THE EFFECTS OF PHONOLOGICAL AWARENESS, RAPID-NAMING, AND VISUAL SKILLS ON EARLY ELEMENTARY STUDENTS’ READING FLUENCY

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS................................................................................................ ii

LIST OF TABLES........................................................................................................... vii

LIST OF FIGURES ....................................................................................................... viii

ABSTRACT..................................................................................................................... ix

CHAPTER

1 INTRODUCTION TO THE PROBLEM.....................................................................1

Rationale for the Study .................................................................................................5
Importance of Early Identification and Intervention .............................................5
Ongoing Debate .....................................................................................................5
A Continuing Attention on Phonological Awareness Research .......................6
New Trends of Reading-Related Vision Research ................................................8
A Rising Attention on Rapid-Naming Skills.......................................................10
Problems with Prior Research .............................................................................11
Why Reading Fluency? .......................................................................................13
Scope of the Study ......................................................................................................13
Delimitations ...........................................................................................................14
Limitations ...............................................................................................................14
Brief Definition of Terms ...........................................................................................14

2 LITERATURE REVIEW ...........................................................................................16

Theoretical Framework .............................................................................................17
Connectionism ..........................................................................................................17
Seidenberg and McClelland’s Connectionist Model .............................................18
Seidenberg and McClelland’s Model on Orthographic Deficits .........................19
Adams’ Reading Process Model ...........................................................................21
Ehri’s Theory of the Development of Word Recognition ....................................23
Prealphabetic phase .................................................................................................24
Partial alphabetic phase .........................................................................................24
Full alphabetic phase ..............................................................................................25
Consolidated alphabetic phase .............................................................................25
Deficit Theories Involving Reading Disabilities ...................................................26
A Core Deficit of Phonological Awareness ................................................................. 26
Double-Deficit Hypothesis ............................................................................................. 28
A Visual Deficit Hypothesis ......................................................................................... 29
Temporal Visual Processing Theory ............................................................................. 33
Components of Successful Reading ............................................................................. 34
Reading Fluency ............................................................................................................ 34
  Definition ..................................................................................................................... 34
  Component ................................................................................................................... 35
Factors of reading dysfluency ....................................................................................... 36
Reading Comprehension ............................................................................................... 37
  Definition ..................................................................................................................... 38
Level of reading comprehension .................................................................................. 38
Factors of reading comprehension .............................................................................. 38
Significant Predictors of Reading Success .................................................................... 39
Linguistic Predictors ....................................................................................................... 40
  Phonological awareness ............................................................................................. 40
  Rapid naming ............................................................................................................. 43
Vision-Related Predictors ............................................................................................ 46
  Eye movement ............................................................................................................ 46
  Visual processing ..................................................................................................... 48
Implication for Research ............................................................................................... 50
Conclusions ................................................................................................................... 52

3 METHODS ................................................................................................................... 54

Introduction ................................................................................................................... 54
  Research Questions ..................................................................................................... 54
  Hypotheses ................................................................................................................ 55
Methods ......................................................................................................................... 56
  Settings ....................................................................................................................... 56
  Participants ................................................................................................................ 56
  Measures ..................................................................................................................... 58
Data Collection .............................................................................................................. 59
  Procedure .................................................................................................................... 59
  Test Instruments ....................................................................................................... 59
  Inter-coder Reliability ............................................................................................... 64
Data Analysis ............................................................................................................... 65
  Overview of Statistical Analysis ................................................................................ 65
  Structural Equation Modeling ..................................................................................... 65
    Overview .................................................................................................................. 65
    Assumptions of SEM analysis ................................................................................. 67
    Analytic Procedures for SEM ............................................................................... 68
    A Proposed model ................................................................................................. 68
    The overall model fit ............................................................................................. 69

4 RESULTS ..................................................................................................................... 72
Descriptive and Inferential Statistics ................................................................. 73
Demographic Characteristics ........................................................................... 73
Means and Standard Deviations on All the Observable Variables ............... 74
Descriptive Statistics on Percentile Scores ...................................................... 76
Gender Differences ......................................................................................... 77
Differences Between Second and Third Graders ......................................... 78
Differences Between Students From Schools in Mid and Low SES Neighborhoods ................................................................. 79
Correllational Analysis ................................................................................... 83
SEM Analysis .................................................................................................. 83
Measurement Model ........................................................................................ 83
Structural Model .............................................................................................. 87
Regression Analysis and Correlational Analysis with SEM ......................... 89
Multiple regression analysis ........................................................................... 89
Summary ......................................................................................................... 93

5 DISCUSSION .................................................................................................. 95

Introduction .................................................................................................... 95
Summary of the Results ................................................................................. 96
Interpretations of the findings ........................................................................ 97
Rapid Naming ................................................................................................ 97
The Relationship between Rapid Naming and Eye Movement .................. 97
The Relationship between Visual Factors and Reading Fluency ............... 99
Discussions on Study Limitations ................................................................. 101
Measurement Issues ..................................................................................... 101
Generalizability Issues ................................................................................ 102
Implication for Future Research and Practice ............................................ 103
Future Research Directions ......................................................................... 103
Selecting Reading Assessments ................................................................... 103
Effective reading intervention for subtypes of RD ...................................... 104
Advanced technology ............................................................................... 106
SEM ........................................................................................................... 107
Implications for Practices .......................................................................... 109
The earlier the better ............................................................................... 109
Early literacy with at risk children ......................................................... 110
Careful observations of visual problems ................................................. 111
Comprehensive vision screening policy ................................................ 112
Conclusions ................................................................................................. 113
A Comprehensive Set of Indicators of RD ............................................... 114
A Balanced Approach .............................................................................. 115

APPENDIX PARENT INFORMED CONSENT FORM ........................................... 119

LIST OF REFERENCES ................................................................................... 121

BIOGRAPHICAL SKETCH .............................................................................. 136
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>54</td>
</tr>
<tr>
<td>3-2</td>
<td>55</td>
</tr>
<tr>
<td>3-3</td>
<td>56</td>
</tr>
<tr>
<td>3-4</td>
<td>57</td>
</tr>
<tr>
<td>3-5</td>
<td>58</td>
</tr>
<tr>
<td>4-1</td>
<td>73</td>
</tr>
<tr>
<td>4-2</td>
<td>74</td>
</tr>
<tr>
<td>4-3</td>
<td>75</td>
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<tr>
<td>4-4</td>
<td>76</td>
</tr>
<tr>
<td>4-5</td>
<td>77</td>
</tr>
<tr>
<td>4-6</td>
<td>78</td>
</tr>
<tr>
<td>4-7</td>
<td>80</td>
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<tr>
<td>4-8</td>
<td>81</td>
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<td>4-9</td>
<td>85</td>
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<tr>
<td>4-10</td>
<td>86</td>
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<tr>
<td>4-11</td>
<td>88</td>
</tr>
<tr>
<td>4-12</td>
<td>91</td>
</tr>
<tr>
<td>4-13</td>
<td>92</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-2</td>
<td>Adams’s Reading Process Model</td>
<td>22</td>
</tr>
<tr>
<td>2-3</td>
<td>Adams’s Reading Process Model with Breakdowns</td>
<td>37</td>
</tr>
<tr>
<td>3-1</td>
<td>A Proposed Model</td>
<td>70</td>
</tr>
<tr>
<td>4-1</td>
<td>SEM Reading Fluency Model with Correlation Coefficients</td>
<td>90</td>
</tr>
<tr>
<td>4-2</td>
<td>Independent Latent Variables with Correlation Coefficients</td>
<td>92</td>
</tr>
</tbody>
</table>
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THE EFFECTS OF PHONOLOGICAL AWARENESS, RAPID-NAMING, AND VISUAL SKILLS ON EARLY ELEMENTARY STUDENTS’ READING FLUENCY

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Reading is at the core of the educational experience and its ability is an essential key to success in our society. Unfortunately, 20% of U.S. children have serious reading difficulties. As a consequence, there have been numerous efforts to search for reliable indicators for early reading problems as well as to develop early intervention programs for young children at risk for reading difficulties. In spite of these enormous efforts on early detection and intervention, some students failed to learn to read. In addition, some of those study findings regarding factors that affect reading have revealed inconsistent outcomes. In response, this current study was designed to clarify factors that have been controversial and inconsistent. Since components of reading are quite broad, this focused only on factors related to reading fluency. Two hundred and ten early elementary students participated in this study. Twelve measures were administered in order to determine the relationships of phonological awareness, rapid-naming and visual skills on reading
fluency. Data were analyzed in various methods including ANOVA, correlational analysis, and SEM.

Results from descriptive statistics indicated that there was no significant gender difference on all the measures. However, there were significant differences between second and third graders in several measures including rapid-naming, eye movement, reversal, and reading fluency rate measures. As predicted, third graders were superior to second graders on all the measures. The results indicated that mean scores of students who go to schools in higher SES neighborhoods are higher than those of students who attend to schools in lower SES neighborhoods on all the measures. Specifically, except the rapid-naming variables, there were statistically significant mean differences between these two groups on most of the measures. The results of correlational analysis revealed that there are significant relationships between reading fluency and four constructs including phonological awareness, rapid-naming/eye-movement, reversal, and visual perception skills. Finally, SEM results showed that the suggested reading fluency model has a good fit, and measures used in this study were significant indicators of their respective latent variables. No modification of the measurement model was needed since all of the fit indices met the criteria for a good fit. Furthermore, the multiple regression analysis indicated that among the four independent constructs, the rapid-naming/eye-movement construct has the highest correlation with reading fluency. These results imply that these factors should be importantly considered to indicate young children’s reading problems.
CHAPTER 1
INTRODUCTION TO THE PROBLEM

The ability to read is the gateway to knowledge. Worldwide, today’s economy demands a universally higher level of literacy achievement than at any other time in the past. Many service-related and information-based jobs have been developed and increased, and these jobs requires higher level of literacy. Moreover, advanced vocational or academic training is required now for a wide variety of positions that previously high school dropouts might be able to take. Therefore, ensuring advanced literacy achievement for all students is indispensable for an economic necessity. More recently, using computers and accessing the Internet to get information have become a part of our life. Today, the ability to read thus has become a basic means to live a successful life.

As children progress through school, they are expected to be able to read in order to succeed academically. However, some children experience difficulties with reading and constantly experience frustration and failure. Approximately, 40% of fourth-grade students performed below basic levels on the National Assessment of Educational Progress (NAEP, 2001). This longitudinal national assessment revealed that since 1992 the proportion of students who performed below basic levels of reading chronically maintained about the 40% rate. In particular, researchers estimated that approximately 15% to 20% of all children have severe reading difficulties (Fletcher & Lyon, 1998; Lyon & Fletcher, 2001) and need special education services due to their reading-related learning disabilities. In the field of special education, 50% of all students with disabilities
are identified as having learning disabilities. Further, it is estimated that approximately 85% of students with learning disabilities have severe reading problems (Lyon & Fletcher, 2001). If these children continuously experience reading difficulties in school, frustration and failure can affect their motivation and their approach to the task of learning (Smith, Simmons, & Kameenui, 1998). Eventually, reading difficulties may also affect all aspects of a person’s life. Therefore, many reading researchers and the NAEP (2001) have warned that reading failure in the schools of the United States has reached alarming proportions. Early reading failure in schools may also continue to affect Americans’ literacy rates. The National Adult Literacy Survey (National Center for Educational Statistics, 1999) reported that nearly one-fourth of adult Americans were functionally illiterate. With this alarming caution, Congress has finally reauthorized the Elementary and Secondary Education Act (ESEA) after a 3-year period of debate and consideration. In addition, the No Child Left Behind (NCLB) Act of 2001 was signed into law by President Bush in January 2002. Since the passage of this law, reading programs for young children have been more actively implemented. Under this legislative support, we are hoping to have more positive outcomes in the near future.

Preventing the problem is the most effective in many ways. However, preventing reading disabilities is dependent on identifying those factors that contribute to children’s reading disabilities. Fortunately reading disabilities (RD) have been studied from various perspectives over the past two decades, and research has provided cumulative insight into the factors that contribute to RD. There is a general consensus in the literature that deficits in phonological processing of reading are correlated with RD. For example, a large number of research studies have indicated that a child’s lack of understanding of the
sound structure of language (phonological awareness) is one of the strong contributors of RD (Adams, 1990; Torgesen, Wagner, & Rashotte, 1994; Torgesen, Wagner, & Rashotte, 1997). Most reading researchers widely believe that phonological processing abilities are crucially related to reading and that phonological awareness is the core deficit of children of RD. However, recent research has built on this consensus to extend beyond it (Stringer & Stanovich, 2000) with a multi-dimensional view of reading. As a result, other linguistic factors have been studied beyond phonological awareness. Specifically, a rapid-naming deficit received significant consideration as one of the key indicators of RD (Wolf & Bowers, 1999).

Compared to linguistic factors, there is much less agreement on other factors that influence reading skills, such as vision-related factors. However, studies on factors that impact reading are continuously presented in the research literature because there is a strong belief that reading is not only a linguistic process but also dependent upon visual input (i.e., deciphering written language) (Boden & Brodeur, 1999). In particular, many connectionist theories that rely on the combined activity of numerous simple, interlinked, neuron-like processing units, suggest that knowledge is constructed by the strengthening of connections among processing units for reading (Adams, 1990; McClelland, Rumelhart, & Hinton, 1986; Seidenberg & McClelland, 1989). For example, Adams’ reading process model (1990) contains a system of four processing units, including the phonological processor, the orthographic processor, the meaning processor, and the context processor. The model suggests that reading is successfully processed by the connection of these four different units. Therefore, it is understandable to examine other process units rather than focusing only on the phonological process unit. In addition,
there is another theory, the double-deficit theory, which was recently acknowledged in the field of RD research, that proposes that developmental reading disability can be characterized with respect to two specific deficits in phonological awareness and visual naming speed (Bowers & Wolf, 1993; Wolf, 1991). The second deficit concerns deficiencies in rapidly accessing and retrieving names for visual symbols (Bowers & Swanson, 1991; Bowers & Wolf, 1993). Recently, Functional magnetic resonance imaging (fMRI) added important information about reading processes. For example, studies on visual processes highlighted that the M pathway’s projections are to post parietal and frontal cortex, involved in the generation of saccades and attention shift (Perry & Zeki, 2000). The results of this study suggest that there is scientific evidence on the relationship between visual processing and reading.

Although reading researchers and practitioners have long believed that phonological awareness is a major facet of the problem, recent neurological findings (e.g., Perry & Zeki, 2000) on dyslexia have provided additional evidence on a visual deficit as one of the important factors of RD. At the same time, some researchers constantly suggest that there may be a certain percentage of children who have RD and visual deficits affecting reading development (Eden, Stein, Wood, & Wood, 1995; Rayner, 1998). Due to empirical research findings and scientific evidence, a multidimensional viewpoint on factors related to RD has more widely been accepted recently. Therefore, it is appropriate to investigate visual aspects of reading to ascertain whether they affect RD or at least certain types of RD. In the next section, the rationale for the current study will be provided in detail with various perspectives.
Rationale for the Study

Importance of Early Identification and Intervention

Unfortunately, children who perform poorly in reading in first and second grades have a tendency to continue experiencing difficulties throughout their schooling (Blachman, 2000). A large number of studies revealed that early reading failure seriously affects future reading ability. For example, Francis, Shaywitz, Stuebing, Shaywitz, and Fletcher (1996) found that approximately 75% of the children who had difficulties in reading in the third grade would still be struggling with reading at the end of high school. As these children grow, they face increasing obstacles to reading development (Torgesen & Burgess, 1998). As a result, the importance of early identification and intervention on reading has been recognized among reading researchers. A review study estimates that the number of children who are typically identified as poor readers and served through either special education or compensatory education programs could be reduced by up to 70% through early identification and prevention (Lyon et al., 2001). Effective prevention efforts, however, depend on the effective early identification of students with reading difficulties. Hence, there is a vital need to identify key indicators of RD for young children to reduce the impact of reading difficulties and prevent the problems in the earliest stage.

Ongoing Debate

As a consequence, much research has been conducted in order to identify the major factors associated with reading disabilities. Overall, there are two parallel perspectives on this issue. A foremost source of debate among researchers is whether reading difficulties are the result of one or more than one type of processing problem. To date, many researchers argue strongly that most reading difficulties are a result of verbal/linguistic
processing deficits (e.g., Mann, 1991; Velluntino, 1979). Some other researchers, however, have demonstrated evidence that reading involves a combination of multiple factors related to an individual’s experiences, ability, and neurological functioning. Some of the latter researchers argue that visual abilities contribute to children’s reading abilities (e.g., Eden et al., 1995; Lovegrove, Garcia, & Nicholson, 1990; Rayner, 1997; Watson, 1990). However, such studies of reading-related visual skills yield inconsistent findings. Some researchers were able to find that there is a significant difference in visual skills between children with RD and non-RD (e.g., Morad, Lederman, Avni, Atzmon, Azoulay, & Segal, 2002) while some were not (e.g., Velluntino, 1987).

In the context of discussions of visual deficits, there is an increasing consensus on the hypothesis that these processing problems may not be general but may characterize a small group of severely affected children. It means that not all children with RD have visual processing deficit but some of children may have visually related reading problems. If all children with reading disabilities receive the same type of instruction, which is solely based on phonological awareness, the programs may not be beneficial for a group of children who have reading disabilities that are associated with other factors such as a rapid-naming deficit and a visual deficit. Therefore, we should be aware of subgroups of reading disabled children for effective early identification and intervention.

A Continuing Attention on Phonological Awareness Research

Over the past two decades, no area of reading research has caught as much attention as phonological awareness. The term "phonological awareness" began appearing in the research literature in the late 1970s and early 1980s (Clark & Uhry, 1995). Early research on phonological awareness recognized that most poor readers have difficulty tapping out the number of phonemes in a word as well as in adding or deleting
a phoneme or reserving the order of phonemes in a word (Liberman, 1973; Liberman, Shankweiler, Fischer, & Carter, 1974; Lundberg, Olofsson, & Wall, 1980). Since the 1980s, there has been increasing agreement among reading researchers that problems in phonological processing are a major factor in reading difficulties. Additionally, numerous prediction studies have demonstrated that understanding the sound structure of language (phonological awareness) is a strong predictor of later reading success. For instance, Catts and his colleagues observed 604 young children longitudinally and indicated over 70% of poor readers had a history of language deficits including phonological awareness and oral language in kindergarten (Catts, Fey, Zhang, & Tomblin, 1999).

During the 1990s, research demonstrating the importance of phonological awareness to the reading process grew rapidly and become widely adapted in the field of education. In response, a huge number of research studies were actively conducted. On the basis of such empirical research studies, reading intervention studies, focusing on instruction of phonological awareness, have continuously been implemented (Clark & Uhry, 1995). Based on the findings, researchers (e.g., Adams, 1990; Catts et al., 1999; Torgesen, Wagner, & Rashotte, 1994; Togesen et al., 1997) strongly agree that the problem associated with phonological awareness is a confirmed factor in reading difficulties. Recently, functional magnetic resonance imaging (fMRI) revealed the brains of dyslexics show less activation in the language centers of brain (Broca's area) during phonological awareness tasks, and researchers indicated that letter identification lights up the extrastriate cortex in the occipital lobe and that the superior temporal gyrus and parts of the middle temporal and supramarginal gyri are activated during word meaning assessment (Shaywitz, 1996). Therefore, assessing skills on phonological awareness
should be continuously considered for improving the predictability of identifying children at risk for RD as well as developing effective early intervention programs.

**New Trends of Reading-Related Vision Research**

Compared to phonological awareness research, studies of reading-related visual skills have a long history with three eras (Rayner, 1998). More than century ago, Hinshelwood (1895) concluded that poor reading ability was probably due to impaired visual memory for words and letters (as cited in Eden et al., 1995). Since his study, research has been implemented vigorously. Recently, Rayner (1998) did an extensive review of studies focusing on reading-related vision—especially eye movements. In his review he recognized the trends of prior research and divided research studies from the late 1890s up to the early 1990s into three eras. According to his review, the first era extended from the late 1890s up until the 1920s. During this first era, the basic facts of eye movements were discovered. These included saccadic suppression (i.e., do not perceive any visual information during an eye movement), saccadic latency, and the size of the perceptual span (Rayner, 1998). Findings from a variety of studies in the first era were the foundation of eye-movement research. Contrary to the first era, the second era (from 1920s until the mid-1970s) produced little research since researchers believed they had learned almost everything on eye movements, given the technology at that time (Rayner, 1998). However, the third era (since the late 1970s) is drawing a different picture. An advanced technology led to an enormous amount of research being implemented to investigate the possibility of a relationship between visual skills and reading (Rayner, 1998). The technological improvement on measurements allowed vision research to be more accurately and more easily implemented.
A variety of experimental research studies revealed differences between disabled and nondisabled readers on visual skills in the area of reading. However, research on relationship between visual problems and reading was criticized by reading researchers due to technical problems of the research designs. Specifically, methodological problems in the experimental approaches were detected. Along with such criticisms, some researchers believed that only language factors were involved in reading (e.g., Vellutino, 1987). Therefore, studies in this area were somewhat neglected among reading researchers. Furthermore, since 1980, increased attention on studies related to phonological awareness may have contributed to underestimating research in other aspects of reading. Despite heavy criticism and underestimation, many reading researchers revealed that visual skills play an important role in reading (e.g., Eden et al., 1993, 1995; Watson et al., 2003). Recently, methodological problems were reduced through using more advanced measurements with sufficient evidence of validity and reliability and through carefully selecting appropriate research designs. Moreover, the multidimensional viewpoint on reading is beginning to be more widely accepted among reading researchers. Most recently, Habib, a neuroscientist, offered scientific evidence on the roles of a visual deficit on RD (2000). Functional magnetic resonance imaging (fMRI) has provided new information concerning the neuroanatomical location of the system affected in RD (Eden & Zeffiro, 1998). By utilizing fMRI, researchers have found that both dyslexic and normal readers can see stationary dots on a screen but finding moving dots was more difficult to detect in dyslexic readers compared to normal readers. Furthermore, dyslexic participants show no activation of the MT (V5) visual cortex, which detects motion, during reading and seeing these moving dots while normal
readers do have activation of the MT (V5) cortex (Eden & Jeffüro, 1996; Zeffiro & Eden, 2000). An impairment of the magnocellular (M) pathway might even affect the generalized timing mechanisms of the cerebellum (Fawcett, Nicolson, & Maclagan 2001). The visual cortex is divided into 6 different areas; V1, V2, V3, V4, MT/V5. In the visual cortex, there are two distinct pathways call Parvocellular Pathways (P Pathways) and Magnocellular Pathways (M Pathways) that carry information about what and where objects are. In particular, M pathway runs from area V1 to V2 to V3 and MT/V5 and represents information about dynamic properties such as motion and spatial relations among objects.

