16-36 (mean = 21.32), 13 males and 28 females, were recruited for this study from Molloy College, Rockville Centre, NY. Announcements were made in classes, posters circulated asking for students to volunteer for a study on reading, and professional colleagues were contacted and provided flyers to post in their offices. In addition to demonstrating academic success as evidenced by their ongoing education, all participants were administered a standard reading comprehension assessment, the Nelson Denny Reading Test. All participants reported being native English speakers, with corrected or normal vision, normal speech, language and hearing, and no known neurological deficits. The participants included 9 high school students and 33 individuals who had one or more years of college. When questioned about their educational history, 11 of the 41 participants reported that they had had childhood learning difficulty. These 11 individuals reported some type of instructional support (e.g. reading tutor, resource room). However, all report functioning in their current educational environment without academic support services.

B. Materials

Reading Skill

Reading Comprehension

The Nelson Denny Reading Test (Brown, Fischo, Hanna, 1993) was administered to each participant. This test requires the individual to read a series of passages and answer a set of multiple-choice questions. This measure was administered with paper and pencil according to the protocol established in the test manual in a quiet, well-lit room, free of distractions.

Participants were instructed to read as many passages as possible in the allotted time and answer the multiple-choice questions (as specified in the instruction manual). The time limit using the standard administration is 20 minutes. Given the slow word recognition of poor readers, the extended time option was made available to facilitate performance and accurately evaluate skill. The extended time of up to 32 minutes was allowed for each individual. Of the 41 participants 16 completed the entire test in 20 minutes or under and the remainder of the participants used the extended time. The examiner noted that some of the individuals who took the extended time had actually completed the test but used the extended time to review their responses for accuracy. Individuals were instructed as follows:

"Please read each of the passages and answer the multiple choice questions on the score form by filling in the appropriate bubble with your pencil. I will be timing how long it takes you to complete the test. If you should finish before you have reached the maximum time limit permitted please tell me so that I may stop the clock."

Oral Text Reading

In order to determine fluency during text reading, individuals read aloud a passage of approximately 200 words from a previous version of the Nelson Denny Reading Test. This oral reading was tape recorded and timed with a stopwatch. Three measures were derived from this oral passage reading: 1. reading speed (words per minute or WPM), 2. number of words read correctly per minute (correct-WPM), and 3. a dysfluency measure (total number of oral reading errors that interrupt the smoothness and reflect a lack of automaticity of reading).

The examiner determined the number of words read per minute (WPM) by timing each participant and calculating their overall reading time for the passage. The number of words in the passage was divided by the reading speed in order to derive WPM. In calculating WPM no consideration was given to errors or the types of errors produced.

In order to calculate correct-WPM and dysfluency, an analysis of oral reading errors was performed by listening to the recorded passage reading for each participant and transcribing errors. Each error was recorded for each participant using the following categories: 1. the number of real word substitutions (e.g. **"strain"** for **"string"**), 2. the number of real word repetitions (e.g. "**physics...physics**;" " **The**

absolute measure...the absolute measure..."), 3. the number of grammatical morpheme errors (e.g. **"waked"** for **"waking," "pursue"** for **"pursued," "comprehended"** for **"comprehend"**), 4. the number of nonword productions as errors (e.g. **"estrined"** for **"estranged"**), 5. the number of pauses caused by explicit evidence of decoding difficulty (e.g. "...ex...extra...extemporaneous"), 6. the number of word additions (e.g. adding the word **"on"** in the sentence **"He went** (on) **his way.**"), 7. word omissions (e.g. **"He went** (all) **the way home.**"), 8. transpositions (e.g. **"He went never...**" for **" He never went..."**). For each error category (1-8), each occurrence counted as one error, regardless of the length of the occurrence (e.g. The reader reads " ...**physics...physics**..." and " ...**the absolute measure...the absolute measure**..." and each of these count as one error despite the length of the repetition).

Once the number of errors was determined in each category for each participant, it was possible to calculate the correct-WPM, or accuracy, of each individual. Correct-WPM was derived by determining the number of words correctly read in the passage by each participant and dividing that number by the time it took an individual to complete the oral reading of the passage. For this analysis no consideration was given to the errors that resulted in correct word reading: 1.the number of pauses caused by explicit evidence of decoding difficulty when the correct word was eventually produced (e.g. "...**ex...extra...extemporaneous**"), 2. the number of word additions (e.g. adding the word **"on"** in the sentence **"He went** (on) **his way.**"), 3. transpositions (e.g. **"He went never...**" for **" He never went..."**), 4. the number of real word repetitions (e.g. "**physics...physics;**" **" The absolute**

measure...the absolute measure..."). Only those errors resulting in wrong word production or no word production were counted in this analysis. The following error types would be considered a wrong word production: 1. real word substitutions (e.g. "**strain**" for "**string**"), 2. grammatical morpheme errors (e.g. "**waked**" for "**waking,**" "**pursue**" for "**pursued,**" "**comprehended**" for "**comprehend**") 3. nonword productions (e.g. "**estrined**" for "**estranged**") 4. word omissions (e.g. "**He went** (all) **the way home**.").

Lastly, the measure of fluency was determined. This measure was calculated by totaling all the errors made by each individual in all of the previously identified 8 error categories.

In addition to the examiner, a second rater, a student of speech-language pathology, independently completed an error analysis of 50% of the oral text reading samples. Interrater reliability for the number of oral reading errors was 91% agreement.

Decoding and Single Word Reading Aloud

Since poor oral readers are hypothesized to have poor decoding skills, the participants performed two decoding tasks. The first, the Reading subtest of the Wide Range Achievement Test III (WRAT-3) (Wilkinson 1993) was used for the single-word reading task. The test, normed for individuals aged 5-75, requires reading a list of 42 words aloud (e.g. **letter, residence, longevity**). The test was administered according to the guidelines specified in the administration manual. The instructions to the participants were as follows:

" I will give you a card with words on it. Look at each word and read it aloud. Read the words on the top line first and than proceed row by row until you finish the list. Some words will be familiar and others will not. Please do the best you can to read all the words."

The examiner sat next to each participant and noted performance on a score sheet.

The second decoding task was nonword reading. The initial 18 participants, who participated in the protocol early in the development of this project, were administered an experimental nonword list which was composed of 4 practice items and 35 target letter-string units, composed of one and two syllables, ranging in length from 4-8 with a mean of 6.17 (e.g. **culk, uldrane** see Appendix A) (Bruck 1990). Based on the results of the pilot study and a suspicion that these nonwords were not sufficiently complex, the stimuli for the nonword-reading task were changed. The experimental test used for the first 18 participants was replaced with the Word Attack subtest of the Woodcock Johnson (WJ). The Woodcock Johnson task is composed of 29 nonwords and 2 practice items varying in both letter length and syllable length (e.g. **chur, darlanker**). Twenty-four of the participants were administered the Woodcock Johnson (either as their primary nonword reading task [n=23], or after being called back to participate in this task [n=1]). Since not all participants were able to return for retesting, raw data from the two different nonword reading measures are reported separately in the tables. Subsequently, the raw scores on these 2 nonword measures were converted to z-scores in order to complete the statistical analysis.

The nonword reading task (either the experimental task or the Woodcock Johnson) was administered on a computer screen. Individuals were presented with practice words before the task items began and were able to self-pace the task using the space bar on the computer. The instructions to the participants were as follows:

"A string of letters forming a nonword will appear in the center of the screen. Please look at the nonword and say it aloud as quickly as possible. Press the space bar on the computer and the next word will appear. The task will begin with some practice items."

Nonwords were transcribed phonetically on a score sheet for the experimental task and errors were noted on the score sheet. The prepared score form was used for the Word Attack subtest of the Woodcock Johnson and the number of nonwords read correctly was determined.

Two raters individually scored the WRAT-reading, and nonword reading tasks. The first rater was the examiner. The examiner scored these tasks on prepared score sheets during administration and later calculated the number correct. The second rater was a student of speech-language pathology who listened to the taped procedures and scored the responses on prepared score sheets. Interrater reliability on these tasks was 96%.

Silent Single-Word Reading

To examine the hypothesis that lexical access is possible despite poor decoding skill, participants also engaged in a semantic judgment task. This experimental reading task, the Single-Word Silent Reading Test (SWSRT) consists of 40 word pairs, 20 pairs of synonyms (e.g. **demonstrate/illustrate**) and 20 non-synonym foils (e.g. **estuary/respire**) (see Appendix B). The word-pairs were matched for letter-length and frequency of occurrence in English (according to Kucera and Francis, 1967). The letter-length of the synonyms ranged from 4-12 with a mean of 7.97 and the frequency of occurrence in English ranged from 1- 73 with a mean of 21.4. The foils ranged in letter-length from 4-11 with a mean letter-length of 7.63 and their word frequency ranged from 1-54 with a mean of 14.98. Word frequency was intentionally low in order to challenge skilled readers and prevent the student participants from reaching ceiling performance.

The 40 word-pairs were presented on a computer screen and the participants were asked to judge as quickly as possible if the words were the same in meaning (synonyms) or not. The word-pairs were displayed, one pair at a time in a vertical format (one word on top of the other) to avoid the need for left to right eye-tracking movements. Prior to the actual testing, three practice word-pairs were presented. The practice items were followed by 40 randomized word pairs, 20 synonym pairs and 20 foils. Participants indicated their response by depressing a computer key. The word-pair remained on the screen until the individual depressed a response key and the inter-stimulus interval was 1000 milliseconds. Reaction time measures (RT) were automatically tabulated and stored for each word-pair for each individual by the computer. This RT measurement initiated when the word-pair appeared on the screen and ended when the individual depressed a response key. The mean reaction time of correct responses was calculated for each individual. Reaction times +/- 3SD from the mean on correct items for an individual participant were excluded from the data. The participants were instructed as follows:

"Two words, a word-pair, will appear in the center of the computer screen. The words will be separated by a "plus" sign. Some of these words have the same meaning to each other (or synonyms) and some do not have the same meaning. As an example, for this task the words **bush** and **shrub** are the same in meaning and could be used interchangeably in a sentence. However, the words **cat** and **dog** are not the same in meaning and could not be used interchangeably in the same sentence (They are both animals, but they are different animals). Read these words silently and respond 'yes' or 'no' by pressing the designated button on the computer as quickly as possible."

Additionally, in order to determine individual familiarity for oral reading with the words on the SWSRT, the 24 participants were asked to read aloud the 80 items on the previously described SWSRT. This reading always occurred at some point after the silent synonym judgment administration of the SWSRT. The 80 SWSRT items were printed in Times New Roman 14 point font on an examination card. Participants were instructed as follows:

" I will give you a card with words on it. Look at each word and read it aloud. Read the words in the first column and then proceed by column until you finish the list."

The examiner sat next to the participant and noted errors on a prepared record sheet.

Spelling Skill

Spelling may provide evidence of group differences in the orthographic and phonological representation of words. Therefore, individuals' spelling skill was assessed using The Experimental Spelling Test (Fischer et al., 1985), as well as the spelling subtest of the Wide Range Achievement Test III (WRAT). As mentioned in Chapter I, The Experimental Spelling Test is comprised of three parts totaling 120 words. Each part consists of 40 words that differ in their degree of orthographic transparency (Appendix C). The test is composed of transparent words with high-frequency spelling patterns (e.g. **yam, inflate**), words with ambiguous portions (e.g. **picnickers, omitted**) and low orthographic frequency words, believed to require morphophonemic knowledge in order to spell (e.g. **Fahrenheit, gnaw**). The three lists are balanced for syllable length (mean = 2.8) and the frequency of occurrence in written English (mean = 6.1) (See Fischer et al. for a complete description of the test construction). The Experimental Spelling Test (Fischer et al., 1985) was administered by the examiner who said each of the 120 words aloud 2 times. The participant wrote each word out on a prepared sheet of paper.

The spelling subtest of the WRAT is a standardized assessment tool, containing 40 items of varied length and orthographic complexity. The spelling subtest of the WRAT-3 was administered according to the protocol established in the manual. That is, each word was stated by the examiner and used in a sentence.

The Experimental Spelling Test and WRAT-Spelling were independently judged by three raters. The first rater was the examiner. The additional two raters were students. Student number one scored the performance on the task of 20/41 of the participants and student number 2 scored 30/41 of the participants. The examiner used the original score forms in order to judge the number correct. The additional two raters used photocopies of the participants' score forms. When it was unclear from the handwriting what the participant intended, two of the raters came to an agreement with regard to the spelling. Interrater reliability was 97%.

Cognitive Skills

Wechsler Adult Intelligence Scale III

The verbal and nonverbal scales of the Wechsler Adult Intelligence Scale III (WAIS III) (Wechsler 1997), normed for individuals 16-89 years old, were administered. The WAIS III is comprised of 14 subtests: 1. Picture Completion 2. Vocabulary 3. Digit-Symbol Coding, 4. Similarities 5. Block Design, 6.Arithemetic, 7. Matrix Reasoning, 8. Digit Span, 9. Information 10. Picture Arrangement 11.

Comprehension 12. Symbol Search 13. Letter-Number Sequencing, 14. Object Assembly. All of the subtests were administered to each participant. This allowed the experimenter to derive a verbal IQ, nonverbal IQ and full scale IQ score for each participant. The verbal IQ is based on the following subtests: Vocabulary, Similarities, Arithmetic, Digit Span, Information, and Comprehension. The nonverbal IQ is derived by using the following subtests: Picture Completion, Digit-Symbol Coding, Block Design, Matrix Reasoning, and Picture Arrangement. Full scale IQ is determined by the combined performance on the verbal and nonverbal measures. Additionally, index scores where determined on Verbal Comprehension (using the Vocabulary, Similarities and Information subtests), Working Memory (using the Arithmetic, Digit Span and Letter-Number Sequencing subtests), Perceptual Index (using the Picture Completion, Block Design, and Matrix Reasoning index scores) and Processing Speed (using the Digit-Symbol Coding and Symbol Search tasks).

The WAIS III was administered according to the protocol in the test manual. The examiner administered the test in a comfortable, quiet environment.

Working Memory Capacity

Additionally, the Reading Span Test, a measure of working memory, was administered (Daneman and Carpenter, 1980). The protocol for administration of these measures was based on the protocol established by Daneman and Carpenter. The participants silently read three sets of unrelated sentences in each of five sentence categories (A sentence category was comprised of either 2 sentences, 3, 4, 5, and 6 sentences). Sentences range in length from 11-16 words, each sentence ending in a different word. Each sentence set (a set of 2, 3, 4, 5, or 6 six sentences) was followed by a true/false question pertaining to one of the previously read sentences. The task, self-paced, was presented on computer.

The working memory capacity score, as detailed by Daneman and Carpenter (1980) was calculated for each participant. This score is derived based on the category (e.g. two sentences, three sentences, etc.) in which the participant is able to orally recall the sentence-final words in two out of three sets (e.g. A participant recalls correctly two-out-of-three entire sets in the four-sentence set; his working memory score= 4). A score of .5 is given when one of the three sets is recalled (e.g. A participant gets 3/3 sets correct in the three-sentence set and 1/3 in the four sentence set. Her working memory = 3.5).

Since some individuals learn this task with greater ease than others, a modified working memory score (MWM score) was also calculated. This score was used to explore individual performance differences on this task. The MWM score is calculated based on the notion that an individual may fail to recall 2/3 in a given sentence-set (e.g. three sentences), but may move forward to accurately identify 2/3 sentence-final words in the 4 sentence set. In this situation the individual would be given the higher score of 4, despite having performed less accurately on the three-sentence set.

Rapid Automatized Naming

Since it has been previously noted in the literature that the reading disabled have difficulty with rapid access of lexical information, speed of retrieval was evaluated using a Rapid Automatized Naming Test (RAN) (Denckla and Rudel, 1976). As previously mentioned above, RAN can be administered using numbers, colors, letters and objects or a combination of any of these. Denckla et al. (1976) indicate that for dyslexic children letters and numbers are relatively easy and colors and objects are more difficult to name in quick succession. Goldberg-O'Rourke, Cohen, and O'Brien (2001) report that there are differences in the RAN performance of children when the original task format (number of items and pattern of stimuli) is altered. In a study comparing the original RAN letter task administered by Denckla and Rudel and the Rapid Letter Naming task of the Comprehension Test of Phonological Processing (CTOPP) (Wagner, Torgesen and Rashotte, 1999), Goldberg-O'Rourke et al. found the original RAN to more accurately identify those individuals with a reading deficit. Therefore, the RAN task used for this study was comprised of letters and colors, employing the format (number of items and pattern of stimuli) of the original task.

