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EFFECTS OF FAST FORWORD ON PHONOLOGICAL AWARENESS AND RAPID NAMING SKILLS OF AT-RISK STUDENTS

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ABSTRACT

EFFECTS OF FAST FORWORD ON
PHONOLOGICAL AWARENESS AND RAPID NAMING SKILLS
OF AT-RISK STUDENTS

The current study examined the efficacy of Fast ForWord, a computer-based intervention designed to improve the auditory processing skills associated with language development and the subsequent acquisition of reading skills. The study used a randomized pre-test and post-test control design to examine the impact of Fast ForWord on the phonological awareness and rapid naming skills, of students who have failed to meet proficiency on the Connecticut Mastery Test in Reading as measured by the Comprehensive Test of Phonological Processing. The sample was recruited from a target population of 78 students from an urban school, between grades four and eight who were identified as at-risk students by scoring at the basic or below basic level on the 2008 Connecticut Mastery Test in Reading. A multiple regression and a two- group MANOVA were conducted as the methods in data analysis in this research. Results of the MANOVA indicated no significant differences in the levels of the independent variable, as defined by treatment and control group. Results of the multiple regression indicated that percentage of program completion predicted posttest phonological scores but not posttest rapid naming scores. Connecticut Mastery Test in Reading scores, when entered in the regression model, did not predict posttest phonological awareness or posttest rapid naming scores.

APPROVAL PAGE

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Doctor of Education Dissertation

EFFECTS OF FAST FORWORD ON PHONOLOGICAL AWARENESS AND RAPID NAMING SKILLS OF AT-RISK READERS

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CHAPTER ONE: EFFECTS OF FAST FORWORD ON THE PHONOLOGICAL AWARENESS AND RAPID NAMING SKILLS OF AT-RISK STUDENTS

The National Assessment of Educational Progress (NAEP), is often referred to as "The Nation's Report Card" (National Center for Educational Statistics, [NCES] 2008). NAEP provides a standardized measure of student skill level that can be compared yearly, providing educators with a tool to evaluate nationwide, the effectiveness of curriculum and instruction. Descriptive scores are presented in the following achievement categories: (a) students who perform at the advanced level are described as having superior skills; (b) students at the proficient level are described as having the skills needed to master grade level text; and, (c) students at the basic level are described as having a partial mastery of skills needed for proficiency (NCES, 2008). Since 1992, NAEP results, as listed in Table 1, have remained fairly constant, and indicate that between 20% to 40% of participating students consistently fall in the below basic range (Lee, Grigg, & Donahue, 2007). These students lack the reading skills needed to master grade level text.

Table 1

Percentage of Students Scoring Below Basic on the NAEP Reading Assessment

Year	Grade 4	Grade 8	Grade 12
1992	38%	31%	20%
1994	40%	30%	25%
1998	40%	27%	24%
2002	41%	25%	26%
2005	41%	27%	27%
2007	33%	26%	N/A

The Nation's Report Card, 2007

Torgesen (2002) related this problem to effective instruction and stated: "In spite of all our knowledge about reading and reading instruction, there is a wide-spread concern that public education is not as effective as it should be in teaching all children to read" (p. 8). In their review of more than 40 years of reading research, Vellutino, Fletcher, Snowling and Scalon (2004), emphasized the impact that direct, individualized, and systematic instruction had on reading skills and attributed most reading problems to the lack of appropriate instruction.

Rationale

Determining what constitutes appropriate reading instruction presents a challenge to educators because reading is a complex, dynamic, and interactive process that is unique for each student (Wolf, 2007). Understanding the instructional needs of students and designing effective interventions could reduce the number of students who struggle with reading (Torgesen, 2002). Torgesen estimated that the use of systematic and evidence-based instruction would reduce the proportion of the population who would fall below the 30^{th} percentile on normed reading measures to between 2% and 6% (Torgesen 2002). In order to determine what constitutes appropriate instruction, educators need research that guides instructional decisions about content, program selection, and implementation (Lyon, 2001).

Research studies specific to content were summarized by The National Reading Panel (2000) and resulted in an outline of key components that were considered integral parts of reading instruction. The components included phonological awareness, fluency, decoding, vocabulary, comprehension strategies, and motivation. The research also generated the development of numerous teaching strategies for each component (Center for the Improvement of Early Reading Achievement, 2003; National Reading Panel, 2000).

Studies that guided instructional decision-making specific to program efficacy, selection, and implementation procedures within classrooms were lacking (Foorman & Torgesen, 2001), as were studies specific to the efficacy of individualized interventions (Wanzek & Vaughn, 2007). The lack of studies in these areas presented a problem for educators who needed research-based information specific to program efficacy (what works), implementation procedures (how it works), and treatment effects for students with different skill levels (for whom it works).

The current study has addressed the topic of instruction for students who struggle with reading and had a specific focus on an instructional program that targeted processing skills related to word reading. While not all struggling readers have weaknesses in word reading, those who do require direct and individualized instruction (Snow & Biancarosa,

2004) that targets processing skills (Vellutino et al., 2004). The current study has focused on two processing skills related to word reading: phonological awareness and rapid naming. Phonological awareness was chosen because a causal relationship between word reading and phonological processing has been established (Wagner & Torgesen, 1987). Rapid naming was chosen because of its correlation with word reading speed (Wolf, Bowers, & Biddle, 2000a). In order to comprehend text, word reading needs to be both accurate and automatic; and phonological awareness and rapid naming skills are key to this process (Savage, 2004).

The purpose of the current study was to examine the efficacy of Fast ForWord, a program that purports to improve two of the basic processing skills essential to reading**:** phonological awareness and processing speed, as measured by rapid naming, in a format that provides individual and systematic instruction (Tallal 2004). The rationale is that conducting an efficacy study would provide educators with the information needed to determine whether Fast ForWord is an appropriate instructional option for struggling readers.

Statement of the Problem

National reading scores in 2007 continued to indicate that between 26% and 33% of students nationwide failed to meet basic reading goals (Lee, Grigg, & Donahue, 2007), in spite of research studies that have outlined essential skills and processes (Vellutino et al.,2004). The problem has been attributed to ineffective instruction (Torgesen, 2002; Shaywitz, Lyons, & Shaywitz, 2006). Research indicated that struggling readers benefited from instruction that (a) targeted specific skills; (b) was individualized, and (c) was implemented in a systematic manner (Torgesen, 2002). Research also indicated that phonological awareness and rapid naming skills were markers for reading problems, showing that poor skills in either area placed a student at-risk (Wolf, 2007). However, phonological skills could be improved if instruction were intense and explicit (Odegard, Ring, Smith, Biggan, & Black, 2008). Research specific to the improvement of rapid naming has been limited (de Jong & Vrielink, 2004).

Fast ForWord targeted phonological skills and purported to improve auditory processing speed (Tallal, 2004). The program provided individualized instruction and was presented in a systematic format that was both intense and motivating. These factors suggested that it would be a viable and effective option for struggling readers. Independent efficacy studies that examined the impact of Fast ForWord on broad-based reading and language skills were inconclusive. One small, clinic-based study had examined the impact of Fast ForWord on reading and phonological skills, and results indicated a significant treatment effect (Gaab, Gabrieli, Deutsch, Tallal, & Temple, 2007). In comparison, results from efficacy studies conducted in school settings were not significant. In the latter studies, researchers noted limitations related to program completion and student selection, factors which generated questions about the impact on outcome measures (Gillam et al. 2008; Borman, Benson & Overman, 2009).

The problem addressed in the current study is the lack of school-based studies that examine the impact of Fast ForWord on phonological skills. The literature indicated a need for a study that would examine (a) the impact of Fast ForWord on phonological awareness and rapid naming skills of struggling readers in a school setting; (b) explore the relationship between program completion and outcome measures; and (c) examine treatment effects across groups. Examining the treatment effects of Fast ForWord on phonological awareness and rapid naming, two basic processing skills that are correlated with reading, will provide educators with data needed for decision making specific to Fast ForWord as an instructional program for struggling readers.

Definitions of Key Terms

The following terms and definitions apply to this study:

1. *Phonological awareness* involves both awareness of and access to the sound structure of language (Torgesen et al., 1999).
2. *Rapid naming* is a measure of fluency and involves the ability to quickly and efficiently retrieve phonological information stored in memory (Torgesen et al., 1999).
3. *Temporal processing* refers to the ability to recognize and sequence visual and auditory information that is presented in rapid succession (Gillam, 1999).
4. *At-risk students* are defined as those students who fall below proficiency on standardized state assessments and not able to master grade-level text (Connecticut State Board of Education, 2008).
5. *Basic (Level 2)* refers to student performance that shows a partial demonstration of grade-level skills and a need for assistance to complete grade-level tasks (Connecticut State Board of Education, 2008).
6. *Below Basic (Level 1)* refers to student performance at this level that shows a limited demonstration of grade-level skills and a need for significant assistance to complete grade-level tasks (Connecticut State Board of Education, 2008).

Related Literature

The Reading Process

The National Reading Panel (2000) listed phonological awareness, decoding, fluency, comprehension, and vocabulary as essential reading components. Vellutino et al. (2004), in a model depicting the cognitive processes and knowledge requirements needed to decode and comprehend words and text, highlighted both the complexity and the relational aspects of reading. Research from various fields has contributed to a growing body of knowledge that suggests reading is a complex, dynamic, and interactive process that incorporates core components, but these components represent unique properties for each individual (Wolf 2007). Although the processes and knowledge base associated with these core components represent unique properties for each individual, phonological processing and rapid naming skills have been found to be reliable markers for reading problems, providing a framework for the identification and remediation of at-risk students (Wolf, 2007).

Phonological Awareness and Rapid Naming

Phonological awareness and rapid naming are two components of the broader category of phonological processing. Phonological awareness refers to understanding that spoken and written words are made up of sound units, and rapid naming refers to the ability to access phonological information quickly and efficiently (Torgesen, Wagner & Rashotte, 1994). Phonological processing weaknesses have been widely accepted as the primary reason for reading difficulties (Savage, 2004). The construct of rapid naming has also been correlated with reading difficulties, but debate continues about whether or not it represents an aspect of phonological processing or is a separate process

(Schatschneider & Torgesen, 2004). Phonological awareness has been shown to improve with treatment (Lovett, Steinbach & Frijters, 2000) but studies that have examined improvement in rapid naming were lacking.