With such new trends, reading-related vision research has been more actively undertaken. However, since the findings are still contradictory and inconclusive, there is a critical need to clarify whether visual factors are correlated to reading abilities of a certain group of children.

A Rising Attention on Rapid-Naming Skills

There is a growing consensus that rapid-naming skills are significantly related to reading ability (e.g., Swanson & Wolf, 1999; Wolf, 1997). Originally, research from the field of cognitive psychology provided evidence that individuals with RD have a deficit in naming speed (Wolf, 1997; Wolf & Obregón, 1997). Basically, a naming-speed deficit refers to the inability to retrieve rapidly the spoken referent for a visual stimuli (Badian, 1997). Traditionally, rapid-naming skills have been considered as a part of phonological skills (Wagner & Barker, 1994; Wagner & Torgeson, 1987). However, Wolf and her colleagues provided evidence that a naming-speed deficit is another core deficit, along with a phonological processing deficit, by showing a modest correlation between phonological awareness and rapid-naming variables. Researchers who argue for a double-
deficit theory also have concerns about two certain types of group (e.g., Wolf, 1991; Wolf & Bowers, 1999). Actually their research findings (Wolf & Bowers, 1999) suggest that there are three types of RD based on processing deficits: a group of children with mostly a phonological processing deficit, a group who have mostly a naming deficit, and a group who have both phonological and rapid-naming deficits. Obviously, the last two groups of children who have a rapid-naming deficit would not be well served if early intervention programs that are mainly based on phonological awareness skills were provided. In sum, although a growing body of research supports the importance of rapid-naming skills as a separate indicator from phonological awareness of RD, it is still inconclusive. Hence, there is a need to replicate such studies to clarify this issue.

Problems with Prior Research

While phonological awareness has captured researchers’ attention, reading-related vision studies have received less attention. As a result, there has been a lack of research, particularly in the field of education. Specifically, only a few correlation studies involving both visual skills and verbal skills in the regression models have been undertaken (e.g., Eden et al., 1993, 1995). Moreover, a lack of research has revealed inconsistent results. To illustrate, while McKinney, Short, and Feagans (1985) reported that only 7% of a sample with learning disabilities showed severe visual problems, Watson (1990) reported that 52% of a sample of students with reading disabilities exhibited some type of visual processing problems. In addition to inconsistency, the findings were conflicting and yielded mixed outcomes. For example, some researchers were able to indicate a significant difference in the visual abilities between poor readers and nondisabled readers (e.g., Watson, 1990). In contrast, others found no such differences between the two groups (e.g., Vellutino, 1987).
Disagreement is also recognized in studies on a rapid-naming deficit. As mentioned before, a large body of evidence has accumulated in favor of the importance of a rapid-naming factor in reading development and a key indicator of reading disability (e.g., Wimmer, Mayringer & Landerl, 2000; Wolf & Bowers, 1999). However, the evidence is somewhat inconsistent, and there are gaps in the evidence. Moreover, some issues still remain. Although many studies have found phonological awareness and naming speed to have significant independent unique effects on current or later reading (e.g., Badian, 1997, 1998; Kirby & Parrila, 1999; Manis, Doi, & Bhadha, 2000; Scarborough, 1998; Torgesen, Wagner, Rashotte, Burgess & Hecht, 1997), the outcomes varied based on when assessment occurred, how many indicators were used in their models, and what other variables were used in their equations. Moreover, some other studies indicated that one or the other individual effect disappears when prior achievement, which is an autoregressor, is included in the regression model (e.g., Torgesen et al., 1997). This issue is discussed in further detail later in Chapter 2.

Another problem is that the intervention studies are mostly limited to investigating the effectiveness of their certain programs (e.g., Torgeson et al, 1997). Almost all reading programs appeared to be very effective and helpful in improving children’s reading acquisition levels. However, the intervention researchers failed to take a close look at a group of students who have shown no gains despite an intensive reading support with specially designed approaches based on linguistic components. Among children who do not show any improvement, some children may suffer from other problems such as visual deficits that affect their reading. Hence, there is a need to clarify possible factors that are associated with people with no gains after reading interventions.
Why Reading Fluency?

Reading fluency encompasses the speed or rate of reading as well as the ability to read materials with expression. Meyer and Felton (1999) defined fluency as "the ability to read connected text rapidly, smoothly, effortlessly, and automatically with little conscious attention to the mechanics of reading, such as decoding" (p. 284). Children are successful with decoding when the process used to identify words is fast and nearly effortless or automatic. The concept of automaticity refers to a student's ability to recognize words rapidly with little attention required to the word's appearance. The ability to read words by sight automatically is the key to skilled reading (Ehri, 1998). Researchers have utilized reading rate for their studies since a student's reading rate is simply calculated by dividing the number of words read correctly by the total amount of reading time. Furthermore, Fuchs, Fuchs, and Maxwell (1988) found that students' fluency was more highly correlated with their scores on a standardized reading comprehension test than were oral and written retellings, question answering, or cloze tests. Shinn, Good, Knutson, Tilly, and Collins (1992) provided additional support for the use of fluency measures to monitor progress in reading. Therefore, reading fluency rate was selected as a dependent variable measure for this study.

In response, this research was designed to clarify the relationship among reading fluency and phonological awareness, naming speed, and visual factors simultaneously with structural equation modeling.

Scope of the Study

This study was conducted within a limited scope. Therefore, there were delimitations and limitations in conducting the present study. They are described in this section.
Delimitations

This study was geographically limited to one school district, Alachua County, in north-central Florida. The 210 subjects were selected from five schools in this medium-sized district. The study was conducted with early elementary students, especially with second- and third-grade students since people’s visual skills are fully developed by ages 6 to 7. Therefore, kindergarten and first-grade students were excluded from this study. Subject selection did not include consideration for gender or ethnicity.

Limitations

This study was conducted with second- and third-grade students. Therefore, the findings of this study are generalized to older or younger students. Due to time limitations, some assessment subtests were excluded for this study. For example, a subtest of CTOPP (Comprehensive Test of Phonological Processing), segmentation, for assessing phonological awareness was not included as an observed variable.

Brief Definition of Terms

An understanding of terminology that was applied in this study is necessary to the interpretation of this examination. The following section defines relevant terms as they apply to this study.

Phonological awareness refers to a conscious sensitivity to the sound structures of language. It includes the ability to detect, isolate, blend, segment, and otherwise manipulate the sounds in language (Adams, 1990; Snow, Burns, & Griffin, 1998; Torgesen & Bryant, 1994).

Phoneme refers to the smallest unit of spoken language. For example, the word ‘chin’ contains three phonemes (/ch/ /i/ /n/).
Rapid naming is the ability to recall quickly and to verbalize the name of a presented object. Naming speed is typically assessed by the Rapid Automatic Naming (RAN) Test (Denckla & Rudel 1974, 1976), which requires children to name familiar colors, pictured objects, digits, and letters (Wagner & Togeson, 1987, as cited in Manis, Seidenberg, & Doi, 1999) and subtests of CTOPP Comprehensive Test of Phonological Processing (CTOPP) (Wagner, Torgesen, & Rashotte, 1999).

Orthographic processing refers to the use of printed symbols (i.e., orthographic information) to process written language (Wagner & Marker, 1994).

Eye movement is one of the visual efficiency skills that include accommodation, binocular vision, and ocular mobility. Eye movement in reading-related research is involved in abilities of tracking and fixation.

Visual processing skills refer to a group of visual cognitive skills used for extracting and organizing visual information from the environment and integrating this information with other sensory modalities and higher cognitive functions (Scheiman, 2002).
CHAPTER 2
LITERATURE REVIEW

In order to have a better understanding of reading development based on roles of
cognitive processing, this section reviews three areas of the literature regarding
theoretical background based on connectionist theories: key deficit theories underlying
children’s reading disabilities, the components of successful reading, and significant
predictors of reading success in the previous and current literature. As a theoretical
framework for this study, connectionism and connectionist reading models were
employed and are discussed in Chapter 2. The latter section of Chapter 2 includes four
general deficit theories including core deficit of phonological processing, a double-deficit
hypothesis, a visual deficit theory, and a visual temporal processing theory, identifying
causes of RD in the literature to date. For early identification of reading disabilities, two
significant linguistic indicators—phonological awareness and rapid naming—and two
visual related indicators—eye movement and visual processing—are discussed in the
final section of Chapter 2 based on prior literature that includes findings of empirical
studies. Currently, researchers in diverse fields as neuroscience, cognitive psychology,
educational psychology, special education, and reading have influenced this topic. The
present study reviewed journal articles and books from many of these disciplines.
Therefore, within this literature review, the terms “reading disability” (RD) and
“dyslexia” were used interchangeably to describe a person who has “a specific and
significant impairment in reading abilities, unexplainable by any kind of deficit in general
intelligence, learning opportunity, general motivation or sensory acuity” (Habib, 2000, p. 2374). The current research provides a reliable set of predictors of reading achievements focusing on both verbal and visual factors.

**Theoretical Framework**

The theoretical framework of understanding children’s reading process in this literature review section is primarily grounded in connectionist theories that were originally based on interaction models of the information processing theory. In this section, general characteristics of connectionism, Seidenberg and McClelland’s connectionist model for visual word recognition, and Adams’ reading acquisition model are briefly discussed in order to explain the connections between reading behaviors and the brain’s cognition and perception. In addition, Ehri’s theory of reading development is also explained to understand the procedures of reading developments of young children.

**Connectionism**

Simply stated, connectionism is a theory of information processing. Connectionists originally adopted the view that the basic building block of the brain is the neuron. Connectionism offers a new approach to explaining human cognitive activities. While classical cognitive theories use explicit, often logical, and rule-based theories in a serial manner, connectionist systems rely on the combined activity of numerous simple, interlinked, neuron-like processing units. In order to begin the reading process, Seidenberg and McClelland (1989) developed a connectionist model based on an interactive theory in an information-processing theory. Commonly, all connectionist models, including a Seidenberg and McClelland word recognition model, have several similar properties. They all have a set of interconnected simple processing units. The types of units include input units, output units, and hidden units. Input units accept the
information either from the sensory channels or from other parts of the network. Output units put out the information. They either control the information directly or send those to other parts in the network. Hidden units communicate with the input and output units internally. Most of the important work in a connectionist model occurs in the units and their connections. Furthermore, there is no central control within the connections, and the processing is spread across the entire network. In fact, all units have their own activation value. However, each unit itself is meaningless and not active since the cognitive processing produces output when the connections between units occur. In particular, to understand the act of reading as connectionism, we should carefully consider Seidenberg and McClelland’s parallel distributed processing model.

**Seidenberg and McClelland’s Connectionist Model**

Seidenberg and McClelland (1989) developed a connectionist word recognition model by describing a parallel distributed processing (PDP) system consisting of four different processors: context, meaning, orthographic, and phonological. In their PDP model, they developed a general connectionist framework for thinking about how lexical knowledge is obtained, represented in the brain, and used in processing (Manis et al., 1999). Simply stated, their reasoning is that reading involves a series of associations or connections resulting in accumulated lexical knowledge (Clark & Uhry, 1995). Actually, the concept of PDP is based on the belief that “intelligence emerges from the interaction of a large number of simple processing units, each sending excitatory and inhibitory signals to other units” (McClelland et al., 1986, p. 10). In addition, their PDP model involves connections in both directions between context and meaning and then additional two-way connections between meaning, orthography, and phonology (see Figure 2-1).
That is, connections between any two processors can trigger other associations in any direction and contribute to the overall reading process.

In order to increase the processing capabilities inherent in networks, they include a set of hidden units in their model. Hidden units are considered important since they mediate between the pools of representational units (Seidenberg & McClelland, 1989). More interestingly, Seidenberg and McClelland used computational simulations of word learning to provide evidence of the interactive nature of the relationship between phonology and orthography. By reducing the number of hidden units, Seidenberg and McClelland were able to simulate poorer performance in fluency, naming, and visual processing, which are characteristics found in people with dyslexia. The following section of their model focuses on the role visual processing plays within their model. It provides the reason for poor reading when visual processing is not working properly in this model.

Seidenberg and McClelland’s Model on Orthographic Deficits

Seidenberg (1992) schematically illustrated the main component of the existing model. One component considers the orthographic representations. “The model starts by encoding a letter string as a pattern of activation across the orthographic units” (Seidenberg, 1992, p. 262). Letter recognition is a computational process. However, the process may fail to activate appropriated orthographic representation when this component fails to operate. This could occur due to abnormalities in visual processes or damage to the orthographic representations themselves (Seidenberg, 1992).
Figure 2-1. Seidenberg and McClelland’s Word Recognition Model

The model performed as in the simulations with 100 hidden units. Actually, the “normal” model was configured with 200 hidden units, but for this simulation they reduced a number of hidden units for the simulation. They reported that “with fewer computational resources, the model was still able to learn; however, it performed poorly on irregular words and non-words even after extensive training” (Seidenberg, 1992, p.
21

For another simulation, they damaged the input orthographic representation and found that the outcomes of two damage simulations produced similar results. Through these findings, they argued that two very different types of impairments yielded a “dyslexic” pattern of performance; only one of these corresponds to a visual processing deficit (Seidenberg, 1992, p. 265). Hence, Seidenberg (1992) noted that the simulations confirm that there must be more than one source causing RD. He also described that “this might go some way toward explaining why only some children whose behavior fits the dyslexic profile exhibit visual processing deficits” (Seidenberg, 1992, p. 265).

Adams’ Reading Process Model

With a thorough review of reading research, Adams (1990) framed her view of the reading process based on connectionist theory. Since 1990, Adams’s connectionist model has been used as a foundation for understanding reading processes. Basically, Adams’ reading model includes four interrelated processors: orthographic, phonological, meaning, and context (see Figure 2-2). She accentuated the connectivity among four processors that are crucial for a skilled reader. Although each processor functions independently in reading, the four units should work simultaneously for successful reading.
As seen in Figure 2-1, each processor is systematically connected and works cooperatively to obtain meaning from reading. According to Adams (1990), the system begins its work when the orthographic processor obtains visual information from printed materials and delivers visual input to the meaning processor. If the printed word was recognized and connected to a reader’s lexical memory, the meaning processor automatically interprets the word. However, if the word is unfamiliar to a reader, the phonological processor begins to compensate for the orthographic processor. At that time, a reader simply tries to sound out the word and determines whether the word is unfamiliar or familiar (i.e., in the reader’s listening vocabulary). Based on the cooperation of these two processors, the activities of these two processors can connect to the meaning processor. In addition, the context processor helps a reader to understand
context and predict future developments. Thus, the context processor reinforces the
connectivity among these three processors for a reader. As a result, its work increases the
processing speed of the other three units. Furthermore, the context processor helps a
reader to verify and choose the real meaning of a word based on its context, which also
may improve comprehension. For a skilled reader, each of the four reading processors
should play a unique role but also function simultaneously, collaboratively, and
automatically with little conscious effort (Adams, 1990).

**Ehri’s Theory of the Development of Word Recognition**

Understanding how normal reading develops is crucial to the understanding of
what goes wrong during the development of reading in children with RD (Clark & Uhry,
1995). Many researchers in the reading community have proposed theories to explain
how readers develop reading abilities. In particular, Ehri’s theory proposes the four
developmental stages of word recognition by sight word. Adams (1990) mentioned that
the ability to read words by sight is dependent upon the strength of the connections that
have been developed between the orthographic and phonological processors. Ehri’s
theory highlights such connections between the orthographic and phonological processors
accessing connections that they have formed between letter in the spellings specific
words and phonemes detected in pronunciation” (p. 298). Eventually, her viewpoint was
developed under the connectionist view (Ehri, 1992). She described that a reader’s ability
to read progresses through a series of phases, and “each phase is defined by the kind of
connections that are formed between visual cues seen in print and information about a
specific word stored in memory” (Ehri, 1992, p. 123). The four phases are described
below.
Prealphabetic phase

During this first phase, children begin to recognize words in their environment (Ehri, 1991, 1992, 1995). Since children under this phase have little knowledge about letters, they create connections between salient features of a word and the meaning of the word (Ehri, 1991, 1992, 1995). The visual cues selected by children in this stage might be part of the spelling, shapes, or colors. Simply, a large yellow arch shape logo of McDonald can be a typical example of a visual cue (Ehri, 1992). Therefore, Ehri (1991) indicated that the identification of the word occurs at the semantic rather than the phonological level, and the connections are visual and nonphonetic in this first stage of word recognition. She also described that “because most connections formed between spellings and meaning are arbitrary, they are easily forgotten unless practiced frequently” (Ehri, 1992, p. 125). However, to become a skilled reader, children should be able to form the connections systematically between the printed word and the meaning. In the second phase of Ehri’s theory the reader finally begins to use letter-sound relations.

Partial alphabetic phase

During this second phase, “learners begin using their letter knowledge to form visual-phonetic connections between letters seen in spellings and sounds detected in pronunciation of words they are learning to read” (Ehri, 1992, p. 126). Compared to the first phase where connections are arbitrary, those in the second phase are systematic. Moreover, if only one connection occurs in the first stage, more connections are formed in the second phases since a reader uses letters. Another main difference between two phases is that the primary connection in Phase 1 is formed between a spelling and its meaning, whereas the main connection in Phase 2 is between a spelling and its pronunciation (Ehri, 1992). They use more reliable and systematic information, but they
are not yet able to use the full cipher in this stage. Therefore, this stage is referred to as the partial alphabetic phase (Ehri, 1991). Novice readers in this stage use incomplete letter-sound correspondences to access words in memory. They may use the first or last letter sounds, ignoring the medial phonemes in the work (Ehri, 1992) such as recognizing the word ‘book’ by the /b/ and the /k/. However, the readers should be able to utilize the full cipher for their skillful reading.

**Full alphabetic phase**

Ehri (1992) described that “cipher sight word reading refers to the process of reading sight word by setting up connections in memory between the entire sequence of letters in spelling and phonemic constituents in the word’s pronunciation” (p. 132). In contrast to readers in Phase 2 who may use some letters of spellings, readers in the third phase can form connections out of the “complete array of letters connected to the phonemic structure of the word” (Ehri, 1992, p. 134). For example, in a word with four phonemes, ‘desk,’ a reader at the cipher reading phase would be able to create connections out of all four letters and correspond phonemes to determine the correct pronunciation (Ehri, 1999). Children who gain the ability to utilize the cipher can become proficient readers (Gough, Juel, & Griffith, 1992).

**Consolidated alphabetic phase**

Finally, mature readers can analyze the common spelling patterns such as ‘-ing,’ ‘-cal,’ and ‘com-.’ It means that they are able to recognize these patterns as a chunk. If children encounter such combinations of letters more often, they may have stronger concepts of such combinations and the speed of orthographic processing will be faster. Therefore, connections to new words become more efficient and occur more rapidly. As a result, readers in this final stage can improve their ability of word recognition
enormously. Consequently, Ehri’s theory of word recognition implies why some children are not very skillful at reading words (Ehri, 1992). They may not have opportunities to put through the sequential processes. More specifically, the following section discusses predominant deficit theories that explain a causal role of RD.

**Deficit Theories Involving Reading Disabilities**

Different theories are often used to explain children’s reading disabilities. These theories serve as highlights of the different processing systems involved in reading. Through the huge amount of prior reading research, everyone probably agrees with the fact that all children with reading disabilities are not the same. Therefore, it is essential to know the basis of the RD and to match the program of instruction to the inefficient information processing system. Here are four general deficit theories identifying causes of RD in the literature to date. Recently, studies on process factors involving reading have been extensively conducted underlying the progress of neuroscience.

**A Core Deficit of Phonological Awareness**

A consensus among reading researchers is that phonological processing is the core deficit in RD. During the last 25 years, researchers and educators have been looking for valid and reliable predictors of reading difficulties in order to prevent problems and provide effective early intervention. Moreover, based on findings from a large amount of reading research, many intervention programs for children with reading difficulties have been developed over the years. One intervention that has attracted much recent attention involves teaching phonological awareness skills to children. One important reason why educators are so interested in phonological awareness is that research indicates that it is the best predictor of early reading acquisition, better even than IQ, vocabulary, or listening comprehension (Stanovich, 1988). In general, phonological awareness often
refers to the conscious awareness of or sensitivity to the sounds of speech apart from their meaning (Snow et al., 1998; Torgeson, 2000).

Many researchers have specifically indicated that symptoms such as slow rate of reading, spelling errors, and errors on function words in reading and writing could be accounted for poor phonological skills (e.g., Aaron & Joshi, 1992). In addition, many reading researchers indicated that phonological awareness interventions have been successful. For example, Torgeson et al. (1997) reported that two types of research support the phonological deficit perspectives as the core-causing factor of reading difficulties. First, predictive research studies have determined that a measure of phonological awareness is a major predictor of later success in reading. Torgeson et al. (1997) used a set of predictors for their logistic regression model and indicated that letter-name knowledge and phonological awareness predicted, with 91% accuracy, which children would be in the bottom 10% when they become second graders. Second, intervention studies have shown that instruction in phonological awareness improve reading acquisition. Researchers also have highlighted that a group of children who were assigned to have instructions in phonological awareness have a significantly low retention rate in special classes (9%) compared to two other groups with different instructions and a group with non-treatment (25%, 30%, and 41%, respectively) (Torgeson et al., 1997).

Through vigorous research during the past two decades, it has become obvious that a lack of ability in phonological awareness is the most widespread barrier to reading acquisition (Adams, 1990; Goswami, 1993; Torgeson et al., 1997). Until recently, however, researchers were unable to map cognitive functioning in the brain during
cognitive processes. Now, researchers are able to identify regions of the brain that are activated during cognitive processes such as reading through functional magnetic resonance imaging (fMRI). Anatomical work and functional brain imaging studies support the notion of a left perisylvian dysfunction as a basis for the phonological deficit (e.g., Pugh et al., 2000; Temple et al., 2003; Shaywitz et al. 2000). The phonological theory, however, does not explain the other deficits of dyslexia. For example, there is a limitation of explaining dyslexia with the phonological theory because the visual system on reading process cannot be accounted for by phonological theory.

**Double-Deficit Hypothesis**

The double-deficit hypothesis of reading disabilities is currently popular among those who investigate the neurological components of reading disabilities. The double-deficit hypothesis was developed by Wolf and Bowers (2000) based on their research findings showing that there are only modest correlations between phonological awareness measures and Rapid Automatized Naming (RAN) performance in groups of dyslexic children. They also found that dyslexic children as a group exhibit both phonological awareness deficits and naming-speed deficits. Originally, naming speed deficits were considered by some to be part of a phonological deficit (Wagner & Torgesen, 1987). However, through such findings, Wolf and her colleagues argued that a naming speed deficit is a separate deficit from a phonological deficit and affects reading acquisition independently from phonological processing (Olson, Forsberg, & Wise, 1994). Further, they suggested that there are different degrees of reading disability and different types of processing impairment.