Two charts, or matrixes, of 5 items repeated in a random sequence of 50 were used as stimuli. The examiner administered the RAN task by presenting the charts one at a time. The participant was told to identify the items on the chart as quickly as possible. The instructions were as follows:

" I am going to give you a chart and on that chart you will find a series of letters (or colors). You are to identify the items as quickly as you can, starting in the upper left hand corner of the chart and go across each row until you complete the chart. I will be timing you."

Task performance was timed with a stopwatch.

Since this task was introduced after the pilot data were gathered, and not all participants returned in order to complete this task, a total of 33 participants were administered the RAN task.

C. Procedure

Thirty-two of the participants were individually tested in one session lasting approximately 3 hours. Since the experimental protocol was modified slightly after piloting, and the experimenter wished to include the pilot data in this study, 6 of these participants were initially tested in a 3-hour session but later recalled for approximately ½ hour in order to participate in the additional tasks. The remainder of the participants, three in total, were tested in two sessions, each of approximately 1-½ hours.

After participants signed the informed consent form, the protocol began with the completion of a questionnaire (See Appendix D). The questionnaire enabled the examiner to gather general information (See Appendix E) as well as engage each participant in informal conversation. This conversational period allowed the examiner, a certified speech-language pathologist, to informally assess each participant for fluency, or smoothness of connected speech. This assessment was necessary to insure that no dysfluent speakers (stutterers) be included in this study.

Once the questionnaire and conversation were completed, participants, seated comfortably at a table with two sharpened pencils, began the tasks. The order of reading comprehension, single-word reading, nonword reading, paragraph reading, spelling, RAN and working memory task presentation varied across participants. There were 8 test protocols in which each task varied in its order of presentation. In each different protocol any given task was preceded and followed by a different task (e.g. **Protocol 1**- 1. Nelson Denny, 2. oral paragraph reading, 3. Experimental Spelling Test, 4.WRAT, 5. Nonword Reading, 6. Silent Single-Word Reading Test, 7. Reading Span Test, 8. RAN; **Protocol 2**- 1. oral paragraph reading, 2. Silent Single-Word Reading Test 3. Nonword Reading, 4. Reading Span Test, 5. WRAT, 6.RAN, 7. Experimental Spelling Test, 8. Nelson Denny, etc.). Each individual was administered the WAIS III as the final aspect of the protocol. All were given the opportunity to take breaks between tasks.

Oral reading of text, nonwords, single-words, and the RAN task was tape-recorded using either a Marantz PMD201 portable cassette recorder with a built in microphone or a Sony TCM-354V cassette-corder with a Sony EMC-T6 voice-activated body microphone worn approximately 6 inches from the mouth on the individuals' collar. Their audiotaped responses were used for subsequent analysis.

Chapter III: Results

A. Reading Measures

Speed

Recall that the first of the four questions was whether it is possible for individuals who are slow, inaccurate oral readers to possess compensatory skills that result in their having good reading comprehension with good semantic access while demonstrating poor oral reading skill. Therefore, in order to determine if there were slow readers in the group, initial analysis of the data involved calculating oral reading rates for each participant on the 200-word standardized passage taken from an earlier version of the Nelson Denny Reading Test. The oral reading of the passage was timed and the mean rate of reading was determined for each participant by calculating the number of words read in one minute (WPM). As stated in the method section, in calculating WPM no consideration was given to errors or the types of errors produced.

WPM ranged from 80-158; mean=119.46; SD 23.08. Nine of the 41 participants were judged to have slow, often inaccurate, reading (at least 1standard deviation below the mean on this task; slow readers' mean= 88.08; SD 6.48). Ten of the 41 participants were judged to have fast, or fluent reading (1 standard deviation above the mean on this task; fast readers' mean=148.63; SD=5.78). Twenty-two of the readers were judged to be mid-paced oral readers, neither slow, nor fast, fluent readers (mid-paced readers' mean= 119.05; SD=18.37).

As previously mentioned in the description of the participants, when questioned about their educational history, 11 of the 41 participants reported learning differences that required some type of educational support (e.g. reading tutor, resource room, etc.) (see Table 1 for their data). Of these 11, five were classified in the slow, dysfluent, oral readers group. One of the self- identified individuals with a history of learning differences was classified in the fast, fluent oral reading rate (participant 40 WPM= 143) and five of the self-identified learning disabled read at rates that placed them in the mid-paced category. Thus, four of the nine slower, dysfluent, readers did not report any history of learning or reading difficulty.

Reading Errors and Accuracy

To test this hypothesis that slow oral readers are likely to be inaccurate readers, it was necessary to determine the accuracy of participants' oral reading skill. Accuracy of reading the passage of text ranged from 94-100%. The mean accuracy of oral reading for the group was 98%, suggesting that this passage contained words that were generally familiar to the participants and could be considered easy text. Participants made a total of 137 reading errors reflecting inaccuracy (e.g. word substitutions) (mean= 3.32; SD 3.36).

The previously identified slow readers were generally less accurate then the fast readers (see Table 2). The nine slow readers made a total of 111 errors within 8 categories (mean number of errors per individual= 12.33). The ten fast readers made a total of 26 errors in the 8 categories (mean number of errors per individual= 2.60) (See Figure 2 and Figure 3). All readers made errors, however, fluency was not always disrupted by the errors. For example, participant 24 made only one error. This error was a nonword error and the production of this nonword did not interrupt fluency (participant 24 WPM= 143). In contrast, participant 41, a slow, dysfluent reader, made a total of 20 errors, 8 of which involved repetitions of one or more words (e.g. "**reality...reality**..." "**in which...in which**...") and 5 of which were purposeful pauses for explicit decoding (e.g. "**e..evol...evolutionary**..."). These errors did disrupt the flow of reading (participant 41 WPM=93.54). As is noted on Figure 3, generally speaking, the faster an individual's oral reading, the more accurate they read. However, it should be noted that participants 4 and 8, both slow, dysfluent oral readers, were accurate in their reading. Participant 4 made 2 oral reading errors that influenced accuracy and participant 8 did not make any errors that influenced accuracy. Table 2 provides the total number of reading errors for the fast and slow readers and is reported as the measure of "fluency."

An examination of the overall errors reveals that the fast readers made fewer overall errors. As mentioned above, the 10 fast, fluent readers made 26 errors in total and in contrast, the slow, dysfluent readers made 111 reading errors. Both groups made numerous errors in the "explicit decoding" category (e.g."...**ter...terres...terrestrial...**"), as well as the "repetition" category ("**in the**

world...in the world...")(See Figure 2). Note, however, that the slow group made 15 word substitution errors (e.g. "...**realty**..." for "...**reality**..." or, "...**of**..." for "...**and**..."), while the fluent readers did not make any such errors. Table 3 provides a summary of the breakdown of errors according to error category.

Once the number of errors was determined in each category for each participant it was possible to calculate the Correct-WPM (C-WPM) of each individual. Correct-WPM was derived by determining the number of words correctly read in the passage by each participant in one minute and dividing that number by the time it took an individual to complete the oral reading or the passage. As previously discussed in the method section, for this analysis no consideration was given to the errors that resulted in correct word reading (i.e. the number of pauses caused by explicit evidence of decoding difficulty when the correct word was eventually produced [e.g. "...**ex...extra...extemporaneous**"]; the number of word additions [e.g. adding the word **"on"** in the sentence **"He went** (on) **his way**."]; transpositions [e.g. **"He went never**..." for **" He never went..."**]; the number of real word repetitions [e.g. "**physics...physics**;" " **The absolute measure...the absolute measure..."**]). Only those errors resulting in a wrong-word production or no word production were considered in this analysis. The following error types would be considered a wrong-word production: 1. real word substitutions (e.g. **"strain"** for **"string"**), 2. grammatical-morpheme errors (e.g. **"waked"** for **"waking," "pursue"** for **"pursued," "comprehended"** for **"comprehend"**) 3. nonword productions (e.g. **"estrined"** for **"estranged"**) 4. word omissions (e.g. **"He went** (all) **the way home**.").

Correlation coefficients were calculated between the two measures of speed (WPM), (C-WPM), and the accuracy measure, dysfluency (the number of overall errors made by each participant). The correlation between WPM and C-WPM was significant ($r=.998$, $p=<.01$). The correlation between WPM and dysfluency was significant ($r= -.692$, $p=<.01$), as was the correlation between C-WPM and dysfluency ($r= -.722$, $p=<.01$).

In summary, the slow readers were generally inaccurate and dysfluent, when compared to the fast readers who were fluent. Moreover, only the slow readers made word substitution errors.

Decoding and Word Reading

Since fluency is believed to be largely dependent on decoding and word reading, the total number of items read aloud correctly was calculated for each participant on the following tasks: 1. the WRAT-reading subtest, 2. the nonword reading tasks (experimental task and word attack of the Woodcock Johnson), 3. the oral reading of the items on the SWSRT. The raw scores ranged from 42-55 on the WRAT-reading subset (mean= 48.90; SD=3.40). On the experimental nonword reading task, raw scores ranged from 20-34 (mean= 27.72; SD=3.78). Standard scores ranged from 504-532 on the word attack subtest of the Woodcock Johnson (mean=519.29; SD=6.59). The raw scores ranged from 68-80 on the oral reading of the items on the SWSRT (mean= 76.66; SD=3.43). The mean number correct for slow, mid-paced, and fast readers, as well as the group mean, on these tasks is reported in Table 5. Overall, for each of these tasks (WRAT-Reading, nonword reading, and SWSRT-oral), the slow readers are found to have the lowest mean scores. The relation of these variables with oral reading skill and reading comprehension is discussed in a later section of this dissertation, *Relations Between Oral Reading, Silent Reading and Predictor Variables.* Additionally, the WRAT-reading subtest is discussed in the section entitled, *Variance in Fluency.*

Silent Single-Word Reading

The total number of word pairs correctly identified as synonyms during this silent-reading task was calculated as well as reaction time for each word pair and a mean reaction time was determined for each participant. Once individual means were calculated, a group mean was calculated. The maximum score possible on the SWSRT was 40. Raw scores on this task ranged from 27-38 (mean number correct on the SWSRT for the 41 participants was 32.41; standard deviation= 2.85). The mean reaction time on this task was 2729.15 milliseconds with a standard deviation of 1243.62. The means for correctness and reaction time on the semantic access task for slow, mid-paced, and fast readers, as well as the group mean, are reported in Table 5. Correlation coefficients were calculated and are reported in the section of this dissertation entitled, *Relations Among Oral Reading, Silent Reading and Predictor Variables,* which is found in this chapter. Performance on the single-word silent reading task was found to correlate with that on both oral reading (r=.505; p=<.01) and the Nelson Denny Test of Reading Comprehension (r=.448;p=<.01). Therefore, it appears that for the group of individuals in this study, the faster and more accurately they read aloud, the more accurate their silent semantic access.

B. Cognitive Measures

The second question posed in this study was whether there is a correlation between cognitive factors (working memory, speed of access, and IQ) and efficient lexical access. In order to answer this question, participants were administered the WAIS III, the Reading Span Test (in order to determine working memory capacity), and a rapid automatized naming task (colors and letters). Full-scale, performance and verbal IQ's were calculated for all participants on the WAIS III. Correlation coefficients were calculated and are reported in the section of this dissertation entitled, *Relations Among Oral Reading, Silent Reading and Predictor Variables,* which is found in this chapter. The mean Full Scale IQ score was 107.54 (SD= 11.96), mean Verbal IQ score 110.73 (SD=14.05), and the mean Performance IQ was 101.71 (SD=11.49). Group means are reported in Table 5. Additionally, mean scores were calculated on each of the WAIS III Index Scores (verbal comprehension, perceptual, working memory, and processing speed). The mean score on the Verbal Comprehension Index (VCI) was 112.80 (SD= 14.10), the Perceptual Index (PI) was 102.19 (11.99), the mean score on the Working Memory Index (WMI) was 100.00 (SD=13.64) and the Processing Speed Index (PSI) was 103.83 (SD= 15.82). The mean WAIS Index Scores are reported in Table 5.

Since working memory is considered an important variable influencing reading performance and use of a recall task (as is used in the WAIS) has been challenged in the literature as poorly assessing working memory, the Reading Span Test, an additional measure of working memory, was administered. However, as previously noted, some individuals appeared to require training in this task while others did not. Additionally, it was observed that some individuals learned the task without difficulty, and proceeded through the task without effort, but seemed to lose attention, failing to perform optimally at a particular level, yet performing well at the more difficult level. Thus, both a working memory capacity score (WM score), as well as a modified working memory capacity score (MWM), were calculated for each individual. The working memory capacity scores ranged from 2-6 (mean=2.91; SD= 1.06), as did those of the modified working memory capacity scores (mean=3.42; SD= 1.14). WM and MWM Group means are reported in Table 5.

C. Rapid Automatized Naming

Rates of completion of the both the RAN colors and letters tasks were calculated in seconds for each participant. Thirty-two participants were administered the RAN tasks. Scores ranged from 17.58 –39.73 seconds for the RAN color task and from 11.51-36.47 seconds on the RAN letter task. The group mean on the RAN color task was 26.22 (SD 6.45) and the mean on the RAN letter task was 18.53 (SD=4.94). Group means are reported in Table 5.

D. Relation Among Oral Reading, Silent Reading Skill and Predictor Variables

To address whether oral reading, silent reading and the predictor variables were related to each other, correlation coefficients were calculated among oral text reading, reading comprehension as measured by the Nelson Denny, age, silent word reading as measured by the SWSRT, WRAT-Reading, nonword reading, word attack, spelling (WRAT-Spelling; Experimental Spelling Test), RAN colors, RAN letters and the WAIS-III, all variables that are believed to influence reading performance. The results are reported in Table 4. As predicted, oral reading rate (WPM) was significantly correlated with WRAT-Reading (r=.672, p= <.001), nonword reading (r=.486, p=.001), both spelling tasks (WRAT-Spelling, r=.452, p=.003; Experimental Spelling Test, r=.742, p= <.001) and the Processing Speed Index (PSI) of the WAIS-III (r=.451, p=.003). Also as predicted, there was a significant correlation between the Nelson Denny Reading Test and the SWSRT (r= .448, p= .003). Additionally, contrary to the prediction, there was a significant correlation found between performance on the Nelson Denny (reading comprehension) and oral reading rate (WPM) (r=.496, p=.001). There was a significant correlation between the RAN colors and letters and both WPM and the Nelson Denny Test (RAN colors and Nelson

Denny r= -.421; p=.018; RAN letters and Nelson Denny r= -.394, p=.026; RAN colors and WPM r= -.697; p=<.01; RAN letters and WPM r= -.616, p=<.01). Furthermore, the correlation between the Nelson Denny and the PSI of the WAIS-III was not significant (r= .220; p=.168). Since the age range of the participants ranged from 16-36, correlation coefficients were calculated between age and all other variables. There were no significant correlations found between age and any of the variables (Table 4).

E. Spelling Measures

The third research question was, is there a correlation between spelling and oral reading skill? In order to answer this question, scores were determined on the two spelling measures, the Experimental Spelling Test and the WRAT-Spelling measure, by calculating the total number of words spelled correctly. Raw scores were determined for performance on the WRAT-Spelling subtest. The Experimental Spelling Test had a maximum number correct of 120 and the scores ranged from 54-101. The mean number correct was 77.34 with a standard deviation of 11.48. The maximum raw score on the WRAT-spelling is 55 and the scores ranged from 37-53 (mean= 43.75; SD= 3.74). Group Means and standard deviations for these two tasks are reported in Table 5. Indeed, the answer to the third research question is that there is a correlation between oral reading and spelling tasks (WRAT-Spelling, r=.452, p=.003; Experimental Spelling Test, r=.742, p= <.001).