Fast ForWord

Fast ForWord targets the auditory processing skills thought to underlie phonological awareness (Tallal, Miller, & Fitch, 1993). The program purports to increase auditory temporal processing speed, improving one's ability to access and recognize discrete differences in sounds. Fast ForWord presents acoustically modified speech in an individualized, game-like format. As participants move through a series of levels in each game, the computer adjusts the rate of speech presentation according to student response, eventually reaching a normal rate of presentation. Fast ForWord follows a protocol based on brain plasticity studies that suggest structural changes in the brain occur when learning situations are intense, frequent, and motivating (Tallal, 2004). Students are expected to participate daily, but time and duration can be individualized. For example, a student might participate for 30 minutes daily for 12 to14 weeks or 50 minutes daily for 10 to 12 weeks. Time allotments, levels of instruction, and presentation of activities are automatically generated by the computer. Completion levels and daily participation have varied across independent efficacy studies and may have had an impact on treatment effects (Cohen, Hodson & O'Hare, 2005; Porkoni, Worthington & Jamison, 2004; Rouse & Krueger 2004; Troia, 2004). The current study has included an examination of the impact of completion rate on treatment effects.

Phonological Processing Theory

Paula Tallal, a cognitive neuroscientist, generated a hypothesis suggesting that many language-based disabilities stem from difficulties in auditory temporal processing (2004). She found that **c**hildren with speech and language difficulties and subsequent reading problems found it difficult to hear differences in speech sounds that required rapid processing, such as distinguishing between “ba” and “da” (Tallal, 2004). Inefficient processing at the sound level had an impact on the development of phonological, language, and subsequent reading skills. Tallal’s theory that inefficient timing mechanisms interfered with the ability to accurately and rapidly process sounds led to the development of a remediation program called Fast ForWord, which was designed to improve auditory temporal processing skills.

Methodology

Research Questions

This study examined the following research questions:

1. Is there a significant difference in phonological awareness and rapid naming skills for students who participate in the Fast ForWord intervention and those who do not?
2. To what extent and in what manner can variation in the phonological awareness composite posttest scores be explained by the percentage of completion of the Fast ForWord program and state scores on the Connecticut Mastery Test in Reading?

3. To what extent and in what manner can variation in the rapid-naming posttest scores be explained by the percentage of completion of the Fast ForWord program and state scores on the Connecticut Mastery Test in Reading?

Hypotheses

1. Students participating in the Fast ForWord program intervention will have significantly higher scores in phonological awareness and rapid naming skills than those in the control group.

2. Fast ForWord program completion and state scores on the Connecticut Mastery Test in Reading will significantly explain the manner and variation in phonological awareness composite posttest scores.

3. Fast ForWord program completion and state scores on the Connecticut Mastery Test in Reading will significantly explain the manner and variation in rapid naming posttest scores.

Participants

The target group (n = 78) consisted of students in grades four through eight who scored at basic (Level 2) or below basic (Level 1) on the 2008 grade-level Connecticut Mastery Test in Reading. The school principal sent a letter of explanation of the study with attached permission slips to the parents. Permission was secured (n = 56), and a stratified sample of students from each level (basic n = 20, below basic n = 36) were randomly assigned to either the treatment or the control group for a total of 28 students per group.

Data from the 2007-2008 profile provided by the Connecticut State Board of Education indicated the target school was a traditional urban elementary school of approximately 456 students in grades kindergarten to eight. The total number of teaching staff was 30, with 20% being of minority status. Seventy-eight percent of the staff held a master's degree or higher and had an average of nine years' teaching experience. Student demographics are outlined in Table 2.

Table 2

Demographics of Total Student Population

Race and Socioeconomic Status	Percentage
Hispanic	47%
Black	39%
Asian	1%
White	11%
Free and reduced lunch	95%

Connecticut State Board of Education's Strategic School Profile 2007-2008.

Instrumentation

The Comprehensive Test of Phonological Processing is an instrument designed to assess phonological awareness, memory, and rapid-naming skills for subjects between the ages of 5 and 24 (Wagner, Torgesen, & Rashotte, 1999). For this study, only the variables of phonological awareness and rapid naming were examined. The general battery consisted of composite scores for each of these areas with two core subtests for each composite. The phonological awareness core subtests included the Elison, an orally presented task that requires segmenting words, and Blending Words, an audiotaped task that requires the subject to listen to word segments and blend them together. The rapid-naming tasks are timed tasks that require the subject to visually scan and name a series of letters and numbers printed on one page.

The Connecticut Mastery Test (CMT) is a criterion-referenced test designed to measure student performance across subject areas based on statewide curriculum goals and objectives. The Connecticut Master Test in Reading is made up of two separate subtests: Degrees of Reading Power (DRP) and Reading Comprehension. The DRP incorporates a multiple-choice, cloze format that measures comprehension on passages that increase in difficulty. The reading comprehension subtest incorporates multiple-choice and open-ended questions and reports ability specific to four strands that include general comprehension, interpretation, inferences, and structure (Connecticut Mastery Test, Fourth Generation, Language Arts Handbook, 2008).

The CMT raw scores are converted to scaled scores that range from 100 to 400, as outlined in Table 3, with corresponding performance and descriptive categories.

Table 3

Connecticut Mastery Test Interpretations

Levels	Category	Scaled score	Grade-level skill
1	Below basic	100 – 201	Very limited
2	Basic	202 – 216	Limited
3	Proficient	217 – 234	Adequate
4	Goal	235 – 278	Consistent
5	Advanced	279 – 400	Exceptional

Note. The above data is derived from the *CMT Interpretive Guide*, Connecticut State Board of Education, 2008.

Procedure

The following procedures were undertaken to complete this study:

Student selection. Students were selected according to their scores on the 2008 Connecticut Mastery Test in Reading. The target population included all students in the school who scored at the basic or below-basic level.

Contacting parents. A letter of introduction was sent to parents of students in the target group in early January 2009 and included a cover letter from the principal. The letter provided a brief overview of the study and a permission slip. Parents were informed that their consent could be withdrawn at any time and participation was voluntary.

Sample selection. Once permission slips were secured, pretesting took place. One school psychologist, one speech pathologist, and one special-education teacher administered the testing. Students were assigned numbers for confidentiality purposes, and test material was coded accordingly.

When testing was completed, students were randomly assigned to either the treatment or the control group. Students in the control group will have the opportunity to participate in the program at a time to be determined by the school administrators.

Staff training. Training for pretest and posttest assessment consisted of one group session to review the standardized procedures, as outlined in the manual, for test administration. The staff who conducted the pretest and posttest assessment had previous experience administering the Comprehensive Test of Phonological Processing and were familiar with these standardized procedures.

Training for the implementation and monitoring of the Fast ForWord program was conducted by the primary researcher and two representatives from Scientific Learning, the company that produced the program. The primary researcher provided one training session for the special education staff and the literacy coach. The session consisted of an overview of the program and implementation procedures. Each participant was provided with a manual published by Scientific Learning that provided explicit instructions for implementing the program and monitoring student progress. Once the program began, the primary researcher was available on site twice a week for the duration of the study. During the program, Scientific Learning provided one on-site visit to answer questions and model coaching techniques.

Implementation. In compliance with the protocol outlined in the training manual, the Fast ForWord Language Program was delivered for 50 minutes a day, five days a week. The program took place for approximately 12 weeks. The principal was responsible for assigning and monitoring staff. Two special-education teachers, one literacy coach, and two teachers' aides were assigned because of their interest level and time availability. Assigned staff, consisting of teachers and educational assistants, monitored the students during the treatment. Posttesting of phonological awareness and rapid naming skills was conducted at the end of the 12-week session.

Design and Analysis

This study employed a quantitative approach using a randomized pretest and posttest with a control group design for research question one. The independent variable was the processing skill intervention, with two levels: Fast ForWord treatment and no-treatment instruction. The dependent variables included phonological awareness and rapid naming and were assessed using the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999).

Posttreatment differences between the groups were analyzed. Since there were two dependent variables, a multivariate analysis of variance (MANOVA) was conducted to determine the relationship of the independent variable on the posttest composite scores. The correlation between the dependent variables met the criteria for MANOVA.

A multiple regression correlation design was used to analyze data for the second and third research questions. The criterion variable**s** for the second and third research questions were the posttest composite scores, rapid naming, and phonological awareness. The predictors were state scores on the Connecticut Mastery Test for Reading (basic and below basic levels), the percentage of completion of Fast ForWord language-based games, and the percentage of completion of sound-based games. The *Statistical Package for the Social Sciences, Version 13.0,* (Nie, 1968) package was utilized for the multiple regression analysis of the results.

CHAPTER TWO: REVIEW OF THE LITERATURE

The review of the literature will include research on the following topics: (a) the reading process and underlying cognitive skills; (b) an overview of phonological processing and the subcomponents of rapid naming and phonological awareness; (c) the phonological deficit theory and the role of temporal auditory processing; and (d) Fast ForWord, including the program's objectives, format, and efficacy. The literature review will be followed by a chapter summary.

In the first section, reading will be presented as a dynamic, language-based task that incorporates a number of cognitive processing skills required to read words and comprehend text. The focus of the literature review will be on word reading and related processing skills since comprehension depends on accurate and fluent word reading.

The second section will review the construct of phonological processing and its causal relationship to word reading. Two subcomponents of phonological processing—phonological awareness and rapid naming—will be described, as will studies that support a correlation between these skills and word reading. Included in this section will be a review of studies that have found that phonological skills improve when instruction is individualized, explicit, and systematic.

Next, Tallal's theory of temporal auditory processing will be presented in the context of the broader phonological deficit theory. Phonological processing will be described, and the role of temporal auditory processing will be highlighted.

Finally, an overview of Fast ForWord, a program designed to improve temporal auditory processing skills, including phonological awareness and processing speed, will be presented. The overview will include a description of the program, including the instructional format in which it is delivered and a review of efficacy studies specific to Fast ForWord. The chapter will conclude with a summary.

The Reading Process

The ultimate goal of reading, according to Gough's "simple view" (Gough, 1996) is to be able to recognize words and understand what they mean. Reading was initially regarded as a visually-based task (Denckla, 1974), but research over the last four decades has led to the conceptualization of reading as a language-based task that was described as a written manifestation of speech (Vellutino, et al. 2004). Although primarily language-based, the ability to read and understand words requires skills and knowledge across a number of modalities (Vellutino et al.; Torgesen, 2002). Word reading and comprehension depend on: (a) language skills, such as phonological processing, grammar, semantics, and vocabulary; (b) an understanding that language can be represented by print; and (c) the complex interaction between underlying visual, linguistic, and memory skills (Vellutino et al.). However, the reading process begins with a strong foundation in language (Wolf, 2007).