More specifically, there are three subtypes of dyslexic children: one having a dominant phonological deficit but little naming-speed deficit, one exhibiting the naming-
speed deficit but little phonological awareness deficit, and one with both deficits (Wolf & Bowers, 1999). Obviously, the second and the third groups of children are important in this theory because the two subgroups with only a naming-speed deficit and both deficits may not be well supported if reading intervention, which is only based on phonological awareness approaches, is provided (Wolf & Bowers, 1999). Wolf and Bowers (1999) mentioned that researchers have found that about a fifth of dyslexic children mainly suffered from naming-speed deficit and not from a phonological awareness deficit. More interestingly, Lovett, Steinbach, and Frijters (2000) found that more than half of the participants suffered from both deficits. Furthermore, extensive data replicated the existence of these three subtypes of reading disabilities in several language systems (e.g., German, Dutch, and Finnish), and they provided various evidence on the existence on the subtypes based on double deficit hypothesis (e.g., Deeney, Gidney, Wolf, & Morris, 1999). It is interesting that speed of processing and semantic fluency are included in some of the recently produced tests for dyslexic children.

Beyond a double deficit hypothesis, some researchers even argue for a triple deficit hypothesis. For example, Badian (1997) purported evidence for a triple deficit hypotheses implying that orthographic factors involving visual skills should also be considered. The author found that there was a significant difference between the RD group and the non-RD group on an orthography test, the Jordan Left-Right Reversal test, which is a visual perception test.

A Visual Deficit Hypothesis

Another hypothesis is that problems in reading acquisition are linked to deficient visual perception. More than a century ago, James Hinshelwood, an ophthalmologist practicing in Scotland, called his patients with RD “congenital word blindness” and
believed that these problems were related to the left hemisphere of the brain, which controls the storage of visual memory because these children seemed to have difficulty remembering names of letters and words (Clark & Uhry, 1995). In 1928, Samuel Orton, an American neurologist, theorized that people perceive visual inputs from both right and left visual fields and relay this input as mirror images to the visual cortices (Clark & Uhry, 1995). For most people, one side of brain becomes dominant over the other and suppresses the image from the non-dominant hemisphere; however, he believed some people who poorly perform ‘dominance’, may perceive backward images. He believed this poor dominance might produce reading problems (Clark & Uhry, 1995). Therefore, from the early 20th century, vision research related to RD has been continuously undertaken. However, researchers revealed that reversal and sequencing errors did not appear in a large proportion of people with RD, and most of people with RD showed more oral reading errors. Moreover, Vellutino (1978, 1983) indicated that poorer readers are as good as nondisabled readers on copying confusable letters and words from memory. Rather, they showed problems at naming and pronouncing the items. With these findings, he concluded that visual deficits could not explain RD. Moreover, several major reviews of the evidence concluded that visual deficits are not a major cause of reading disability (Stanovich, 1982; Velluntino, 1979). Since then, numerous studies have demonstrated that understanding the sound structure of language (phonological awareness) is a strong predictor of reading success.

In contrast, studies on visual processing factors have been under heavy attack by reading researchers during the last three decades. As discussed earlier, inconsistent and conflicting findings have fueled the debate and have hindered research on visual
processing within reading research. In addition, researchers pointed out that many of the processing measures used in education lack reliability and validity (Moats & Lyon, 1993). Some even strongly stated that the case is completely closed (Stanovich, 1992). Nevertheless, many researchers recently tried to revisit this area of reading and provide reliable evidence on differences between disabled and nondisabled children in visual recognition experiments.

More recently, one visual deficit theory, “saccadic-suppression deficit,” emerged surrounding eye movement and visual pathways. When people’s eyes view visual stimuli such as letters, words, and any stationary things, they fixate briefly (for roughly 200 to 300 ms). After viewing, it takes about 10 to 40 ms to construct an image in the brain before the next fixation. It means visual information from the saccade is suppressed. If this saccadic suppression, which insures a series of discrete images, is not achieved, the images may be overlapped (Pollatsek, 1993). Since erratic eye movement has been observed in children with RD, researchers have continuously indicated that poor readers do have characteristic difficulties on visual ability measures (e.g., Eden et al., 1995). The measurements used for recent studies have been more carefully selected, and most of them are nationally standardized instruments (e.g., Developmental Eye-Movement test or Visual- Motor Integration test). Since many reading researchers have begun to have a multi-dimensional view of the reading process, the case against visual processing factors seems to have become weaker, and in recent years more studies in this area have been introduced in educational journals. Even though many reading researchers agree that a phonological factor is a major predictor of reading difficulties, some of them also believe visual processing may play an important role (Eden et al., 1993, 1995; Rayner 1998;
Temple et al., 2000). In particular, many studies in the medical field still focus on determining the relationship between reading and visual skills. To illustrate, one study found that children with reading difficulties had a specific disability in the shifting of attention and were only able to maintain attention for a short period of time (Facoetti, Paganoni, Turatto, Marzola, & Mascetti, 2000). As a result, researchers assumed that deficits of visual attention may hinder efficient visual processing during reading (Facoetti et. al., 2000). Casco, Tressoldi, and Dellantonio (1998) also found significant differences between disabled and nondisabled readers on visual search tasks. These findings suggested that children with the lowest performance on tasks that included searching for a target letter in a set of background letters showed both a significantly slower reading rate and a higher number of visual search errors in comparison to children with higher performances on such visual search tasks. Other studies have compared visual and verbal abilities as indicators for prediction of reading disabilities. One study compared the phonological and visuo-spatial abilities of a selected group of 17 children with reading disabilities and 21 without reading disabilities (Eden et. al., 1993). Interestingly, this study recognized that there are some visual tasks such as eye movement and visual search that are equally reliable at distinguishing between good and poor readers as phonological tests (Eden et al., 1993). In sum, in recent years vision research has begun to be more widely accepted by reading researchers. Due to advanced instruments and a multi-dimensional viewpoint on the reading process, vision research has been vigorously implemented and profoundly approached. Further, such research findings suggest there may be a certain group of children who have RD and visual problems affecting reading development.
Temporal Visual Processing Theory

The ability to process and retain pieces of information presented in a rapid sequence is a vital part of learning to read. Specifically, this is related to a role of visual processing in the reading process, the speed of process. Simply, there are two systems that transmit information from the eye to brain. The sustained or ‘parvocellular’ system operates during the fixation, and the transient or ‘magnocellular’ system works during saccades or movements to the next fixation (Clark & Uhry, 1995). In order to explore this theory, a number of researchers conducted experiments and demonstrated that the transient system operates slowly in some poor readers in comparison with nondisabled readers (Boden & Brodeur, 1999; Livingstone, 1993; Lovegrove, 1992). For example, Boden and Brodeur (1999) hypothesized that adolescents with RD are slower at processing visual information than normal readers and thus experience greater visual persistence. Through the findings from two types of computer-based activities, the authors concluded that the adolescents with RD demonstrated deficits in visual temporal processing, which is the processing of rapidly presented visual information, due to visual persistence. Previously, Di Lollo, Hanson, and McIntyre (1983) stated that children with RD show slower visual information processing and longer duration of visual persistence compared to the control group. Similarly, Richards, Samuels, Turnure, and Ysseldyke (1990) found that children with RD require longer response times on variations of visual tasks; thus, the authors concluded that children with RD demonstrate slower information processing. Based on the findings, we can assume there may be a relationship between rapid visual naming and visual processing skills. Hence, further investigation should be implemented to clarify the relationship.
Components of Successful Reading

What is reading? Reading is a comprehensive and active process in which readers shift between sources of information (what they know and what the text says), elaborate meaning and strategies, check their interpretation (revising when appropriate), and use the social context to focus their response (Walker, 1996, p. 4). Other authors defined reading as the act of simultaneously reading the lines, reading between the lines, and reading beyond the lines (Manzo & Manzo, 1993, p. 5). The first part of their definition, reading the lines, refers to the act of decoding the words in order to construct the author's basic message. The next part, reading between the lines, refers to the act of making inferences and understanding the author's implied message. Finally, reading beyond the lines involves the judging of the significance of the author's message and applying it to other areas of background and knowledge. In other words, reading is more than translating print into the spoken word (decoding). Reading is getting meaning from print. People who have not developed automatic word recognition skills may have comprehension problems because their energy is focused on identifying words rather than thinking about what they mean. Many of these children may read very slowly and often have to read things more than once to understand them. Others have automatic word recognition skills but cannot comprehend what they read. In that sense, the reading process can be divided into two areas: reading fluency and comprehension.

Reading Fluency

Definition

Unfortunately, there are still no consensual definitions of reading fluency (Wolf & Katzir-Cohen, 1999). However, it is closely related to the subset of time-related terms and frequently related with other terms such as automaticity, speed of processing, reading
rate/speed, and word recognition rate/proficiency. During the last two decades, research on reading fluency was actively undertaken, and many reading researchers suggested definitions of reading fluency. Through a thorough review of previous fluency literature, Wolf and Katzir-Cohen (1999) proposed their own working definition:

In its beginning, reading fluency is the product of the initial development of accuracy and the subsequent development of automaticity in underlying sublexical processes, lexical processes, and their integration in single-word reading and connected text. These include perceptual, phonological, orthographic, and morphological processes at the letter, letter-pattern, and word levels, as well as semantic and syntactic processes at the word level and connected-text level. After it is fully developed, reading fluency refers to a level of accuracy and rate where decoding is relatively effortless; where oral reading is smooth and accurate with correct prosody; and where attention can be allocated to comprehension. (Wolf & Katzir-Cohen, 2001, p. 219)

Wolf and Katzir-Cohen (2001) looked at fluency not so much as an outcome but as a developmental process that is shaped and influenced by all the linguistic systems that give us knowledge about words.

**Component**

Three major types of processes have been recognized as prominent in the development of fluency: orthographic, phonological, and semantic. Interestingly, Adams (1990) added emphasis to morphological and syntactic knowledge systems. For example, Adams proposed that both orthographic and semantic information are necessary for learning morphological knowledge and that both patterns and roots (e.g., Latin and Greek roots) make up many words. Researchers emphasize the connections that link orthographic, semantic, phonological, and morphological systems. In other words, reading fluency involves every process and subskill involved in reading. Consequently, language comprehension processes and higher-level processes affecting language comprehension (the application of world knowledge, reasoning, etc.) do not become fully
operative in comprehending text until the child has acquired reasonable fluency (Adams, 1990; Hoover & Gough, 1990; Perfetti, 1985; Stanovich, 1991; Sticht & James, 1984; Vellutino et al., 1991; Vellutino, Scanlon, & Tanzman, 1994).

**Factors of reading dysfluency**

Why do some people fail to read fluently? There must be specific factors that affect reading fluency. During the last two decades, many reading researchers have provided evidence on factors related to reading fluency (Wolf, 1991; Wolf, Bowers, & Biddel, 2000). They suggested that there is evidence that impaired readers break down across the continuum of processes. Through a thorough review of previous fluency literature, Meyer and Felton (1999) provided a summary of the existing research on explanations of dysfluency. Three major areas were identified within their review:

1. A breakdown takes place in the lower level processes. In Figure 2-3,(1) represents a breakdown in this lower level. At this level, dysfluent reading results from deficits in phonological processing and/or orthographic processing systems that affect the timing and coordination of these systems. Researchers indicated that the largest contribution to slowed word-reading rate among dyslexic readers in the slowed speed of processing in perceptual stages (Farmer & Klein, 1995; Tallal, Miller, & Fitch, 1993).

2. In this level, a breakdown takes places when people make higher order semantic and phonological connections between words, meaning, and ideas.(2) represents a breakdown in connections to meaning processor. In this level, dysfluent reading is resulted from deficits that occur after perceptual identification has been completed.

3. This breakdown may involve the slowed retrieval of names, meaning, or both (German, 1992; Wolf et al., 2000).

4. A breakdown in syntactic processing can be the last factor of dysfluency.(3) represents the last level of breakdown. In this level, dysfluent readers may have deficits exhibited in a lack of prosody and rhythm in oral reading and a lack of sensitivity to prosodic cues.
Reading Comprehension

As mentioned previously, reading is an interactive, holistic process involving the reader, the text, and instruction (Maria, 1990). The skillful reader is able to orchestrate a complex system of skills and knowledge. Since reading is a holistic process it is difficult to divide the concepts into fluency and comprehension. To be an effective reader, a well-developed system of decoding and comprehension skills is required (Rumelhart, 1977). Readers who decode quickly and accurately coordinate this process with the processes involved in the comprehension of the text (Anderson, Heibert, Scott, & Wilkinson, 1985).
Definition

Reading comprehension is the ability to understand or get meaning from text (any type of written material). Fountas and Pinnell (1996) emphasized that reading comprehension is not something that only happens after reading. He defined reading comprehension as the thinking done before, during, and after reading. (Fountas & Pinnell, 1996, p. 323). Others researchers defined it as the interaction between the text being read and the reader's existing prior knowledge, and expectations will generate meaning and comprehension (Leu & Kinzer, 1995). Comprehension is the reason for reading and a critical component of all content learning.

Level of reading comprehension

Specifically, Vacca and Vacca (1996) divided reading comprehension into three levels:

1. Literal (reading the lines): People get information explicitly from the text.
2. Interpretive (reading between the lines): People put together information and use information to express opinions and form new ideas.
3. Applied (reading beyond the lines): People perceive relationships and make inferences.

Factors of reading comprehension

Broadly, many researchers identified three factors affecting reading comprehension: reader, text, and activity. In addition, variations in the context in which they occur play an important role. However, these factors are intertwined and do not operate independently of the others in any authentic act of reading comprehension. First, effective readers bring to the task of reading an array of capabilities and dispositions. Reader differences in such capabilities as fluency in word recognition, oral language
ability (Pearson & Fielding, 1991; Pressley, 2000), and domain knowledge (Dole, Duffy, Roehler, & Pearson, 1991), along with differences in such dispositions as the reader’s motivation, goals, and purposes, are important sources of variability in reading comprehension. Second, text is the second element affecting reading comprehension. Duke (2000) documented that children who attend schools in poor districts have many fewer texts available than do children who attend schools in richer areas; the availability of texts in homes and libraries varies similarly. Texts that treat certain social issues or that require an interpretation and appreciation of alternative perspectives may be considered inappropriate by parents from some cultural or religious groups. Text factors thus interact with reader, activity, and context in determining the difficulty of comprehension. Third, activity refers to the acts a reader engages in with a text, and it encompasses purpose, operations, and consequences. Reading comprehension can be improved with strategies when readers themselves apply across a number of different texts (National Reading Panel, 2000). For example, teachers may teach students to activate their own background knowledge, to draw inferences as they read, or to restate information in the text (Chan, Cole, & Barfett, 1987). The successful activation of two areas of reading—fluency and comprehension—completes reading.

**Significant Predictors of Reading Success**

Many studies including longitudinal studies have been conducted to identify the predictors of current and later reading ability. Such studies yielded many important predictors of RD. Currently, phonological awareness and rapid-naming variables are very frequently involved in prediction studies. Further, a critical role of phonological and naming speed factors in classifying reading disabilities have been identified by many reading studies (e.g., Morris et al., 1998). Within the field of reading-related vision
research, eye movement and visual processing factors are considered as key indicators of reading difficulties. Therefore, these four individual predictors are discussed further in this section.

**Linguistic Predictors**

Among various linguistic indicators, the two most frequently identified factors that are significantly correlated to later reading ability are phonological awareness and rapid-naming deficit. During the last 25 years, research has provided a greater understanding that phonological awareness is a foundation of reading acquisition. As a consequence, an assessment of phonological awareness skills always has been included in early identification of RD. Along with phonological awareness, a wider variety of recent studies has highlighted rapid-naming skills as being highly correlated with their later reading abilities (e.g., Wolf, 1999; Wolf & Bowers, 1999). Therefore, the following section provides a neutral overview of the two skills and evidence of empirical studies as key linguistic predictors of RD.

**Phonological awareness**

In the 1970s, Isabelle Liberman and Donald Shankweiler introduced the significant concept of phonological awareness to the field of reading (Liberman, 1973; Liberman et al., 1974). They argued that an alphabetic system requires that readers have awareness that words are made up of individual speech sounds (i.e., phonemes). Hence, if a child is not sufficiently aware of the speech segments in spoken words, the child may have difficulties in reading. These researchers and their colleagues studied young children and poor readers and confirmed that they were lacking in awareness of the sound structure of words (Liberman et al., 1974); that is, the children had difficulties performing activities that require one to reflect on the speech sounds in words (e.g., counting the number of
phonemes in a word) (Liberman et al., 1974). Currently phonological awareness is the widely accepted term and generally is used as an umbrella label for all levels of conscious awareness of the sound elements in words. Simply, phonological awareness is an ability to understand a word’s sound structure, and it is critical for the efficient decoding of printed words and the ability to form connections between sounds and letters when spelling (Torgeson, 1997). In general, researchers indicate phonological awareness includes five levels of language skills (e.g., Chard & Dickson, 1999). According to Chard and Dickson (1999), these five levels of phonological awareness skills (rhyming, phoneme identification, blending, segmentation, and manipulation) emerge following a developmental hierarchy. The earliest developing phonological awareness skill was rhyming and is the most challenging phonological awareness skill. It involves the ability to manipulate phonemes (Chard & Dickson, 1999). More specifically, Adams (1990) further described five levels of phonological awareness in terms of abilities to (a) hear rhymes and alliteration as measured by knowledge of nursery rhymes, (b) do oddity tasks (comparing and contrasting the sounds of words for rhyme and alliteration), (c) blend and split syllables, (d) perform phonemic segmentation (such as counting out the number of phonemes in a word), and (e) perform phoneme manipulation tasks (such as adding, deleting a particular phoneme, and regenerating a word from the remainder). As explained above, there are various dimensions of phonological awareness. A tapping task, which was first used by Liberman (1973), is involved in developing children’s phonological awareness. Liberman had children use a wooden dowel to tap the number of sounds they could hear in spoken sentences and then in words (Liberman, 1973). Over the last 25 years, a huge amount of research has suggested that students who enter school
with little knowledge of phonological awareness experience less success in reading than students who have sufficient knowledge of phonological awareness (Adams, 1990; Mann & Brady, 1988; Stanovich, 1988). Overall, the studies of phonological awareness for young children are twofold: First, the power of phonological awareness to predict children’s reading ability enables early identification of students at risk for RD (e.g., Mann, 1993; Torgeson et al., 1997; Watson et al., 2003), and, second, the effectiveness on instruction, based on phonological awareness, has been recognized when compared to other types of instruction or no instruction (O’Connor, Jenkins, Leicester, & Slocum, 1993; Torgeson et al., 1997; Vellutino & Scanlon, 1987). Research firmly established the strong relationship between phonological awareness and reading acquisition. Along with phonological awareness, some intervention studies suggest that naming speed may be a critical component in successful reading, and it may be a reason why not all children respond to phonological awareness (e.g., O’Connor et al., 1993; Torgeson Wagner, Simmons, & Laughton, 1990). Although phonological awareness has been considered as the strongest indicator of RD, until recently we were not able to form an image of the brain of a living person engaged in reading (Clark & Uhry, 1995). The relationship between phonological awareness and RD has been confirmed through recent studies using fMRI (e.g., Pugh et al., 2000; Temple et al., 2000; Temple et al., 2003; Shaywitz et al., 2000; Wood, Relton, Flowers, & Naylor, 1991). For example, Temple et al. (2000) examined dyslexic and normal readers (age ranged from 8-12) by using fMRI during reading. They used fMRI in order to examine neurological differences between dyslexic and normal readers during phonological and orthographic tasks of rhyming and matching visually present letters. During letter rhyming for a phonological task, both dyslexic and
normal readers had activity in left frontal brain regions, whereas only normal readers had activity in left temporo-parietal cortex. During letter matching performance for an orthographic task, while normal readers showed activity throughout extrastriate cortex, dyslexic readers had little activity in that region. Their findings suggest that children with RD may be characterized by disruptions in the neural bases of both phonological and orthographic processes (Temple et al., 2000).