F. Variance in Fluency

In order to determine which factors contribute to fluency, a regression analysis was performed. WPM was used as the dependent variable and the variables associated with phonological skill and speed were entered into the equation (Experimental Spelling Task, WRAT-Spelling, WRAT-Reading, PSI,) as predictors. The variables were entered into the equation in the order: Experimental Spelling WRAT-Spelling, WRAT-Reading, and PSI. The Experimental Spelling Task was the strongest predictor of the variance in oral reading fluency (WPM) (R^2= .551, Beta= .636; p= <. 001). The WRAT-Spelling measure did not contribute any unique variance to WPM (R^2 change= .007, Beta= -.295, p=.035) and the contribution of WRAT-Reading (single-word aloud) though significant (R^2 change=.043, Beta= .311, p=.035) was extremely small and eliminated when PSI was added to the equation (PSI R^2 change= .095, Beta=.327, p=002). The resulting regression model is provided in Table 6 (A).

A second analysis was completed with WPM as the dependent variable and the Experimental Spelling Test and PSI as the predictors. When the Experimental Spelling Test was entered into the equation the R^2 =.551, p=<.001. When PSI was entered into the equation the R^2 change was .079 (R^2=.630, p=<.007). Together the Experimental Spelling Test and PSI account for 63% of the variance in WPM (oral reading) (see Table 6B).

In order to determine if semantic knowledge and memory contribute over and above WPM to the variance in reading comprehension, an additional regression analysis was performed with the Nelson Denny Reading Test as the dependent variable and SSWRT, WMC, and WPM as the predictors. Only WPM contributed significantly to the variance in the Nelson Denny Reading Test (see Table 6C), regardless of the order that the predictors were entered into the equation.

G. Individual Differences

The final question in this study asked whether it is possible to find individuals who show dissociations in skill, even when there are strong correlations among the variables for the group. In order to examine individual differences and dissociations in skill, performance on each task for each participant was rank ordered from 1-41, with 1 being the best score on a task (e.g. the most correct; the fastest, etc.) and 41 being the worst (e.g. the fewest correct, slowest, etc).(As botht the TAN tasks were administered to only 31 participatns, the ranks for these tasks ranged from 1-31) If several participants performed equally well on a task (e.g. all achieved a 72 on Experimental Spelling task) all were assigned the average of the ranks that they jointly occupied.

Since the group consists of individuals with fast and slow oral reading skills, rank ordering of the fast and slow readers is reported in Appendix F. Additionally, since this study is comprised of some individuals who reported a history of learning differences, some who were slow, dysfluent readers and some who were not, rank ordering is reported for individuals who reported a history of learning differences in Appendix F.

Since unanticipated discrepancies in skill were of interest, it was important to establish a strong criterion by which to explore individual differences and dissociations.

Once rank was established for each individual on each task, it was possible to investigate individual differences and dissociations in skill. Specifically of interest were those individuals who ranked high on one critical measure (e.g. WPM (oral reading) or reading comprehension) and low on another measure (e.g. working memory capacity).

As reported above, overall there was a significant correlation between reading comprehension, as measured by the Nelson Denny Reading Test, and WPM (oral reading rate). Additionally, there was a significant correlation between WPM and C-WPM (correct-WPM) and both of those measurements were significantly correlated with dysfluency (total number of errors). However, the first research question asked whether is it possible for individuals who are slow, inaccurate oral readers to have good reading comprehension with good semantic access. Therefore, it was important to establish if it were possible to be a slow, dysfluent reader and nonetheless have good reading comprehension with good semantic access.

Data from two of the slow readers (participants 4 and 8), did meet less stringent criteria suggesting a disparity in performance (see Table 8). Participants 4 and 8 had standard scores of 231 and 235 respectively on the Nelson Denny Reading Test (group mean=221.02; SD=18.17). Participant 4 had an oral reading rate of 91.2 WPM and participant 8 had an oral reading rate of 92 WPM (mean=119.44: SD=23.09), both slow for this group (participant 4 ranked scores: WPM/oral reading rate= 37; Nelson Denny = 17; participant 8 ranked scores: WPM/oral reading rate= 36, Nelson Denny 9.5). Thus these two individuals demonstrate a discrepancy between reading comprehension skill and reading fluency (as measured by WPM). However, note that participant 8 had a ranked score of 4 on the nonword reading task. So, while this individual demonstrates good nonword reading skill, participant 8 is, nonetheless, a slow oral reader. In summary, participant 8 demonstrates a dissociation between decoding (as measured by nonword reading) and WPM (oral reading), with relatively good reading comprehension.

Additionally participants 4 and 8, both of whom have relatively good reading comprehension with slow oral reading rates, appear to have relatively efficient lexical access during SWSRT (single word silent reading test) (participant 4 RT=2292 [rank=18], participant 8 RT= 2428 [22], group mean RT= 2729;SD 1243.62) (see Table 8). So, despite their poor reading aloud, neither of these individuals demonstrated particularly slow word recognition skill.

The second question asked in this study was whether there is a correlation between cognitive factors (working memory, IQ, and RAN) and reading skill. Overall, working memory index scores of the WAIS III correlate with WPM (oral reading). However, the more rigorous measure of working memory, the working memory capacity scores, did not correlate with WPM. Examination of the ranked performance on the working memory capacity measure reveals three individuals who are slow readers who also scored very high on the working capacity measure (see Table 11). Additionally, one slow reader, participant number 7, had a ranked score of 2 on the verbal comprehension index, a measure of verbal language, and a rank of 39 on WPM (oral reading) (Table 7). It should also be noted that participant 21, a mid-paced reader, had a dissociation between reading comprehension (as measured by the Nelson Denny Reading Test and SWSRT) and performance IQ, as well as the perceptual index of the WAIS III (See Table 9). So, despite the overall significant correlation found between cognitive factors, there were individuals who displayed a dissociation between either reading comprehension or oral reading and one or more of the cognitive factors.

Furthermore, it was hypothesized that processing speed may influence reading. Overall, there was a significant correlation between WPM (words per minute) and the PSI (processing speed index of the WAIS III) (r= .451, p=<. 01). However, the correlation was not significant between the Nelson Denny and PSI (r=. 220, p= .17). Two mid-paced readers, numbers 16 and 21, provide particularly good evidence of the influence of processing speed on reading. Participant number 16 had a standard score of 235 on the Nelson Denny Reading Test with a ranked score of 9.5 (group mean= 224.86; SD= 15.93) and an oral reading rate of 125 WPM with a ranked score of 19.5 (group mean= 120.51; SD= 23.38) (Table 9). In contrast, participant number 21 had a standard score of 247 with a ranked score of 2 on the Nelson Denny Reading Test, and an oral reading rate of only 103 WPM with a ranked score of 29, which is relatively low for the group. An examination of their individual performance scores on the WRAT-reading and WRAT-spelling, both untimed measures, reveals them to perform similarly. There was some difference between their performance on the experimental spelling test (participant 16 scored 64, ranked score 34.5; participant 21 scored 79, ranked score 20; mean= 77.03, SD=11.93).

However, the most distinctive difference between these two participants is their score on the Processing Speed Index (PSI) of the WAIS III. Participant 16, who had a faster oral reading rate, had a PSI score of 137, ranked score 2 (group mean= 103.83; SD= 15.82). Participant 21, who had a relatively slow oral reading rate, had a PSI score of 86 with a ranked score of 35.5 (group mean= 103.83; SD= 15.82) (See Table 10). Additionally, if we examine the data of participants 4 and 8, who evidenced a disparity between oral and silent reading skill, it can be noted that they both had relatively low PSI scores (group mean PSI= 103.83, participant 4 PSI= 86, ranked score= 35.5; participant 8 PSI= 81, ranked score= 39) (see Table 7).

The third question posed in this study was whether there was a significant correlation between reading and spelling and indeed, there was a significant correlation between WPM (oral reading rate) and both the WRAT-Spelling measure and the Experimental Spelling Test. In addition, performance on the Experimental Spelling Test was found to significantly correlate with performance on the Nelson Denny Reading Test. Examination of the ranked scores for both spelling measures (WRAT-Spelling and Experimental Spelling test) revealed that no individual who participated in this study met the criteria established of scoring between 1-5 on one measure and 36-41 on the other measure. Slow readers were generally poor spellers. However, note that participant 8, the slow-reading individual with good nonword reading skill (ranks 36 and 4 respectively on WPM and nonword reading), performed better on both spelling measures than the other slow readers. The ranks of slow, dysfluent readers ranged from 10-40.5 on the WRAT-Spelling task and 15-41 on the

Experimental Spelling Test (Participant 8: WRAT-Spelling rank=10; Experimental Spelling rank= 15).

In summary, despite group correlations among the variables there are individuals who demonstrate dissociations between reading skill and cognitive skill, and, between reading skill and decoding skill. However, no one evidenced a dissociation between reading skill and spelling skill. Since there is the possibility that these extreme scores demonstrating a dissociation were obtained by chance, and upon retesting some scores may regress to the mean, additional testing would be required in order to rule out this possibility. However, there were several measures of speed, memory, reading and spelling within this protocol, thereby reducing the likelihood of regression of any of these scores to the mean.

History of Learning Differences

Eleven participants who volunteered for this study reported a history of learning or reading differences. Additionally, there were four participants who were classified here as slow readers who reported no academic difficulty (see Appendix G). Examination of all the scores of the 9 dysfluent readers, 5 of whom reported a history of learning differences and 4 of whom did not, reveals generally similar overall performance (see Appendix H). However, an examination of the ranked performance of the individuals with reported learning differences reveals individual strengths. It is particularly interesting to note that several of these individuals ranked very high in the nonword reading task (participant 8, rank=4; participant 9, rank= 2;

participant 12, rank = 3) and several ranked well in the working memory capacity measure (participant 7, rank= 13; participant 8, rank=3; participant 12, rank=13; participant 40, rank=8). The working memory scores attained by these 4 individuals are 1 SD above the group mean (mean=2.91;SD=1.06) (see Table 7).

Similarly, the group who reported a history of learning differences included 7 fluent oral readers that had had reading-instruction support outside the classroom. In fact, one individual, participant 6, a college senior, reported requiring assistance through her second year of college. However, an examination of this individual's performance provides little evidence of difficulty (see Table 12). The scores suggest that this individual has achieved a level of skilled reading, rendering decoding as well as reading comprehension proficient. Indeed, her performance did not reveal any residual deficits. While the nature of her original deficit is unclear, she has, either as a result of remediation, or by compensation, or a combination of the two, become a skilled reader.

Chapter IV: Discussion

Recall that acquired deficits such as deep dyslexia and surface dyslexia provide support for the notion that individuals may have two reading routes, a lexical reading route and a phonological reading route. The evidence from individuals with acquired reading disorders suggests that either the whole word lexical route or the phonological route may be impaired. Similarly, the heterogeneity of developmental dyslexia suggests the potential for deficits via either the phonological or lexical route. And, despite the literature suggesting that efficient decoding and rapid word recognition are a prerequisite for fluency and reading comprehension, individuals with hyperlexia and dementia provide evidence that, in fact, fluent oral reading and rapid word recognition are possible without understanding. The purpose of the current study was to further investigate the association and possible dissociation between oral reading fluency and reading comprehension, and to explore factors linked to the variance in reading fluency.

A. Relation Between Oral Reading Fluency and Reading Comprehension

The critical component in proficient reading is a demonstration of skilled reading comprehension. As discussed in the introduction, the literature suggests that reading comprehension is correlated with oral reading skill. Recall that Bruck (1990) found that the presence of a context increased word-reading accuracy. The data in this dissertation suggest that the more proficiently young adults perform on reading comprehension measures, the faster and more accurate they are when reading aloud. In addition, the data reported here provides evidence of rare individuals who possess strengths and weaknesses in underlying skills. Therefore, while the overall data are consistent with the literature reporting a correlation between reading comprehension and oral reading fluency (e.g. Tan and Nicholson, 1997), there are individuals who evidence differences in the strengths of their component skills, consistent with the recent report of Jackson and Doellinger (2002). In view of the individual strengths in cognitive function and decoding that have been reported in poor oral readers in this dissertation study, we must consider the factors that have been hypothesized to contribute to reading skill and may therefore influence reading behavior.

B. Decoding and Phonological Skill

Since proficient, fluent reading aloud relies on rapid access to phonological information, it was predicted that oral reading rate (WPM) would be correlated with single-word reading aloud, nonword reading, and spelling. Indeed, there were significant correlations found between oral reading fluency and these factors. Furthermore, examination of the mean scores for slow, mid-paced and fast readers on the nonword reading task, word attack and WRAT-Reading measures suggested that performance on these decoding tasks generally improved as reading rate increases. This finding of an association between decoding and reading skill is consistent with the literature (e.g. Leinonen, Muller, Leppanen, Aro, Ahonen, and Lyytinen, 2002; Snowling, 1980) and with an assumption in the dual route-model that normal readers have both routes available, though their reliance on the phonological route diminishes as their reading skill becomes more automatic.

However, despite the correlation between decoding and reading skill, two participants (participants 4 and 8 who were both slow, dysfluent readers with relatively good comprehension) were found to have good decoding skills. Nonetheless, the oral reading skill for these two individuals is slow. The fact that these two individuals were able to decode well during the nonword reading task and were nonetheless dysfluent oral readers is somewhat surprising. However, these two participants, though dysfluent, were generally accurate readers. Text reading was timed in order to determine fluency of reading. However, the oral decoding tasks (nonwords and single words) in this study were not timed tasks. Therefore, although decoding skill has been demonstrated to be an important contributor to reading fluency, evidence was uncovered to suggest that additional factors may constrain reading fluency in some individuals.

C. Lexical Access

Lexical access, or the ability to associate in memory and retrieve an orthographic representation and its semantic representation, is critical to the development of reading comprehension. To measure speed and accuracy of lexical access, the participants in this study engaged in silent and oral reading tasks and silent and oral timed tasks.

There was a significant correlation found between the RT on the SWSRT and the Nelson Denny Reading Test, both silent reading tasks. The more accurately and faster individuals performed on the SWSRT, the better their reading comprehension. There was also a correlation between the RAN tasks and reading (both WPM and reading comprehension). These significant correlations are consistent with previous reports of a relation between speed of word recognition and reading skill (Bruck, 1990; van Leij and van Daal, 1999; Rubin and Johnson, 2002). However, although there was a significant correlation between RAN and oral reading (WPM) (both oral), the correlation between oral reading (WPM) and the RT on the SWSRT (silent task) was not significant.

Since, as reported above, there was an overall correlation between nonword reading and oral reading skill, one possible explanation for variation in reading fluency could be that this is related to deficient decoding skill, which is in keeping with much of the literature (e.g. van Leij and van Daal, 1999). Alternately, it could be argued that fluency of reading is influenced by a deficit in the speed of lexical access (e.g. Bowers, 1993). These data support the notion that speed of task performance is associated with reading. However, further investigation is warranted in order to determine if rapid word retrieval for oral tasks and silent tasks may involve different processes that are task dependent.

D. Spelling Skill and Reading Skill

Based on the premise that poor readers have underlying deficits in the phonological mechanism, it was predicted that spelling would be correlated with oral reading rate. The data presented here clearly support the notion that spelling and oral reading, as well as spelling and silent reading are linked to each other. This finding is consistent with previous reports (e.g. Bruck, 1993). In order to take words and encode them into graphemes, or spell with consistent accuracy, one must possess an adequate knowledge of phonemes and how they relate to graphemes and morphophonological structure. Spelling errors made by skilled adult readers may provide us an initial indication of their reading skill. Future analysis of their error patterns may provide us with insight into readers' knowledge of phoneme-grapheme correspondence and morphophonological structure.

E. Cognitive Factors Influencing Reading Performance

The literature suggests that cognition, vocabulary, inferencing skill, and syntactic skill are interlinked. Therefore, this investigation considered the cognitive factors that were deemed likely to influence reading performance, particularly intelligence and working memory.