Language skills provide the base from which reading emerges (Whitely, Smith, & Connors, 2007) and continue to play a role in the development of reading skills. Wolf (2007) highlighted the role of language in her description of early reading stages **(**see Table 4).

Table 4

The Developmental Stages of Early Reading Skills

Stage 1	In infancy, exposure to language facilitates phonemic representations.
Stage 2	Phonemic representations establish the foundation for phonological processing; the ability to understand that words consisted of sounds.
Stage 3	As toddlers, exposure to print, in the context of being read too, facilitates an understanding that sounds can be represented by letters, and these letters form words that have meaning.
Stage 4	In school, formal reading instruction reinforces the grapheme (letter)-phoneme (sound) relationship and readers began to decode words independently.
Stage 5	Fluent and automatic word reading allows attention to shift to comprehension and language continues to play a dynamic role.

Note. This is a summary of Wolf's (2007) developmental stages.

Wolf's (2007) description of the reading process emphasized the reciprocal relationship between reading and language skills in that exposure to language is needed to understand text**,** and exposure to text expands the language base. Developmentally, readers move from being active listeners to being word readers to being active participants in the comprehension process, in which the reading merges with personal background knowledge and experience (Wolf, 2007, p. 114-145).

Word Reading and Comprehension

Central to the reading process is the ability to read a word and understand it (Torgesen, 2002). A reader's difficulty in either word reading and/or comprehension has been found to be a criterion that distinguishes poor readers from good readers (Snow, Burns, & Griffin, 1998). Research supports a correlation between word reading and comprehension. Berninger, Abbott, Vermeulen, and Fulton (2006) examined the relationship between word reading and comprehension in a study ($n = 96$) of teacher-referred second graders screened for poor reading skills. Correlations were computed using real-word and nonsense-word reading speed and accuracy scores as predictors, with comprehension scores as outcomes. Two findings emerged from the results. Phonological decoding (nonsense word reading) was significantly correlated ($r = .47$, $p < .001$) with comprehension; and accuracy ($r = .71$, $p < .001$) and rate ($r = .73$, $p < .001$) of real-word reading were found to be strong predictors of comprehension. The researchers concluded that "phonological decoding appears to be a bridge to real-word reading, which, as it improves, increasingly becomes a bridge to reading comprehension" (p. 340). Phonological skills, therefore, were a prerequisite for word reading, and word reading was a prerequisite for comprehension.

Phonological Processing

The impact of phonological processing on word reading has been widely accepted. The literature supports a causal relationship between phonological processing and word reading (Wagner & Torgesen, 1987; Liberman, Shankweiler, & Liberman, 1989); and phonological processing deficits have been identified as the primary cause of reading problems (Torgesen & Wagner, 1998). There is also evidence in the literature that phonological processing can improve with direct, intense, individual instruction (Vellutino et al., 2004), but these instructional conditions have been difficult to implement in classroom settings (Forman & Torgesen, 2001). The following section will present an overview of the concept of phonological processing, with an emphasis on two subcomponents—phonological awareness and rapid naming. It will also include a review of studies that have examined the relationship between phonological processing, reading, and instruction.

Liberman, Shankweiler, and Liberman (1989) introduced the concept of phonological processing with the suggestion that reading a word was more complicated than listening to a word. Spoken words were easily recognized as single units that carried meaning. Reading a word, however, required understanding that words may sound like one unit but are actually made up of a number of segments, a principle they referred to as the "alphabetic principle" (p. 5). Liberman et al. (1989) argued that teaching the association between a letter and a sound was not explicit enough for beginning readers who needed an understanding that words were made up of sound segments that could be isolated and manipulated. They referred to this as an understanding of the phonological properties of the word and articulated that this understanding developed as a result of direct instruction.

Phonological processing broadly refers to one's ability to process sounds in language, and it has been conceptualized as a cognitive skill that remains stable over time (Torgesen, et al., 1994). Wagner and Torgesen (1987) described phonological processing as consisting of three subcomponents: phonological awareness, phonological memory, and phonological retrieval. According to their description, phonological awareness refers to an understanding that words are made up of sound segments**;** phonological memory refers to the process of storing phonological information**;** and phonological retrieval as measured by rapid naming refers to the ability to access phonological information stored in memory (Wagner & Torgesen, 1987).

While research results were consistent in supporting a causal relationship between word reading and phonological processing (Wagner & Torgesen, 1987), delineating and defining the construct of phonological processing continues to be explored. The role of phonological awareness is well-established, but the role of rapid naming and phonological memory continues to be explored.

Studies that have examined the role of rapid naming have been inconclusive. In some studies, rapid naming has not been found to make a unique contribution to word reading (Torgesen,Wagner, Rashotte, Burgess, & Hecht, 1997) while others (Wolf & Bowers, 1999) have shown that rapid naming accounts for skills that go beyond phonological processing and represent a separate construct (Wolf**,** Bowers, & Biddle, 2000). Differences in the ability of phonological awareness and rapid naming to predict word reading were found. Kirby, Parrila, and Pfeiffer (2003) examined the extent to which phonological awareness and rapid naming skills of kindergarten students (n = 161) could predict word reading in Grade 5. Consistent with Torgesen et al. (1994), the authors found that for kindergarteners, phonological awareness skills predicted word reading in first and second grade but in grades three through five, rapid naming was found to be a stronger predictor.

Hogan, Catts, and Little (2005) found similar results in a longitudinal study (n = 570) that examined the relationship between phonological awareness in kindergarten and later word reading skills in Grades 2 and 4. Results indicated that phonological awareness predicted word reading in kindergarten, Grade 1, and Grade 2. However, after Grade 2, word reading itself was found to be the strongest predictor of later word reading.

Although the role of rapid naming in the reading process continues to be debated (Vellutino et al., 2004; McCallam et al., 2006), phonological memory, as pointed out by Schatschneider and Torgesen (2004) in a review of dyslexia research, has not been as strong a predictor as phonological awareness and rapid naming. Torgesen, Wagner, and Rashotte (1994) designed a longitudinal study to measure the developmental progression of phonological awareness, rapid naming, and phonological memory from kindergarten through second grade and to examine the impact of each of these components on word reading in Grade 1 and Grade 2. The sample ($n = 288$) included students in kindergarten, first and second grade. In order to assess phonological processing, the researchers identified five correlated constructs. These constructs included phonological analysis, phonological synthesis, rapid serial naming, isolated naming, and phonological memory. Student skill level in each of the five areas was assessed yearly, as was word reading skill. Results indicated each of the five components were found to be strong predictors for decoding in kindergarten, but only phonological analysis and rapid serial naming were found to predict decoding for students in Grades 1 and 2. A significant correlation ($r = .82$, $p < .001$) was found between the phonological analysis skills of kindergarten students and word reading skills of first grade students. A correlation was also found between the rapid serial naming skills of kindergarten students' and first grade students' word reading skills ($r = .66$, $p < .001$). Rapid naming skills in Grade 1 were found to correlate with word reading in second grade ($r = .70$, $p < .001$). Memory skills in kindergarten were not found to predict word reading for students in first or second grade.

Other studies have also found that phonological awareness and rapid naming are better predictors of word reading than memory. Cutting and Denckla (2001) examined the relationships between word reading and processing skills in a sample ($n = 79$) of average students in Grades 1, 2, and 3. The processing skills included phonological awareness, rapid naming, memory, processing speed, and orthographic knowledge, with word reading as the dependent variable. Their findings were in keeping with those of other studies that found phonological awareness and rapid naming skills to have a direct effect on word reading. While a correlation between memory and word reading ($r = 0.31$, $p < 0.01$) was found, memory did not play a significant role in predicting word reading.

Bell, McCallum, and Cox (2003) also found phonological awareness and rapid naming to be stronger predictors of word reading in a group of older students than memory. The researchers investigated processing skills associated with reading in a sample of students ($n = 105$) in kindergarten through Grade 6. Students were evaluated with standardized assessments designed to measure phonological awareness, rapid naming, memory, visual processing, word reading, and comprehension. The assessment battery included a total of 11 subtests that were grouped into three separate factors: auditory processing, visual-processing/speed, and memory. Results indicated that auditory processing contributed 43% of the variance in word reading. Visual-processing/speed added 23% to the predictive equation, and memory contributed an additional 19%. A correlation matrix between phonological awareness, phonological memory, rapid naming, word reading, and comprehension indicated positive correlations between phonological awareness, word reading ($r = 0.57$, $p < .01$), and comprehension ($r = 0.61$, $p < .01$). Correlations between rapid naming, word reading ($r = 0.71$, $p < .01$), and comprehension ($r = 0.73$, $p < .01$) were also found. The literature indicated that phonological awareness and rapid naming predict word reading. In addition, the literature indicated that these variables were stronger predictors of word reading than memory was.

The literature related to phonological processing supports a strong causal relationship between phonological processing and word reading (Wagner & Torgesen, 1987). Phonological processing has been conceptualized as consisting of three correlated but separate subcomponents that include phonological awareness, rapid naming, and phonological memory (Wagner & Torgesen, 1987). The role and definition of rapid naming has generated controversy (Vellutino et al., 2004). However, of these three components, the literature suggests that phonological awareness and rapid naming are stronger predictors of word reading (Torgesen, Wagner, & Rashotte, 1994) than memory. These components are the focus of this study. The following sections will summarize research specific to phonological awareness and rapid naming.

Rapid Naming

Rapid naming refers to the ability to efficiently retrieve stored information. It is assessed by measuring the speed and accuracy by which subjects can name objects, colors, letters, and digits (Torgesen & Wagner, 1998). Rapid naming has been conceptualized by some researchers as a task that represents part of the phonological process (Wagner & Torgesen,1987) and as a separate construct by others (Wolf, Bowers & Biddle, 2000a,).