**Rapid naming**

Rapid naming is the ability to recall quickly and to verbalize the name of a presented object. Naming speed is typically assessed by Rapid Automatic Naming Test (RAN; Denckla & Rudel 1974, 1976), which requires children to name familiar colors, pictured objects, digits, and letters (Wagner & Togeson, 1987, as cited in Manis et al., 1999). Originally, Denckla and Rudel (see Clark & Uhry, 1995) found that the length of time it took to name these stimuli varied with age and reading ability. Older children were able to name quicker than younger children, and children with higher reading ability were quicker than poor readers. This hypothesis was confirmed through continuing studies. Recently, there is a growing consensus that RAN is highly correlated with reading ability (e.g., Bowers & Swanson, 1991; Wolf, 1991) and serves as an accurate, early, time-efficient predictor of reading achievement (Bowers & Wolf, 1993; Wolf, 1991). Over the last two decades, an extensive body of research indicated that rapid-naming skill is strongly related to reading development (Badian, 1993; Bowers, 1996; Wolf, Bally, & Morris, 1986; Wolf & Bowers, 1999). Unfortunately, researchers have provided mixed findings, and such findings vary greatly across studies. For example, the relationship between rapid-naming and phonological deficits in RD becomes a subject of
controversy. More specifically, Manis and his colleagues (1999) indicated two remaining issues in rapid naming:

1. Is a rapid-naming skill simply a part of phonological skills?
2. What processing skills are involved in rapid naming?

As described previously, several researchers argued that rapid naming is correlated with reading because these two are highly related to phonological coding skills (Share, 1995; Wagner & Togeson, 1987). Notably, Torgeson et al, (1997) pointed out that one limitation of predictive studies is the autoregressive effects of prior reading skills. When they did not control the effect of prior reading skills, they were able to indicate separate contributions of phonological and rapid-naming factors. On the other hand, when the autoregressive effect was factored out, rapid naming was no longer accounted for reading outcomes, but phonological awareness was still accounted for variance in reading. In contrast, Meyer, Wood, Hart, and Felton (1998) reported somewhat opposite findings. They conducted a study with older children, Grades 5 and 8, and yielded different results. They found that rapid naming was the only variable that significantly predicted later word identification for children with RD (not for average readers) when the autoregressive variables (Grade 3 word identification, IQ, and socioeconomic status) were controlled. Further, when autoregressor was factored out, rapid naming still accounted for variance in later reading development, but phoneme segmentation did not. Researchers (Bowers & Wolf, 1993; Wolf, 1997; Wolf & Bowers, 1999) argued that even though rapid naming may rely on and share variance with some phonological tests, some aspects of rapid naming such as speed of processing and sensitivity to temporally ordered information cannot be explained by phonological processing (Manis et al., 1999). Some researchers have tried to provide evidence by examining correlations between
phonological skills and rapid-naming skills of study participants (Felton & Brown, 1990) and identifying subgroups of children with RD (e.g., Korhonen, 1991; Lovett, 1995; Wolf & Bowers, 1999). For example, Korhonen (1991) conducted cluster analyses to identify subgroups among third graders with learning disabilities (LD). They were able to identify one subgroup of children who were characterized by their slow rapid naming. They further noted that this particular subgroup showed the least progress in reading achievement. Similarly, Lovett (1995) was also able to identify three subtypes among children with severe RD by assessing pretreatment diagnostic testing. Three subtypes were identified according to whether they had a phonological deficit only, a naming speed deficit only, or both deficits. Compared to children in a control group, all subjects, in general, made significant progress after 35 hours of intervention, which involved phonological awareness and word identification strategy trainings. However, the subgroup with a phonological deficit only made much further gains compared to the other two groups. This finding suggests that the remedial program, which is mainly based on phonological awareness, is not very effective for children who mainly have a naming speed deficit. In that sense, a rapid-naming predictor is a useful avenue of identifying children who may need additional assistance above and beyond the kinds of remedial approaches that are effective for poor readers with no naming deficit (Scarborough, 1995). Additionally, a reading-related vision research added a naming variable for the multiple regression model (Eden et al., 1995) and indicated that naming to confrontation on the Boston Naming Test proved to be significantly more difficult for the RD group than for the non-RD group.
Vision-Related Predictors

Since many studies estimated that 70% to 85% (e.g., Getman, 1981; McGurk & McDonald, 1976) of what we learn comes through vision. For example, McGurk and McDonald (1976) addressed the degree of development of how people’s visual skills significantly determine how effectively one is able to learn. According to Getman (1981), there is a significant relationship between vision and school achievement. Specifically, empirical studies indicate that 80% of all learning during a child’s first 12 years is obtained through vision (Getman, 1981). One interesting study examined the link among learning disabilities, delinquency, and visual ability and found that significant numbers of juvenile offenders had one or more visual deficiencies (Johnson, Nottingham, Stratton, & Jaba, 1996). Further, Johnson and his colleagues (1996) reported that 97% of students with behavioral problems and learning difficulties failed at least one of the vision subtests (tracking, fusion, acuity-near, acuity-distant, convergence, hyperopia, color vision, and visual motor integration). Byrne (1992) described several concerns in the field of reading research. One important viewpoint he highlighted was the “difficulties in visual perception as underlying RD may not be a dead issue” (p. 2). Although the visual aspects of RD were largely ignored until recently, a wider variety of literature indicated visual and ocular motor abnormalities, that is, eye movement and a visual processing factor in subjects with dyslexia (Fisher & Weber, 1990) as risk factors of reading difficulties. Therefore, these two skills are discussed further in this section.

Eye movement

Specifically, visual efficiency skills include accommodation, binocular vision, and ocular mobility. Some visual efficiency skills such as eye movement, tracking, and fixation are frequently mentioned in reading-related research. Reading begins with the
input of information through the visual-motor system. Basically, a variety of eye-related muscles are involved in eye movement. Measuring eye movement involves an examination of the number of fixations, duration of fixation, and the sequence of picture elements fixated. These eye fixations are called saccades and become more articulated as a child grows. When a preschooler looks between different objects, he or she typically uses head and neck movements rather than eye movements. By age 6 or 7, the child should be able to read a book or a board with proper eye movements and without moving his or her head or body (Schieman, 2002). Due to body or neck movement, a student who has low functioning eye-movement skills may have difficulties in keeping his or her place while reading or adding numbers in columns (Scheiman, 2002). Further, reading speed may be reduced due to slow eye movements, recurrent loss of place, or due to a small span of recognition (the width of text that is processed per fixation). Therefore, we may conclude that underachieved or incorrectly developed eye movement may be associated with reading difficulties. A study conducted with a selected group of 17 children with reading disabilities and 21 without reading disabilities found that visual tasks such as eye movement and visual search are able to differentiate good and poor readers as well as phonological tests (Eden et al., 1993). Specifically, Eden and his colleagues (1995) found some visual deficits including vertical tracking and vergence control in eye movement skills were stronger predictors than some other verbal skills. Their findings strongly support the hypothesis that some children with reading difficulties have visual problems. In summary, Rayner (1995) recapitulated the process of reading and eye movements by introducing five principal issues: (a) the span of effective vision, (b) integration of information across eye movements, (c) eye movement control (where to
fixate), (d) eye movement control (where to move), and (e) models of eye movement control. His research confirmed that the average span of perception can be determined by computing the number of words per fixation. As a result, slow reading speed may be highly correlated with eye movement.

**Visual processing**

Visual processing skills refer to a group of visual cognitive skills used for extracting and organizing visual information from the environment and integrating this information with other sensory modalities and higher cognitive functions (Scheiman, 2002). Visual processing skills are classified as visual spatial skills, visual analysis skills, and visual motor integration skills. As mentioned earlier, Adams (1990) stated that reading is accomplished through complex and interrelated processes, one of which is the visual process. Therefore, when determining the relationships between vision and reading, tests of visual processing should be involved rather than limiting the evaluation to eye health and visual acuity. For a skilled reader, the identification of a printed word begins with a visual process that operates on the visual forms of letters that make up a word and then instantaneously generates other processes including the phonological decoding process, to which printed letters and the sounds of the language correspond (Adams, 1990). Many researchers have considered visual processing one of several factors that may affect children’s reading abilities. There are some concrete examples. Kavale (1982) used meta-analysis to establish the relationship between visual-perceptual skills and reading. In his review, the 161 studies produced a total of 1,571 correlation coefficients, of which 1.062 indicated the relationship. Across all visual perceptual skills (visual discrimination, visual memory, visual closure, visual spatial relationship, visual-motor integration, visual association, figure ground discrimination, and visual-auditory
integration) and reading achievement skills, the 1,062 coefficients yielded an average correlation, 376 with a standard deviation of .139 and a standard error of .004. The correlation ranged from .01 to .89 with a median of .408. Among the visual perceptual skills, he identified that visual memory and visual discrimination skills were most significantly related to reading achievement. More interestingly, even after IQ was factored out, visual discrimination ability as measured in these studies was still highly related to reading (Kavale, 1982). The findings of his extensive meta-analysis imply that visual perceptual skills appear sufficiently associated with reading achievement to be considered among the complex of factors to the prediction of reading ability (Kavale, 1982). In order to examine the proportion of children with RD, Watson and Willow (1993) reviewed 14 clinical studies and indicated that approximately 20% of low-achieving readers have some type of visual problem such as a visual-spatial problem, a visual-perceptual deficit, or a visual memory problem. Furthermore, Aaron and Joshi (1992) reported that children are more likely to process printed words as visual information rather than as phonological information. They also found that some participants tend to disregard the orientation of letters and words and then make reversal errors. Vellutino and Scanlon (1988) also concluded that poor readers make more reversal errors due to their weakness in decoding skills and that they are therefore less coherent in their visual processing of printed words. After those poor readers were taught to use strategies regarding visual processing, they made very few reversal errors. With more wide perspectives, one research study revealed the relationship between general academic performances and visual perceptual skills. Watson et al. (2003) administered standardized sensory, perceptual linguistic intellectual, and cognitive tests to 470 children
who entered the first grade over a 3-year period. The results of 36 tests and subtests were divided into four factors, including reading-related skills (phonological awareness, letter and word recognition); visual cognition (visual perception, visual spatial perception, visual memory); verbal cognition (language development, vocabulary verbal concepts); and speech processing (the ability to understand speech under difficult listening conditions). Not surprisingly, the profiles of factor scores showed that reading-related skills have the biggest impact on reading and other academic performance. Notably, the second strongest predictor of both reading and mathematics grades was the visual cognition factor.

Overall, vision researchers addressed vision as not entirely innate but as a skill that continues to develop after birth and is influenced by the visual environment and the individual’s experience. If a child’s visual system has not developed to its optimal level, visually demanding activities such as reading may appear to be inefficient or uncomfortable for the child. Although a child has a good visual acuity (clarity of sight), it does not necessarily assure that the child does not have any visual problems. An extended view of the definition of vision may enhance the understanding of children with reading difficulties in terms of visual skills.

**Implication for Research**

The review of the literature provided a theoretical basis and empirical evidence on early identification of reading disabilities. Empirical studies to date have presented knowledge of factors necessary for early identification of reading disabilities. Overall, such evidence indicated that phonological awareness and other factors including visual-naming skills and visual-processing abilities are associated with the development of reading skills. However, those evidence are still not clear. Some researchers have argued
that questions and disagreements are still remained about the visual factors as one of the contributors to reading disabilities. However, the findings of many other studies from various perspectives allow us to assume that there may be a considerable relationship between a visual deficit and RD, at least for a certain percentage of children. There are the remaining issues that need to be further studied in the future.

First, this present review revealed that there are still some questions surrounding the visual deficit factor, and it is worthy of further investigation. Although a limited number of children with RD may have visual characters, we need to identify risk factors at the earliest stage to prevent or reduce influences of RD. Although previous literature indicated mixed findings on the relationship, there has been an increasing interest in the area of visual skills since more recent empirical research provided concrete evidence. Furthermore, there is a growing consensus that at least a group of children with RD have vision-related RD. However, little research has been done to indicate the specific proportion of children with RD who have visual deficits. Therefore, it is important to understand better what proportion of children with RD have visual deficits and whether these deficits are truly related to reading achievement (Feagans & Merriwether, 1990).

Second, the autoregressor effects are an unsolved issue in rapid-naming research. As noted previously, Torgeson et al. (1997) discussed a limitation of predictive studies in terms of the autoregressive effects of prior reading skills. Torgeson et al. (1997) argued that rapid naming is not a separate predictor of RD and the rapid-naming skills are included in phonological skills by providing evidence. When they did not control the effect of prior reading skill, they were able to indicate a separate contribution of phonological and rapid-naming factors. However, when the autoregressive effect was
factored out, rapid naming no longer accounted for variances in reading outcomes but phonological awareness still accounted for variances in reading (Torgeson et al., 1997).

On the other hand, Meyer et al. (1998) found contradictory results. When autoregressive variables were controlled, rapid naming still accounted for variance in later reading development, but phoneme segmentation did not. Therefore, it is important that autoregressor effects should be clearly considered when researchers conduct prediction studies.

Finally, a growing body of research established the necessary measurements for effective identification of early elementary students with reading disabilities. However, questions still remain about the most effective and reliable set of measurements for early primary graders of reading disabilities. Scarborough (1998) analyzed predictive studies and suggested that researchers use a multivariate approach to early, accurate screening of children. In her review, she indicated that such studies use a wide variety of variables that ranged from cognitive skills to family and school-based risk factors. In addition, combinations of variables used in each study vary greatly across studies. Although various types of measures are effective to detect children with RD in the early ages, we cannot give every possible assessment to each student. This approach is not cost and time effective. Therefore, it is essential to identify the most promising combination of predictors of early reading achievement that directly relates to the reading process (Goswami & Bryant, 1990).

**Conclusions**

The review of literature adds support to two conclusions:

1. Phonological processing is the most powerful cognitive variable determining later reading ability.
2. Phonological awareness is not enough to explain all types of reading disabilities.

Along with phonological awareness, the current review searched for other significant variables that may be associated with RD. Many connectionist theories and empirical researchers provided an insight that there may be other aspects of reading related to RD. From this review process, rapid-naming and visual deficits were seriously considered as significant variables determining later reading development. Overall, studies of phonological awareness, naming speed, and visual deficits as predictors of reading development have value in helping to understand the nature of the cognitive processes underlying reading. Therefore, the purpose of this study was to determine the effects of three variables including phonological awareness, rapid-naming, and visual skills on the reading levels of early elementary students. Further, this study investigated how the three variables are interrelated to their reading levels.
CHAPTER 3
METHODS

Introduction

The purpose of this study was to determine the effects of various variables including phonological awareness, rapid-naming, and visual skills on the reading levels of early elementary students. In addition, this study investigated how these variables are interrelated to their reading levels. In Chapter 3, the research methods of the study are described including the participants, research instruments, data collection procedures, and methods of data analysis employed by this study.

Research Questions

Three research questions were investigated (Table 3-1).

Table 3-1. Research Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>Is the combination of phonological awareness, rapid-naming, eye-movement/orthographic skills and visual perception skills significantly associated with the level of reading fluency?</td>
</tr>
<tr>
<td>Question 2</td>
<td>Among phonological awareness, rapid-naming, eye-movement/orthographic skills and eye-movement/orthographic skills, what is the most strongly correlated with the level of reading fluency?</td>
</tr>
<tr>
<td>Question 3</td>
<td>Among phonological awareness, rapid-naming, eye-movement/orthographic skills and visual perception skills what latent variables should be included in this reading fluency model?</td>
</tr>
</tbody>
</table>
Hypotheses

Based on the research questions and prior discussion, the following null hypotheses were generated for this study (Table 3-2).

Table 3-2. Hypotheses

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Null Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis 1</td>
<td>Phonological awareness, rapid-naming, and visual skills are not significantly associated with reading fluency.</td>
</tr>
<tr>
<td>Hypothesis 2</td>
<td>Phonological awareness measures are not significantly associated with reading fluency.</td>
</tr>
<tr>
<td>Hypothesis 3</td>
<td>Rapid-naming measures are not significantly associated with reading fluency.</td>
</tr>
<tr>
<td>Hypothesis 4</td>
<td>Eye-movement/Orthographic measures are not significantly associated with reading fluency.</td>
</tr>
<tr>
<td>Hypothesis 5</td>
<td>Visual perception measures are not significantly associated with reading fluency.</td>
</tr>
<tr>
<td>Hypothesis 6</td>
<td>Phonological measures are not significantly correlated with rapid-naming measures.</td>
</tr>
<tr>
<td>Hypothesis 7</td>
<td>Phonological measures are not significantly correlated with Eye-movement/Orthographic measures.</td>
</tr>
<tr>
<td>Hypothesis 8</td>
<td>Phonological measures are not significantly correlated with visual perception measures.</td>
</tr>
<tr>
<td>Hypothesis 9</td>
<td>Rapid-naming measures are not significantly correlated with eye-movement/orthographic measures.</td>
</tr>
<tr>
<td>Hypothesis 10</td>
<td>Rapid-naming measures are not significantly correlated with visual perception measures.</td>
</tr>
<tr>
<td>Hypothesis 11</td>
<td>Eye-movement/orthographic measures are not significantly correlated with visual perception measures.</td>
</tr>
</tbody>
</table>
Methods

Settings

Five school sites in a north central Florida district were selected for this study. The schools were selected to represent a distribution of both low- and middle-income populations. The socioeconomic level of the schools is based on the percentage of students in the school receiving lunch support. The specific percentage of students who participate in the free and reduced lunch program and percentage of nonwhite students enrolled in each school are presented in Table 3-3.

Table 3-3. Descriptive Information for Schools

<table>
<thead>
<tr>
<th>School</th>
<th>Total Enrollment</th>
<th>% of Nonwhite Students</th>
<th>% of Students that receive lunch support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>611</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
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<td>59</td>
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</tr>
<tr>
<td>4</td>
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</tr>
<tr>
<td>5</td>
<td>985</td>
<td>43</td>
<td>31</td>
</tr>
</tbody>
</table>

Participants

For this investigation, 210 second- and third-grade students from five public schools in an urban area of north-central Florida participated in this study. Reading researchers have come to believe that success or failure in reading is largely determined by the student’s experiences in Grades Kindergarten through Grade 4. As a consequence, reading research on the determinants of processes of reading achievement has been focused on this age range. Therefore, this study took second- and third-grade students as study participants who were falling into the most commonly researched developmental
stage. Students with diverse academic achievement levels were recruited; however, inclusion was limited to children who were primarily English speaking and currently had no special education due to mental retardation, visual impairments, and hearing impairments. The sample size was appropriate for an SEM model with three factors for this study. According to Stevens (1996), a good rule of thumb is 15 cases per predictor in a standard ordinary least squared multiple regression analysis. Since SEM is closely related to multiple regression in some respects, 15 cases per measured variable in SEM can be reasonable. Bentler and Chou (1987) suggested that researchers who use SEM may go as low as five cases per parameter. More generally, Loehlin (1992) reported the result after reviewing the literature; in the class of model with two to four factors, the investigator should plan on collecting at least 100 cases, with 200 being better (if possible). Demographic data in this study are shown in Table 3-4.

**Table 3-4. Demographic Data**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total N=210</th>
<th>Frequency</th>
<th>Percentage(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>97</td>
<td>46.2</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>113</td>
<td>53.8</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
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</tr>
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<td>African-American</td>
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<td>65</td>
<td>31.0</td>
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<tr>
<td>Hispanic</td>
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<td>21</td>
<td>10.0</td>
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<tr>
<td>Asian-Pacific</td>
<td></td>
<td>12</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>Grade</strong></td>
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<td></td>
</tr>
<tr>
<td>2(^{rd}) Grade</td>
<td></td>
<td>111</td>
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<tr>
<td>3(^{rd}) Grade</td>
<td></td>
<td>99</td>
<td>53.8</td>
</tr>
</tbody>
</table>

Forty six percent (n=97) were male students and 54% (n=113) were female students. The sample of five public schools included a diverse population; 53% were Caucasian; 31% were African-American; 10% were Hispanic; and 6% were Asian-Pacif-
Pacific Islanders. Forty six percent were second graders, and 54% were third graders.

Their ages ranged between 7 and 10 with the majority being 8 or 9.

**Measures**

The early elementary students who participated in this study completed twelve assessments with the instruments. Table 3-5 presents all the variables that were examined in the study. In addition, descriptions of the test instruments are presented in detail in the next section.

Table 3-5. Test Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Latent Variable: Factor</th>
<th>Observed Variable (Test Instrument)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological Awareness</td>
<td></td>
<td>1. Phoneme elision (CTOPP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Blending phonemes into words (CTOPP)</td>
</tr>
<tr>
<td>Rapid- Naming</td>
<td></td>
<td>1. A serial naming of digits (CTOPP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. A serial naming of letters (CTOPP)</td>
</tr>
<tr>
<td>Orthographic and Eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement Skills</td>
<td></td>
<td>1. Orthographic (J L- RRT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Eye movement (DEM)-Vertical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Eye movement (DEM)-Horizontal</td>
</tr>
<tr>
<td>Visual Processing Skills</td>
<td></td>
<td>1. Visual Discrimination (TVPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Visual Memory (TVPS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Visual Closure (TVPS)</td>
</tr>
<tr>
<td>Dependent Variable</td>
<td>Reading Fluency</td>
<td>1. Oral Reading Fluency I (DIBELS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Oral Reading Fluency II (DIBELS)</td>
</tr>
</tbody>
</table>

Abbreviations:
Dynamic Indicators of Basic Early Literacy Skills (DIBELS); CTOPP: Comprehensive Test of Phonological Processing, J L- RRT: Jordan Left-Right Reversal Test; DEM: Developmental Eye Movements Test; TVPS:NM-R: Test of Visual-Perceptual Skills (non-motor)-Revised.
Data Collection

Procedure

Permission forms for participation in the study were obtained from at least one parent or guardian of each study participant. The tests were administered individually to the study participants, who returned signed parental permission slips and met the inclusion criteria previously presented, in a designated place. All test items from the research instruments were read and carefully explained to the participants so that those with reading difficulties could participate in the study. This researcher and six other research assistants administered the research tests to all participants. Six research assistants were graduate students in education and took two half-day training sessions in test administration. Each participant was administered the test battery from 28 March 2004 through 17 May 2004.

Test Instruments

Dynamic Indicators of Basic Early Literacy Skills (DIBELS). A subtest of DIBELS, Oral Reading Fluency (ORF), was conducted. It is a measure that assesses fluency with text—the ability to translate letters-to-sounds-to-words fluently and effortlessly. The fluent reader is one whose decoding processes are automatic, requiring no conscious attention and used as a dependent measure for assessing reading fluency. It is a set of standardized, individually administered measures of early literacy development. The tests are designed to be short (1 minute) fluency measures used to regularly monitor the development of prereading and early reading skills (DIBELS). Such capacity then enables readers to allocate their attention to the comprehension and meaning of the text. The measures were developed upon the essential early literacy domains discussed in both the National Reading Panel (2000) reports to assess student
development of phonological awareness, alphabetic understanding, and automaticity and fluency with the code. Each measure has been thoroughly researched and demonstrated to be reliable and valid indicators of early literacy development and predictive of later reading proficiency to aid in the early identification of students who are not progressing as expected. When used as recommended, the results can be used to evaluate individual student development as well as provide grade-level feedback toward validated instructional objectives. The website http://dibels.uoregon.edu displays reliability and validity information for the DIBELS ORF: test-retest reliability for elementary students ranges from .92 to .97; alternate form reliability ranges from .89 to .94, and criterion-related validity ranges from .52 to .91. Spring benchmark goals for a trajectory of progress of words correct per minute in grade-level material (Good, Simmons, & Kame'enui, 2001)

Comprehensive Test of Phonological Processing (CTOPP). In order to assess phonological awareness and rapid-naming, the Comprehensive Test of Phonological Processing (CTOPP) is used. In particular, two subtests including a test of phoneme elision and blending into words is utilized for assessing phonological awareness. The subtest of CTOPP, the Phonological Awareness Quotient (PAQ), measures an individual’s awareness and access to the phonological structure of oral language. Specifically, these two measures were administered to determine students’ abilities to process and manipulate sounds. One subtest of CTOPP, the Rapid-Naming Quotient (RNQ) measures the examinee’s efficient retrieval of phonological information from long-term or permanent memory, as well as the examinee’s ability to execute a sequence of operations quickly and repeatedly (Wagner et al., 1999). A serial naming of digits and
letters is used for assessing rapid naming. The CTOPP provides percentiles, standard scores, and age and grade equivalents. Subtest standard scores have a mean of 10 and a standard deviation of 3. The Phonological Awareness has a mean of 100 and a standard deviation of 15. Age and grade equivalents show the relative standing of individuals’ scores. The CTOPP was normed on over 1,600 individuals ranging in age from 5 through 24 and residing in 30 states. Over half of the norming sample came from children in elementary school (through Grade 5), where the CTOPP is expected to have its widest use. The demographic characteristics of the normative sample are representative of the U.S. population as a whole with regard to gender, race, ethnicity, residence, family income, educational attainment of parents, and geographic regions. The sample characteristics were stratified by age and keyed to the demographic characteristics reported in the 1997 Statistical Abstract of the United States. Reliability of the CTOPP was investigated using estimates of content sampling, time sampling, and scorer differences. Most of the average internal consistency or alternate forms of reliability coefficients (content sampling) exceed .80. The test/retest (time sampling) coefficients range from .70 to .92. The magnitude of the coefficients reported from all the reliability studies suggests that there is limited error in the CTOPP and that examiners can have confidence in the results (Wagner et al., 1999).