Intelligence

In the introduction it was suggested that verbal IQ measures would appear more closely linked to a linguistic task such as reading than performance IQ. If there were a correlation between IQ and reading comprehension skill, it was hypothesized that verbal IQ measures would more likely reveal that correlation. In this sample of individuals, both verbal and nonverbal IQ was found to significantly correlate with reading comprehension as well as with WPM (oral reading rate). This finding of a significant correlation between reading and performance IQ is consistent with the reports in the literature (e.g. deJong and deJong, 1996).

However, while IQ was found to significantly correlate with reading skill, one interesting dissociation was found in the WAIS III data set. The Processing Speed Index (PSI) of the WAIS III was found to correlate with the WPM (oral reading rate) for text reading. However, PSI was not significantly correlated with the performance of the Nelson Denny Reading Test in this study of young adult readers. This finding in conjunction with the previously discussed finding of a correlation between RT on the SWSRT and the Nelson Denny Test (both silent tasks), and the absence of a correlation between RT on the SWSRT (silent) and WPM (oral reading), further supports the notion that processing speed differences may influence reading performance in a variety of ways (Berninger, Abbott, Billingsley and Nagy 2001).

Recall that the processing speed index (PSI) of the WAIS-III is determined by having the individual perform the Digit-Symbol Coding subtest and the Symbol Search subtest. These two subtests are designed to assess rapid access to visual information. A low PSI score suggests that a reader has difficulty rapidly and accurately accessing visual information (either for coding, where copying is required, or, for searching, where matching visual symbols is required). During skilled oral reading, an individual must rapidly examine the visual unit (word or word string), match that unit with a known unit in the lexicon by integrating the graphemic and phonemic information, access the phonological output representation and utter the result. It is possible that the slowness in visual processing contributes to reduced reading speed and may, in fact, inhibit the integration of the graphemic and phonemic information required in order to efficiently utter the words. During silent reading tasks phonological access is not necessarily obligatory, and therefore, the slower speed of processing would not necessarily place an added constraint on silent reading skill.

Therefore, based on the data presented here it can be hypothesized that some individuals may have insufficient capacity to rapidly integrate the visual and phonological representation in order to read aloud proficiently. In contrast, during silent reading the reader has the opportunity to access semantic information directly from the orthographic unit.

Working Memory

As you will recall, the literature argues that the larger the working-memory capacity of an individual, the more material (or concepts) likely to be stored and available for use during reading (e.g. Masson and Miller, 1983). Therefore, it was predicted that individuals with larger working-memory capacity (WMC) would have superior reading comprehension skills. This notion was not supported by the data. Overall, the correlation between working memory and reading comprehension was not significant.

In the analysis of individuals evidencing dissociations, recall that participant 8 demonstrated a dissociation in WPM and nonword reading with good reading comprehension relative to the overall group, and had a relatively larger working memory capacity score. Additionally, recall that participant 8 was found to have a poor PSI score (rank of 39 out of a possible 41). This observation implies that participant 8 has a strong ability for the manipulation and storage of information during reading tasks. And, while a low PSI score may inhibit the integration of information needed for oral reading, the larger WMC may facilitate the manipulation and storage of information necessary for reading comprehension.

Furthermore, while the evidence from this study that working memory capacity is linked to reading comprehension skill is questionable, recall that three of the nine slow readers were ranked within the top 10% of the group in their WMC score, (participant 8, 35, 41 ranked 3, 1 and 5.5 respectively) and two of the slow readers, participants 8 and 35, had ranked scores on reading skill and working memory capacity that met with the stringent criteria established here to distinguish them as having a dissociation between oral reading skill and working memory capacity (participant 8 rank WPM= 36, WMC=3; participant 35 rank WPM=38, WMC= 4). Additionally, participants 8 and 35, who evidenced the dissociation, were previously identified as being among those slow readers who made fewer overall reading errors, therefore being slow, accurate readers. If, as the literature suggests, a larger working memory capacity facilitates the manipulation and storage of information, the reading accuracy of these two individuals may be facilitated by their ability to store and assemble linguistic components during reading (e.g. phonology, words). The fact that these individuals with a dissociation between working memory and reading were found in this relatively small group of 41 individuals suggests that this is factor that warrants further investigation employing more sensitive measures of reading comprehension and perhaps working memory.

F. Oral Reading Rate and Errors

In the current study, the participants were classified according to speed as being slow readers, fast readers, or mid-paced readers based on reading rates (WPM) during the oral passage reading. Berninger, Abbott, Billingsley and Nagy (2001a) point out that reading rate alone does not provide sufficient information by which to judge reading behavior. Therefore, an analysis of oral reading errors, resulting in a dysfluency score, and the calculation of Correct-WPM was completed. These calculations enabled the investigator to consider speed and accuracy of oral reading and provided evidence that speed and accuracy are linked to each other in these individuals.

Berninger, et al. suggest that three different mechanisms may contribute to reading rates. First, they suggest that slowness in processing may be problematic. Indeed the data presented here support the notion that slow processing may interfere with reading orally. According to Berninger et al., readers with slow processing would be characterized as being slow but accurate readers. In this study there are individuals who could be identified as "slow processors," most notably participants 4, 8, and 21, all identified as having low PSI scores. Participants 4, 8, and 21 made few errors that influenced their reading accuracy (2, 0, and 3 respectively). It could be hypothesized that slowness in the ability to process the visual information may result in the poor synthesis of visual (orthographic information) and phonological information (speech sounds), resulting in an error. In other words, the slowness in visual processing of the written letters may inhibit access to words. Slow but accurate readers may reduce their reading rate as a strategy to correctly access words and therefore avoid making reading errors.

Second, Berninger, et al. (2001a) propose that an individual's limitation in automatic decoding may result in slow oral reading with false starts and repetitions. They argue that individuals with a lack of automaticity nonetheless are likely to possess good monitoring which results in self-correction during oral reading and therefore accuracy. Indeed, in this dissertation study both slow and fast readers made errors that took the form of false starts and repetitions. However, in this sample of individuals accuracy and speed were highly correlated, and the error analysis suggested variability in error types in both the fast and slow readers. Clearly, the slower readers made more errors that disrupted accuracy. However, there were individuals in the fast and slow groups who made errors in various error categories.

In this group of young adult readers, 24% of the errors made by the slow dysfluent readers were in the form of repetitions and 34% of those made by fast fluent readers were in the form of repetitions. One could surmise that all of these errors were made as a result of a "lack of automaticity." If automaticity is defined as the rapid automatic recognition and retrieval of words during reading one can conclude, therefore, that all the slow readers lack automaticity as a function of their slowness across tasks. In the slow, dysfluent readers the processing problems may be chronic. In the case of the fast, fluent readers this slowness in processing may be transient. It could be hypothesized that a transient slowness in processing might occur in any individual. When a transient interruption in processing rate occurs, automaticity may be temporarily disrupted, resulting in a word repetition error, or a sudden dysfluency. Quite simply, this interruption may be due to poor attention to the reading situation. Additional evidence would be required in order to determine if these individuals lacked automaticity, as Berninger et al. hypothesize, or if the apparent lack of automaticity is only an artifact of slow processing.

Lastly, Berninger et al. suggest that some slow oral readers may have impaired monitoring ability. Moreover, they propose that an underlying deficit in executive function may result in impaired monitoring ability. This impaired monitoring ability is hypothesized to result in a reader who is generally poor at "recognizing the language structure." Indeed, it seems logical that impaired self-monitoring may result in poor oral reading. If monitoring is deficient and results in uncorrected reading errors, we would need to consider if the deficiency is based within the language mechanism, as the authors suggest, or if perhaps the deficit is based in another locus. Monitoring could be deficient due to a deficit in a cognitive mechanism (e.g. speed of integration of graphemic, phonological and lexical information or deficits in executive function), or in the auditory-language feedback mechanism (ability to consciously recognize the production of a verbal error).

Some dysfluent readers may be incapable, perhaps due to capacity constraints, of effectively using the auditory feedback system during reading. A reader may produce a nonword in place of a real word and fail to correct the error, as occurred in this study 16 times. The reader may continue to read and lack the capacity to recognize via the auditory feedback system that the nonword was produced. Or, the reader may not inhibit the production of a nonword due to a deficit in the phonological buffer, the mechanism proposed to filter such errors (Jackson and Coltheart, 2001). Alternately, the apparent "poor self-monitoring" of the individual who reads a nonword for a real word may be due to a deficit in word knowledge. In essence, the written word confronted by the reader is not a part of the reader's phonological output lexicon. Therefore, the failure to correct that nonword may be the result of a lack of linguistic knowledge.

In fact, 8% of the errors made by the fast, fluent readers were uncorrected nonwords. Thirteen percent of the errors made by slow, dysfluent readers were uncorrected nonwords. Additional evidence would be needed in order to determine if the production of these nonwords is due to a deficit in the phonological output lexicon or a deficit in the phonological buffer.

Also, it seems plausible that the slow readers and fast readers may employ different cognitive strategies when reading and therefore their errors may be the result of different processes, as Greenberg, Ehri and Perin (2002) posit in their study comparing low-literate adults and normally developing children, all with reading levels between the third and fifth grade. Since the adults were more apt to make real-word substitution errors and children more likely to make nonword reading errors, the authors hypothesize that perhaps the two groups (children and low-literacy adults) utilize different cognitive processes. The adults, they propose, rely more heavily on visual memory when reading, causing them to say real words that are visually similar to the target words. In contrast, they propose that children rely more on phonological decoding, which results in nonword error productions.

In this study none of the fast, fluent adult readers made real-word substitution errors. However, the slow, dysfluent readers made numerous real-word substitution errors. And, as previously discussed, there was at least one individual in both groups who made at least one nonword error. The Greenberg et al. analysis was based on word-reading errors in a single-word reading task. In this study, by contrast, readers read aloud in context on the task for which reading errors were analyzed. The presence of context should reduce the likelihood of producing both word and nonword substitution errors. However, despite the presence of context, the young adult readers in this dissertation study made both real word errors and nonword errors. The production of real-word errors and nonword reading errors suggests that some readers may bypass the semantic mechanism during this oral reading task. However, this does not preclude the possibility that the visual characteristics of the words trigger the errors. An additional analysis of these reading errors may provide useful information. It would be valuable to determine if both the nonword and real-word errors are visually related to the target words, or, if the real-word errors have a semantic basis.

In summary, an analysis of the oral reading errors suggests that all readers have the potential to make oral reading errors regardless of their rate of reading. The most rapid readers in this study made reading errors. However, these errors were generally fewer than the slow, dysfluent readers and therefore, not likely to disrupt fluency. Rapid recognition of graphemes, and an association of graphemes with phonemes, is critical to fluent reading aloud. The low processing speed scores of the slow, dysfluent readers suggest that individual differences in the speed of processing may inhibit the rapid consolidation of the graphemic and phonological information. Based on the data reported here, it is hypothesized that some dysfluent readers are slow processors of orthographic information, which contributes to their oral reading errors. This slowness in processing is likely to be associated with a variety of different types of reading errors such as those seen among the dysfluent readers in this study.

G. History of Learning Differences

In this group of skilled readers, while 11 reported a history of reading, or learning differences, there were four participants who were dysfluent oral readers who did not report such difficulties. There are at least two possible explanations for the performance of the latter group. First, these individuals may have been reluctant to share their history of learning differences, perhaps out of fear or embarrassment. The second possibility is that these participants were recognized as having had good reading comprehension throughout their education and therefore their processing differences were never noted or considered relevant. The anecdotal reports of these participants suggest that interventions, personal habits and self-awareness of skill vary markedly. Since original records documenting learning differences and past academic records for these participants were not available to this examiner at this time, it is difficult to draw any conclusions with regard to learning differences and individual reading performance.

H. Theoretical Models of Reading

Dual route theory suggests that readers have access to words in the mental lexicon via either the phonological route, or via the word form mechanism (e.g. Coltheart, 2003, Coltheart, Patterson and Marshall, 1980; Coltheart, Curtis, Atkins and Haller, 1993). Alternately, the connectionist theory suggests that individuals possess separate, yet connected, mechanisms for phonological and orthographic processing and the connections between these mechanisms are strengthened by increased use (Harms and Seidenberg, 2001; Seidenberg and McClelland, 1989). As was pointed out in the introduction, evidence for these models comes largely from research on disordered individuals, as well as computer simulations.

Research suggests that slow word recognition skills and poor decoding skills persist into adulthood for some individuals, despite repeated efforts to improve these skills. Therefore, contrary to the notion proposed by connectionist theory, for such individuals repeated use and stimulation of the mechanism may not result in improved access.

While there may be disagreement on the path that information takes once the visual system is stimulated by written words, proponents of both theories would generally agree that lexical representation and grapheme-phoneme representation are required in order to learn to read for meaning. However, evidence from brain-damaged patients with dissociations in skill demonstrates that there may be individuals who possess strength in one of these representations and weakness in the other (e.g. they are good at decoding written language but poor at understanding and integrating meaning). Furthermore, Jackson and Doellinger (2001, 2002) provide evidence of college students who have a weakness in decoding with good reading comprehension. Rapid access and integration of graphemes and phonemes are required for fluent oral reading. However, based on the evidence of Jackson et al. it appears that this rapid access to grapheme-phoneme representation may not be a necessary for skilled reading comprehension in all individuals.

Coltheart (1993, 2003) suggests that word reading in normal adults can be accomplished via either the orthographic input lexicon or via letter-to-sound rules. If the letter-to-sound mechanism is employed, Coltheart suggests that semantic mediation may not occur. That is, it is possible to circumvent the semantic mechanism when reading is being accomplished via the orthographic input lexicon and nonetheless utter the word. Evidence from individuals with hyperlexia and dementia, those who read aloud words they do not understand, supports this notion.

Word-reading errors made by individuals in this study (real word substitutions and nonword substitutions in context) are consistent with the notion that the semantic mechanism can be bypassed when reading aloud in context. Based on the model proposed by Coltheart (2003), Figure 4 is a simplified illustration of two routes by which word reading may occur.

The initial process of word recognition is visual analysis, which occurs in the mechanism of Figure 4 labeled, (B) Visual Analysis. Visual analysis involves letter recognition, regardless of the form of the letter (e.g. uppercase, lower case, font). Once letter recognition has occurred the reader may access that word by one of two mechanisms: (C) Phoneme-Grapheme Representation or (D) Lexical Representation. The grapheme-phoneme representation mechanism (C) is the mechanism that is used in order to take individual graphemes and convert them to phonemes, or sound them out. This is the mechanism that is used when learning to read words. This mechanism may also be used in other situations. For an example, this mechanism may be used when reading pseudowords without lexical representation (e.g. uldrane), or unfamiliar words like foreign names or places. Alternately word recognition may occur via access to the lexical representation mechanism (D). This mechanism contains words that are in the orthographic and/or phonological lexicon of the reader. Therefore, when readers are exposed to a familiar word that is part of their orthographic and/or phonological lexicon, they can access that word directly via the lexical representation mechanism and achieve comprehension (F). For reading aloud, efficient access to the phonological structure of the word is obligatory. When reading for comprehension, access to the phonological structure is not obligatory, if accurate visual analysis and recognition of a word by its orthographic structure has occurred.

This dissertation study assessed accurate efficient assess to phonological and semantic information during oral reading and silent reading tasks. Individuals in this study made oral reading errors during text reading, but they were not required to demonstrate their comprehension of the text. In contrast, Jackson et al. required readers to read aloud and demonstrate their comprehension of the text they had read aloud. Readers in both protocols made reading aloud errors. Therefore, access to lexical and semantic information may be possible as a distinct process from access to grapheme-phoneme information. For skilled adult readers we expect the rapid integration of graphemic, phonological and semantic information. Since error words were produced in context while reading aloud, the production of these errors suggests that oral reading is capable of being performed without semantic mediation. Additional investigation and evidence are required in order to further develop this premise.

Chapter V: Conclusion

Generally speaking, the better young adults' reading comprehension, the better their oral reading skill. Furthermore, there are numerous cognitive variables that correlate with reading skill. However, some of the individuals discussed here displayed a dissociation between variables.