Rapid naming tasks were first developed by Denckla (Denckla & Rudel, 1974). Denckla (1974) suspected that poor readers lacked the automaticity needed to read words fluently and recognized the need to collect normative data related to fluency. Denckla & Rudel (1976) designed a study that examined the developmental progression of naming skills in a randomized sample of students who were considered to be average students (as determined by teachers), between the ages of 5 and 10 (n = 180). Each subject was presented with different naming tasks that were categorized along content lines (objects, colors, letters, and numbers). For example, subjects were given a sheet that had lines of single digits presented in a serial format and were asked to name each digit. A response time for each task was recorded. Results from the study indicated that age accounted for variance on all tasks ($p < .01$), meaning the older the student, the faster the response. Accuracy across tasks for students over the age of 6 was high, but letter and number naming was found to be more automatic than object and color naming across groups. Denckla's findings led to the development of the Rapid Automatized Naming Test (Denckla & Rudel, 1974), a tool that provides a way to assess rapid naming skills.

The ability to assess rapid naming skills provided a way to examine skill differences between typical and dyslexic readers. Denckla and Rudel (1974) examined the differences in response time between typical and dyslexic readers and between dyslexic and learning-disabled students. In their study, subjects (n = 120) between the ages of 7 and 10 who were considered to be average students (as determined by teachers) acted as controls, and their performance was compared to the performance of subjects (n = 128) diagnosed with learning disabilities who were subdivided into two groups: dyslexic or nondyslexic.

The researchers found group differences in the response time on rapid naming tasks between normal and learning-disabled students ($F(2, 236) = 44.08$, $p < .001$). Learning-disabled students had slower response times when compared to average students. Performance differences were also found between subgroups of learning-disabled students ($F(2, 236) = 42.93$, $p < .001$). Learning-disabled students with poor reading skills were slower to respond than were learning-disabled students with average reading skills.

A difference between dyslexics and learning-disabled subjects on an object-naming task was supported in a later study (Denckla & Rudel, 1976). Numerous other studies replicated and expanded these early findings and suggested that the rate of performance on rapid naming had been found to distinguish typical from poor readers (Wolf, Bowers, & Biddle, 2000a). The performance time of poor readers was slower than that of average readers.

In an effort to explore factors related to the timing differences between typical and poor readers, Obregon (as cited in Wolf et al., 2000a), calculated the pause time between each individual response on a serial naming task. The sample was small ($n = 12$) but included both typical and dyslexic readers. Results provided preliminary data that indicated dyslexic students, in contrast to typical readers, exhibited a longer duration between each response in a serial naming task. The finding indicated that dyslexic students needed a longer response time to process the stimulus, retrieve the name, and move to the next stimulus. Wolf et al. have suggested that the need for a longer response time emerged during tasks that required the integration of skills and might represent a more complex timing problem across modalities.

The relationship between rapid naming, timing differences, and word reading are not fully understood. Cutting and Denckla (2001) proposed that the difficulty inherent in understanding rapid naming is due to the complex system of processes that need to be integrated during a rapid-naming task. These include attention, visual processing, phonological processing, articulatory processes, and timing. However, research into problems with general timing mechanisms across visual, motor, and auditory domains has been inconsistent and requires additional study (Savage, 2004).

While not fully understood, the results of studies of rapid-naming tasks were found to be an effective way to differentiate between typical and poor readers and between subgroups of poor readers. Wolf and Bowers (1999) described subtypes of readers who could be grouped according to their skill levels on phonological and rapid-naming tasks. Table 5 presents an overview of these proposed subtypes and associated reading skills.

Table 5

Subtypes of Readers According to Processing Skill

Subtype	Skill level	Word reading skill
Phonological deficit	Poor phonological Intact rapid naming	High fluency-low word reading
Rapid-naming deficit	Poor rapid naming Intact phonological	Low fluency-high word reading
Double deficit	Poor in both	Low fluency-low word reading

Note. Adapted from Wolf and Bowers (1999).

Results from a study conducted by Lovett, Steinbach, and Frijters (2000) were consistent with Wolf and Bower's (1999) proposed subtypes. The researchers conducted a post hoc analysis of scores from a sample of students with reading scores two standard deviations below normal (n = 166) and found that students could be grouped according to rapid naming and phonological scores. An ANOVA conducted on pretreatment scores indicated that the subjects differed in ability on measures of phonological awareness and rapid naming. A group of subjects (n = 31) had below-average phonological scores but average rapid-naming scores; other subjects (n = 33) had average phonological scores but below-average rapid naming scores; and some had below-average scores in both (n = 76). Differences in word-reading scores were also found, leading the researchers to propose that phonological awareness and rapid-naming skills could be used to categorize readers according to level of reading need.

Morris et al. (1998) offered additional support for categorizing students according to processing skill levels. Using assessment data on students identified with reading problems (n = 376), Morris et al. examined the possible identification of subtypes of poor readers. Cluster analyses yielded a total of seven subtypes of readers with shared characteristics. The subtype names represent weaknesses specific to each group. The global deficit subtype, for example, represents subjects with deficits in each of the areas assessed while the rate group represents the group with weakness in rapid naming. The seven subtypes are: (1) global deficit, (2) rate, (3) phonology-memory-lexical, (4) phonology-memory-spatial, (5) phonology-memory-rate, (6) phonology-rate, and (7) math-Attention Deficit Hyperactivity Disorder. Phonological processing weaknesses were present in all but rate and the math- ADHD group. The rate group had no phonological weakness but did exhibit difficulties on tasks that required processing speed.

Studies that examined reading subtypes provided additional data suggesting rapid naming was a separate construct (Katzir, Young, Wolf, Morris, & Lovett, 2008). The finding would have practical implications for instruction and remediation. Screening for difficulties in phonological and rapid-naming skills could be an effective way to identify struggling students and to begin designing interventions (Vellutino, Scanlon, & Lyon, 2000). For example, students with poor phonological skills would need direct instruction in phonological awareness but might not need fluency instruction. Slow but accurate word readers, on the other hand, might not need phonological instruction but would benefit from strategies that increase reading rate.

While the concept holds promise, the research supporting the construct of rapid naming as a separate entity and its role in reading has remained controversial (Vellutino et al., 2004). In a review of the literature on the role of rapid naming in reading and the relationship between rapid naming and phonological processing, Vukovic and Siegel (2006) concluded that studies have been inconsistent. Vukovic and Siegel noted variability across studies in terms of sample groups and definitions of what constituted a poor reader, were inconsistent. In addition, differences in methodology made it difficult to draw concise conclusions from the available studies. Vulovic and Siegel did conclude that data did not support rapid naming as having a primary and separate impact on reading. Instead, they found that the majority of studies reviewed found rapid naming to be a phonological variable.

Phonological Awareness

Wagner and Torgesen (1987) referred to phonological awareness as the awareness of the phonological structure of words that depended on the auditory ability to distinguish different levels of sound units. Sound units could vary in size, from representing a whole word to representing a syllable to representing the smallest unit of sound, a phoneme (Torgesen, 1987). Phonological awareness was found to follow an age-based developmental progression. Liberman, Shankweiler, Fischer**,** and Carter (1974) looked at the phonological skills of preliterate children and noted that skill development moved from syllable awareness to phoneme awareness, a progression that was found to occur across languages (Goswami, 2002). Manifestations of the developmental progression began with the ability to segment syllables by age 3; followed by onsets (initial consonant) and rimes (remaining vowel/consonant) by ages 4 to 5; followed by phonemes, the individual units of a sound, which developed concurrently with reading instruction (Anthony & Francis, 2005; Goswami, 2002). Age-based guidelines led to the development of tasks that could be used to assess phonological processing. These tasks included auditory discrimination, sound blending, segmenting, counting, sound deletion, sound substitution, and rhyming (Smith, Simmons, & Kameenui, 1995).

Poor readers were found to have difficulties with phonological tasks. Liberman, et al. (1989) recommended that students with poor phonological skills receive "intensive, direct, and systematic training in the phonological structure" (p. 27) of words. Lovett et al. (1994) were among the first researchers to examine the treatment effects of instructional programs on word reading and phonological skills. Their sample (n = 62) included students with a mean age of 9 who fell below the 25th percentile on a normed reading measure. The study examined the impact of two word identification instructional programs that differed in orientation from a control group. Students were randomly assigned to one of three groups.

Over the course of the study, each group received instruction four times a week for a total of 35 instructional hours, however, the content in each group varied. Group 1 received direct instruction in phonological and letter-word skills, group 2 received a strategy-based method for word identification, and group 3 (the control) received a study skills program. When compared to the control group, both treatment groups made gains on reading measures. A significant program effect was found for the group that received direct instruction in phonological skills ($F(2, 49) = 6.17$. $p < .004$), with univariate analyses indicating the effect was related to improvement on sound analysis and blending tasks, with respective effect sizes of .44 and .67.

Results from a longitudinal study designed to examine the impact of direct, intensive, individualized instruction on phonological and word reading skills also found that phonological and word-reading skills could be improved (Torgesen, et al., 1999).

Kindergarten students (n = 180) with scores below the 30th percentile on normed tasks of phonological, rapid-naming, and vocabulary skills, were selected to participate in a 2.5-year program. The program included four 20-minute sessions per week of individual instruction in phonological skill development for the duration of the program. The subjects (see Table 6), were assigned to one of four groups with equal numbers of students (n = 45) in each group.

Table 6

Description of Experimental Groups

Group 1	80% of instructional time allocated to direct instruction in phonological and word reading skills
Group 2	42% of instructional time allocated to direct instruction in phonological and word reading skills
Group 3	Regular classroom support
Group 4	No treatment control group

Torgesen et al., 1999.

A pretest was administered to students in the three treatment groups at the beginning of kindergarten. Reading and phonological skills were assessed over time. Assessments occurred at the end of kindergarten and at the beginning and end of first and second grades. A total of 138 subjects remained in the study by the end of second grade and these students had received an average of 88 instructional hours over the course of the study. Results indicated that students who received the most direct, time intensive instruction in phonological skills and word reading made the most gains ($p < .05$) in phonological and reading skills.

Foorman, Francis, Fletcher, Schatschneider, and Mehta (1998) looked at the impact of explicit instruction on phonological skills and word reading for a group ($n = 258$) of at-risk (defined as eligible for Title 1) first- and second-graders from an urban district. Subjects were assigned to four treatment groups that differed in instructional methods and content. Instruction was delivered 30 minutes a day, five days a week for the school year. To monitor progress, assessments that measured phonological and reading skills were conducted four times over the year. Using growth curve analyses, individual changes over time were analyzed. When age, ethnicity, and IQ were controlled, significant differences in growth were found among groups on phonological measures conducted at the end of the year. Results indicated that the students who received direct instruction in phonological skills had higher scores on reading measures compared to the subjects who received less explicit instruction ($F(1, 165) = 5.34$, $p = .022$).