**Jordan Left-Right Reversal Test (J L-RRT).** The Jordan Left-Right Reversal Test (J L-RRT) is used for assessing one visual skill regarding orthographic processing. It tests memory for spatial orientation of upper/lower case letters and numerals. Visual reversals have been commonly accepted as one of a constellation of symptoms of learning disabilities in children (Jordan, 1980). The J L-RRT is a norm- referenced test
that assesses visual reversals of letters, numbers, and words in students ranging in age 5 through adult. This test was normed on over 3,000 individuals ranging in age from 5 through 12. The normative sample includes all socioeconomic levels, and 10% of this sample came from nonwhite racial backgrounds. For this test, the child scans rows of upper- and lower-case letters and numerals and crosses out any that are incorrectly oriented. The score is the number of errors. Test-retest reliability coefficients for Level I, given in the test manual, range from 0.87 (ages 8 and 9) to 0.98 (ages 6-6 to 6-11) (Jordan, 1980).

**Developmental Eye Movements Test (DEM).** The DEM is used for assessing a visual skill regarding eye movement. The most direct way to measure the quality of fixations and eye movements with reading is by direct movements recording. However, for young children, indirect measure is more applicable (Watson et al., 2003); therefore, it was utilized for this study. The developmental eye movement test (DEM) was designed to determine if children with reading defects have defective eye movements by comparing horizontal and vertical movements in a number naming task. The DEM was normed with 534 individuals selected from elementary school populations. The sample was equally drawn from rural public schools, suburban public schools, and suburban parochial schools. Each age and grade group was composed of an equal number of males and females. This test incorporates two number-calling subtests, one in vertical array and one in horizontal array. The vertical subtest measures an individual’s visual-verbal automatic calling skills, whereas the horizontal subtest assesses ocula-motor function. This is the only test that separates the two functions (Garzia, Richman, Nicholson, & Gaines, 1990). The test also includes a pretest component in which the child must read a
row of numbers quickly to determine automatic number knowledge. If the child is unable to perform this pretest satisfactorily, the DEM cannot be meaningfully administered. Test-retest reliability coefficients for both vertical and horizontal DEM tests, given in the test manual, are .89 and .86.

**Test of Visual-Perceptual Skills (non-motor)-Revised [TVPS:NM-R].** The visual processing assessment instrument for this study was Test of Visual-Perceptual Skills (non-motor)-Revised [TVPS:NM-R] (Gardner, 1994). The TVPS: NM-R is a test of visual perceptual processing ability that does not incorporate motor involvement. Children aged 4 through 13 can be tested through this instrument. It is designed for psychologists, learning specialists, optometrists, occupational therapists, remedial specialists, educators, and other professionals. The TVPS: NM-R was designed to measure seven distinct areas of a child's visual-perceptual skills: Visual Discrimination, Visual Memory, Visual-Spatial Relationships, Visual Form Constancy, Visual Sequential Memory, Visual Figure-Ground, and Visual Closure. Each of the seven subtests contains 16 items, arranged in order of difficulty, and can be administered to individual children. The TVPS: NM-R is quick and easy to administer, requiring approximately 10 to 20 minutes of testing time and only 3 to 5 minutes to score. Standardization was achieved on 1,032 children, most of whom lived in the San Francisco Bay Area but some of whom came from various states in the United States. The ages of the subjects in the standardization sample ranged from 4 years to 12 years. The reliability coefficients for the total score ranged from .83 to .91. Test results from the field study have been converted into perceptual ages, scaled scores, and percentiles for each of the seven subtests, along with perceptual quotients, percentiles, and median perceptual ages for the
combined scores of all subtests. It was chosen because its normative data are superior to those of any other test of visual processing currently available. Among seven subtests of visual perceptual skills, three subtests were selected, including visual discrimination, visual memory and visual closure based on previous research findings. For example, Kavale (1982) conducted a meta-analysis of the relationship between visual perceptual skills and reading achievement. In this meta-analysis, 1,571 correlation coefficients were collected from 161 studies. This analysis yielded that tests of visual memory, visual discrimination, and visual closure are most significantly related with reading achievement. Therefore, these three subtests were conducted to examine visual perceptual skills. The descriptions of subtests are as follows:

1. *Visual discrimination:* A subject’s ability to match or determine exact characteristics of two forms when one of the forms is among similar forms.

2. *Visual Memory:* A subject’s ability to remember for immediate recall (after four or five seconds) all of the characteristics of a given form, and being able to find this form from an array of similar forms.

3. *Visual closure:* A subject’s ability to determine, from among four incomplete forms, the one that would be the same as the completed form (Gardner, 1994).

**Inter-coder Reliability**

In general, inter-coder reliability examines the extent to which different interviewers, observers, or coders using the same instrument or measure get equivalent results. For this study, all the assessments for 45 students (out of 210 participants, 21.5%) was conducted by two assessors. Actually, the main assessor administered all the tests, and the other assessor observed and recorded separately. The inter-coder reliability for this study was examined with Cohen's kappa by using SPSS. The range of coefficients on each test was quite high, ranging from .92 to 1.00. Therefore, they were acceptable.
Data Analysis

Overview of Statistical Analysis

The SPSS and LISREL 8.30 (Joreskog & Sorbom, 1996) were used to conduct all statistical analyses. The criterion for significance tests for all a priori hypotheses was set at $\alpha = .05$. To test the first hypothesis, the relationship between reading fluency and four latent variables, structural equation modeling with latent variables was used. To test Hypotheses 2 through 5, a regression analysis with SEM was used to examine the relationship among four independent variables and one dependent latent variable. Finally, to test Hypotheses 6 through 11, a correlational analysis was conducted to determine significant relationships between four independent latent variables.

Structural Equation Modeling

Overview

Structural Equation Modeling (SEM) was conducted by using LISREL 8.30. LISREL 8.30 program defaults to the maximum likelihood fitting function for estimating a model’s parameters (Joreskog & Sorbom, 1996). This method consists of a measurement model to define hypothetical latent constructs in terms of measured variables, and a structural model to depict relationships among latent constructs. The SEM is a multivariate method combining aspects of factor analysis and multiple regression in analyzing a set of interrelated relationships among manifest and latent variables simultaneously. The advantages of SEM compared to most other conventional statistical methods include the following capabilities.

First, the basic statistic in SEM is the covariance. Covariance is generally a more appropriate statistic in SEM than correlation, and covariance statistics convey more information than correlations. A correlation matrix is not suggested since SEM assumes
that the variables are unstandardized. While conventionally analyses such as ordinary least square regression attempt to minimize differences between observed and expected individual cases, SEM aims to minimize differences between observed and expected covariance matrices. In other words, SEM, based on the covariance statistic, attempts “to understand patterns of correlations among a set of variables and to explain as much of their variances” (Kline, 1998, pp. 10-11).

Second, SEM allows separating measurement error from hypothesized relationship among constructs that cannot be operated by conventional analyses. For example, a regression coefficient is composed of two elements: structural coefficient between the independent and dependent variable and the reliability for the predictor variable. By distinguishing a structural model from a measurement model, SEM can examine the relationship among constructs that are not influenced by measurement errors (Newcomb & Bentler, 1988).

Third, SEM allows incorporation of latent variables into analyses unlike conventional analyses that focus only on observed variables. Since SEM is not limited to relations among observed variables, it gives researchers more flexibility to study any combination of relations.

Finally, SEM allows researchers to estimate very complicated multivariate relationships, while conventional analyses cannot accommodate multiple indicators of the same construct due to potential problems such as multicollinearity. Even conventional multivariate techniques that deal with multiple dependent variables cannot examine relations simultaneously and only examine a single relationship at a time. However, SEM
allows examining a series of relationships of multiple dependent variables simultaneously.

Therefore, during the last three decades, SEM has become a widely used methodology for specifying, estimating, and testing hypothesized interrelationship among meaningful variables in behavioral and social sciences (Joreskog & Sorbom, 1996). Applications of the SEM methodology in education research are also on the increase. In order to apply SEM in estimating the causal model of the present study, all structural modeling was performed with the LISREL program.

**Assumptions of SEM analysis**

SEM requires certain assumptions to be met such as continuous variables, normality, and linearity of all relationships. Therefore, it is important to examine whether the assumptions of SEM have been met. First, variables used in SEM are typically continuous (Kline, 1998). All the variables used in the present study are continuous variables. Another requirement of SEM is the linearity of relationship between exogenous and endogenous variables. In order to examine the linearity, residual plots against independent variables are closely examined. In case of a violation of the linearity assumption, the use of transformed independent variables was considered to uphold these requirements. For each variable, the present study evaluates the linearity assumption by plotting the studentized residuals against the predicted values. Also, the correlation matrix indicates that multicollinearity is not a problem for multivariate analysis as there is only one correlation among the independent variables that is higher than .50. Frequency distributions, skewness and kuutosis of the data, and normal probability plots are inspected to examine normality. In addition, a covariance matrix analyzed with the Maximum Likelihood method (ML) is applied for the present study because ML is found
to be fairly robust with the data that violate multivariate normality (Bollen & Long, 1993). Finally, this study replaces missing values with the mean values of each variable based on valid responses because SEM is sensitive to the presence of missing variables.

**Analytic Procedures for SEM**

To assure that both models are properly specified, it is critical to follow the three steps of SEM: (a) identify a proposed model, (b) evaluate the model fit, and (c) modify the model if the original model fit is bad.

**A Proposed model**

First, SEM begins with what is a conceptual rather that a statistical component: causal model. Therefore, based on previous literature and prior discussions, a reading model was proposed. In general, the models were established through three distinct phases. First, a measurement model confirmed the validity of the constructs that were used in later structural models. The purpose of this model was to identify the constructs with reduced error variance, and the constructs could be established by a factor analysis. Second, a predictive structural model was created to test the direct effects of multiple predictors on reading. Third, a mediated reading model was structured to test hypotheses. Figure 3-1 presents the model for this study that includes three factors that can be related to reading levels. A causal model is a hypothesis about the field of variables that affect one or more dependent variables of interest, presented formally as a path diagram. The diagram in Figure 3-1 demonstrates that early elementary children’s level of reading is correlated with phonological awareness, rapid-naming, and visual skills. The model was overidentified to meet basic requirement for model identification. In other words, the number of parameters must be less than the number of observations. The overidentified model resulted in positive degrees of freedom, which allowed for the rejection of the
model. For this study a model was identified based on previous findings and hypotheses in the literature.

In a path diagram, observed or measured variables are represented as rectangles, whereas latent variables that have been derived are represented as circles or ovals. Relations between variables in SEM, whether the variables are latent or measured are represented by path diagram, with collections of variables connected by lines and arrows. Variables with lines having one-way arrows pointed to them are dependent variables in the model. In this model, one latent dependent variable, reading fluency, is indicated. Variables that are the sources of lines with arrows and have no arrow leading into them are independent variables. In this model, three latent independent variables are estimated: phonological awareness, rapid-naming and visual skills. The curved arrow between latent variables represents the covariance or correlation between the two independent variables in predicting the dependent variables.

The overall model fit

The SEM requires that models be formally specified for estimation and model testing (Hoyle, 1995). In terms of model testing, the first step estimates the goodness-of-fit of the hypothesized research model. This is typically done using a chi-square ($\chi^2$) to determine if differences between the data and the model are statistically significant and can evaluate the relative fit of models of differing complexity.
Figure 3-1. A Proposed Model

Maximum likelihood generates an estimated chi-square statistic and as such provides a probability value indicative of the overall fit of the model since the distribution of chi-square value is known (Bollen, 1989). The value of the chi-square statistic, in relation to the model’s degrees of freedom, determines whether the fitted residuals, resulting from $\sum - \sum(\theta)$, deviate from the population values of zero. The differences between the corresponding elements of the implied covariance matrix (theory) and the observed covariance matrix (reality) consist of the matrix of residuals.
The lower the chi-square value gained from the accumulation of these residuals, the more likely the theory represents the reality.

However, such tests are sensitive to sample sizes, and the probability of rejecting any model increases when a sample size increases even with minimal deviation from the model. Therefore, Bentler and Bonett (1980) suggested that $\chi^2$/df ratio ($df$: degree of freedom) as a more appropriate measure of model fit. This ratio should not be bigger than 5 for models with a good fit (Bentler, 1990). In addition to the chi-square statistic, the root mean square error of approximation (RMSEA) and the non-normed fit index (NNFI) are used for evaluation for the significance of the relations between the constructs of all models. According to Bentler and Bonett (1980), these two indices were determined to be robust with relatively small sample sizes and non-normal or skewed distributional form (see also, Browne & Cudeck, 1993; Neuhaus & Swank, 2002). The second step in model estimation is to examine the path significance of each association in our research model and variance explained ($R^2$ value) by each path. The LISREL reports raw and standardized estimates for all specified paths, along with standardized errors and test statistics for each path.
CHAPTER 4
RESULTS

Research findings presented in this chapter consist of four parts. The first part presents descriptive and inferential statistics on the sample. The second part of this chapter discusses the results of correlational analysis using all of the available variables for this study. Third, the results of how this model fits with the measurement model are presented, and a structural model also is presented. Finally, another correlational analysis and regression analysis with SEM approaches are discussed with the finalized SEM model.

The following hypotheses were tested in this study:

H1 Phonological awareness, rapid-naming, and visual skills are not significantly associated with reading fluency.

H2 Phonological awareness measures are not significantly associated with reading fluency.

H3 Rapid-naming measures are not significantly associated with reading fluency.

H4 Eye-movement/Orthographic measures are not significantly associated with reading fluency.

H5 Visual perception measures are not significantly associated with reading fluency.

H6 Phonological measures are not significantly correlated with rapid-naming measures.

H7 Phonological measures are not significantly correlated with Eye-movement/Orthographic measures.

H8 Phonological measures are not significantly correlated with visual perception measures.

H9 Rapid-naming measures are not significantly correlated with eye-movement/orthographic measures.
H10 Rapid-naming measures are not significantly correlated with visual perception measures.

H11 Eye-movement/orthographic measures are not significantly correlated with visual perception measures.

**Descriptive and Inferential Statistics**

**Demographic Characteristics**

Descriptive statistics for the study’s demographic characteristics are presented in Table 4-1. The sample of this present study consisted of 210 second- and third-grade students: 97 male students (46.2%) and 113 female students (53.8%). Approximately 53.3% of the children were Caucasian; 31.0% were African-American children; 10% were Hispanic; and 5.7% were Asian/Pacific Islanders. The mean age of the sample was 8.5 years. Additional descriptive information of the sample on observed variables is presented in Table 4-2.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>%</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
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<td><strong>Gender</strong></td>
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</tr>
<tr>
<td>Male</td>
<td>97</td>
<td>46.2</td>
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<td>.50</td>
<td>7~10</td>
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<tr>
<td>Female</td>
<td>113</td>
<td>53.8</td>
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<td></td>
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<td><strong>Ethnicity</strong></td>
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<td>Caucasian</td>
<td>112</td>
<td>53.3</td>
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<td>.50</td>
<td>7~10</td>
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<tr>
<td>African-American</td>
<td>65</td>
<td>31.0</td>
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<td>Hispanic</td>
<td>21</td>
<td>10.0</td>
<td></td>
<td>.50</td>
<td>7~10</td>
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<td>Asian-Pacific</td>
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<td>5.7</td>
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<tr>
<td><strong>Grade</strong></td>
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<td></td>
</tr>
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<td>111</td>
<td>52.9</td>
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<td>.50</td>
<td>7~10</td>
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<tr>
<td>3\textsuperscript{rd} Grade</td>
<td>99</td>
<td>47.1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td>8.5</td>
<td>.50</td>
<td>7~10</td>
</tr>
</tbody>
</table>
Table 4-2. Means and Standard Deviations on All of the Observable Variables

<table>
<thead>
<tr>
<th>Latent Variables</th>
<th>Observed Variables (scale)</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonological Awareness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elision (correct items out of 20)</td>
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<td>12.84</td>
<td>4.38</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Blending into words (correct items out of 20)</td>
<td></td>
<td>12.73</td>
<td>3.27</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td><strong>Rapid Naming</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit naming (time in secs)</td>
<td></td>
<td>36.76</td>
<td>10.68</td>
<td>17</td>
<td>89</td>
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<tr>
<td>Letter naming (time in secs)</td>
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<td>40.67</td>
<td>11.79</td>
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<tr>
<td><strong>Eye Movement/Orthographic Skills</strong></td>
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<td>199</td>
</tr>
<tr>
<td>DEM horizontal test (time in secs)</td>
<td></td>
<td>3.30</td>
<td>3.48</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Reversal Test (reversal errors)</td>
<td></td>
<td>12.82</td>
<td>2.27</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td><strong>Visual Processing Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Discrimination (correct items out of 16)</td>
<td></td>
<td>12.19</td>
<td>2.41</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Visual Memory (correct items out of 16)</td>
<td></td>
<td>10.26</td>
<td>3.39</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Visual Closure (correct items out of 16)</td>
<td></td>
<td>121.93</td>
<td>45.26</td>
<td>29</td>
<td>258</td>
</tr>
<tr>
<td>Reading Fluency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency I (wpm*)</td>
<td></td>
<td>109.48</td>
<td>39.39</td>
<td>21</td>
<td>208</td>
</tr>
</tbody>
</table>

* wpm: word per minute

**Means and Standard Deviations on All the Observable Variables**

The means and standards deviations for the subjects on each test are displayed in Table 4-2. Additionally minimum and maximum scores are presented in the same table.

For phonological awareness, the mean scores on elision and blending into words of this sample were 12.84 and 12.73, respectively. According to this result, the average score of digit naming was approximately 4 seconds lower than that of letter naming. This result implies children take longer time to recall letters than numbers. The average raw score for the Jordan Left-Right Reversal test was 3.30 for this sample. This score indicates the error score of this sample. According to the manual of the Jordan Left-Right Reversal test, the raw score can be converted to percentiles for boys and girls separately. Jordan indicates that approximately a 25 percentile score for boys in the age level of 8.6 is 4 and
for girls in the same age level is 3. The 50 percentile score for both boys and girls is approximately 2. For the Fluency I test, a child was requested to read a story that is rated as one grade below, and for the Fluency II test, another story that is rated as the same grade of each student was provided. Therefore, the average score of Fluency II was lower than that of Fluency I. Carver (1990) presented approximate reading rates for students in Grades 2-12. According to Carver’s (1990) analysis, the average reading fluency (wpm) for 2.5 grade students is 121. The subjects in this current study are within a range of an average reading fluency score.

Table 4-3. Criteria for Percentile Cutoff

<table>
<thead>
<tr>
<th>Latent Variables</th>
<th>Criteria for Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Variables (scale)</td>
<td>&gt; 25 %tile 25<del>50 %tile 50</del>100 %tile</td>
</tr>
<tr>
<td>phonological awareness</td>
<td></td>
</tr>
<tr>
<td>Elision (correct items out of 20)</td>
<td>0~ 9 10<del>13 13</del>20</td>
</tr>
<tr>
<td>Blending into words (correct items out of 20)</td>
<td>0~ 10 11<del>14 15</del>20</td>
</tr>
<tr>
<td>rapid naming</td>
<td></td>
</tr>
<tr>
<td>Digit naming (time in secs)</td>
<td>&gt;= 46 37~45 &lt;=36</td>
</tr>
<tr>
<td>Letter naming (time in secs)</td>
<td>&gt;= 50 40~49 &lt;=39</td>
</tr>
<tr>
<td>eye movement/orthographic skills</td>
<td></td>
</tr>
<tr>
<td>DEM vertical test (time in secs)</td>
<td>&gt;= 52 46~51 &lt;=45</td>
</tr>
<tr>
<td>DEM horizontal test (time in secs)</td>
<td>&gt;= 64 55~63 &lt;=54</td>
</tr>
<tr>
<td>Reversal Test (reversal errors)--- Boys</td>
<td>&gt;= 5 4 0~3</td>
</tr>
<tr>
<td>Reversal Test (reversal errors)--- Girls</td>
<td>&gt;= 4 3 0~2</td>
</tr>
<tr>
<td>visual processing skills</td>
<td></td>
</tr>
<tr>
<td>Visual Discrimination (correct items out of 16)</td>
<td>1~ 6 7<del>9 10</del> 16</td>
</tr>
<tr>
<td>Visual Memory (correct items out of 16)</td>
<td>1~ 6 7<del>9 10</del> 16</td>
</tr>
<tr>
<td>Visual Closure (correct items out of 16)</td>
<td>1~ 4 5~ 7 8 ~ 16</td>
</tr>
<tr>
<td>reading fluency</td>
<td></td>
</tr>
<tr>
<td>Fluency I +Fluency II (wpm) /2---2nd Graders</td>
<td>&lt;= 70 70~ 90 &gt;= 91</td>
</tr>
<tr>
<td>Fluency I +Fluency II (wpm) /2---3rd Graders</td>
<td>&lt;= 80 81~ 110 &gt;= 111</td>
</tr>
</tbody>
</table>
Descriptive Statistics on Percentile Scores

Descriptive statistics on percentile scores are also considered and presented in Table 4-4. In terms of phonological awareness, children who belong to the lowest percentile score group on elision are 36.2%. However, the number of children who belong to the lowest group in terms of ‘blending into words’ was much lower (17.6%) compared to elision (36.2%). Surprisingly, the number of children who acquired lower than the 25 percentile score on DEM-horizontal test was too many (51.0%) compared to DEM-vertical test. The criteria were determined by DEM manual. Therefore, this result implies that this criterion score should be reconsidered and adjusted to the logical level.