Furthermore, while all readers are vulnerable to making oral reading errors, including overt attempts to decode words, the slow, dysfluent readers make more overall errors that involve morphological components and word substitutions. These errors have the potential to alter the meaning and/or syntax of the text and are, therefore, linguistically-unexpected production errors.

This study provides data suggesting that three factors contribute to oral reading fluency: 1. visual processing speed 2. word reading skill 3. knowledge of how speech sounds relate to graphemes and morphophonological structure. The evidence suggests that the integration of linguistic (phonological) and cognitive (processing speed) capability is a critical factor influencing oral reading skill.

Evaluation of an individual's reading skill is often based on oral reading fluency. Since reading comprehension is correlated with oral reading skill, one could argue this to be a reasonable assumption. However, there are those individuals for whom the integration of orthographic and phonological information may be constrained by processing speed limitations. Therefore, it becomes critical that educators carefully evaluate all the strengths and weaknesses of individuals separately in order to adequately assist each student attain their optimal reading skill.

A. Future Research

This study has verified that component skills (i.e. phonological and cognitive) are associated with fluent reading. As this work progresses, it would be useful to evaluate reading comprehension using a variety of protocols. More thorough evaluation of the ability to integrate explicit and implicit information during text reading may add useful information regarding variation in skill.

Additionally, investigation into the factors influencing reading fluency across a greater age range will contribute information with regard to developmental and age-related changes. It would be useful to recruit younger and older reading-disabled individuals and investigate the factors that contribute to their reading fluency and comprehension.

Furthermore, this study is comprised of volunteer students three-quarters of whom reported no history of reading or learning difficulties. Had students been recruited specifically because they had a history of reading disability, the data might have revealed a greater number of students exhibiting a dissociation between oral reading skill and silent reading comprehension. In the future, using a larger sample of reading-disabled individuals may facilitate understanding individual differences that contribute to reading success.

If indeed it is possible to compensate for deficits in the phonological mechanism and nonetheless attain skilled reading comprehension, further exploration into the mechanisms that facilitate that compensation will improve our ability to provide appropriate instructional methodology for a wider variety of individuals.

Table 1. Participants with a self-reported history of learning differences

Participant Numbers

	1	**32**	**7**	**8**	**18**	**10**	**11**	**12**	**9**	**6**	**40**	**Mean** **n=11**	**Group Mean** **n=41**
Age	36	22	18	23	18	21	23	19	20	22	18	21.82 (5.09)	21.32 (3.96)
Oral Reading WPM	80	80	81	92	94	101	103	128	129	132	143	105.73 (23.25)	119.44 (23.06)
Nelson Denny	198	187	203	235	203	221	233	239	193	234	214	214.54 (18.82)	221.02 (18.17)
Nelson Denny %ile	18	20	55	54	51	44	47	93	20	32	56	44.54 (21.89)	54.15 (25.76)
Wide Range Achievement Test-Reading (WRAT-Reading) (max=57)	45 (32%ile)	45 (42)	49 (73)	47 (53)	44 (45)	42 (25)	45 (70)	51 (83)	52 (81)	51 (77)	48 (68)	47.18 (3.28)	48.90 (3.40)
Nonword Reading (max=35)	23		24	32	25	20	28	33	34	25		27.11 (4.91)	27.72 (3.78)
Word Attack (WJ)		508									514		519.29 (6.59)
Single-Word Silent Reading Task (SWSRT) (max=40)	29	32	35	33	27	30	31	30	31	33	33	31.27 (2.24)	32.41 (2.85)
Reaction Time/SWSRT (milliseconds)	3251	3494	2313	2428	2088	2235	3315	2029	2596	1777	4348	2715.82 (784.41)	2729.14 (1243.62)
Experimental Spelling Test (max=120)	76	54	57	82	60	63	76	76	81	81	85	71.91 (11.19)	77.34 (11.48)
Wide Range Achievement Test–Spelling (WRAT-Spelling) (max=55)	45 (63%ile)	42 (53)	41 (53)	46 (77)	37 (30)	40 (39)	43 (30)	43 (66)	48 (86)	48 (86)	42 (61)	43.18 (3.37)	43.75 (3.45)
Working Memory (2-6)	2	2.5	3	5	2	2.5	2.5	3	2	2	4	2.77 (.95)	100 (13.64)
IQ Full	84	96	116	106	91	91	104	110	96	106	109	100.82 (9.37)	107.54 (11.96)
Processing Speed Index (PSI- WAIS)	84	99	81	81	99	91	108	103	93	103	99	94.64 (9.36)	103.83 (15.82)

Table 2. Speed (WPM), Accuracy of Reading (C-WPM), and Dysfluency for the Slow and Fast Readers.

	Slow Readers									Fast Readers									
	1	**4**	**7**	**8**	**18**	**19**	**32**	**35**	**41**	**2**	**14**	**17**	**24**	**26**	**27**	**28**	**29**	**30**	**40**
WPM [1]	80	91	81	92	94	96	80	85	93	142	150	142	143	152	158	154	152	148	143
C-WPM [2]	79	90	79	92	90	91	76	84	90	142	150	142	142	152	158	154	151	148	143
Dysfluency [3]	11	7	9	3	17	18	18	8	21	2	1	3	1	2	3	3	3	4	4

[1] Word Per Minute (speed of reading passage)
[2] Correct-Words Per minute (accuracy of oral reading)
[3] Dysfluency (total number of reading errors of all types)

Table 3. Oral reading errors in slow, dysfluent readers and fast, fluent readers

Error Type	**Dysfluent Readers** WPM mean= 88.08 SD=6.48 n=9			**Fluent Readers** WPM mean= 148.63 SD=5.78 n=10		
	Number of errors	**Number of participants producing this error**	**Mean (for those making the error)**	**Number of errors**	**Number of participants producing this error**	**Mean (for those making the error)**
Explicit Decoding	33	8	4.12 (1.64)	9	6	1.5 (.55)
Repetition (one or more words)	23	7	3.29 (2.29)	9	7	1.29 (.84)
Grammatical Morpheme	19	5	3.8 (2.77)	4	3	1.33 (.58)
Real Word Substitutions	15	8	1.87 (.834)	0	0	0
Nonword Substitution	14	2	7 (1.41)	2	2	1
Word Addition	5	3	1.66 (.58)	1	1	1
Transposition	1	1	1	1	1	1
Word Omission	1	1	1	0	0	0
Total	111	N/A	N/A	26	N/A	N/A

Table 4. Correlations between factors

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Oral Paragraph Reading	.496**	-.113	.742**	.486**	.452**	.672**	.505**	-.263	-.056	.075	.528**	.459**	.597**	.445**	.376*	.491**	.451**	-.677**	-.633**
2. Nelson Denny		.004	.469**	.340*	.268	.403**	.448**	-.500**	.156	.204	.429**	.346*	.437**	.443**	.322*	.249	.220	-.416*	-.358*
3. Age			.157	-.139	.234	.018	.059	-.021	-.053	-.087	-.194	-.161	-.216	-.078	-.151	-.114	-.067	-.051	.121
4. Experimental Spelling				.408**	.692**	.744**	.473**	-.200	.162	.191	.473**	.281	.473**	.527**	.222	.413**	.239	-.373	-.311
5. Nonword Reading z -scores					.392*	.476*	.184	-.312*	-.069	.075	.324*	.219	.324*	.292	.194	.254	.231	-.606**	-.482**
6. WRAT-Spelling						.631**	.424**	-.212	.032	.032	.285	.225	.307	.379*	.118	.215	.336*	-.228	-.140
7. WRAT-Reading							.494**	-.298	.294	.271	.667**	.311*	.614*	.662**	.247	.552**	.227	-.297	-.248
8. Semantic Task								-.197	.210	.255	.632**	.427**	.640**	.664**	.438**	.513**	.159	-.018	-.057
9. Mean RT									.058	-.038	-.233	.043	-.118	-.241	.033	-.232	-.187	.374*	.440*
10. Working Memory										.835**	.309*	.330*	.370*	.261	.204	.371	-.100	.280	.435*
11. Modified WM											.283	.378*	.366*	.221	.255	.465**	.116	.085	.173
12. Verbal IQ												.330*	.370*	.261	.204	.371*	-100	-.026	-.101
13. Performance IQ													.789**	.416*	.899**	.393*	.476**	-.207	-.043
14. Full IQ														.826**	.749**	.712**	.243	-.144	-.119
15. Verb Comp															.476**	.581**	-.008	-.066	-.148
16. Perceptual Index																.388*	.294	-.190	-.126
17. Working Memory Index																	.020	-.049	-.078
18. Processing Speed Index																		-.451**	-.332
19. RAN Colors																			.784**
20. RAN Letters																			

*Correlation is significant at the .05 level

**Correlation is significant at the .01 level

Table 5. Mean performance scores of slow, fast and mid-paced oral readers

	Slow Dysfluent Readers n=9		**Mid-Paced Readers** n=22		**Fast Fluent Readers** n=10		**Group Mean** n=41	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Oral Reading Rate (WPM) (range 80-158)	88.08	6.48	119.05	12.56	148.63	5.78	119.44	23.09
Nelson Denny	208.11	17.04	221.18	18.37	232.30	10.65	221.02	18.17
Age (range=16-36)	22.55	5.83	20.68	2.61	21.4	4.27	21.32	3.96
Experimental Spelling Test (max. 120) (range= 57-101)	67.67	10.21	76.13	9.14	88.70	7.60	77.34	11.48
Nonword Reading (max. 35) n=18 (range=20-34)	26.20 n=5	3.56	27.60 n=10	4.03	30.66 n=3	2.08	27.72	3.78
Word Attack (WJ) (standard score) n=25 (range=504-532)	511.25 n=4	7.77	518.00 n=12	5.95	523.87 n=8	4.64	519.29	6.59
Wide Range-Spelling (max. 55) (range=37-51)	41.89	3.18	43.86	3.81	46.20	3.08	43.75	3.45
WRAT-Reading (max.57) (range= 42-55)	46.89	2.03	48.45	3.50	51.70	2.41	48.90	3.40
SWSRT (oral) (max. score 80) (range= 68-80)	74.00 n=4	3.16	76.00 n=12	3.78	79.00 n=8	.925	76.66	3.43
SWSRT (silent) (max. 40) (range= 27-38)	30.44	2.92	34.45	2.67	34.10	2.23	32.41	2.85
Reaction Time SWSRT (milliseconds) (range=1319-8488)	3245.22	2025.77	2718.04	741.83	2289.10	1208.35	2729.14	1243.62
Working Memory Capacity (2.0-6.0) (range=2-5.5)	3.39	1.47	2.68	.81	3.00	1.08	2.91	1.06
Table 5 con't								

Table 5. Mean performance scores of slow, fast and mid-paced oral readers (continued)

	Slow Dysfluent Readers n=9		**Mid-Paced Readers** n=22		**Fast Fluent Readers** n=10		**GroupMean** n=41	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Modified Working Memory Capacity (2.0-6.0) (range=2-5.5)	3.40	1.78	3.47	.99	3.33	1.14	3.42	1.14
Full IQ (range=84-135)	101.33	11.84	104.36	8.34	120.10	10.49	107.54	11.96
Verbal IQ (range=84-145)	105.11	12.73	107.36	11.46	123.20	13.95	110.73	14.05
Performance IQ (range=84-127)	96.11	11.43	99.59	9.75	111.40	10.10	101.71	11.49
Verbal Index (range=88-148)	109.44	14.04	108.86	12.06	124.50	12.93	112.80	14.10
Perceptual Index (range=78-125)	98.00	12.44	99.68	10.52	111.50	10.68	102.19	11.99
Working Memory Index (range=80-139)	94.00	11.28	97.95	13.54	110.10	11.28	100.00	13.64
Processing Speed Index (range=79-137)	89.44	8.83	106.36	15.97	111.20	12.85	103.83	15.82
RAN Colors (seconds) (range=17.58-43)	33.75 n=6	7.17	26.18 n=19	4.78	21.31 n=9	2.90	26.22	6.45
RAN Letters (seconds) (range=11.51-36.47))	25.45 n=6	6.68	18.22 n=19	2.89	15.35 n=9	2.86	18.53	4.94

* Unless otherwise indicated all participants within a group (slow, fast or mid-paced readers) engaged in each task. If the entire group did not participate in a given task the "N" is indicated

Table 6. Multiple Regression Analysis

A. Regression analysis with the interaction terms entered in order 1,2,3,4 and WPM as the dependent variable.

	B	**Beta**	**R^2**	**R^2 Change**	**Sig.**
1 Experimental Spelling	1.279	.636	.551	.551	.000
2 WRAT Spelling	-1.818	-.295	.558	.007	.035
3 WRAT Reading	2.113	.311	.601	.043	.035
4 PSI	.477	.327	.696	.095	.002
Total variance explained .696					

B. Regression analysis with the interaction terms entered in order 1,2 and WPM as the dependent variable.

	B	**Beta**	**R^2**	**R^2 Change**	**Sig.**
1 Experimental Spelling	1.351	.673	.551	.551	.000
2 PSI	.422	.290	.630	.079	.007
Total variance explained .630					

C. Regression analysis with the interaction terms entered in order 1,2, 3 and Nelson Denny Reading Test as the dependent variable.

	B	**Beta**	**R^2**	**R^2 Change**	**Sig.**
1 SWSRT	1.42	.224	.201	.201	.181
2 WM	2.239	.131	.205	.004	.363
3 WPM	.308	.391	.315	.110	.020
Total variance explained .315					

Table 7. Rank-ordered task performance for slow and fast readers

	Slow Readers									Fast Readers									
	1	4	7	8	18	19	32	35	41	2	14	17	24	26	27	28	29	30	40
Chronological Age	36	20	18	23	18	27	22	21	18	20	18	17	20	20	18	28	29	26	18
WPM [1]	40	37	39	36	34	33	41	38	35	10	5	9	7.5	3.5	1	2	3.5	6	7.5
Dysfluency[2]	11	7	9	3	17	18	18	8	20	2	1	3	1	2	3	3	3	4	4
Nelson Denny	35.5	17	33	9.5	33	26	40	29.5	38.5	13	6	6	3.5	3.5	20	13	9.5	27.5	27.5
WRAT-R[3]	35	25.5	22	28	39	25.5	35	17.5	30.5	6	17.5	17.5	3.5	1.5	17.5	12	1.5	12	25.5
Nonword Z scores	20	12	19	4	17	16	21	11	22	9	3	7	6	11	6	6	8	11	16
SWSRT (silent)[4]	36.5	40	10	17.5	40	38	24	17.5	33	17.5	10	5.5	28.5	5.5	24	10	1	24	17.5
RT SWSRT[5]	32	18	20	22	14	26	36	15	41	8	13	21	3	1	2	4	5	40	39
WRAT-S[6]	16.5	22.5	33	10	40.5	39	27.5	16.5	37	4	3	10	1.5	10	27.5	20	10	10	27.5
Exp Spell	24	21.5	40	15	38	39	41	29.5	29.5	4.5	8	27.5	2.5	1	17.5	10	6	2.5	11.5
Working Memory Capacity	35.5	9.4	13	3	35.5	35.5	22.5	1	5.5	35.5	35.5	22.5	9.5	13	22.5	22.5	2	22.5	8
Full IQ	41	40	9.5	24	38.5	29	33.5	15	7.5	15	5	2.5	6	2.5	7.5	21	1	11	19
Verbal IQ	41	32	6	23	36.5	21	38	19.5	9.5	13.5	13.5	1	5	4	15	11.5	3	17	28.5
Performance IQ	37	41	20.5	20.5	37	32.5	26.5	13.5	6.5	23	1	10.5	15.5	2.5	5	26.5	2.5	6.5	20.5
VCI[7]	19	15	2	8	17	11	20	11	9	8	6	2	4	1	10	6	4	9	13
PI[8]	33	39.5	7	16.5	39.5	28	28	16.5	13	24.5	1.5	9.5	18.5	1.5	3	28	13	4	20.5
PSI[9]	37	35.5	39	39	24.5	32.5	34	20	39	2	10.5	30.5	10.5	10.5	7	28	10.5	13.5	24.5
WMI[10]	37	33	10.5	28.5	37	23.5	37	8	17.5	23.5	17.5	5	5	21.5	5	17.5	1	13	10.5
RAN Colors				20	22	23	31	30	32	5		11	6	18	1	4	13	15	2
RAN Letters				29	18	23	30	32	33	6		7	5	17	1	10	27	8	2