Foorman et al. also found that while direct and individualized instruction improved phonological and reading skills, not all subjects responded to the intervention. In examining treatment effects across groups, the researchers found that 16% of the students in the group receiving the most direct and intensive instruction in phonological skills failed to make gains. The percentage suggested that even when instruction was appropriate, some students might not respond to the first attempt at intervention. Whiteley, Smith, and Conners (2007) found that 66% of subjects made gains in phonological skills after 15 weeks of treatment, but of this group, 16 out of the 43 students needed more time and more individualized instruction to make progress.

Torgesen (2000) referred to these students as treatment resisters and articulated a need for studies that explored differences in response to intervention.

Theories of Phonological and Temporal Auditory Processing

Much of the information about the relationship between phonological awareness and reading has been drawn from studies examining factors that interfere with reading acquisition. Phonological awareness has been found to differentiate good and poor readers (Wagner & Torgesen, 1987). This finding has been supported by numerous studies that have "led to a growing consensus that the most influential cause of difficulties in learning to read is the failure to acquire phonological awareness and skill in alphabetic coding" (Vellutino et al., 2004, p. 12). In fact, Shaywitz, Lyon, and Shaywitz (2006) indicated that phonological processing problems were the cause of most reading disabilities.

However, Chiappe, Stringer, Siegel, and Stanovich (2002) noted that research exploring etiologies specific to phonological processing problems continues to be debated. For example, Smith et al. (1995) consolidated pertinent findings from their review of research studies and proposed that phonological problems begin at the level of auditory perception: "If poor perception, then poor quality of representation or coding. If poor coding, then poor durability in storage. If poor durability in storage, then poor retrieval" (p. 7). While there is agreement that problems at the level of speech perception have been found to impact phonological skills (Mody, 2003; Goswami, 2002; Liberman et al., 1989; Tallal & Percy, 1973), discrete causal factors continue to be explored.

Paula Tallal, a neuropsychologist who has focused her research on the etiology of language impairments in children, has proposed that speech perception and subsequent phonological development are impacted by difficulties in processing rapid temporal information (Tallal & Piercy, 1973; Tallal, 2004). The primary theory underlying the current study, the temporal auditory processing theory, has emerged from research conducted by Tallal (2004). The theory suggests that slow temporal processing interferes with one's ability to make distinctions between sounds that occur in rapid succession. Difficulties at this level of speech perception have an impact on the development of phonemic representations and on the subsequent development of phonological and language skills (Tallal, Miller, Jenkins, & Merzenich, 1997). The intervention program used in this study, Fast ForWord, is based on the work of Tallal. Fast ForWord was designed to improve processing skills at the level of speech perception, which in turn would have a distal impact on phonological, language, and reading development.

Tallal (2004) expanded the phonological deficit theory with the hypothesis that phonological processing difficulties stem from poor phonological representations and these poor representations are caused by problems in temporal auditory processing. Auditory processing problems are referred to as difficulties at the level of perception and can be categorized according to skill level on tasks that assess auditory closure, auditory figure ground, auditory integration, and temporal processing. Temporal processing refers to the ability to integrate and sequence auditory signals (Moncrieff, 2004).

In an early study, Tallal and Piercy (1973) developed a battery of tests to assess auditory processing skills specific to detection, discrimination, sequencing, processing speed, and memory. They used these tests to compare the performance of language impaired students (n = 12) and a nonimpaired control group (n = 12). Results indicated that language-impaired students could detect, associate, and sequence sounds with the same accuracy as the control group when the rate of presentation was slowed. Rate of presentation, as described in the context of the study, referred to the length of the interstimulus interval (ISI) between tones presented to the subjects. The ISI is an interval or space between tones and is measured in milliseconds. The higher the ISI, the longer the interval. An ISI of 250 ms, for example would represent a longer duration between tones than a shorter ISI of 150 ms (Tallal & Piercy, 1973). The researchers concluded that performance differences emerged as the ISI became shorter in duration, a result that led to the hypothesis that some language-impaired children had deficits in the rate at which they processed sounds (Tallal et al., 1996).

Booth, Perfetti, MacWhinney, and Hunt (2000) reported a similar relationship between performance on auditory tasks and the duration of the ISI in two studies**:** one sample with children (n = 35) and one sample with adults (n = 32). In both studies, the subjects were asked to listen to a series of two to three tones and repeat the series back to the experimenter. An ANOVA indicated a significant effect for tone ISI for children (F $(1, 279) = 8.70$, $p < .01$) and adults (F $(1, 255) = 8.33$, $p < .01$). The findings indicated that when the interval between each tone was increased, both children and adults repeated the series more accurately.

Although performance differences on auditory tasks were found, research that examined the impact of processing speed on reading tasks were not as conclusive. Chiappe et al. (2002) designed a study that examined the relationship between temporal processing, phonological processing, and reading. Sample groups included adults who were poor readers (n = 30), adults who were average readers (n = 32), and children who were average readers (n = 31). Participants were asked to listen to two syllables and indicate the order in which they were presented. The ISI varied for each series. Results indicated no difference between adult poor readers, adult normal readers, and reading level controls (children) on the auditory processing tasks. Results from the study did indicate that the adult poor readers had lower scores on phonological tasks ($F(2, 90) = 30.00$ $p < .001$) than adult normal readers.

Tallal (1980) examined the correlation between auditory temporal processing and reading in a study with learning disabled students ($n = 20$) and a normal control group ($n = 12$), between the ages of 8 to 12. Tallal looked at the effect of ISI on their ability to discriminate and sequence tones and explored the relationship between processing and reading. Results from a rank-ordered correlation ($R = .81$) indicated that the more difficulty a child had in responding to rapidly presented information, the more trouble he or she had reading nonsense words.

Tallal hypothesized that the difficulty was related to a lag time of milliseconds that interfered with the ability to process what are referred to as stop consonants. Tallal said, “for example, in the syllables /ba/ and /da/, the only differentiating cues occur within the initial 40-msec formant transition” (Tallal, 2004, p. 722). Difficulty distinguishing sounds at this level would lead to phonemic representations that were inaccurate, which in turn would impact the development of phonological skills.

Marshall, Snowling, and Bailey (2001) noted and addressed the need for studies that explored the relationship between rapid auditory processing and phonological awareness. They designed a study with students between ages 6 to 13 ($n = 82$) that examined the relationship between the performance on a rapid auditory processing task and the performance on phonological tasks. Pretest evaluations indicated average cognitive and reading scores for students across age ranges. A test similar to Tallal's assessment was used to assess auditory processing. Results indicated a significant effect for age across both phonological and rapid auditory tasks, suggesting a developmental progression for both variables. Significant correlations ($p < .01$) between rapid auditory processing and phonological scores on rhyme ($r = .57$), phoneme deletion ($r = .39$), and nonword reading ($r = .42$) were also found**;** and these results suggested a relationship between phonological awareness and auditory processing.

In a second study, Marshall et al. (2001) restricted the sample to dyslexic students ($n = 17$). The same outcome measures were used (the auditory processing task and phonological tasks) but results indicated that the dyslexic group had low scores on the phonological measures but not on the rapid auditory tasks. The finding challenged Tallal's assumption of a relationship between phonological difficulties and rapid auditory processing. Tallal's theory had also been challenged by other studies that found no evidence of a correlation between rapid auditory processing skills, phonological skills, and reading (Mody, Studdert-Kennedy**,** & Brady, 1997; Nittrouer, as cited in Marshall et al., 2001). In addition, Tallal's hypothesis generated controversy among researchers who suggested that difficulties in language were not related to temporal processing issues but rather to phonological/linguistic issues (Gillam, 1999). Vellutino et al. (2004), in a review of studies related to Tallal's theory, noted limited support for a relationship between temporal processing and phonological weaknesses.

Although the relationship between temporal auditory processing and phonological skills continued to be debated, Tallal's theory led to the development of Fast ForWord, a program designed primarily to improve temporal auditory processing speed. Tallal reasoned that improved temporal auditory skills would extend to secondary gains in general language and reading skills.

Fast ForWord

Fast ForWord was designed to improve the temporal auditory processing skills suspected to underlie phonological problems and was developed at Scientific Learning, a corporation formed by Tallal and colleagues Merzenick, Miller, and Jenkins in 1996 (Scientific Learning Corporation [SLC], 2009).

Tallal (2004) hypothesized that phonological problems occurred at the level of phonemic representation, and problems with phonemic representation occurred at the level of speech perception. Tallal suggested that difficulties at the level of speech perception stemmed from an inability to process rapid and successive sounds accurately. Inaccurate perceptions at the sound level created imprecise representations at the phonemic level, which interfered with phonological representations. Fast ForWord addresses problems at the level of speech perception.

It does this via a computer-generated algorithm that produces levels of speech that are acoustically modified to slow and enhance auditory stimuli (Nagarajan et al., 1998). Each exercise consists of speech sounds and tones that are modified. The modified speech is embedded in the exercises and, as the subjects progress through the levels within each exercise, the rate of sound presentation gradually increases until the presentation reaches the level of normal speech. The modified speech alters and slows the presentation of sounds that occur in rapid succession.

According to Tallal's theory, decreasing the speed at which sounds are presented allows those subjects who have temporal processing problems to access these sounds accurately and more efficiently. Exposure and repetition are thought to result in the formation of more accurate phonemic representations. Progress through these levels assumes an increased ability to process speech sounds more efficiently (Tallal et al., 1996). The exercises also incorporate a point system and on-screen animations to maintain interest.

One goal of the program is to maintain a level of play that is challenging but not frustrating. The computer alters the rate of speech presentation according to individual student responses. The adaptive feature allows for an individualized program for each student. A predetermined number of correct responses, for example, result**s** in a more challenging level of speech presentation. The goal is to move through the acoustically modified levels of speech until reaching the level at which speech is presented in a normal, unmodified format (SLC, 2009).

Adherence to the program protocol is considered essential and requires daily play five days a week. The intensity and frequency of play is developed to ensure optimal learning. To facilitate implementation in school settings, five different protocols that vary in length of time per day and projected number of weeks needed for completion are offered (SCL, 2009).