<table>
<thead>
<tr>
<th>Latent Variables</th>
<th>&lt;25 Percentile (at risk)</th>
<th>25-50 Percentile (some risk)</th>
<th>&gt;50 Percentile (low risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Variables</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td><strong>Phonological Awareness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elision</td>
<td>76 (36.2)</td>
<td>33 (15.7)</td>
<td>100 (48.1)</td>
</tr>
<tr>
<td>Blending into words</td>
<td>37 (17.6)</td>
<td>87 (41.4)</td>
<td>86 (41.0)</td>
</tr>
<tr>
<td><strong>Rapid Naming</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit naming</td>
<td>35 (16.7)</td>
<td>36 (17.1)</td>
<td>139 (66.2)</td>
</tr>
<tr>
<td>Letter naming</td>
<td>34 (16.2)</td>
<td>71 (33.8)</td>
<td>105 (50.0)</td>
</tr>
<tr>
<td><strong>Eye Movement/Orthographic Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEM vertical test</td>
<td>60 (28.6)</td>
<td>39 (18.6)</td>
<td>111 (52.9)</td>
</tr>
<tr>
<td>DEM horizontal test</td>
<td>107 (51.0)</td>
<td>38 (18.1)</td>
<td>65 (31.0)</td>
</tr>
<tr>
<td>Reversal Test</td>
<td>64 (30.5)</td>
<td>30 (14.3)</td>
<td>116 (55.2)</td>
</tr>
<tr>
<td><strong>Visual Processing Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Discrimination</td>
<td>6 (2.7)</td>
<td>25 (4.8)</td>
<td>194 (92.4)</td>
</tr>
<tr>
<td>Visual Memory</td>
<td>6 (2.7)</td>
<td>17 (8.1)</td>
<td>187 (89.2)</td>
</tr>
<tr>
<td>Visual Closure</td>
<td>11 (5.2)</td>
<td>41 (19.5)</td>
<td>158 (75.2)</td>
</tr>
<tr>
<td><strong>Reading Fluency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency I + Fluency II</td>
<td>36 (17.1)</td>
<td>39 (18.6)</td>
<td>135 (64.3)</td>
</tr>
</tbody>
</table>

Interestingly, the results of the three tests of visual perception skills are consistent with prior studies. Many researchers have argued that 3% to 5% of all children may have vision-related reading disabilities. For example, Watson and Willows (1993) reviewed 14
clinical studies and indicated that approximately 20% of low-achieving readers have some type of visual problems such as visual-spatial problems, visual-perceptual deficits, or visual-memory problems. This sample includes 36 children who show very low reading fluency level (less than 25 percentile). Therefore, approximately 20% of children with low-reading fluency may have vision-related reading problems.

**Gender Differences**

Group means on all measures were calculated, and a one-way analysis of variance (ANOVA) was conducted to see if there are any gender differences. Table 4-5 provides a summary of the one-way ANOVA of all the measures.

<table>
<thead>
<tr>
<th>Latent Variables</th>
<th>Observed Variables</th>
<th>Boys</th>
<th>SD</th>
<th>Girls</th>
<th>SD</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonological Awareness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elision</td>
<td>13.12</td>
<td>4.47</td>
<td>12.61</td>
<td>4.32</td>
<td>.714</td>
<td>.399</td>
</tr>
<tr>
<td></td>
<td>Blending into words</td>
<td>12.60</td>
<td>3.45</td>
<td>12.85</td>
<td>3.11</td>
<td>.308</td>
<td>.579</td>
</tr>
<tr>
<td><strong>Rapid Naming</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Digit naming</td>
<td>37.95</td>
<td>11.89</td>
<td>35.74</td>
<td>9.45</td>
<td>2.239</td>
<td>.136</td>
</tr>
<tr>
<td></td>
<td>Letter naming</td>
<td>42.00</td>
<td>13.61</td>
<td>39.52</td>
<td>9.88</td>
<td>2.321</td>
<td>.129</td>
</tr>
<tr>
<td><strong>Eye Movement/Orthographic Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEM vertical test</td>
<td>49.10</td>
<td>16.42</td>
<td>46.45</td>
<td>11.83</td>
<td>1.836</td>
<td>.177</td>
</tr>
<tr>
<td></td>
<td>DEM horizontal test</td>
<td>70.45</td>
<td>26.49</td>
<td>67.84</td>
<td>22.12</td>
<td>.607</td>
<td>.437</td>
</tr>
<tr>
<td></td>
<td>Reversal Test</td>
<td>3.39</td>
<td>2.82</td>
<td>3.23</td>
<td>3.98</td>
<td>.112</td>
<td>.738</td>
</tr>
<tr>
<td><strong>Visual Processing Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Visual Discrimination</td>
<td>12.79</td>
<td>2.43</td>
<td>12.86</td>
<td>2.04</td>
<td>.044</td>
<td>.835</td>
</tr>
<tr>
<td></td>
<td>Visual Memory</td>
<td>12.16</td>
<td>2.69</td>
<td>12.21</td>
<td>2.15</td>
<td>.020</td>
<td>.887</td>
</tr>
<tr>
<td></td>
<td>Visual Closure</td>
<td>10.12</td>
<td>3.55</td>
<td>10.38</td>
<td>3.25</td>
<td>.320</td>
<td>.572</td>
</tr>
<tr>
<td><strong>Reading Fluency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fluency I (wpm*)</td>
<td>119.64</td>
<td>45.89</td>
<td>123.89</td>
<td>44.82</td>
<td>.460</td>
<td>.498</td>
</tr>
<tr>
<td></td>
<td>Fluency II (wpm)</td>
<td>108.13</td>
<td>40.27</td>
<td>110.63</td>
<td>38.76</td>
<td>.209</td>
<td>.647</td>
</tr>
</tbody>
</table>

* wpm: word per minute
On all the assessment, the girls’ performance was superior to boys’. However, no significant gender differences were found. Because gender difference is minimal, these findings of this study are consistent with pervious studies.

**Differences Between Second and Third Graders**

A one-way analysis of variance (ANOVA) was conducted to see if there were any differences between second and third graders on all the observed measures. Table 4-6 provides a summary of the one-way ANOVA of all the measures.

<table>
<thead>
<tr>
<th>Latent Variables</th>
<th>2nd Graders</th>
<th>3rd Graders</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonological Awareness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elision</td>
<td>13.12</td>
<td>12.61</td>
<td>.950</td>
</tr>
<tr>
<td>Blending into words</td>
<td>12.60</td>
<td>12.85</td>
<td>1.909</td>
</tr>
<tr>
<td><strong>Rapid Naming</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit naming</td>
<td>37.95</td>
<td>35.74</td>
<td>15.541</td>
</tr>
<tr>
<td>Letter naming</td>
<td>42.00</td>
<td>39.52</td>
<td>14.332</td>
</tr>
<tr>
<td><strong>Eye Movement/Orthographic Skills:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEM vertical test</td>
<td>49.10</td>
<td>46.45</td>
<td>9.391</td>
</tr>
<tr>
<td>DEM horizontal test</td>
<td>70.45</td>
<td>67.84</td>
<td>23.821</td>
</tr>
<tr>
<td>Reversal Test</td>
<td>3.39</td>
<td>3.23</td>
<td>9.249</td>
</tr>
<tr>
<td><strong>Visual Perception Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Discrimination</td>
<td>12.79</td>
<td>12.86</td>
<td>4.257</td>
</tr>
<tr>
<td>Visual Memory</td>
<td>12.16</td>
<td>12.21</td>
<td>1.771</td>
</tr>
<tr>
<td>Visual Closure</td>
<td>10.12</td>
<td>10.38</td>
<td>5.850</td>
</tr>
<tr>
<td><strong>Reading Fluency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency I (wpm***</td>
<td>114.14</td>
<td>130.66</td>
<td>7.171</td>
</tr>
<tr>
<td>Fluency II (wpm)</td>
<td>104.48</td>
<td>115.08</td>
<td>3.844</td>
</tr>
</tbody>
</table>

* Statistically significant at the 0.05 level (2-tailed test)
** Statistically significant at the 0.01 level (2-tailed test)
*** wpm: word per minute

On all of the assessments, the performance of third graders was superior to that of second graders. However, no significant group differences were found on phonological awareness measures. On the other hand, there were statistically significant differences on rapid-naming and eye movement/reversal measures between second and third graders.
For visual perception skill measures, the results of VD and VC measures indicated that there are significant differences between second and third graders. However, the level of VM seems to be similar between second and third graders. For the Fluency I test, third graders seemed to read significantly faster than second graders. For the Fluency II test, p-value was 0.051, indicating there is a marginal difference between second and third graders.

**Differences Between Students From Schools in Mid and Low SES Neighborhoods**

Since data on lunch support of each participant were unavailable, the sample was divided into two groups. The first group of students were currently going to schools (School 3 and 4) in the lower SES neighborhood. More than 50% of students in the lower SES neighborhood schools (within this study) get lunch support. A one-way analysis of variance (ANOVA) was conducted to determine if there are any differences between the two groups of students on all the observed measures. The results indicated that mean scores of students who go to schools in higher SES neighborhood (Schools 1, 2, and 5) are higher on all the measures. On most of the measures, significant mean differences were detected between the two groups except rapid-naming variables. Table 4-7 provides a summary of the one-way ANOVA of all the measures.

**Correlational Analysis**

A correlational analysis was performed using all of the available observed variables. The correlation matrix is presented in Table 4-8. Surprisingly, a closer examination reveals that some indicators of theoretical constructs (e.g., phonological factors) have very weak correlations on reading fluency.
Table 4-7. ANOVA Summaries on Group Differences (Schools with Lower/Higher SES Students)

<table>
<thead>
<tr>
<th>Latent Variables</th>
<th>Students from Schools in Low- SES Neighborhood (n= 91)</th>
<th>Students from Schools in Mid- SES Neighborhood (n=119)</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Phonological Awareness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elision</td>
<td>11.71</td>
<td>4.29</td>
<td>13.71</td>
</tr>
<tr>
<td>Blending into words</td>
<td>12.05</td>
<td>2.93</td>
<td>13.25</td>
</tr>
<tr>
<td><strong>Rapid Naming</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit naming</td>
<td>37.75</td>
<td>11.03</td>
<td>36.01</td>
</tr>
<tr>
<td>Letter naming</td>
<td>42.43</td>
<td>13.36</td>
<td>39.32</td>
</tr>
<tr>
<td><strong>Eye Movement/Orthographic Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEM vertical test</td>
<td>48.29</td>
<td>14.46</td>
<td>47.21</td>
</tr>
<tr>
<td>DEM horizontal test</td>
<td>69.91</td>
<td>25.78</td>
<td>68.39</td>
</tr>
<tr>
<td>Reversal Test</td>
<td>4.15</td>
<td>3.26</td>
<td>2.65</td>
</tr>
<tr>
<td><strong>Visual Processing Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Discrimination</td>
<td>12.37</td>
<td>2.45</td>
<td>13.17</td>
</tr>
<tr>
<td>Visual Memory</td>
<td>11.41</td>
<td>2.60</td>
<td>12.78</td>
</tr>
<tr>
<td>Visual Closure</td>
<td>9.54</td>
<td>3.33</td>
<td>10.82</td>
</tr>
<tr>
<td><strong>Reading Fluency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency I (wpm)</td>
<td>103.43</td>
<td>40.68</td>
<td>136.08</td>
</tr>
<tr>
<td>Fluency II (wpm)</td>
<td>95.37</td>
<td>36.41</td>
<td>120.26</td>
</tr>
</tbody>
</table>

* Statistically significant at the 0.05 level (2-tailed test)
** Statistically significant at the 0.01 level (2-tailed test)

For the most part, correlations measured within constructs are higher than those across constructs. Two variables of phonological awareness, elision and blending into words, are significantly related to each other ($r=.373$, $p < .01$), and two rapid-naming variables are highly correlated ($r=.849$, $p < .01$). However, unlike elision, the other variable, blending into words, has relatively low correlations with dependent observed variables, Fluency I and II ($r=.110$ and $r=.081$) and has no statically significant correlations. The highest correlation is detected in the relationship between Fluency I and Fluency II ($r=.936$, $p < .01$). Since reversal test scores are calculated with error scores, this variable is negatively related to two phonological variable, elision and blending into
words ($r = - .137, p < .05$ and $r = .011, p > .05$). This result represents that children who score higher on the reversal test are less likely to have higher score on elision. However, it shows that there is no significant relationship between reversal and blending into words.

Table 4-8. Correlation Matrix of Phonological Awareness, Rapid-Naming, and Visual Skills and Reading Fluency

<table>
<thead>
<tr>
<th></th>
<th>Elision</th>
<th>Blending</th>
<th>Digit RN</th>
<th>Letter RN</th>
<th>DEM-V</th>
<th>DEM-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elision</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blending</td>
<td>.37**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit RN</td>
<td>-15*</td>
<td>-.01</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter RN</td>
<td>-12</td>
<td>-.02</td>
<td>.85*</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEM-V</td>
<td>-.16*</td>
<td>.01</td>
<td>.89*</td>
<td>.81**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>DEM-H</td>
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<td>-.10</td>
<td>.67**</td>
<td>.66**</td>
<td>.67**</td>
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</tr>
<tr>
<td>Reversal</td>
<td>-.14*</td>
<td>-.01</td>
<td>.24**</td>
<td>.23**</td>
<td>.22**</td>
<td>.22**</td>
</tr>
<tr>
<td>VD</td>
<td>.19**</td>
<td>.17*</td>
<td>-.27**</td>
<td>-.32**</td>
<td>-.27**</td>
<td>-.39**</td>
</tr>
<tr>
<td>VM</td>
<td>.18**</td>
<td>.18*</td>
<td>-.23**</td>
<td>-.27**</td>
<td>-.19**</td>
<td>-.32**</td>
</tr>
<tr>
<td>VC</td>
<td>.25**</td>
<td>.19**</td>
<td>-.24**</td>
<td>-.24**</td>
<td>-.24**</td>
<td>-.33**</td>
</tr>
<tr>
<td>Fluency I</td>
<td>.31**</td>
<td>.11</td>
<td>-.60**</td>
<td>-.60**</td>
<td>-.58**</td>
<td>-.57**</td>
</tr>
<tr>
<td>Fluency II</td>
<td>.25**</td>
<td>.08</td>
<td>-.61**</td>
<td>-.60**</td>
<td>-.57**</td>
<td>-.59**</td>
</tr>
<tr>
<td>Reversal</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VD</td>
<td>-.28**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VM</td>
<td>-.27**</td>
<td>.55**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VC</td>
<td>-.36**</td>
<td>.49**</td>
<td>.56**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency I</td>
<td>-.39**</td>
<td>.35**</td>
<td>.37**</td>
<td>.50**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Fluency II</td>
<td>-.38**</td>
<td>.32**</td>
<td>.36**</td>
<td>.46**</td>
<td>.94**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed test)
** Correlation is significant at the 0.01 level (2-tailed test)

As predicted, all of the indicators of visual perception skills are positively related to each other and statistically significant at the .01 level. Additionally, all of the indicators of visual perception skills are positively related to Fluency I and II and statistically significant at the .01 level. The correlations among constructs provide some preliminary evidence for the hypothesized model. Since rapid-naming scores are the time in seconds (seconds to name 40 letters/40 digits), they are negatively correlated with phonological
awareness and reading fluency factors. However, they are positively correlated with eye-
movement/reversal factors because eye-movement scores are also the time in seconds to
read numbers vertically and horizontally, and reversal scores indicate error scores.
Furthermore, all of the vision-related variables and reading fluency variables are
significantly related. Surprisingly, one of the observed variables, blending into words,
from a phonological factor has a very weak relationship with other reading-related
variables. One important fact has been detected through the correlation analysis is that
there are very high correlations between the two variables in rapid-naming and
vertical/horizontal eye movement variables. For example, DEM vertical test scores are
highly correlated with digit rapid naming and letter rapid naming ($r = 0.849$ and $r = 0.805$
respectively). Since the two constructs are significantly correlated with each other, if we
assign these scores to different constructs, it would violate one of assumptions in SEM,
multicollinearity. In some cases, multiple regression results may seem paradoxical. Even
though the overall P value is very low, all of the individual P values are high. This means
that the model fits the data well, even though none of the X variables has a statistically
significant impact on predicting Y. How is this possible? When two X variables are
highly correlated, they both convey essentially the same information. For the current
study, a rapid naming variable is very highly correlated with an eye movement variable.
In this case, neither may contribute significantly to the model after the other one is
included, but together they contribute a great deal. If you removed both variables from
the model, the fit would be much worse. So, the overall model fits the data well, but
neither X variable makes a significant contribution when it is added to the model last.
When this happens, the X variables are collinear, and the results show multicollinearity.
Therefore, modification of the measurement model may be necessary. The modified measurement model is discussed in detail in the next section.

SEM Analysis

The SEM analysis provides comprehensive statistical techniques to examine and investigate the relationship between measured variables and latent constructs. SEM is a priori: a model makes theoretical sense and its statistical correspondence to the data is reasonable. SEM is contained of two components; the measurement model and the structural model and SEM approaches usually follow three steps. First, measurement model fit was evaluated by using confirmatory factor analysis and second, the structural model fit was evaluated. Finally, model modification is taken place if a model fit of a structural model is worse than one of a measurement model. However, in this study, the structural model fit was fairly good. In response, the last step was not necessary to perform.

Measurement Model

The purpose of the measurement model was to create the constructs that would be used in the later structural model. The validity of the constructs was determined by confirming the significant relations between the observed variables that were assumed to be theoretically related. The purpose of this model is to identify the constructs with reduced error variance, and the constructs can be established by a factor analysis. A confirmatory factor analysis was completed in order to determine whether the variables load on five factors that can be labeled as phonological awareness, rapid-naming, eye-movement/orthographic skills, visual skills, and reading fluency. Findings appear to have adequately validated the five-factor structural model of phonological awareness, rapid-naming, eye-movement/orthographic skills, visual processing skills, and reading fluency.
That is, the model of this study includes the five latent variables with 12 observed variables. The variables loaded neatly onto five factors, as predicted. The following model is the estimation of the author’s model. The pattern of fixed and free parameters in a structural equation model defines two components of the general structural equation model: the measurement model and the structural model. The measurement model is that component of the general model in which latent variables are prescribed (Hoyle, 1995). The results of goodness of fit on the measurement model are shown in Table 4-9. The fit of the original, hypothesized model (Figure 3-1) was adequate because the chi-square was statistically significant ($\chi^2 (66) = 1708.237$), and the additional fit indices showed that the model has fairly good fit (NFI= .937, NNFI= .943, and RMSEA= .079). However, as discussed in the previous section, there is a fatal problem in this proposed measurement model. There are very high correlations between the two variables in rapid-naming and vertical/horizontal eye movement variables. For example, DEM vertical test scores are highly correlated with digit rapid naming and letter rapid naming ($r= .849$ and $r= .805$). This is an evidence of multicollinearity in this model. Therefore, new constructs were re-identified. Table 4-9 presents a modified constructs and goodness of fit results for the newly identified measurement model. As predicted, a measurement model fit became much greater with this modification ($\chi^2 (45) = 78.160$, NFI= .954, NNFI= .970, CFI = .980, SRMR= .050, RMSEA= .057).

Therefore, within the measurement model, all of the measured variables were significant indicators of their respective latent variables, and no modifications of the measurement model were needed since all of the fit indices met their criteria for good fit.
Table 4-9. Factors for Variables in the Overall Model and Goodness of Fit Results of the Measurement Model

<table>
<thead>
<tr>
<th></th>
<th>Proposed Constructs</th>
<th>Modified Constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed Variables</td>
<td>Observed Variables</td>
</tr>
<tr>
<td>Factor 1</td>
<td>Phonological Awareness</td>
<td>Phonological Awareness</td>
</tr>
<tr>
<td></td>
<td>Elision</td>
<td>Elision</td>
</tr>
<tr>
<td></td>
<td>Blending into words</td>
<td>Blending into words</td>
</tr>
<tr>
<td>Factor 2</td>
<td>Rapid Naming</td>
<td>Rapid Naming/Eye-movement</td>
</tr>
<tr>
<td></td>
<td>Digit rapid naming</td>
<td>Digit rapid naming</td>
</tr>
<tr>
<td></td>
<td>Letter rapid naming</td>
<td>Letter rapid naming</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eye-movement-vertical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eye-movement-horizontal</td>
</tr>
<tr>
<td>Factor 3</td>
<td>Eye-movement/Orthographic Skills</td>
<td>Orthographic Skills</td>
</tr>
<tr>
<td></td>
<td>Eye-movement-vertical</td>
<td>Reversal</td>
</tr>
<tr>
<td></td>
<td>Eye-movement-horizontal</td>
<td></td>
</tr>
<tr>
<td>Factor 4</td>
<td>Visual Processing Skills</td>
<td>Visual Processing Skills</td>
</tr>
<tr>
<td></td>
<td>Visual Discrimination</td>
<td>Visual Discrimination</td>
</tr>
<tr>
<td></td>
<td>Visual Memory</td>
<td>Visual Memory</td>
</tr>
<tr>
<td></td>
<td>Visual Closure</td>
<td>Visual Closure</td>
</tr>
<tr>
<td>Factor 5</td>
<td>Reading Fluency</td>
<td>Reading Fluency</td>
</tr>
<tr>
<td></td>
<td>Reading Fluency I</td>
<td>Reading Fluency I</td>
</tr>
<tr>
<td></td>
<td>Reading Fluency II</td>
<td>Reading Fluency II</td>
</tr>
<tr>
<td>Goodness of Fit</td>
<td>$\chi^2 (66) = 1708.237$</td>
<td>$\chi^2 (45) = 78.160$</td>
</tr>
<tr>
<td>Results</td>
<td>NFI=.937</td>
<td>NFI=.954</td>
</tr>
<tr>
<td></td>
<td>CFI=.962</td>
<td>CFI=.980</td>
</tr>
<tr>
<td></td>
<td>SRMR=.072</td>
<td>SRMR=.050</td>
</tr>
<tr>
<td></td>
<td>RMSEA=.079</td>
<td>RMSEA=.057</td>
</tr>
<tr>
<td></td>
<td>90% Confidence Interval of RMSEA</td>
<td>90% Confidence Interval of RMSEA</td>
</tr>
<tr>
<td></td>
<td>(.059~.099)</td>
<td>(.033~.079)</td>
</tr>
</tbody>
</table>

Based on all the goodness of fit indices, this measurement model fits the data well.