[1] Words Per Minute (oral reading)
[2] Dysfluency (total number of reading errors)
[3] Wide Range Achievement Test-Reading
[4] Single-Word Silent Reading Test
[5] Reaction Time Single-Word Silent Reading Test
[6] Wide Range Achievement Test-Spelling
[7] Verbal Comprehension Index
[8] Perceptual Index
[9] Processing Speed Index
[10] WorkingMemory Index

Table 8. Comparison of reading comprehension, oral reading rate (WPM), nonword reading, word reading aloud, cognitive measures and SWSRT for participants 4 and 8

	Participant 4	Rank	Participant 8	Rank	Group Mean
WPM[1] (Oral Reading)	91.2	37	92.0	36	119.4 (23.09)
Nelson Denny Standard Score	231	17	235	9.5	221.02 (18.17)
WRAT-Reading (max.57)	48	25.5	47	28	48.90 (3.40)
Nonwords (experimental) (max.35)	27	12	32	4	27.72 (3.78)
SWSRT (max.40)	27	40	33	17.5	32 9 (2.85)
Reaction Time SWSRT[2] (milliseconds)	2292	18	2428	22	2729.14 (1243.62)
Working Memory Capacity (2-6)	3.5	9.5	5.0	3	2.91 (1.06)
Full IQ	90	40	106	24	107.54 (11.96)
Verbal IQ	99	32	108	23	110.73 (14.05)
Performance IQ	80	41	102	20	101.71 (11.49)
PSI[3]	86	35.5	81	39	103.83 (15.82)

[1] Words Per Minute (oral reading)
[2] Single-word Silent Reading Test
[3] Processing Speed Index (WAIS)

Table 9.Task performance rank-ordered for mid-paced readers

	Participants																					
	3	***5***	***6***	***9***	***10***	***11***	***12***	***13***	***15***	***16***	***20***	***21***	***22***	***23***	***25***	***31***	***33***	***34***	***36***	***37***	***38***	***39***
WPM	13	25	15	16.5	31	28	18	30	21.5	19.5	16.5	29	23	26	27	21.5	14	12	24	32	11	19.5
Nelson Denny	20	22	13	37	23.5	15	6	23.5	29.5	9.5	9.5	2	31	17	33	20	17	1	35.5	41	25	38.5
WRAT-R	17.5	22	12	8.5	41	35	12	30.5	35	39	12	35	8.5	25.5	30.5	22	3.5	6	39	30.5	6	17.5
Nonword	17	15	17	2	23	10	3	9	10	10	8	14	1	18	5	14	8	14	14	18	13	11
SWSRT (silent)	5.5	22.5	17.5	28.5	33	28.5	33	28.5	33	12.5	5.5	5.5	17.5	17.5	36.5	5.5	24	24	33	40	2	12.5
RT SWSRT	24	7	6	25	17	33	12	35	29	31	30	10	27	19	37	34	28	16	9	23	11	38
WRAT-S	16.5	1.5	5.5	5.5	37	22.5	22.5	27.5	40.5	27.5	10	27.5	16.5	33	37	33	16.5	10	33	33	16.5	22.5
Exp Spell	8	21.5	17.5	17.5	36.5	24	24	32	34.5	34.5	11.5	20	17.5	36.5	33	27.5	13.5	8	26	31	4.5	13.5
Working Memory Capacity	13	22.5	35.5	35.5	22.5	22.5	13	13	35.6	22.5	35.5	35.5	22.5	5.5	22.5	22.5	22.5	5.5	35.5	22.5	5.5	35.5
Full IQ	27	19	24	33.5	38.5	27	15	19	12	22	15	30.5	9.5	27	35.5	24	32	15	37	35.5	4	30.5
Verbal IQ	25.5	17	25.5	27	40	32	7.5	23	19.5	35	7.5	17	9.5	28.5	39	11.5	30	23	32	36.5	2	34
Performance IQ	24	17	18	39.5	30	10.5	26.5	13.5	8	4	26.5	39.5	10.5	15.5	30	34.5	32.5	10.5	37	34.5	20.5	30
VCI	9	7	17	12	22	14	10	10	13	19	5	8	9	16	20	7	15	7	21	18	3	13
PI	24.5	22.5	18.5	41	36.5	9.5	28	13	7	5	7	38	13	13	31.5	28	36.5	22.5	34.5	31.5	20.5	34.5
PSI	4	2	20	30.5	32.5	15.5	20	7	5	2	41	35.5	17	15.5	20	34	13.5	20	28	28	24.5	7
WMI	30.5	17.5	3	13	37	33	25	26	17.5	37	17.5	21.5	8	13	33	27	28.5	30.5	8	40.5	2	40.5
RAN Colors	14	25	8			17			3	10	19	27		26	16	29	9	7	24	21	28	12
RAN Letters	20	22	11			12			4	19	13	28	16	31	9	14	25	3	21	26	15	24

Table 10. Silent reading, oral reading and processing speed differences in individuals 16 and 21

	Participant 16	Participant 21	Group Mean	SD
WPM[1]	125	103	119.44	23.06
Nelson Denny	235	247	221.02	18.17
PSI[2]	137	86	103.83	15.82
Nelson Denny Rank	9.5	2	N/A	N/A
WPM[1] Rank	19.5	29	N/A	N/A
PSI[2] Rank	2	35.5	N/A	N/A

[1] Words Per Minute (oral reading)
[2] Processing Speed Index (WAIS)

Table 11. Participants with a dissociation in ranked scores meeting the stringent requirements set forth of a ranked score of 1-5 in one measure and 36-41 in the other measure.

	Slow Readers				Mid- Paced Readers		
	7	8	35	41		9	21
Chronological Age (actual)	18	23	21	18		20	25
WPM [1]	39	36	38				
Nelson Denny				38.5		37	2
WRAT-R[2]							
Nonword		4				2	
Word Attack (WJ)							
SWSRT (oral)[3]							
SWSRT (silent)[3]							
RT SWSRT[4]							
Exp Spell							
WRAT-S[5]							
Working Memory Capacity		3	1	5.5			
Full IQ							
Verbal IQ							
Performance IQ							39.5
VCI[6]	2						
PI[7]							38
PSI[8]							
WMI[9]							
RAN Colors							
RAN Letters							

[1] Words Per Minute (oral reading)
[2] Wide Range Achievement Test-Reading
[3] Single-Word Silent Reading Test
[4] Reaction Time Single-Word Silent Reading Test
[5] Wide Range Achievement Test-Spelling
[6] Verbal Comprehension Index
[7] Perceptual Index
[8] Processing Speed Index
[9] Working Memory Index

Table 12. Scores for the fluent participant who reported a history of reading differences as compared to the group mean

	Group Mean		Participant 6
Nelson Denny (standard score)	221.02	(18.17)	234
WRAT-Reading (max. 57)	48.90	(3.40)	51
Nonword Reading (max.35)	27.72	(3.78)	25
SWSRT (max.40)	32.41	(2.85)	33
Reaction Time/ SWSRT	2729.15	(1243.62)	1777
Experimental Spelling Test (max.120)	77.34	(11.48)	81
WRAT Spelling (max.57)	44	(3.74)	48
Working Memory	2.91	(1.06)	2
IQ	107.54	(11.96)	106

Figure1. Predicted correlations between variables

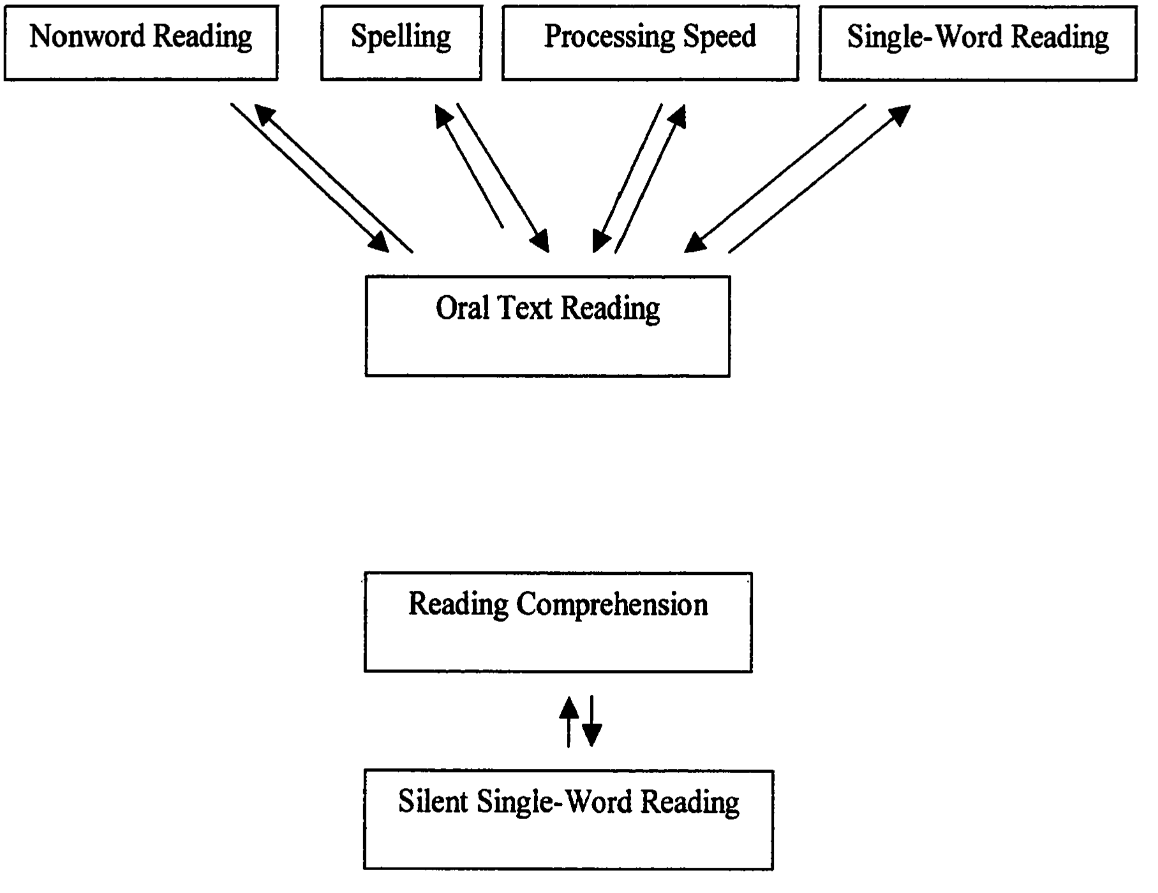
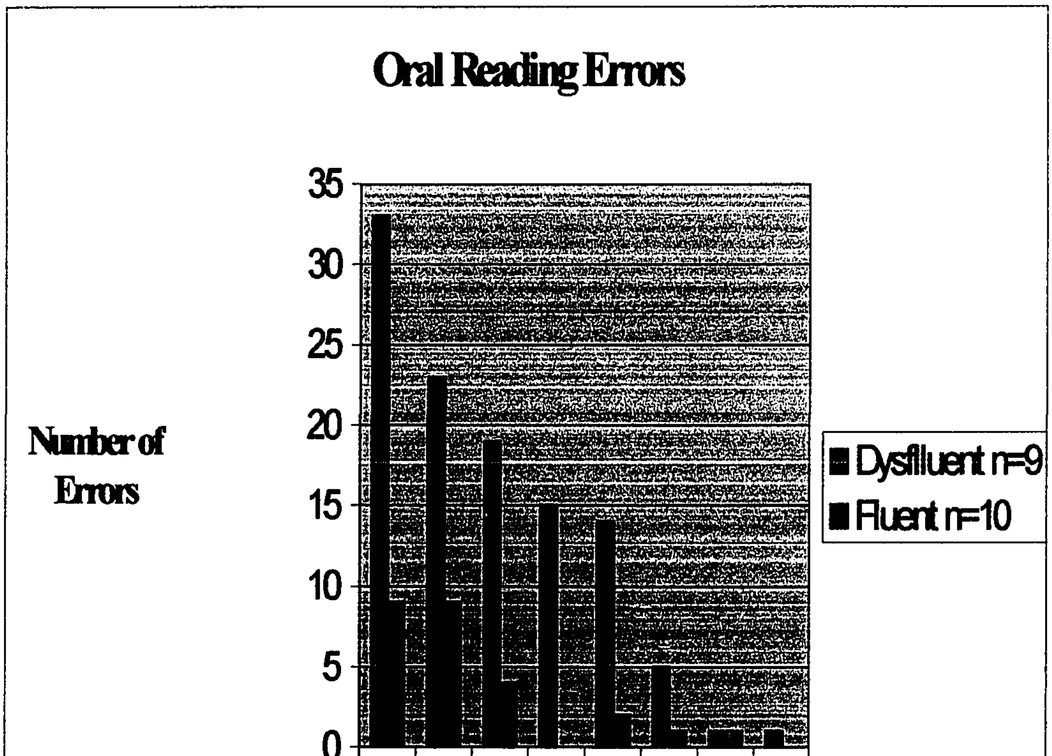


Figure 2. Oral reading errors by error type for fluent and dysfluent oral readers



	A	B	C	D	E	F	G	H
Dysfluent n=9	33	23	19	15	14	5	1	1
Fluent n=10	9	9	4	0	2	1	1	0

Error Type

A. Explicit Decoding
B. Repetition
C. Morpheme
D. Word Substitution
E. Nonword Substitution
F. Word Addition
G. Transposition
H. Word Omission