The product line includes different programs that cross age and skill levels. Fast ForWord Language is used in the current study and consists of two programs, each with two levels. One program is for elementary students (Language, version 2, and Language to Reading) and the other is for middle to high school students (Literacy and Literacy Advanced). The only difference**s** between the programs are graphic presentations and age- based language content (Professional Development Training Workbook, 2007).

The elementary version consisted of seven exercises designed to target specific skills: four involved sound presentations and three involved word/sentence presentations. The middle to high school version consisted of six exercises: three sound-based and three language-based. Both versions targeted specific skills, including phonological fluency and memory, auditory sequencing, listening, following directions, vocabulary, and grammar and syntax. Cognitive skills developed across games included auditory processing, working memory, sequencing, and sustained attention (Professional Development Training Workbook, 2007).

Scientific Learning provided a data tracker that would outline attendance, compliance, and completion. Daily attendance could be recorded as could time of play for each exercise. The compliance measure provided a way to assess adherence to the protocol. It was calculated by dividing the number of minutes a subject trained by the number of minutes of required training. An 80% compliance rate, for example, would indicate that the student missed a day. Completion rates for each exercise were also provided. Completion corresponded to the level of speech presentation, the goal being to reach the level of normal speech. Normal speech was introduced once a student progresses through 80% or more of the levels in each exercise. Compliance and completion rate was important in that treatment benefits were assumed to be incremental depending on the amount and level of exposure to the speech presentations.

Scientific Learning had collected data supporting efficacy from private providers and schools, but efficacy claims had been controversial due to the lack of independent, peer-reviewed studies (Veale, 1999). A search of the literature produced 10 independent published studies; of these, five were described by the authors as randomized control studies. A comprehensive review of those independent, randomized control studies follows with references made to the other studies.

Rouse and Kruger (2004) conducted a school-based study that examined the impact of Fast ForWord on language and reading outcomes. The sample (n = 374) included students in Grades 3 through 6 from four schools in an urban district. The selection criteria included a score at or below the 20th percentile on the state test of reading**,** and input from building principals regarding availability. The description of the randomization procedure suggested random assignment to group within each grade in each school (total of treatment n = 197 and control n = 177). The authors noted that variations between grades and school were addressed with randomization blocks.

Outcome measures included a computerized reading assessment called the Reading Edge that had been purchased by Scientific Learning to serve as a built-in pre- and posttest option for the program. The authors reported limited to no validity or reliability studies for the instrument. The Clinical Evaluation of Language Fundamentals, Third Edition, was used to measure language skills but given the time requirements to administer, the measure was administered to a random sample (n = 70) of treatment and control students in Grade 4. Whether or not the sample represented the group of fourth graders across the four schools or was specific to one school was not described. The third and fourth outcome measures included assessments that were routinely given by classroom teachers every eight weeks as part of the Success for All program and results from a standardized test used by the state to monitor progress**,** respectively. Results indicated no significant difference between treatment and control groups on any of the outcome measures, but the authors did note problems with program compliance and completion (between 38% and 51% of the students completed the program).

Borman, Benson, and Overman (2009) also designed a school-based study that examined the impact of Fast ForWord on the reading skills of an at-risk population in an urban setting. The purpose of the study was to examine efficacy and treatment effects for students with varying degrees of reading difficulty. A secondary purpose was to examine rate of compliance in a school setting and the impact on treatment effects.

The sample (n = 415) was drawn from a group of students in Grade 2 and Grade 7 from eight different schools who had scores at or below the 16th percentile on a nationally normed test used by the district. Random assignment to group was made within each grade level within each school and resulted in 11 randomization blocks. Within each block, students were randomly assigned to either treatment (n = 210) or control (n = 205) groups.

The outcome measures used to compare groups included the Comprehensive Test of Basic Skills, Fifth Edition, (Borman, Benson, & Overman, 2009) a test used by the district to assess language and reading skills**,** and a teacher survey. The test had been administered to district students just prior to treatment. Those students participating in the study were reassessed with a different form after the treatment was completed. The authors described the test as a valid and reliable reading achievement test. A preliminary data analysis resulted in the removal of 32 cases. These cases included outliers and cases that were deemed unreliable because of unusual pretest to posttest changes. Regression models were used to examine the effects and interactions of treatment, program compliance, and the level of pretest skill. Results indicated that for second graders, there was no difference between groups on language or reading measures. The results for seventh-grade students indicated significant main effects of treatment for reading ($p < .05$) that were equivalent to an effect size of $d = 0.21$.

Compliance data indicated that program attendance ranged from 98% to 100% across second- and seventh-grade groups, and 76% to 77% of the subjects spent the expected amount of time on each exercise per day. Completion rates, however, indicated that only 30% of the second graders completed the expected number of levels within each game compared to 72% of the seventh graders. Total program completion criteria, which included attendance, compliance, and completion, indicated that 23% of the second graders and 43% of the seventh graders met program completion criteria. An investigation of the impact of program completion on treatment effects revealed statistically significant effects ($p < .05$) of program completion on reading comprehension for the seventh grade group, with an effect size of $d = .50$.

In a randomized study, Cohen, Hodson, and O'Hare (2005) examined the impact of Fast ForWord and an educational computer software program on phonological, language and reading skills of students ($n = 55$) described as severely language impaired. The study differed from the previously described studies in that Fast ForWord was delivered in a home-based model under parental supervision. Students were randomly assigned to one of three groups: Fast ForWord, computer software, or control. Outcome measures included subtests from two standardized language instruments, a phonological instrument, and a word-reading assessment. Evaluations were administered before treatment, after treatment, and at a six-month follow-up. The ANOVA results used to examine the impact of group on posttest scores were not significant for either language measure but did indicate a significant interaction for the phonological task of rhyming (p = .007). Further analysis revealed that the Fast ForWord group had a higher score at six months than the computer group (p = .02) and the control group (p = .02). Cohen et al. also examined the impact of program compliance and found no relationship between the number of days played and the number of minutes played each day. Cohen et al. did not provide information relative to completion rate (the level completed within each game) for subjects.

Porkoni, Worthington, and Jamison (2004) also designed a randomized study (n = 60) drawing from a population of language-impaired students. Students were assigned to one of three groups: Fast ForWord, Earobics, or Lindamood Auditory Discrimination in Depth. Outcome measures included the Comprehensive Evaluation of Language Fundamentals and two word-reading measures from the Woodcock Johnson Test of Reading. Results indicated that Fast ForWord had no impact on treatment outcomes across measures. The authors included a discussion about general treatment impacts, noting that posttest scores continued to reflect deficits. Pretest language scaled scores for subjects in this sample ranged from 63 to 69 (scores of 100 are in the 50^{th} percentile), and the authors suggested that these students may have represented what Torgesen (2000) referred to as treatment resisters. The authors did not provide data specific to program completion; however, when describing study limitations, the authors noted that “the intervention period was short and precluded most students from reaching criteria for games” (p. 156).

In another comparison study, Gillam et al. (2008) recruited 216 language-impaired students from nine districts and randomly assigned subjects to one of four groups: Fast ForWord, Earobic, Individualized Speech, and a condition that served as a control. Outcome measures included the Comprehensive Assessment of Spoken Language, selected subtests from the Comprehensive Test of Phonological Processing, and an auditory processing task. Evaluations were conducted after program completion, after three months, and after six months. Results indicated a significant effect for time across all conditions but no significance between groups. There was a significant effect size (.79) for Fast ForWord subjects at six months for one subtest, blending words, a task that requires phonemic synthesis. No differences were found between groups on the auditory processing task.

Significant gains in post-treatment scores on phonological measures were also found in a study conducted by Gaab, Gabrieli, Deutsch, Tallal, and Temple (2007). A sample of dyslexic ($n = 22$) and typical readers ($n = 23$) were evaluated using a standard battery of tests. Results indicated a significant increase between pretest and posttest scores for the treatment group on the phonological awareness ($p <. 01$), phonological memory ($p < .005$), and rapid naming ($p < .005$) scores on the Comprehensive Test of Phonological Processing. Results for the control group on these same measures were not significant ($p > 0.1$). Significant gains were also noted on a nonword reading measure ($p < .0001$) and language scores ($p < .005$).

While not a randomized study, Troia's work (2004) looked at the impact of Fast ForWord on the language and reading skills of migrant students ($n = 191$) with limited English. He looked at differences within the treatment group and found large effect sizes for oral expression (ES = .87) and word reading (ES = 1.03) for those students who fell below the 25^{th} percentile on an English language assessment.

Summary

Word reading and comprehension are key to reading (Torgesen, 2002). Word reading is found to predict comprehension (Berninger et al., 2006). Phonological processing has been found to have a causal relationship to reading (Wagner & Torgesen, 1987) and studies have indicated that phonological skills can be improved when instructional conditions are direct, explicit, and individualized.

The phonological deficit theory suggested that the majority of struggling readers have weaknesses in phonological skills and Tallal hypothesized that these weaknesses were due to problems in temporal auditory processing. Based on this hypothesis, Tallal developed Fast ForWord. The program was primarily designed to improve temporal auditory processing**,** which would have distal effects on phonological, language**,** and reading skills. The theory and the efficacy of the program have been disputed (Gillam, 1999) and both warrant further studies.

The purpose of the current study is to examine the impact of Fast ForWord on outcome measures specific to phonological processing. To date, there have been no independent, published studies that specifically targeted the processing skills of phonological awareness and rapid naming. In an effort to address limitations of the efficacy studies to date, this study also examined the relationship between program completion and outcome measures.

The study also examined whether or not scores from a state reading test, in combination with program completion, would predict treatment outcomes. Torgesen (2006) suggested the need for studies that examined treatment effects using outcome measures that are similar to the standardized tests that states use to measure progress. He argued that outcome measures used in research tended to include standardized reading measures that differ in format from state level tests that measure comprehension. From a practical standpoint, educators are interested in outcomes measures that are tied to school and district goals. While this study did not use a state-level test as an outcome measure, the study did use data from a state test as a method of identifying at-risk students. Examining the nature of the relationship between the outcomes measures and students' scores on the state test might provide information that could be used in student selection. The current study, therefore, examined the impact Fast ForWord had on the phonological and rapid naming skills of at-risk students who failed to reach proficiency on the state reading assessment.