The results of the confirmatory factor analysis are presented in Table 4-10. The italicized numbers represent the t-value. If the t-value is greater than 1.96 with .05 level, it means that the observable variable is statistically significant for this model. All of the t-values on latent variables are greater than 1.96 in Table 4-10.
Table 4-10. Results of Confirmatory Factor Analysis

<table>
<thead>
<tr>
<th></th>
<th>PA</th>
<th>RN/EV</th>
<th>Reversal</th>
<th>VP</th>
<th>RF</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elision</td>
<td>0.777</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.604</td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.559*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blending</td>
<td>0.476</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.227</td>
</tr>
<tr>
<td></td>
<td>(1.101)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.710*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit RN</td>
<td>0.955</td>
<td>(0.052)</td>
<td></td>
<td></td>
<td></td>
<td>0.913</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18.502*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter RN</td>
<td>0.888</td>
<td>(0.054)</td>
<td></td>
<td></td>
<td></td>
<td>0.789</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16.317*</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>DEM-vertical</td>
<td>0.925</td>
<td>(0.053)</td>
<td></td>
<td></td>
<td></td>
<td>0.856</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.470*</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>DEM-horizontal</td>
<td>0.722</td>
<td>(0.060)</td>
<td></td>
<td></td>
<td></td>
<td>0.521</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.946*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reversal</td>
<td>0.933</td>
<td>(0.052)</td>
<td></td>
<td></td>
<td></td>
<td>0.870</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.787*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VD</td>
<td>0.674</td>
<td>(0.068)</td>
<td></td>
<td></td>
<td></td>
<td>0.454</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.879*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VM</td>
<td>0.732</td>
<td>(0.067)</td>
<td></td>
<td></td>
<td></td>
<td>0.537</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.929*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VC</td>
<td>0.777</td>
<td>(0.066)</td>
<td></td>
<td></td>
<td></td>
<td>0.604</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.733*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency I</td>
<td>0.984</td>
<td>(0.051)</td>
<td></td>
<td></td>
<td></td>
<td>0.968</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19.321*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency II</td>
<td>0.956</td>
<td>(0.052)</td>
<td></td>
<td></td>
<td></td>
<td>0.913</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18.332*</td>
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<td></td>
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</tbody>
</table>

In addition to t-value, squared multiple correlations (R2) are displayed in Table 4-10. Since most of them are quite high, I can conclude that reliability of observable measures is fairly satisfactory.
Structural Model

The next step in SEM is construction of a structural model that fits the data as well as the final measurement model with fewer estimated parameters. The structural model is that component of the general model that prescribes relations between latent variables and observed variables that are not indicators of latent variables. In general, the multiple regression model is a structural model without latent variables and limited to a single outcome. However, SEM that includes the combinations of the measurements and structural components allows a comprehensive statistical model that can be used to evaluate relations among variables that are free of measurement error (Hoyle, 1995). The chi-square statistic included in Table 4-11 provides a test of the null hypothesis that the reproduced variance matrix has the specified model structure (i.e., that the model fit the data). First, the chi-square test for the model was statistically significant, $\chi^2 (66)=1708.237$, $p< .05$, indicating a good fit between the model and data. However, several researchers (Bollen, 1989; Bollen & Long, 1993; Joreskog & Sorbom, 1996) noted that the chi-square statistic is influenced by a large sample size (for this data set $N= 210$). In fact, Joreskog and Sorgom (1996) proposed that $\chi^2$ be used as badness rather than a goodness-of-fit measure in the sense that a small $\chi^2$ value (relative to its degrees of freedom) is indicative of good fit, whereas a large $\chi^2$ value reflects bad fit in SEM (Byrne, 1998). Therefore, four additional goodness of fit indices were considered for testing a goodness of fit of SEM model. The criteria for four other indices are listed: CFI shows a good fit at .95 or higher; RMSEA should be between .08 or lower to indicate good model fit (Hu & Bentler, 1999); NFI and NNFI should be close to 1.0 and show a good fit at .90 or higher. These indices except RMSEA range from 0.00 to 1.00, with
values close to 1.00 being indicative of good fit. According to Hu & Bentler (1999), the Root Mean Square Error of Approximation (RMSEA) has only recently been recognized as one of the most informative criteria in covariance structure modeling, and it takes into account the error of approximation in the population and asks the question, “How well would the model fit the population covariance matrix if it were available?” (Browne & Cudeck, 1993, pp. 137-138). This discrepancy measured by the RMSEA indicated that values of less than .05 indicate good fit; values as high as .08 represent reasonable errors of approximation in the population; values from .08 to .10 indicate mediocre fit; and those greater than .10 indicate poor fit (MacCallum, Browne, & Sugawara, 1996). The fit of the original, hypothesized model (Figure 3-1) was adequate because the chi-square was statistically significant ($\chi^2$ (45) = 78.160), and the fit indices showed that the model has a moderate fit (NFI= .954, NNFI= .970 CFI= .980, SRMR= .050, RMSEA= .057).

<table>
<thead>
<tr>
<th>Goodness of Fit Indices</th>
<th>SEM Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>78.160</td>
</tr>
<tr>
<td>df</td>
<td>45</td>
</tr>
<tr>
<td>NFI</td>
<td>.954</td>
</tr>
<tr>
<td>NNFI</td>
<td>.970</td>
</tr>
<tr>
<td>CFI</td>
<td>.980</td>
</tr>
<tr>
<td>SRMR</td>
<td>.050</td>
</tr>
<tr>
<td>RMSEA</td>
<td>.057</td>
</tr>
<tr>
<td>90% Confidence Interval of RMSEA</td>
<td>(.033−.079)</td>
</tr>
</tbody>
</table>

This SEM model, therefore, can be accepted due to a good model fit. As a consequence, these results on goodness of fit can examine the following hypothesis:

H1 Phonological awareness, rapid-naming, and visual skills are not significantly associated with reading fluency.
Based on the several results of indices on this SEM model, phonological awareness, rapid-naming, and visual skills are significantly associated with reading fluency. Therefore, Hypothesis 1 was rejected.

**Regression Analysis and Correlational Analysis with SEM**

**Multiple regression analysis**

A multiple regression analysis was conducted by using SEM to examine Hypotheses 2 through 5. The regression coefficients of four independent constructs and one dependent construct is displayed in Figure 4-1. Table 4-12 represents regressions as well as \( t \)-value. The italicized numbers represent \( t \)-value. If the \( t \)-value is greater than 1.96 with .05 level, it means that the regression between one dependent variable and one independent variable is statistically significant. All of the \( t \)-values on this regression matrix are greater than 1.96. Therefore, the following hypotheses were able to examined by this statistical approach:

- **H2** Phonological awareness measures are not significantly associated with reading fluency.
- **H3** Rapid-naming measures are not significantly associated with reading fluency.
- **H4** Eye-movement/Orthographic measures are not significantly associated with reading fluency.
- **H5** Visual perception measures are not significantly associated with reading fluency.

Hypotheses 2 and 5 were rejected since the correlations are statistically significant. However, due to the adjustment of constructs, the original Hypothesis 3 and 4 could not be examined. Instead, rapid-naming (RN) measures and eye-movement (EM) measures were combined into the modified construct and examined. The results indicate that the RN/EM latent variable is significantly associated with reading fluency. In addition, the
orthographic measure with a single indicator, reversal, is significantly related to reading fluency.

Figure 4-1. SEM Reading Fluency Model with Correlation Coefficients
Table 4-12. Regression Matrix of Four Independent Constructs on Reading Fluency

<table>
<thead>
<tr>
<th></th>
<th>PA</th>
<th>RN/EM</th>
<th>Reversal</th>
<th>VP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF</td>
<td>0.142</td>
<td>-0.497</td>
<td>-0.149</td>
<td>0.264</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.059)</td>
<td>(0.061)</td>
<td>(0.076)</td>
</tr>
<tr>
<td></td>
<td>1.996*</td>
<td>-8.408*</td>
<td>-2.447*</td>
<td>3.487*</td>
</tr>
</tbody>
</table>

The correlation matrix on four independent latent variables is separately presented in Table 4-13. The italicized numbers represent the *t*-value. If the *t*-value is greater than 1.96 with .05 level, it means that the correlation between the two observed variables is statistically significant. All of the *t*-values except a correlation between phonological awareness and reversal on this correlation matrix are greater than 1.96. Therefore, the final SEM model should remove the arrow between phonological awareness and reversal.

H6  Phonological measures are not significantly correlated with rapid-naming measures.

H7  Phonological measures are not significantly correlated with eye-movement/orthographic measures.

H8  Phonological measures are not significantly correlated with visual perception measures.

H9  Rapid-naming measures are not significantly correlated with eye-movement/orthographic measures.

H10 Rapid-naming measures are not significantly correlated with visual perception measures.

H11 Eye-movement/orthographic measures are not significantly correlated with visual perception measures.

These correlations were utilized to examine Hypotheses 6 through 11. Since rapid-naming (RN) measures and eye movement (EM) measures were combined into a modified construct and RN/EM and the reversal variable were left alone in the reversal construct, there may be some confusion in examining these hypotheses. However, Table 4-13 clearly presents the correlations between the independent latent variables.
According to the correlation matrix displayed in Table 4-13, six combinations from four independent latent variables were examined to check their correlations. Five out of six combinations showed a statistically significant relationship. Between phonological awareness and reversal, however, there was no significant correlation.

Table 4-13. Correlation Matrix on Independent Latent Variables

<table>
<thead>
<tr>
<th></th>
<th>PA</th>
<th>RN/EM</th>
<th>Reversal</th>
<th>VP</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RN/EM</td>
<td>-0.181</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.088)</td>
<td></td>
<td>-2.051*</td>
<td></td>
</tr>
<tr>
<td>Reversal</td>
<td>-0.166</td>
<td>0.270</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.092)</td>
<td>(0.071)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VP</td>
<td>0.394</td>
<td>-0.372</td>
<td>-0.451</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>(0.098)</td>
<td>(0.071)</td>
<td>(0.070)</td>
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<tr>
<td></td>
<td>3.999*</td>
<td>-5.254*</td>
<td>-6.401*</td>
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Figure 4-2. Independent Latent Variables with Correlation Coefficients
Summary

In Chapter 4, findings of this study were presented that were consisted of four parts. First, descriptive and inferential statistics on the sample based on ANOVA were presented. For examination of group differences, the sample was divided into two groups with three different perspectives. There was no significant group difference on gender. However, 3rd graders are significantly superior to 2nd graders on many measures. Furthermore, there were significant group differences between students who attend schools in low SES neighborhoods and those who attend schools in mid-SES neighborhoods on many measures.

The second part of this chapter discussed the results of correlational analysis using all of the available variables for this study. For the most part, correlations measured within constructs are higher than those across constructs. For example, two variables of phonological awareness, elision and blending into words, are significantly related to each other (r= .373, p < .01), and two rapid-naming variables are highly correlated (r= .849, p< .01). Overall, most independent observed variables are correlated with dependent observed variables, Fluency I and II.

Third, the results of how this model fits with the measurement model were presented, and a structural model also was presented. Due to the issue related to multicollinearity, new constructs were re-identified. Based on all the goodness of fit indices, this adjusted measurement model fit the data well. Due to a good model fit, this SEM model could be accepted.

Finally, another correlational analysis and regression analysis with SEM approaches were discussed with the finalized SEM model. The regression matrix of four independent constructs and one dependent construct indicated that all of the t-values on
This regression matrix are greater than 1.96. This means that all of the constructs that were suggested should be existed in this SEM model.
In this chapter, I will provide an overview of the current study and summarize the results. A discussion of the study’s strength and limitations also are presented. Based on the research findings, implications for future research and practice are addressed. The conclusions of this study are discussed in the final section.

Introduction

Approximately 20% of U.S. children have serious reading difficulties (Grossen, 1997). It is widely recognized that early reading difficulties tend to persist over time. Researchers demonstrated that early elementary grade students who struggle with reading were highly likely to have reading difficulties in the later elementary grades and even in high school (Juel, 1988; Fransis Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996). As a consequence, there have been numerous efforts to search for reliable indicators for early identification as well as to develop early intervention programs for young children at risk for reading difficulties (e.g., Adams, Foorman, Lundberg & Beeler, 1998; Slavin, Madden, & Wasik, 1997; Torgesen & Bryant, 1993). In spite of these enormous efforts on early detection and intervention, some students fail to learn to read. Why do they fail to learn to read? Researchers searched for important factors that affect RD. Many researchers discovered that phonological awareness is a powerful indicator of RD (Catts et al., 1999; Torgesen, Wagner, & Rashotte, 1994; Togesen et al., 1997). However, other factors such as rapid naming and visual processing factors are
controversial and somewhat overlooked by reading researchers. Therefore, this study was
designed to clarify whether these factors affect children’s reading fluency.

In this study, a reading fluency model was constructed to examine the effects of
phonological awareness, rapid-naming, eye-movement/orthographic skills, and visual
perceptual skills on children’s reading fluency. Two hundred ten subjects from second
and third grades were recruited for this study. Finally, the identified reading model in this
study provided a basis for understanding the influence of various factors including
phonological awareness, rapid-naming, and visual skills on reading.

Summary of the Results

For this study, various measures were used to assess young children’s phonological
awareness, naming speed, and three different types of visual skills including eye
movement, reversal, and visual perceptions. Data from 12 assessments were analyzed
using various methods including ANOVA, correlational analysis, and SEM. A discussion
of the results is organized as follows: (a) descriptive and inferential statistics, (b)
correlational analysis, and (c) structural equation modeling.

Results from inferential statistics indicated that there were no significant gender
difference on any of the measures. However, there were significant differences between
second and third graders in several measures including rapid-naming, eye movement,
reversal, and reading fluency rate measures. As expected, third graders were superior to
second graders on all the measures. Furthermore, the results indicated that mean scores of
students who attended to schools in higher SES neighborhoods were higher than those of
students who attended to schools in lower SES neighborhoods on all measures.
Consistent with prior research which has indicated that approximately 3% to 5% of all
children may have visual problems that affect their reading (e.g., Watson & Willows,
1993), the current research also revealed that 6 out of 210 children (2.7%) are at risk for visual discrimination and visual memory.

The results of the correlational analysis revealed that there were significant relationships between reading fluency and four constructs including phonological awareness, rapid-naming, eye-movement/reversal, and visual perception skills. In particular, the rapid-naming construct had the highest correlation with reading fluency. However, the results of correlational analysis showed that rapid naming variables and eye movement variables were too highly correlated to remain as two separate constructs. If two highly correlated constructs were included in the same model, it would violate one of assumptions of SEM which is multicollinearity. Therefore rapid naming and eye movement variables were combined for further analysis with SEM.

Finally, two separate SEM analyses were conducted with and without an adjustment of constructs. The results showed that the adjusted reading fluency model had a better fit and that the measures used in this study were significant indicators of their respective latent variables. Therefore, the adjusted reading model was selected. Since all of the fit indices met the criteria for a good fit, no further modification of the measurement model was needed.

**Interpretations of the findings**

**Rapid Naming**

As discussed in Chapter 2, ample research has revealed that phonological awareness is the most significant indicator in determining reading disabilities (e.g., Stanovich & Siegel, 1994; Torgesen et al., 1997). Although the present study shows that phonological awareness was significantly correlated with reading fluency, phonological awareness was not the most important indicator in predicting reading fluency problems.
This study demonstrates that rapid naming variables are the most important variables to predict the level of reading fluency for the sample consisted of 2nd and 3rd graders. This result is consistent with several studies that highlight that the relationship between rapid naming and reading ability appears to be the strongest in the early period of reading development (i.e., Grade 4 or earlier; McBride-Chang & Manis, 1996).

The results also indicate that phonological sensitivity is not the only skill necessary to predict problems on reading fluency. One skill in particular, rapid naming, has the highest correlation with reading fluency. Rapid naming factor on reading has been studied in length and found to be of equal importance for predictability of children’s reading difficulties. In particular, the double-deficit theory of reading disability (Bowers & Wolf, 1993; Wolf & Bowers, 1999) contends that a combination of both phonological and rapid naming deficits result in performances at the lowest level while problems with only one skill or the other do not affect performance as drastically. The results add to the growing evidence of a relation between naming speed and reading fluency (de Jong & van der Leij, 2003; Manis et al., 1999; Schatschneider, Carlson, Francis, Foorman, & Fletcher, 2002; Wolf & Bowers, 1999).

To date, there has been some debate about the relationship between phonological awareness and naming speed. Wagner and Torgesen (1987) considered them both a reflection of a unitary phonological process; however, other researchers (Badian, 1993; Felton & Brown, 1990) found no correlation between the two skills. By using correlational analysis, the current study discovered that there is a minimal relationship between phonological awareness and rapid-naming skills. For example, in the study scores on phonological awareness, ‘blending into words’ and ‘elision,’ were not
significantly correlated with letter rapid naming (r= -.02 and r= -.12, respectively). This study is consistent with these research findings highlighting the predictive capacity of naming speed tasks for later reading ability (Bowers & Swanson, 1991; Catts, 1991; Felton, 1992). Therefore, this study suggests that naming speed should be independently and significantly considered when discussing factors related to RD. Furthermore, the results also provide evidence that the double-deficit hypothesis suggested by Wolf and Bowers (1999) is a reasonable hypothesis to accept in reading research.

**The Relationship between Rapid Naming and Eye Movement**

One important fact has been detected through the correlation analysis is that there are very high correlations between the two variables in rapid-naming and vertical/horizontal eye movement variables. For example, DEM vertical test scores are highly correlated with digit rapid naming and letter rapid naming (r= .849 and r= .805 respectively). This result is consistent with a study conducted by Wolf, Bowers, and Biddle (2000). They argued that rapid naming tasks are consisted of intentional, visual, lexical, temporal, and recognition subprocesses that all contribute to naming speed performance. Since two factors are highly correlated if a child struggles with naming speed and seems to have no other linguistic impairment, problems on visual-motor skills should be seriously considered.

**The Relationship between Visual Factors and Reading Fluency**

The regression coefficients of four independent constructs on reading fluency are displayed in table 4-12. According to this regression matrix, the combination of rapid naming and eye movement variables has the strongest predictability of 2nd and 3rd graders’ reading fluency. Moreover, this result demonstrates that the second strongest construct to predict the level of reading fluency is the visual perception skills. This
implies that children who perform poorly in the tests of visual perception skills they have
higher tendency to acquire poor scores on reading fluency. Fortunately, there are only
about 3% of the sample show significant impairments on visual perception skills.
However, on top of severe problems in visual perception skills, their overall scores on
these assessments should be carefully pointed out. Overall, these students showed severe
reversal problems and performed profoundly poor at the tests on oral reading fluency as
well as phonological awareness. Only one out of six students performed in an average
range on phonological awareness and poorly on any other areas. Conventional
intervention based on phonological awareness may not be sufficient for this group of
children. Recently many measures have been developed for early pre-literacy screening
in order to identify children at risk of reading difficulties. In turns, early intervention has
been implemented for at risk children in reading. However, researchers have indicated
that intervention is not successful for everyone. They describe children who fail to benefit
from intervention as 'Treatment Resisters' (e.g., Blachman, 1994; Togesson et al, 1994).
This group of students may be treatment resisters who may fail to respond adequately to
interventions that are sufficient for most poor readers. Therefore, in someway, this study
identified the characteristics which differentiate treatment resisters from those children
who benefit from early phonological based intervention and from children not considered
to be at risk of difficulties.

The results of SEM suggest that four independent constructs including
phonological awareness, rapid naming/eye-moment, reversal, and visual perception skills
are significantly correlated with early elementary children’s reading fluency. In
particular, the multiple regression analysis with SEM indicated that, among the four
independent constructs, the rapid-naming/eye-movement construct has the highest
correlation with reading fluency. These results imply that these four factors should be
critically considered to indicate young children’s reading problems.

**Discussions on Study Limitations**

In this section, the limitations of the study related to measurement and
generalizability issues will be discussed briefly.

**Measurement Issues**

One of the primary limitations of this study relates to the measures used to assess
the areas of reading fluency, phonological awareness, rapid-naming, and visual skills.
First, a limited number of assessment test batteries were used for this study. For example,
phonological awareness was measured by using two subtests of CTOPP: (a) elision, and
(b) blending into words. Even though these two subtests were carefully chosen to
measure phonological awareness and it was believed that they were the two most
applicable areas for second and third graders, other subtests of CTOPP (e.g.,
segmentation and phonological memory) should or could have been included in the study
in order to have a more comprehensive score of phonological awareness. This would
have allowed researchers to determine if phonological memory was related to other
sources of variance such as visual memory and general processing time of rapid naming.

In assessing orthographic skills, only one very basic orthographic task was
administered to the participants, the Jordan Left-Right Reversal Test. This instrument
tests memory for spatial orientation of upper/lower case letters and numerals. However, it
may not have been sufficient to measure orthographic tasks comprehensively. Therefore,
additional measures such as the Gardner Reversal Frequency Tests (Gardner, 1980) could
have been added in order to get a more comprehensive score of reversals.
In terms of determination of children’s visual perception skills, only three subtests, visual discrimination, visual memory, and visual closure, out of the seven subtests for testing visual perception skills (TVPS) were administered. Four other subtests were excluded; visual-Spatial relationships, visual form constancy, visual sequential memory, and visual figure-ground. The rationale for choosing the three subtests was provided in Chapter 3. Although three subtests may have been sufficient to determine the children’s perception skills, the use of all seven subtests to measure visual perception skills could have provided more information on the role visual perception played in reading fluency.

A second limitation was related to ‘selection’, a threat to internal validity. For example, for the ‘blending into words’ measure, the percentage of children whose score was lower than the 25 percentile seems to be surprisingly low (17.6%) compared to the percentage on elision (37%). It is possible that low-achieving readers may have more instruction based practice on phonological awareness and more experiences with taking these types of tests. For example, I asked several students (who received low scores on reading fluency measures and relatively high scores on blending) if they had received reading instruction on blending into words. Most of them said they had received instruction on these skills. Moreover, some of the students were familiar with the CTOPP-Blending into words. This type of measurement error may cause problems in the overall results of the phonological awareness latent variable. Therefore, researchers should carefully consider validity issues in gathering precise data for future research.

**Generalizability Issues**

The participants in the current study were drawn from north central Florida. Even though children belonged to schools with a diverse population, the geographical factor may have affected a variety of factors that impact children’s reading outcome. As
discussed earlier, the results are limited to second- and third-grade students and are not applicable to students younger or older. Therefore, the results of this study cannot be generalized to any graders other than 2\textsuperscript{nd} and 3\textsuperscript{rd} graders.

**Implication for Future Research and Practice**

The results of this study provide implications for future research. Based on the results, the logical next steps for research will be discussed in this section. Furthermore, several implications for future practice are discussed in a later section.