Figure 3.Oral Reading Rate and Reading Errors

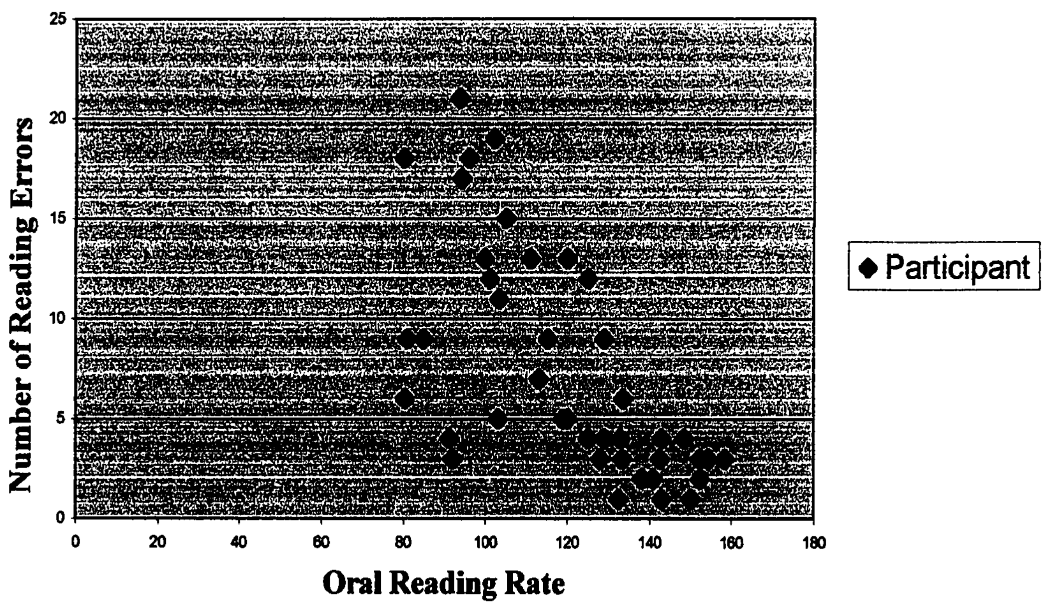
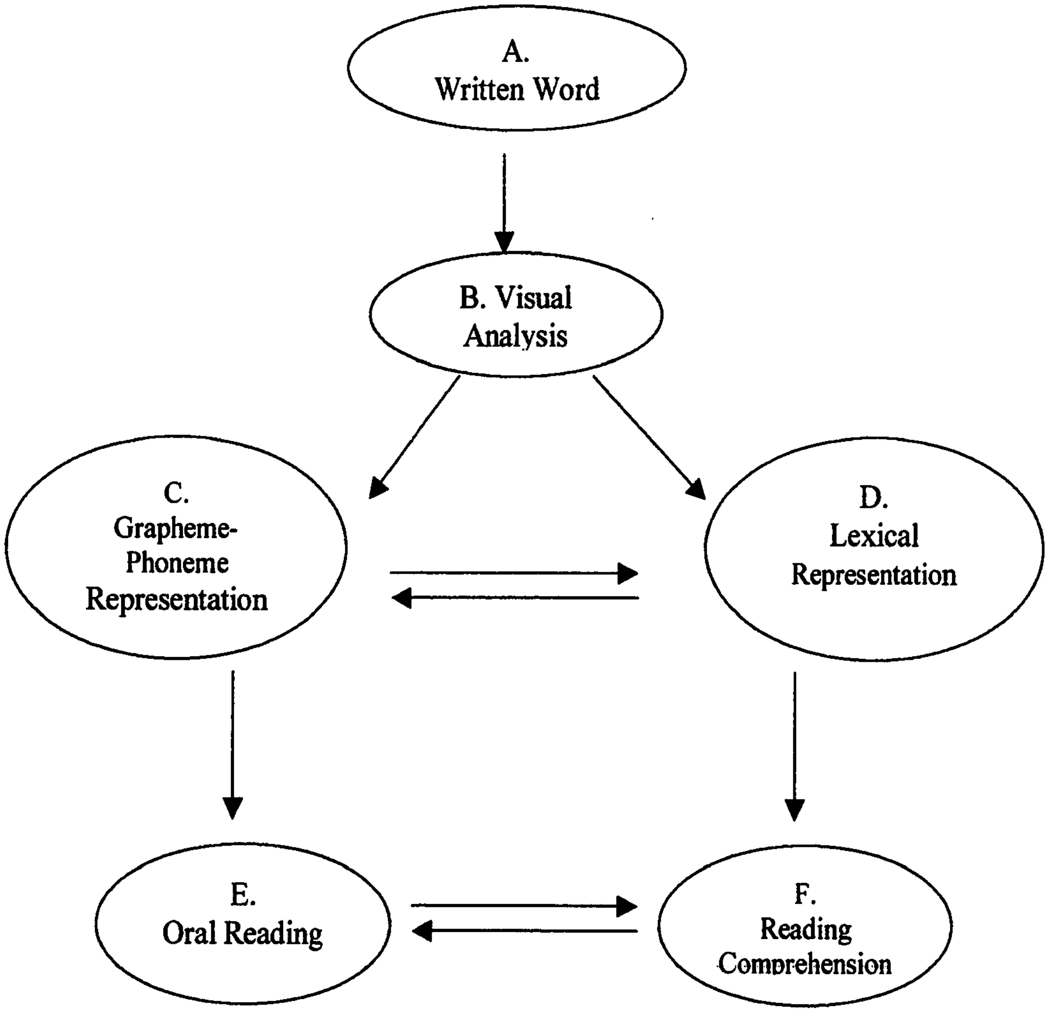


Figure 4. Reading Model



Appendix A
Nonword Reading Task
(Bruck, 1990)

Practice Items:
- plit
- culk
- bipe
- pake

Task Items:
- deet
- chun
- drap
- smin
- lule
- praw
- dounch
- peanch
- chunge
- loarse
- boarst
- drunse
- cumpse
- smedge
- pringe
- smavel
- uldrin
- darple
- borvay
- pimsot
- chadle
- esprew
- carpus
- raliss
- plamid
- pletidge
- mantrone
- smerstle
- roltinse
- cullshew
- barptiss
- churtee
- esprinch
- deestron
- uldrane

Appendix B

Single-Word Silent Reading Test (SWSRT)

Practice Items

number	numeral
hot	cold
send	relay

Test Stimuli		Foils	
nuisance	annoyance	condemn	broader
precise	exact	hinder	demon
manipulate	maneuver	blast	flush
expedite	accelerate	baffle	annoy
catastrophe	calamity	spew	bask
clumsy	awkward	blow	acre
anticipation	expectation	huddle	barrage
careful	cautious	estuary	respire
convey	transmit	employment	accomplish
converge	intersect	demography	calibration
calculate	compute	fungicide	antibiotic
core	nucleus	adaptation	stability
hazardous	perilous	condiment	fledgling
leave	exit	elevate	eject
acquire	obtain	relinquish	dissolution
fast	quick	allowance	decrease
radiate	illuminate	align	depress
appendage	attachment	laborious	effusive
circumscribe	encompass	inoculate	vacuolate
demonstrate	illustrate	satisfaction	employment

Appendix C
Experimental Spelling Test
(Fischer, Schankweiler, & Liberman, 1985)

Level I

1. yam
2. inflate
3. adverb
4. vortex
5. cameo
6. harp
7. terminates
8. trump
9. vacate
10. updated
11. vibrated
12. mandated
13. compensates
14. delimit
15. zebra
16. blunder
17. emit
18. bower
19. repent
20. intertwined
21. uncover
22. diplomat
23. retort
24. canister
25. clustering
26. undiminished
27. terminology
28. mask
29. manifestation
30. definitions
31. frustrated
32. expectation
33. alternate
34. stimulation
35. examiner
36. preventive
37. unemployment
38. punishment
39. establishing
40. electronics

Level II A

1. strapped
2. skillful
3. cancelled
4. picnickers
5. abridgment
6. flier
7. changeable
8. sincerely
9. echoes
10. disbelieve
11. sobbing
12. beige
13. skies
14. unperceived
15. clannish
16. noticeable
17. ninety
18. thinned
19. basically
20. definitely

Level II B

1. misspell
2. aggravate
3. commemorate
4. defensible
5. grammar
6. clearance
7. inexhaustible
8. utterance
9. continuance
10. prevalent
11. dissimilar
12. preferring
13. inspiration
14. omitted
15. repetition
16. indigestible
17. recommend
18. regrettable
19. equipped
20. commiserate

Level III

1. Chihuahua
2. onomatopoeia
3. Fahrenheit
4. plagiarism
5. sarsaparilla
6. hemorrhage
7. sergeant
8. eunuch
9. connoisseur
10. mnemonic
11. reveille
12. desiccate
13. syphilis
14. pygmy
15. sacrilegious
16. diphtheria
17. hieroglyphic
18. thumb
19. gnaw
20. lengthen
21. Wednesday
22. soldered
23. talker
24. subpoena
25. annihilate
26. rhododendron
27. kaleidoscope
28. pyorrhea
29. bourgeois
30. thigh
31. listener
32. slaughter
33. indebted
34. climb
35. answering
36. knock
37. beautifully
38. laugh
39. folk
40. tongue

Appendix D

Questionnaire
Oral Reading/Silent Reading Study

Participant Number: _______

Name: ____

Email___________________________

Phone: ___________________

Date of Birth: ___________________________ Age: ____________________

Native language spoken _________________________________

Do you speak any other languages? ______________

Do you speak these languages at home or work? _____________

Do you use a different speech pattern in social settings (e.g. different dialect, Ebonics, etc.)? _______
If yes, explain

____

____

____

At what age did you begin First grade? ___________

Did you take a foreign language in High school? _____ College? _______

Which language(s)? _______________
How many years of language did you have?_____________________
What was the easiest part of learning a foreign language?

____

____

____

What was the hardest part of learning a foreign language?

____

____

Would you describe yourself as a "good" foreign language learner?

____

Grades? __________

How did these grades compare to your other subjects?

____

Do you have a history of any of the following?

Visual Problems ______ Do you wear glasses for reading? ___

Stroke ______

Hearing Loss ______ When diagnosed? __________

Seizures ______

Attention Deficit Disorder ______ When diagnosed? __________

Neurological Disorders _______

(e.g. Parkinson's Disease, Multiple Sclerosis, etc)

If yes to any of the above please describe:

____

____

____

Do you currently take any prescription drugs on a daily basis? __________

List medications taken:

____

Did you have difficulty learning to read? __________

Did you have difficulty with speech/language? _________

Seen by a Speech-Language Pathologist? ____________ Please Explain

____

Did you receive assistance from anyone while learning to read? ______

Who assisted you? Teacher __________

Reading Specialist __________

Parent ____________

What grade(s) were you in when you received assistance?

____

If possible, please describe the nature of your difficulty when learning to read (if any)

____

____

____

____

____

Do you currently attend school? _________

If yes where?

____

Major: ___________________

If you do not attend school, what are you currently doing?

____

Have you taken the SAT? _____ yes _____ no When? ____________

Score: Quantitative __________

Verbal ____________

Do not remember scores ____________

Do you read for pleasure? _______yes ________no

What kind of material do you read for pleasure?

_______ books (fiction, nonfiction)

_______ magazines

_______ technical manuals (scientific, computer)

_______ electronic publications (e.g. websites)

Do you read the newspaper daily? _______yes _______no

Do any of your family members have a history of difficulty reading (e.g. siblings, parents, grandparents)? ________ yes __________no Who? ___________________

When you read do you hear your "inner speech?" _____ yes _____ no

Would you be interested in participating in additional research? _____yes _____no
Would you like a summary report of my findings? ________ yes ___________ no
If you would like information regarding the outcome of the study please include your name and address below.

____

____

____

Permanent Phone number if different from current phone number

____

Appendix E

General Demographic Information

Participant	Age	Gender	Learning Difference		Yrs of Ed Completed	College Major (if any)	Combined SAT or PSAT score
Dysfluent			Yes	No			
1	36	F	*		15	Speech Path	Don't know
4	20	F		*	13	Education/Psy	1000
7	18	M	*		11	N/A	1150
8	23	M	*		16	Art	Don't know
18	18	M	*		11	N/A	1000
19	27	F		*	16	Graphic Art	900
32	22	M	*		14	Business	1100
35	21	F		*	14	Music	1080
41	18	M		*	11	N/A	950
Mid-Paced							
3	24	F		*	16	Speech Path	900
5	23	F		*	16	Speech Path	890
6	22	F	*		16	Speech Path	880
9	20	M	*		14	Communication	1020
10	21	F	*		15	Speech Path	Don't know
11	23	F	*		16	Special Ed	1100
12	19	F	*		13	Speech Path	1020
13	23	F		*	15	Communication	Don't know
15	16	F		*	10	N/A	Don't know
16	20	F		*	15	Business	990
20	23	F		*	17	Sociology	Don't know
21	25	F		*	15	Speech Path	970
22	20	F		*	14	Speech Path	1210
23	20	F		*	14	Speech Path	1160
25	16	F		*	11	N/A	Don't know
31	18	M		*	12	N/A	1190
33	21	F		*	14	Communication	1090
34	20	F		*	14	Speech Path	1100
36	18	F		*	12	Crim Justice	890
37	20	M		*	14	Accounting	950
38	17	M		*	11	N/A	1150
39	25	F		*	15	Music Therapy	Don't know
Fluent							
2	20	F		*	13	Speech Path	1100
14	18	M		*	12	N/A	1220
17	17	M		*	12	N/A	1310
24	20	F		*	15	Psychology	1160
26	20	M		*	14	Communication	1510
27	18	F		*	12	Biology	1300
28	28	M		*	16	Education	1140
29	29	F		*	16	Education	1220
30	26	F		*	16	Business	1100
40	18	F	*		12	Undecided	980

Appendix F

Rank ordered performance for slow, dysfluent readers with no history of learning differences (A) and slow, dysfluent readers with a reported history of learning differences (B), mid-paced readers with a history of learning differences (C) and the fast reader with a history of learning differences (D)

	A.				B.					C.					D.
	4	**19**	**35**	**41**	**1**	**7**	**8**	**18**	**32**	**6**	**9**	**10**	**11**	**12**	**40**
Oral Reading Rate WPM[1]	37	33	38	35	40	39	36	34	41	15	16.5	31	28	18	7.5
Nelson Denny	17	26	29.5	38.5	35.5	33	9.5	33	40	13	37	23.5	15	6	27.5
WRAT-Reading[2]	25.5	25.5	17.5	30.5	35	22	28	39	35	12	8.5	41	35	12	25.5
Nonword Reading	12	16	11	22	20	19	4	17	21	17	2	23	10	3	16
SWSRT (silent)[3]	40	38	17.5	33	36.5	10	17.5	40	24	17.5	28.5	33	28.5	33	17.5
Reaction Time/SWSRT[4]	18	26	15	41	32	20	22	14	36	6	25	17	33	12	39
WRAT Spelling[5]	22.5	39	16.5	37	16.5	33	10	40.5	27.5	5.5	5.5	37	22.5	22.5	27.5
Experimental Spelling Test	21.5	39	29.5	29.5	24	40	15	38	41	17.5	17.5	36.5	24	24	11.5
Working Memory	9.4	35.5	1	5.5	35.5	13	3	35.5	22.5	35.5	35.5	22.5	22.5	13	8
Full IQ	40	29	15	7.5	41	9.5	24	38.5	33.5	24	33.5	38.5	27	15	19
Verbal IQ	32	21	19.5	9.5	41	6	23	36.5	38	25.5	27	40	32	7.5	28.5
Performance IQ	41	32.5	13.5	6.5	37	20.5	20.5	37	26.5	18	39.5	30	10.5	26.5	20.5
VCI[6]	15	11	11	9	19	2	8	17	20	17	12	22	14	10	13
PI[7]	39.5	28	16.5	13	33	7	16.5	39.5	28	18.5	41	36.5	9.5	28	20.5
PSI[8]	35.5	32.5	20	39	37	39	39	24.5	34	20	30.5	32.5	15.5	20	24.5
WMI[9]	33	23.5	8	17.5	37	10.5	28.5	37	37	3	13	37	33	25	10.5
RAN Colors		23	30	32			20	22	31	8			17		2
RAN Letters		23	32	33			29	18	30	11			12		2

[1] Words Per Minute (oral reading)
[2] Wide Range Achievement Test-Reading
[3] Single-Word Silent Reading Test
[4] Reaction Time Single-Word Silent Reading Test
[5] Wide Range Achievement Test-Spelling
[6] Verbal Comprehension Index
[7] Perceptual Index
[8] Processing Speed Index
[9] Working Memory Index

Appendix G.

Scores for the four dysfluent participants with no reported history of reading difficulty as compared to the group means

	Group Means		Participant			
	Mean	**SD**	**4**	**19**	**35**	**41**
Oral Reading Rate (WPM)	119.44	(23.06)	91.20	95.8	84.86	93.54
Nelson Denny	221.02	(18.17)	231	215	213	188
WRAT-Reading (max.57)	48.90	(3.40)	48	48	50	46
Nonword Reading (max.35)	27.72	(3.78)	27			
Word Attack (WJ)	519.29	(6.59)		514	519	504
Semantic Task (max.40)	32.41	(2.85)	27	28	23	30
Reaction Time/Semantic Task	2729.14	(1243.62)	2292	2706	2247	8488
Experimental Spelling Test (max.120)	77.34	(11.48)	77	59	72	72
WRAT Spelling (max.55)	43.75	(3.45)	43	38	45	40
Working Memory (2-6)	2.91	(1.06)	3.5	2	6	4.5
IQ	107.54	(11.96)	99	102	110	117
PSI*	103.83	(15.82)	86	91	103	81

* Processing Speed Index (WAIS)

Appendix H

Scores for slow dysfluent readers with no history of learning differences (A) and with a reported history of learning differences (B)

	A.					B.				
	4	**19**	**35**	**41**		**1**	**7**	**8**	**18**	**32**
Oral Reading Rate WPM	91.2	95.8	84.86	93.54		80.28	81	92	94	80
Nelson Denny	231	215	213	188		198	203	235	203	187
WRAT-Reading (max.57)	48	48	50	46		45	49	47	44	45
Nonword Reading (max.35)	27					23	24	32	25	
Word Attack (WJ)		514	519	504						508
SWSRT (max.40)	27	28	23	30		29	35	33	27	33
Reaction Time/SWSRT (milliseconds)	2292	2706	2247	8488		3251	2313	2428	2088	3494
Experimental Spelling Test (max.120)	77	59	72	72		76	57	82	60	54
WRAT-Spelling (max.55)	43	38	45	40		45	41	46	37	42
Working Memory (2-6)	3.5	2	6	4.5		2	3	5	2	2.5
IQ	99	102	110	117		84	116	106	91	96
Processing Speed Index	86	91	103	81		84	81	81	99	99

References

Aram, D., & Healy, J. (1988). Hyperlexia: A review of extraordinary word recognition. In L.K.Obler, and D. Fein (Eds.), The Exceptional Brain: Neuropsychology of Talent and Special Abilities. New York, New York: The Guilford Press.