CHAPTER THREE: METHODOLOGY

The following sections describe the premises and procedures for conducting this study. The research questions and hypotheses are presented. In addition, the research design and method of analysis are described, as are descriptions of the setting, participants, and research procedures. Overviews of the data collection and analysis are also included.

Research Questions

The following questions are addressed in this study:

1. Is there a significant difference in phonological awareness and rapid naming skills between students who participate in the Fast ForWord intervention and those who do not?
2. To what extent and in what manner can variation in the phonological awareness composite posttest scores be explained by the percentage of completion of the Fast ForWord program and scaled scores on the Connecticut Mastery Test in Reading?
3. To what extent and in what manner can variation in the rapid naming posttest scores be explained by the percentage of completion of the Fast ForWord program and scaled scores on the Connecticut Mastery Test (CMT) in Reading?

Hypotheses

1. Students participating in the Fast ForWord program intervention will have significantly higher scores in phonological awareness and rapid naming skills than those in the control group.
2. Fast ForWord program completion and scaled scores on the Connecticut Mastery Test in Reading will significantly explain the manner and variation in phonological awareness composite posttest scores.
3. Fast ForWord program completion and scaled scores on the Connecticut Mastery Test in Reading will significantly explain the manner and variation in rapid naming composite posttest scores.

Research Design

This study employed two quantitative research designs. The first design used for research question 1 was a randomized pretest and posttest design used in the analysis of posttreatment differences between groups. The independent variable in this design was the type of instructional program with two levels: Fast ForWord treatment and the regular curriculum. The dependent variables were phonological awareness and rapid naming. These variables were assessed with the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999).

The second research design was a multiple regression correlation design, used for questions 2 and 3, to explain the variation in posttest phonological awareness and rapid naming scores. The criterion variable for research question 2 was the posttest phonological-awareness composite score. The predictors were the scaled scores on the Connecticut Mastery Test in Reading and percentage of completion of the Fast ForWord program. The criterion variable for research question 3 was the posttest rapid naming composite score. The predictors were the scaled scores on the Connecticut Mastery Test in Reading and percentage of completion of the Fast ForWord program.

Data Analysis

In analyzing the first research question, a MANOVA was employed to assess the effect of the independent variable on the two dependent variables. The independent variable was the type of program, with two levels: Fast ForWord treatment and no-treatment instruction. The dependent variables included phonological awareness and rapid naming. Scaled scores for these variables were obtained using the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999).

To answer research questions 2 and 3, a regression procedure was performed with the Connecticut Mastery Reading Test scaled scores and the percentage of completion of Fast ForWord as predictors. The focus was to examine the degree and manner in which these variables impacted the outcome measures of phonological processing (question 2) and rapid naming (question 3). The Statistical Package for the Social *Sciences, Version 13.0* (Nie, 1968) package was utilized for the MANOVA and the multiple regression analysis of the results.

Participants

Setting. The study was conducted in a city in the Northeast with a population of approximately 136,405 people. This racially diverse community had a median income of about $44,000 a year with a cost of living estimate higher than the national average (www.city.data.com). Data from the 2007-2008 profile produced by the Connecticut

State Board of Education indicated that the school system consisted of 13 elementary schools, three comprehensive high schools, and three alternative high schools.

The schools within this district were considered as possible research sites for the following reasons: they were urban, they had been identified by the state as being in need of improvement, and one elementary school had been using Fast ForWord as an intervention for students who had not meet the proficiency goal on the state reading test for a few months.

The target school was selected based on a recommendation from the district office. The elementary school had been designated in need of improvement but had met the state's annual yearly progress goals in the 2007-2008 school year. The target school had a population of 456 students in kindergarten through Grade 8 and a teaching staff of 30. Seventy-eight percent of staff members held masters degrees or higher and had an average of nine years of teaching experience. Demographics of the student population by school, district, and state are presented in Table 7 and highlight the differences between this urban district and its surrounding counterparts in the state

Table 7

Demographics of Student Population by School, District, and State

Racial/ethnic status	State	District	School
Asian	4%	3%	1%
Black	13%	41%	39%
Hispanic	16%	46%	47%
White	65%	9%	11%
Total Minority	35%	91%	88%
Free and Reduced Lunch	29%	>95%	95%

Connecticut State Board of Education, Strategic School Profile 2007-2008.

The principal was interested in implementing a program in the building for the students who continued to fall below the state proficiency goal, and the principal had approached the district about the possibility of implementing Fast ForWord. The researcher met with the building principal and teacher representatives to review the requirements of the study. The requirements included the following: the selected students would participate in the program five days a week for 50 minutes a day for a total of 10 to 12 weeks; teachers would supervise the students and manage data; and students would be available for pre- and posttest sessions. The researcher agreed to provide training for the teachers who would be supervising the students and to be on-site to provide support twice a week. The team agreed to participate and final approval was granted at the district level.

Selection of participants. The target population for this study was students who were considered at-risk because they had failed to achieve proficiency on the Connecticut

Mastery Test in Reading, a state-wide, criterion-referenced test. The Connecticut Mastery Test is administered once a year to all public school students in grades 3 through 8 during a predetermined week in the spring. The target population (N = 78) in the selected school consisted of students who had scaled scores that fell in the basic or below-basic category on the Connecticut Mastery Test in Reading, administered in March, 2008. The principal produced a list of students who met the criteria. At the time of the study (January, 2009), these students were in Grades 4 through 8.

Once the target group was identified, the researcher provided the principal with a letter of explanation of the study and a permission slip to be distributed to the parents of the target group (Appendix C). The building principal dispersed these letters to the teachers, who sent them home with each student. The letter indicated that permission slips should be returned to the classroom teacher by a specified date. In an attempt to ensure that all students had the opportunity to participate, the literacy coach and the principal contacted the parents of the students who had not returned slips by the deadline to confirm their decision. A total of 56 permission slips were secured and the sample group was identified. Grade, age, and gender demographics are provided in Table 8.

Table 8

Grade, Average Age, and Gender of Sample Group

Grade	Population	Sample	Average age	Male	Female
4	19	18	9	9	9
5	10	11	10	5	6
6	15	7	12	4	3
7	9	1	13	0	1
8	25	19	13	13	6
Total	78	56	11	31	25

Sample demographics. The ethnic and socioeconomic representation of the sample, outlined in Table 9, mirrored the total school and district population but not the state population. CMT reading scores were as follows: 36% of the students in the sample had scores at the basic level and 64% of the students had scores at the below-basic level.

Table 9

Demographics of Sample by Group

Racial/SES status	State	District	School	Sample
Asian	4%	3%	1%	2%
Black	13%	41%	39%	33%
Hispanic	16%	46%	47%	56%
White	65%	9%	11%	9%
Total minority	35%	91%	88%	93%
Free and reduced lunch	29%	>95%	95%	95%

Connecticut State Board of Education, *Strategic School Profile, 2007-2008.*

Instrumentation

The Comprehensive Test of Phonological Processing

Description of format and scoring. The Comprehensive Test of Phonological Processing (CTOPP) is a standardized, individually administered instrument designed to assess phonological awareness, memory, and rapid naming skills for subjects between the ages of 5 and 24 (Wagner et al., 1999). The instrument is divided into two versions: one for students between the ages of 5 and 6; the other, for students between the ages 7 and 24. The second version was used in this study. The Comprehensive Test of Phonological Processing contains six core subtests and six supplemental tests. The six core subtests are combined to form three composite scores that represent phonological awareness, phonological memory, and rapid naming. Composite scores for phonological awareness, phonological memory, and rapid naming yield standard scores (M = 100, SD = 15) as do each subscale (M = 10, SD = 3). Tables 10, 11, and 12 provide a description for each composite score and associated subscales.

Table 10

Comprehensive Test of Phonological Awareness: Phonological Awareness

Composite/subscale	Description
Phonological awareness	The ability to understand and access the sound structure of language
Elision	20-item task that requires subject to listen to word, repeat word, delete designated sound, and then to repeat word again without the sound
Blending words	20-item task that that requires subject to listen to recorded, separate sounds and then to put the sounds together to form a word

Wagner, Torgesen, & Rashotte, 1999.

Table 11

Comprehensive Test of Phonological Processing: Phonological Memory

Composite/subscale	Description
Phonological memory	Ability to store phonological information in short-term memory
Memory for digits	21-item task that requires subject to listen to recorded series of digits that increase in length (from two to eight digits), and then to repeat them back verbatim
Nonword repetition	18-item task that requires subject to listen to recorded nonwords, presented one at a time, that increase in length (from three to 15 sounds), and then to repeat them back

Wagner, Torgesen, & Rashotte, 1999.

Table 12

Comprehensive Test of Phonological Processing: Rapid Naming

Composite/subscale	Description
Rapid naming	Ability to efficiently retrieve phonological information from memory
Rapid digit naming	72-item timed task that requires subject to read a page of single digits and randomly arranged them in rows on a page. The task requires that subject read two separate pages. The total time for reading both pages is recorded.
Rapid letter naming	72-item, timed task that requires subject to read a page of six single letters randomly arranged in rows on a page. The task requires that subject read two separate pages.

Wagner, Torgesen, & Rashotte, 1999.

Wagner, Torgesen, and Rashotte (1999) provided results from a confirmatory factor analysis that indicated a strong correlation between phonological awareness and phonological memory ($r = .85$) and a moderate correlation for phonological awareness, and rapid naming ($r = .38$). For this study, two multivariate designs were used and data analysis for both is most robust when variables are moderately but not strongly correlated (Meyers, Gamst, & Guarino, 2006). The decision to eliminate phonological memory was made on the basis of the statistical requirements of the data analysis. The current study, therefore, examined only the variables of phonological awareness and rapid naming.

Validity and reliability. The validity and reliability of the Comprehensive Test of Phonological Processing was established by a normative sample that included 1,656 students, which was representative of national demographics. The age range was 5 through 24 years, with even representation of males and females. Urban students represented the majority of the sample, and racial and socioeconomic factors mirrored the general population (Wagner et al., 1999). Information pertaining to validity and reliability was obtained in a review published in the Mental Measurement Yearbook (2004). The review indicated the following: internal consistency was measured using Cronbach's coefficient alpha, with alpha scores ranging from .83 to .95 on the composite scores; test-retest reliability was reported as adequate with mean correlation coefficients that ranged from .79 to .82 depending on age; and content and criterion related validity was described as well-established (Mental Measurement Yearbook, 2004).