**Future Research Directions**

**Selecting Reading Assessments**

Instruments for assessment of children’s reading levels should be clearly selected and used for detecting problems of reading. The IDEA and Public Law 105-17 require public school systems to evaluate children who are at risk for a reading disability. With legislative support, a growing body of research has established the necessary measurements for effective identification of early elementary students with reading disabilities. However, questions still remain about the most effective and reliable set of measurements for detecting reading disabilities in the early primary grades. Scarborough (1998) analyzed predictive studies and suggested that researchers use a multivariate approach to early and accurate screening of children. In her review, she indicated that such studies use a wide variety of variables that ranged from cognitive skills to family and school-based risk factors. In addition, the combination of variables used in each study varied greatly across studies. Although various types of measures were effective in detecting children with RD in the early ages, it is not feasible to give a full complement of the assessments to each student. This approach is not cost or time effective. Therefore, it is important to identify the most promising combination of predictors of early reading
achievement that directly relate to the reading process (Goswami & Bryant, 1990). Specifically, this study suggests that the psychological assessment for determining a reading fluency problem should include tests for rapid naming, phonological awareness, visual perception, and ocular motor functions. The primary findings of this study revealed that visual perception skills are significantly correlated with children’s reading fluency. Interestingly, reading researchers have ignored the role of nonlinguistic factors (e.g., visual factors) in their research. The current study suggests that future research on reading and language disorders should be aimed at identifying and characterizing all nonlinguistic perceptual deficits and determining the impact of those deficits on reading and language processing.

**Effective reading intervention for subtypes of RD**

Many researchers have reported that reading programs, such as Success for All, the Winston-Salem Project, The Boulder Program and Reading Recovery, were significantly successful in improving children’s reading level. (Clay, 1985, 1993a, 1993b; Hiebert, Colt, Catto, and Gury, 1992; Greaney, Tunmer, & Chapman, 1997). For example, Hiebert, Colt, Catto, and Gury (1992) reported that 77% of the students with reading difficulties who participated in their intervention project were able to achieve primer level reading at the end of first grade. In contrast, only 18% of a comparison group who participated in a traditional Title I program achieved that level of reading proficiency at the end of first grade. While almost half (47%) of the students in the conventional Title I program remained nonreaders at the end of first grade, only 7% of the early intervention students remained nonreaders. Similarly, other research findings suggest that these programs are significantly effective in improving the participants’ reading level (add other citations here). Nonetheless, these programs have failed to take a close look at
children who showed no gains in spite of their extensive and additional support. Presumably, we can conclude that general reading intervention programs can help improve the reading levels of most children at risk for RD. However, these programs may not be responsive to all types of RD.

During the last two decades researchers and practitioners in the reading research community have focused on phonological awareness training for the general population of children with RD. Overall, these phonological awareness programs have improved the reading achievement of children with RD. However, children who have reading problems due to related factors such as a visual processing deficits and visual decoding problems, have not been adequately served when interventions were solely based on a phonological awareness.

The current study detected that there was a group of children who showed higher performances on phonological awareness and lower visual perception scores (approximately 1.5% of the sample) and showed lower scores on reading fluency tests. These children may have problems with visual perception and need additional support other than general reading interventions.

For a subtype of children who show visual perception problems, as revealed in this study, additional support such as comprehensive vision screening should be given. Unfortunately, there is no known visual cause for this type of reading disability and no know effective visual treatment (Romanchuk, 1995).

More recently, a few researchers have searched for subtypes of RD (e.g., Korhonen, 1991; Wolf et al., 1999). For example, Korhonen (1991) used cluster analyses to identify subgroups among third graders with learning disabilities. One subgroup was
characterized by slow naming speed. When follow-up evaluations of the sample were made in sixth grade, it was found that this naming subgroup had shown the least progress in reading achievement, whereas the other children with other cognitive profiles had improved over the three intervening years. It is important to note that only a few studies on subtypes of RD have been conducted to date.

Clearly researchers need to replicate these studies in order to determine subtypes of RD. With knowledge of various subtypes of RD, specific conditions or characteristics of individuals with RD can be identified and effective reading interventions can be provided for these children.

**Advanced technology**

Advanced technology has given us the opportunity to look closely into brain images and eye movement during reading. Most recently, Functional Magnetic Resonance Imaging (fMRI) has added important piece of information about the anatomy of the brain. fMRI is a technique to image brain activity related to a specific task or sensory process. As discussed earlier, it is now known that an impairment of the M pathway might affect the generalized timing mechanisms of the cerebellum (Fawcett et al., 2001). This scientific evidence implies that abnormal function in the specialized brain area V5/MT explains visual problems in people with reading disabilities. Interestingly, studies using fMRI on phonological deficit revealed that the phonological deficit can be traced back to a more general auditory impairment, which has the same biological origin as the visual impairment, namely, a dysfunction of magno-cells in sensory pathways. This tells us that there seems to be an overlap of areas of the brain that have to do with sensitivity to visual motion and phonological segmentation. If the M pathway is impaired
in dyslexic brains, their inability to see visual motion of images on a screen is somehow connected to their weak phonological awareness.

In addition, the Visagraph is another example of advanced technology. It is an eye-movement recording system and provides an objective measure of the efficiency of a student's reading process which reflects his/her visual skills. Furthermore, this system provides detailed information on eye movement such as the number of fixations, number of regressions, length of fixation, rate of reading with comprehension and the overall performance in relation to grade level norms.

As discussed, advanced technology provides us more clear pictures on brain function and eye movements during reading. However, this current study only used paper-pencil tests for assessing such skills since it was believed that paper-pencil tests are convenient to conduct and cost-effective. However, it would be more advantageous if conventional methods as well as new technology were combined for reading research. Future research should provide further insights into the details of visual and language deficits and their effects on reading.

**SEM**

This study was complex using data from twelve different measures. Therefore, a more sophisticated methodology was required in order to analyze all the data. Using SEM became a solution to removing potential problems that result from using too many variables for regression studies. SEM can be utilized very effectively to address numerous research problems. However, SEM is not commonly used in reading research to identify factors related to children's reading difficulties. The use of this model represents a significant contribution to the literature. As discussed in Chapter 3, structural equation modeling has several benefits. According to Fornell (1982), SEM includes several
desirable characteristics that depart from the older generation of multivariate procedures. First, SEM takes a confirmatory approach to the data analysis rather than exploratory analysis, and it lends itself well to the analysis of data for inferential purposes by demanding that the pattern of intervariable relations be specified a priori. Second, SEM provides explicit estimates of either assessing or even correcting for measurement error, while traditional multivariate procedures are incapable of these aspects. Finally, data analyses using SEM can incorporate both unobserved and observed variables with the analyses using the traditional multivariate methods based on observed measurements only. On the other hand, there are some consideration that have to be taken seriously when conducting research studies by using SEM. Brecker (1990) recommended the following for detecting some deficiencies in applications of structural equation modeling. First, the data should be inspected for potential violations of the multivariate normality assumption. Distributional assumptions are likely to be violated when variables are highly skewed or when extreme outliers are present. Second, authors must make every effort to identify equivalent models and to discuss weather such models offer plausible representations of the data. To reduce potential violations on skewness or outliers’ effects, a large sample should be guaranteed for future research.

Taken together, if researchers seriously consider assumptions when analyzing data, SEM can address many problems effectively and provide more reliable results compared to other statistical methods. Therefore, it would be beneficial to continue to apply SEM as a research methodology for future research.
Implications for Practice

The earlier the better

Early recognition of reading difficulties and effective intervention to promote literacy skills are important in preventing life-long educational and social struggles. Stanovich (1986) first used the label, Matthew Effects, to describe how the rich get richer and the poor get poorer in terms of reading. Many studies suggest that a child who fails to make good initial progress in reading finds it increasingly difficult to master reading (add citations). Prevention and early intervention with appropriate teaching methods in early elementary grades can decrease the numbers of special education referrals. As discussed previously, a study by Lyon, et. al, (2001) estimates that the number of children, who are typically identified as poor readers and served through either special education or compensatory education programs, could be reduced by up to 70% through early identification and prevention. If this intervention is delayed until the student is 9 years old, which is when most children are referred to special education, approximately 75% will continue to have difficulties learning to read through high school (Francis et al., 1996). This implies that early identification and intervention of children at risk for RD are crucial for later reading success.

The current study suggests that only one grade level difference makes a huge difference on skills related to reading. On all the measures that were used for the current study, third-grade students were superior to second graders. In addition, average scores on reading Fluency I and II of third graders were significantly higher than second graders. It implies that children develop their reading skills during early elementary years, and those years are a critical time for improving their knowledge of reading.
In addition to attention in literacy instruction in kindergarten though third grade, ensuring high-quality preschool and kindergarten program and literacy environment is significantly important. Children who will probably need additional support for early language and literacy development should receive it as early as possible.

**Early literacy with at risk children**

Unfortunately, the current study demonstrated that, participants from two schools (School 4 & 5) in low-SES neighborhoods showed significantly lower scores on reading fluency skills compared to children from mid-SES neighborhoods (School 1, 2, & 5). Through reviewing the current and previous reading research, it was recognized that there are still many students who enter school without a strong literacy background. In particular, reading researchers have demonstrated that children from low-income families are less likely to have opportunities to build their basic literacy skills (Hart & Risley, 1995; Smith & Dixon, 1995; Whitehurst, 1996) and have higher risk for RD. Therefore, researchers and practitioners have recognized that low socio-economic status (SES) may be one of risk factors of RD, which is related to a lack of opportunity to learn.

Hochenbergher, Goldstein, and Hass (1999) investigated whether teaching mothers with low socioeconomic status (SES) to comment while reading to their children would increase communicative interaction in mother--child dyads and improve the children's emerging literacy skills. They reported that most mothers also increased other conversational acts that set the occasion for positive verbal interactions and increased their responsiveness to their children through the education sessions. In turns, all children demonstrated more assertive and responsive utterances during the commenting intervention and four out of the seven children showed improved emerging literacy skills on a standardized. One way to achieve early literacy would be parent education for low
SES families in order to increase their children’s reading skills and reduce children at risk for reading disabilities.

**Careful observations of visual problems**

This study suggests that some students may have problems with visual perception and processing. In general, many professionals and parents have a limited view regarding vision and tend to perceive that visual acuity is the only component of vision. Problems in identifying children with reading-related vision problems arise when such a limited definition of vision is employed. People who have a limited view of vision are more likely to exclude concerns on visual efficiency and visual processing. However, three interrelated areas of vision need to be incorporated in order to understand how letters or words are seen and perceived in the reading process (Scheiman, 2002). The two other areas are visual information processing (i.e., visual search, spatial awareness, figure-ground discrimination, visual memory) and visual efficiency (i.e., focusing, teaming, eye movements). To illustrate, although a child may have a normal range of visual acuity, he or she also may have visual problems related to other components of vision. In other words, 20/20 visual acuity does not tell us the child’s vision problems such as near vision for near tasks (e.g., reading) and visual processing deficits. It merely provides information about far vision. Hence, it is beneficial for researchers, educators, and parents to have an extended definition of vision in order to identify children with reading-related visual problems. Some children with RD may show abnormal behaviors such as head tilting during near vision tasks (e.g., reading), a lack of eye-hand coordination during a ball game, having a difficulty to copy down the board, etc. Moreover, children who have problems in visual perception skills may complain of visual problems related to reading. For example, they may say that words jump around on the page, that they cannot
keep their place, or that their eyes get tired. In some cases, these complaints may be avoidance behaviors or just symptomatic of task difficulty. However, there may be some cases where RD has a visual component, and such complaints should be carefully evaluated. In terms of reversal errors, it is not believed that children who demonstrate frequent reversals in the first year of reading instruction go on to become poor readers. However, if reversals persist even in the face of systematic instruction, they may be an indication for expert assessment. The current study discovered that approximately 30% of the sample is at risk for reversals, which may be a normal condition for second- and third-grade students. However, if such a problem consistently exists when they become fourth and fifth graders, this would be a strong indicator of a vision-related reading disability. Therefore, teachers, parents, and caregivers should carefully observe these behaviors to detect visual problems.

**Comprehensive vision screening policy**

The research findings in the current and previous literature provide evidence that at least a certain percentage of children suffer from RD related to a visual deficit. This study revealed that 3% to 5% of the sample showed problems on visual perception skills. It is possible to mention that a certain group of children who have visual deficits may not be respond to intervention programs that are solely based on linguistic components. The ideal solution is to assess the visual deficits that interfere with reading development through comprehensive “vision screening” checklist that could be simply administered by the classroom teacher. The implementation of comprehensive vision screening, covering visual processing and visual efficiency beyond visual acuity, would yield a score that predict the presence or absence of reading-related visual problems. However, current vision screening for young children is administered insufficiently as well as
inconsistently across the states. A state-by-state survey, conducted by Cincer et al. (1999), revealed that there are still 15 states that do not have guidelines for visual screening prior to a child’s entrance into formal education. Nevada and Wyoming do not have guidelines even for kindergarten vision screening. In addition, the areas tested in the vision screening vary from state to state. Mostly, they only include a distance acuity test and a limited version of a binocular vision test. These tests may be helpful to detect some refractive errors such as myopia and astigmatism. However, they obviously cannot detect many other vision problems including reading-related visual problems. The current study discovered 3% to 5% of 210 students showed problems on the tests of visual perception skills. Moreover, the results demonstrated that 30% of the sample are at risk of reversal problems with letters and numbers. Comprehensive vision screening during preschool and kindergarten years will be helpful to detect these types of visual deficits in early years. Therefore, it is essential to develop an effective screening test for detecting reading-related visual problems and other types of visual problems.

Conclusions

Reading is at the core of the educational experience and its ability is an essential key to success in our society. Our socially, economically, and technologically advanced society highly values the ability to read. As our society develops, there must be rising demands for literacy. In a technological society, the demands for higher literacy are further increasing. Therefore, a number of people, who do not read well enough to meet the high demands, no longer to have competitive careers. Of course, the current study revealed most children were able to read fairly well. However, some children are struggling with reading. Why do some children in our society have problems in reading? Ample research has suggested that phonological processing is a powerful cognitive
indicator determining later reading ability. On the other hand, some other researchers argue that the phonological awareness factor may not be sufficient to explain all types of reading disabilities. For example, some researchers pointed out that rapid naming might be another powerful indicator in determining problems in reading (Wolf et al., 1999; Bowers et al., 2000) and some other researchers suggested that visual processing deficit could be one of important indicators of vision related reading problems (e.g. Eden et al., 1993). Therefore, along with phonological awareness, the current study searched for other significant variables that may be associated with reading fluency. Many connectionist theories, including Adams’ reading model, were addressed in order to discuss multidimensional components of reading. Moreover, empirical research provided evidence that there may be other aspects of reading that relate to RD. Through a review of the literature, it was noted that rapid-naming and visual deficits were significant variables in determining later reading development. However, there are some remaining issues and questions indicating key risk factors of RD surrounding rapid-naming and visual deficits. This review of the literature leaded me to further study prominent factors related to reading. Since components of reading are quite broad, this research narrowed down and focused only on factors related to reading fluency. For this study, twelve measures were administered, and data were analyzed by using descriptive and inferential statistics, correlational analysis and SEM to determine the effects of phonological awareness, rapid naming, visual factors on reading fluency. Taken together, this study provides the following conclusions.

**A Comprehensive Set of Indicators of RD**

Searching for comprehensive indicators of reading problems is important for early identification and early intervention. We have learned a great deal about the factors that
interfere with the process of learning to read (Snow et al., 1998). Perhaps the greatest contribution in the past two decades is accumulating evidence of a phonological processing deficit as the core problem leading to poor reading (Stanovich & Siegel, 1994). Moreover, ample evidence suggests that this deficit can be addressed effectively through instruction, particularly if the problem is identified early (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998). Consistent with prior research, the current study also revealed that phonological awareness is significantly related to reading fluency. Other than phonological awareness, naming speed and visual factors were taken into consideration in this study, and the results indicated that these two variables are also significant indicators of problems in reading fluency. The results particularly demonstrate that a combination of naming speed and eye movement measures is the most effective indicator to determine a problem with reading fluency. Surprisingly, the visual perception factor was the second most important factor affecting reading fluency. As discussed previously, prior literature indicated mixed findings on the relationship between visual deficits and reading. However, this study recognized that visual skills including eye movement, orthographic-reversal, and visual perceptions are significantly related to children’s reading fluency level. Therefore, a comprehensive set of indicators of RD should include consideration of phonological awareness as well as rapid-naming and visual factors.

**A Balanced Approach**

No single method will be successful with all children; a combination of many approaches may achieve the best results. Therefore, the most effective way to detect children’s reading problems and to provide reading instruction to all students can be through a balanced approach. The current study indicated that three critical components
that affect children’s reading fluency are phonological awareness, rapid-naming, and visual factors. The results showed that each of these components noticeably affect reading ability, especially reading fluency. First, rapid naming was found to be the most critical factor affecting the rate of reading fluency. It is the ability to name visual symbols rapidly. Children must be able to apply the sound and letter knowledge at a quick rate while decoding printed words. Second, the auditory skills of blending, segmenting, and manipulating sounds, as well as perceiving the number and order of sounds within spoken words, are important phonological awareness skills that are necessary for reading. Finally, the ability to visually perceive the sequences and patterns of individually printed shapes, letters, and numbers is also essential for success in reading. In Chapter 2, connectionism was discussed as a theoretical framework of this current study. Philosophers have been interested in neural networks because they may provide a new framework for understanding the nature of the mind and its relation to the brain (Rumelhart and McClelland, 1986). Connectionist models seem significantly well matched to what we know about neurology. The brain is a neural net, formed from massively many units (neurons) and their connections (synapses). With the core of connectionism, several reading models have been suggested. In particular, Adam’s connectionist reading model was discussed in Chapter 2. According to Adams’s connectionist reading model, all four processors need to perform a balanced work and operate simultaneously for skillful reading. If any one processor does not work effectively, the connected system would not operate successfully. The results of this study support connectionist theories in terms of phonological processing and orthographical processing. Phonological awareness is required for a phonological
processor, and rapid-naming and visual perception skills are needed for an orthographic processor. Each processor should work cooperatively and simultaneously for successful reading. Beyond the basic level of processing, the upper level of processors on skillful reading also should be carefully considered. Early reading instruction focuses on teaching a child how to read single words that is related to the basic level of processing. But being good at reading single words is not the only skill your child needs. Being able to read fluently is the next critical developmental step for their later grades. Once they have become good at decoding single words, they need to learn to read easily, quickly and accurately, becoming fluent readers. They tend to read many individual words automatically and understand what they are reading. Needless to say, this is the ultimate goal for reading. It is hard to understand what you are reading when you are not a fluent reader because we need to use a lot of attention to decode single words and there is little left over to use understanding what we have read. Researchers have indicated that children who suffer from severe reading difficulties may not be fluent readers (e.g., Fawcett, Nicholson & Dean, 1996 & Nicholson & Fawcett, 1999). ‘Dyslexic Automatization Deficit’ (D.A.D.) is suggested by Nicholson & Fawcett at Sheffield University in the North of England (Fawcett, Nicholson & Dean, 1996 & Nicholson & Fawcett, 1999). Automatization is the process by which well learned skills become more and more fluent until the child no longer needs to think about them intentionally. They suggested that the two conditions are required for automatic processing. The first one is that it should be fast and the second one is that it needs little conscious effort (Nicholson & Fawcett, 1999). Nicholson and Fawcett (1990) believed that if conscious effort were involved performance would be decreased under dual-task conditions. Under this
hypothesis, they examined the performance of twenty-three thirteen-year-old dyslexic children on a test of motor balance, and compared it to that of the same age controls. To test the "conscious compensation hypothesis" they introduced a secondary task to switch attention away from the primary task. Under single conditions the children performed just the motor balance (primary) task. Under dual conditions they performed the primary task as well as a concurrent secondary task. Dyslexic subjects showed problems on the dual task as opposed to the single task, but there was no such decrease in score for the control subjects. Fluency is essential because it plays an important role as a bridge between word recognition (the basic level of processing for reading; the phonological processor and the orthographical processor) and comprehension (the upper level of processing for reading; meaning processor and context processor). Therefore, a balanced approach based on connectionist theories is necessary to determine early detection of RD and choosing intervention strategies for children with reading problems.
Dear Parent/Guardian,

I am a graduate student in the Department of Special Education at the University of Florida, conducting research on the effects of phonological awareness, rapid-naming, and visual skills on early elementary students’ reading under the supervision of Dr. Vivian Correa. Phonological awareness is the awareness that language is composed of sounds and the understanding of the relationship of these sounds. For assessing phonological awareness, manipulating sounds including deleting, adding, and substituting syllables/sounds will be assessed. For rapid-naming, the ability to efficiently retrieve verbal labels for familiar visual stimuli (e.g., numbers and letters) will be assessed. Within this study, visual skills including visual perceptual skills such as visual memory and visual discrimination and visual motor skills such as eye movement will be assessed. The purposes of this study are 1) to examine reading fluency, phonological awareness, rapid-naming, and visual skills, 2) to detect problems associated with these factors, and finally 3) to determine if phonological awareness, rapid-naming, and visual skills are related to children’s reading level.

The test results will directly help your child. Through assessments of reading efficiency, phonological awareness, rapid-naming, and visual skills, problems in these areas will be detected. In the long run, early identification of problems in these areas is very important since they can be more effectively treated in the early stages. Totally, 20-25 minutes will be taken to accomplish all assessments. With your permission, I would like to ask your child to volunteer for this research.

I will replace their names with code numbers. Your child’s identity will be kept confidential to the extent provided by law. Results will only be reported in the form of group data. However, if you request the individual results of your child’s assessments, they will be provided. Participation or non-participation in this study will not affect the children’s grades or placement in any programs.

You and your child have the right to withdraw consent for your child’s participation at any time without consequence. There are no known risks. Group results of this study will be available in August 2004. If you have any questions about this research protocol, please contact me at (352) 392-0701 ext.262 or my faculty supervisor, Dr. Vivian Correa, at (352) 392-0701. Questions or concern about your child’s rights as research participant may be directed to the UFIRB office, University of Florida, Box 112250, Gainesville, FL 32611, (352) 392-0433. Thank you for your consideration.

Sincerely,

[Signature]
I have read the procedure described above, I voluntarily give my consent for my child, ________________, to participate in Hoyeon Kim’s study of the effects of phonological awareness, rapid-naming, and visual skills on early elementary students’ reading. I have received a copy of this description.

__________________________       _________________________
Parent/Guardian                                                                 Date

__________________________       _________________________
2nd Parent /Witness                                                              Date
LIST OF REFERENCES


Torgeson, J., & Bryant, B. (1994). Test of phonological awareness, Austin, TX: Pro-Ed.


BIOGRAPHICAL SKETCH

Hoyeon Kim was born and raised in Sunchon, Jeon-Nam, Korea. She earned her Bachelor of Arts degree with a concentration in special education for people with visual impairments from Dankook University in 1992. She earned a Master of Arts degree from the graduate program in special education at Dankook University in 1994. Her thesis focused on inclusion for children with visual impairments. She earned a certificate of orientation and mobility specialist from the graduate program in special education, school of education, at California State University at Los Angeles in 2000. Her research includes the effects of visual factors on reading as well as visual screening for young children.