Baddeley, A., Logie, R., & Brereton, N. (1985). Components of fluent reading. Journal of Memory and Language, 24, 119-131.

Berninger, V.W., Abbott, R.D., Billingsley, F., & Nagy, W. (2001a). Processes underlying fluency of reading: Efficiency, automaticity, coordination, and morphological awareness. In M.Wolf (Ed.), Dyslexia, Fluency and the Brain. Timonium, Maryland:York Press.

Berninger, V.W., Abbott, R.D., Brooksher,R., Lemos, Z., Ogier, S., Zook, D., Mostafopour, E. (2000). A connectionist approach to making the predictability of English orthography explicit to at-risk beginning readers: Evidence for alternative, effective strategies. Developmental Neuropsychology, 17, 241-271.

Berninger, V.W., Abbott, R.D., Thomson, J.B., & Raskind, W.H. (2001b). Language phenotype for reading and writing disability: A family approach. Scientific Studies of Reading, 5, 59-105.

Biemiller, A. (1977). Relationships between oral reading rates for letters, words, and simple text in the development of reading achievement. Reading Research Quarterly, 2, 223-253.

Boder, E.(1973). Developmental dyslexia: A diagnostic approach based on three atypical reading-spelling patterns. Developmental Medicine and Child Neurology, 15, 663-687.

Bowers, P. (1993). Text reading and rereading: determinants of fluency beyond word recognition. Journal of Reading Behavior, 25, 133-151.

Brown, J., Fischo, V., Hanna, G. (1993). Nelson Denny Reading Test. Chicago : Riverside Publishing Company.

Bruck, M. (1990). Word-recognition skills of adults with childhood diagnosis of dyslexia. Developmental Psychology, 26, 439-454.

Bruck, M. (1992). Persistance of dyslexics' phonological awareness deficits. Developmental Psychology, 28, 874-886.

Bruck, M. (1993). Component spelling skills of college students with childhood diagnoses of dyslexia. Learning Disability Quarterly, 16, 171- 183.

Caplan, D. (1987). Neurolinguistics and linguistic aphasiology, an introduction. Cambridge Studies in Speech and Communication. Cambridge: Cambridge University Press.

Caplan, D., & Waters, G. (1999). Verbal working-memory and sentence comprehension. Behavioral and Brain Sciences, 22, 22-126.

Castles, A., Datta, H., Gayan, J., & Olson, R. (1999). Varieties of developmental reading disorder: Genetic and environmental influences. Journal of Experimental Child Psychology, 72, 73-94.

Catts, H., & Kamhi, A. (1999). Language and reading disabilities. Needham Heights, MA; Allyn and Bacon.

Coltheart, M. (2003). Modular modeling of language processing: Its implications for understanding and assessing acquired and developmental language disorders. Presentation at the annual meeting of the International Neuropsychological Society, Waikiki, Hawaii.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: Dual route and parallel distributed processing approaches. Psychological Review, 100, 589-608.

Coltheart, M., Masterson, J., Byng, S., Prior, M., & Riddoch, J. (1983). Surface dyslexia. Quarterly Journal of Experimental Psychology, 35A, 469-496.

Craik, F., & Lockhart, R. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Daneman, M., & Carpenter, P. (1980). Individual differences in working-memory and reading. Journal of Verbal Learning and Verbal Behavior, 19, 450-466.

De Jonge, P., & de Jonge P.F. (1996). Working-memory, intelligence and reading ability in children. Personality and Individual Differences, 21, 1007-1020.

Denckla, M., & Rudel, R. (1976). Rapid 'automatized' naming (R.A.N.): Dyslexia differentiated from other learning disabilities. Neuropsychologia, 14, 471-479.

Denckla, M., & Cutting, L. (1999). History and significance of rapid automatized naming. Annals of Dyslexia, 49, 29-44.

Dowhower, S. (1987). Aspects of repeated reading on second-grade transitional readers' fluency and comprehension. Reading Research Quarterly,22, 389- 406.

Dowhower, S. (1994). Repeated reading revisited: Research into practice. Reading and Writing Quarterly: Overcoming Learning Difficulties, 10, 343-358.

Ehri, L. (1980). The development of orthographic images. In U. Frith (Ed.), Cognitive processes in spelling. New York: Academic Press.

Ehri, L. (1986). Sources of difficulty in learning to spell and read. In M.Wolraich and D. Routh (Eds.), Advances in Developmental and Behavioral Pediatrics, Vol.7, Greenwich, Connecticut: Jai Press Inc.

Felton, R., Naylor, C., & Wood, F. (1990). Neuropsychological profile of adult dyslexics. Brain and Language, 39, 485-497.

Fleisher, L., Jenkins, J.R., & Pany, D. (1979). Effects on poor readers' comprehension of training in rapid decoding. Reading Research Quarterly, 15, 30-48.

Finucci, J., Isaacs, S., Whitehouse, C., & Childs, B. (1982). Empirical validation of reading and spelling quotients. Developmental Medicine and Child Neurology,24, 733-744.

Fisher, D., & Peters, C. (1981). Comprehension and the competent reader: Inter-specialty perspectives. New York, NY: Praeger Publishers.

Fischer, F., Shankweiler, D. & Liberman, I. (1985). Spelling proficiency and sensitivity to word structure. Journal of Memory and Language,24, 423-441.

Flynn, J., & Deering, W. (1989). Subtypes of dyslexia: investigation of Boder's system using quantitative neurophysiology. Developmental Medicine and Child Neurology, 31, 215-223.

Frith, U. (1980). Cognitive processes in spelling. New York: Academic Press.

Goldberg O'Rourke, A., Katzir-Cohen, T., & O'Brien, B. (2001, June). What's in a RAN? A comparison of two measures of rapid automatized naming. Poster presentation made at the annual meeting of the Society for the Scientific Study of Reading, Boulder, Colorado.

Goodman, J. (1972). A case study of an " autistic savant": Mental function in the psychotic child with markedly discrepant abilities. Journal of Child Psychology and Psychiatry and Allied Disciplines, 13, 267-278.

Greenberg, D., Ehri, L., & Perin, D. (2002). Do adult literacy students make the same word-reading and spelling errors as children matched for word-reading age? Scientific Studies of Reading, 6, 21-243.

Hatcher, J., Snowling, M., Griffiths, Y. (2002). Cognitive assessment of dyslexic students in higher education. British Journal of Educational Psychology, 72, 119-133.

Harm, M. & Seidenberg, M. (2001). Are there orthographic impairments in phonological dyslexia? Cognitive Neuropsychology, 18, 71-92.

Hillis, A., & Caramazza, A. (1989). The graphemic buffer and attentional mechanisms. Brain and Language, 36, 208-235.

Jackson, N.E. & Coltheart, M.(2001). Routes to reading success and failure: Toward an integrated cognitive psychology of atypical reading. New York, New York : Psychology Press.

Jackson, N., & Doellinger, H.L. (2002). Resilient readers? University students who are poor recoders but sometimes good text comprehenders. Journal of Educational Psychology,94, 64-78.

Jackson, N., & Doellinger, H.L. (2001, June). When do university students who are poor decoders comprehend text adequately? Presentation made at the annual meeting of the Society for the Scientific Study of Reading, Boulder, Colorado.

Just, M., & Carpenter, P. (1992). A capacity theory of comprehension: Individual differences in working-memory. Psychological Review, 99, 122-149.

Katz, R., & Lanzoni, S. (1997). Activation of the phonological lexicon for reading and object naming in deep dyslexia. Brain and Language, 58, 46-60.

King, J., & Just, M. (1991). Individual differences in syntactic processing: The role of working memory. Journal of Memory and Language, 30, 580-602.

Klin, C., Guzman, A., & Levine, W. (1999). Prevalence and persistence of predictive inferences. Journal of Memory and Language, 40, 593-604.

Kucera, H., & Francis, W. (1967). Computational analysis of present-day American English. Providence, RI: Brown University Press.

LaBerge, D., & Samuels, S. (1974). Toward a theory of automatic information processing in reading. Cognitive Psychology, 6, 293-323.

Leinonen, S., Muller, K., Leppanen, P., Aro, M., Ahonen, T., & Lyytinen, H. (2001). Heterogeneity in adult dyslexic readers: Relating processing skills to the speech and accuracy of oral text reading. Reading and Writing: An Interdisciplinary Journal,14, 265-296.

MacDonald, M., Just, M., & Carpenter, P. (1992). Working-memory constraints on the processing of syntactic ambiguity. Cognitive Psychology, 24, 56-98.

Manis, F., Seidenberg, M., Stallings, L., Joanisse, M., Bailey, C., Freedman, L., Curtin, S., & Keating, P. (1999). Development of dyslexic subgroups: A one-year follow-up. Annals of Dyslexia, 49, 105- 134.

Marcel, A. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. Cognitive Psychology, 15, 197-237.

Marcel, A. (1980). Surface dyslexia and beginning reading: A revised hypothesis of the pronunciation of print and its impairments. In M. Coltheart, K. Patterson, & J.C. Marshall (Eds.), Deep dyslexia (p.227-258) London: Routledge and Kegan Paul.

Marsh, G., Friedman, M., Welch, V., & Desberg, P. (1980). The development of strategies in spelling. In U. Frith (Ed.), Cognitive processes in spelling. New York: Academic Press.

Masson, M., & Miller, J. (1983). Working-memory and individuals differences in comprehension and memory of text. Journal of Educational Psychology, 75, 314-318.

McKoon, G., & Ratcliff, R. (1981). The comprehension processes and memory structures involved in instrumental inference. Journal of Verbal Learning and Verbal Behavior, 20, 671-682.

Mercer, C., & Campbell, K. (1998). Great Leaps Reading Program. Micanopy, FL: Diarmuid, Inc.

Moats, L. (1995). Spelling development, disability, and instruction. Baltimore, MD: York Press.

Newton, P., & Barry, C. (1997). Concreteness effects in word production but not word comprehension in deep dyslexia. Cognitive Neuropsychology, 14, 481-509.

Obler, L., & Gjerlow, K. (1999). Language and the brain. Cambridge, UK: Cambridge University Press.

Patterson, K., & Marcel, A. (1977). Aphasia, dyslexia, and the phonological code of written words. Quarterly Journal of Experimental Psychology, 29, 307-318.

Pennington, B., McCabe, L., Smith, S., Lefly, D., Bookman, M., Kimberling, W., & Lubs, H.(1986). Spelling errors in adults with a form of familial dyslexia. Child Development, 57, 1001-1013.

Perfetti, C. & Hogaboam, T. (1975). The relationship between single word decoding and reading comprehension skill. Journal of Educational Psychology,67, 461-469.

Rayner, K. & Pollatsek, A. (1989). The psychology of reading. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Rubin, S. & Johnson, C. (2002). Lexical access in college students with learning disabilities: An electrophysiological and performance-based investigation. Journal of Learning Disabilities, 35, 257-265.

Scarborough, H. (1990). Very early language deficits in dyslexic children. Child Development, 61, 1728-1743.

Schmidt, B.T., Goral, M., Bortz, M., Goldberg, E., & Obler, L.K. (1998, April). Factors influencing single-word reading. Poster presented at the annual convention of the New York State Speech Language and Hearing Association, New York, NY.

Schmidt, B.T., Obler, L.K., Ehri, L., Chodorow, M. (2002, June). Phonological and Lexical Representation: Evidence of a Possible Dissociation between Oral Reading Fluency and Skilled Silent Reading Comprehension. Poster presentation at the annual meeting of The Society for the Scientific Study of Reading, Chicago, Illinois.

Schwartz, M., Saffran, E., & Marin, O. (1980). Fractionating the reading process in dementia: Evidence of word specific print-to-sound associations. In M. Coltheart, K.E. Patterson, & J.C. Marchall (Eds.), Deep dyslexia (pp.259-269). London: Routledge and Kegan Paul.

Schwartz, S. (1984). Measuring reading competence. A theoretical-prescriptive approach. New York, NY: Plenum Press.

Seidenberg, M., & McClelland, J. (1989). A distributed, developmental model of word recognition and naming. Psychological Review, 96, 523-568.

Shallice, T., & Warrington, E. (1975). Word recognition in a phonemic dyslexic patient. Quarterly Journal of Experimental Psychology, 27, 187-199.

Shaywitz, B.A., Fletcher, J.M., Holahan, J.M., Shneider, A.E., Marchione, K.E., Stuebing, K.K., Francis, D.J., Shankweiler, D.P., Katz, L., Liberman, I.Y., & Shaywitz, S.E. (1995). Interrelationships between reading disability and attention deficit hyperactivity disorder. Child Neuropsychology,1,170-186.

Shinn, M., Good, R., Knutson, N., & Tilly, W., (1992). Curriculum-based measurement of oral reading fluency: A confirmatory analysis of its relation to reading. School Psychology Review, 21, 459-479.

Snowling, M. (1980). The development of grapheme-phoneme correspondence in normal and dyslexic readers. Journal of Experimental Child Psychology, 29, 294-305.

Sparks, R. (2001). Phonemic awareness and reading skill in hyperlexic children: A longitudinal study. Reading and Writing An Interdisciplinary Journal, 14, 333-360.

Stanovich, K. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. Reading Research Quarterly, 86, 360-406.

Stanovich, K. (1991). Discrepency definitions of reading disability: Has intelligience led us astray? Reading Research Quarterly, 26, 7-29.

Swanson, H., & Alexander, J. (1997). Cognitive processes as predictors of word recognition and reading comprehension in learning-disabled and skilled readers: revisiting the specificity hypothesis. Journal of Educational Psychology, 89, 128-158.

Swanson, H., & Tranhan, M. (1996). Learning disabled and average readers' working memory and comprehension: Does metacognition play a role? British Journal of Educational Psychology, 66, 333-355.

Tan, A., & Nicholson, T. (1997). Flashcards revisited: Training poor readers to read words faster improves their comprehension of text. Journal of Educational Psychology, 89, 276-288.

Treiman, R. (1984). Individual differences among children in spelling and reading styles. Journal of Experimental Child Psychology, 37, 463-477.

Treiman, R., Kessler, B., and Bick, S. (in press). Context sensitivity in the spelling of English vowels.

van der Leij, A., & van Daal, V. (1999). Automatization aspects of dyslexia: Speed limitations in word identification, sensitivity to increasing task demands, and orthographic compensation. Journal of Learning Disabilities, 32, 417-428.

Wagner, R.K., Torgesen, J.T., & Rashotte, C.A. (1999). Comprehensive Test of Phonological Processing. Austin, Texas: PRO-ED.

Waters, G., & Caplan, D. (1996). The measurement of verbal working-memory capacity and its relation to reading comprehension. The Quarterly Journal of Experimental Psychology, 49 (A), 51-79.

Watkins, R., & Rice, M. (1994). Specific language impairments in children. Baltimore, Maryland: Brooks Publishing Co.

Wechsler D. (1997). Wechsler Adult Intelligence Scale-Third. Edition. San Antonio, TX: Psychological Corporation.

Wilkinson, G.S. (1995). The Wide Range Achievement Test-3. Wilmington: Jastak Associates.

Wolf, M. (1999). What time may tell: Towards a new conceptualization of developmental dyslexia. Annals of Dyslexia, 49, 3-28.

Woodcock, R.W., & Johnson, M.B. (1989). Woodcock-Johnson Tests of Achievement, Chicago: Riverside.