The Connecticut Mastery Test

Description of format and scoring. The Connecticut Mastery Test is a criterion–referenced test designed to measure student performance across subject areas based on state-wide curriculum goals and objectives. The test is administered yearly in Grades 3 through 8. Student performance in reading, math, writing, and science is measured against the Connecticut Curriculum Frameworks (Hendrawan & Wibowo, 2008). This research focuses on scaled scores from the reading test, so only this subtest will be reviewed.

The reading test is made up of two separate subtests: Degrees of Reading Power (DRP) and Reading Comprehension. Separate tests for both the DRP and Reading Comprehension are constructed for each grade level. The DRP incorporates a cloze procedure format that measures comprehension on passages that increase in difficulty. The DRP tests for Grades 3 and 4 include 42 items, and the DRP tests for Grades 5 through 8 include 49 items (Hendrawan & Wibowo, 2008). The reading comprehension test incorporates multiple-choice and open-ended questions. Reading ability specific to four strands is reported**;** these strands include general comprehension, interpretation, inference, and structure (*Connecticut Mastery Test, Fourth Generation, Language Arts Handbook*, 2008).

The reading score is made up of raw scores from the DRP and the Reading Comprehension test, with each contributing 50% to the total score. The DRP responses are converted to a raw score**,** and the reading comprehension raw score is converted to a weighted raw score. Conversion tables for both instruments are available in the CMT technical bulletin (Connecticut State Department of Education, Bureau of Student Assessment, 2008). The CMT raw scores are converted to scaled scores that range from 100 to 400 with corresponding performance and descriptive categories. The descriptive categories are the same across grade levels, but the scaled scores vary from grade to grade. Scaled scores can be used to compare grade-level content areas but cannot be compared across content areas or grade levels. An example of the association between scaled scores, category**,** and reading ability for grade 3 is outlined in Table 13.

Table 13

Connecticut Mastery Test Interpretations for Grade 3 Reading Scores

Level	Category	Scaled score	Grade-level reading ability
1	Below basic	100-201	Very limited
2	Basic	202-216	Limited
3	Proficient	217-234	Adequate
4	Goal	235-278	Consistent
5	Advanced	279-400	Exceptional

Note. Taken from the *CMT Interpretive Guide*, Connecticut State Board of Education, 2008.

Validity and reliability. *The Connecticut Mastery Test: Technical Report* (Hendrawan & Wibowo, 2008) indicates that teacher surveys and a content review process were used to examine content validity in 1984, 1985, and 2000. The content validity of the CMT fourth generation test was examined by an external reviewer, Assessment and Evaluation Concepts, Inc. The authors report that the external reviewer found test items were aligned with the content strands outlined in the Connecticut Frameworks and indicated that concurrent validity was established through correlations with the Metropolitan Achievement Test in 1993 and 2000. However, Hendrawan and Wibowo (2008) did not include the values for the correlations in the technical report. Internal consistency for the reading test across Grades 3 through 8 was measured using Cronbach's coefficient alpha, with alpha scores ranging from .94 to .95.(Hendrawan & Wibowo, 2008).

Procedures

The sample selection process, as outlined in a previous section, resulted in a sample (n = 56) population that represented students who had failed to meet the proficiency goal on the state reading test. This study used a randomized pretest and posttest design for research question 1 and a multiple regression design for research questions 2 and 3. Implementation procedures are described in the following section.

Pretest and Posttest Battery

The pretest and posttest battery used in the first design consisted of one instrument, The Comprehensive Test of Phonological Processing. Four subtests from the instrument were used (elision, blending words, rapid-letter naming and rapid digit-naming) to generate composite scaled scores. The phonological awareness composite scaled score consisted of elision and blending words. The rapid naming composite score consisted of rapid digit naming and rapid letter-naming.

Materials. Permission to use The Comprehensive Test of Phonological Processing was secured from PRO-ED (http://www.proedinc.com). PRO-Ed provided a test kit free of charge for research purposes, and the kit included one package of 25 protocols. A total of 112 protocols (two per student) were needed for pre- and posttesting. Four additional packages of 25 protocols were purchased and supplied to teachers by the researcher. Student names, dates of birth, and ages were recorded on each protocol previous to evaluation. Additional required materials included a stereo cassette player and a stopwatch for each test administrator, both of which were available at the school.

Test administration. A group consisting of one school psychologist, one speech pathologist, and one special-education teacher volunteered to administer the pretest to each of the 56 students in the sample. Each test administrator was familiar with the instrument and had prior experience administering the test. To ensure examiner consistency, the researcher reviewed the standardization procedures as outlined in the manual with the group of test administrators previous to pretesting. Each test was individually administered.

Each test administrator was assigned a specific group of students across grades**,** but the number of assigned students varied from 15 to 25, given the time constraints of the test administrators. In an effort to alleviate conflicts with lunch, specials, and recess, the testing schedule was arranged in collaboration with the principal to coincide with the daily school schedule. Pretesting was completed over two consecutive days in January and posttesting was completed in May.

Random Assignment

Assignment to group was determined after pretesting was completed. To ensure an equal representation of Connecticut Mastery Test in Reading scores across both treatment and control groups, a stratified random assignment procedure was used. Students with scaled scores that fell in the below basic level (n = 36) were assigned to either treatment or control groups using a computerized random table of numbers. The same procedure was used for students with scaled scores that fell in the basic level (n = 20). Each group mirrored the CMT levels represented in the sample and consisted of a total of 28 students per group (see Table 14).

Table 14

CMT Level Representation across Treatment and Control Groups

CMT level	Treatment	Control
Below basic	18	18
Basic	10	10
Total	28	28

Sample Demographics

Program Schedule

Once the treatment group was identified, the principal and the literacy coach determined the schedule for the treatment protocol. A number of factors were considered when scheduling for the program. The schedule needed to accommodate multiple grade schedules**;** the media center needed to be used exclusively for the program during the assigned time block**;** and reading, math, and language-arts classes could not be interrupted. It was determined that the last time block of the day, from 2 to 3 p.m., would best meet the criteria.

Depending on their grade level, the students who participated in the Fast ForWord Program missed science, social studies, or a non-academic class five days a week. Students in the control group followed their normal schedule. A tentative start date in January was planned. The Fast ForWord software needed to be installed on the school server so the principal emailed the program requirements to the technology department. The principal also notified the teachers of the students in the treatment group about the tentative plan. The principal met with the students in the control group and explained that they would have the opportunity to participate in the program either in the spring or the fall of the following year.

Teacher training. Training for the implementation and monitoring of the Fast ForWord program was conducted by the primary researcher and two representatives from Scientific Learning. The first training session was conducted by the researcher and included all members of the special-education staff, the literacy coach, and two educational assistants. The session was conducted to introduce the study, provide an overview of the program, and review implementation procedures. Each participant was provided with a manual published by Scientific Learning that provided explicit instructions for implementing the program and monitoring student progress.

After this initial introductory training session, the principal assigned three special-education teachers, the literacy coach, and the two educational assistants to supervise and coach the students. In a supervisory capacity, these teachers were expected to monitor attendance, ensure that the computers and headphones were working, and facilitate a quiet working environment during the treatment. In a coaching capacity, these teachers were expected to monitor individual compliance and provide positive feedback to students.

A representative from Scientific Learning provided one additional training session for these teachers during the first week of the program. The purpose of this session was to answer questions and model coaching techniques. Additional support was offered by the primary researcher twice a week, on-site, for the duration of the program. This researcher had both experience with and knowledge of program implementation procedures and requirements.

Treatment implementation. The Fast ForWord program consists of a series of programs that can be used with elementary and with middle and high school students. In order to address developmental differences, there is one series for elementary students: Language, followed by Language to Reading, and one series for middle and high students: Literacy, followed by Literacy Advanced. The series differ in graphic presentation and language content.

The two programs in each series are designed to be used either independently or sequentially. Scientific Learning provided access to both programs for the duration of the study. Each program required an approximate 10 to 12 week time commitment. Given that the current study began in January and ended in May, it was the intent of the researcher that the students complete the first program in each series; The Language program for the younger students and the Literacy program for the older students. If, during the course of the study, students reached the 80% completion level established by Scientific Learning, the student had the option of switching to the second program. The Fast ForWord Program was delivered 50 minutes a day, five days a week, over a 12-week period. An overview of the elementary sequence, exercise, and associated skill set is provided in Table 15. An overview of the middle/high school sequence, exercise, and associated skill set is provided in Table 16.

Table 15

Elementary Sequence: Language and Language to Reading

Language: exercises and skills	Language to reading: exercises and skills
Sky gym: auditory sequence	Jumper gym: sequencing
Moon ranch: fluency, memory	Paint match: memory
Hoop nut: fluency, memory	Polar planet: word analysis
Whalien match: word recognition	Tomb trek: word analysis
Robo-Dog: vocabulary	Cosmic reader: comprehension
Ele-bot: language conventions	
Space commander: following directions	

Note: Taken from *Professional Development: Training Workbook* (2007).

Table 16

Middle/High Sequence: Literacy and Literacy Advanced

Literacy: exercises and skills	Literacy advanced: exercises and skills
Space racer: auditory sequence	Meteor ball: word analysis
Galaxy goal: fluency, memory	Laser match: word analysis
Spin master: fluency, memory	Sky rider: organization
Lunar tunes: word recognition	Lunar leap: phonological awareness
Stellar stories: language conventions	Galaxy theater: comprehension
Star pics: word recognition	
Space commander: following directions	

Note: Adapted from *Professional Development: Training Workbook* (2007).

Students in Grades 4 and 5 began with the language program. If students completed 80% of the levels in the majority of exercises in the language program, they were switched to the language-to-reading program. Students in Grades 6, 7, and 8 began with the literacy program. If students completed at least 80% of the levels in the majority of these exercises, they were switched to the literacy advanced program.

The program began the first week in February and continued through April. Taking winter and spring vacation weeks into consideration, a total of 50 possible sessions (10 weeks) were calculated. Adherence to the five-day-a-week protocol was difficult to maintain given snow days, half-day sessions, and unforeseen circumstances (fire drills and computer difficulties, for examples). In all, a total of 37 sessions were held. The students in Grades 4 and 5 attended an average of 34 sessions, with a range from 29 to 37 days. The students in Grades 6, 7, and 8 attended an average of 30 sessions with a range from 21 to 37 days.

Statement of Ethics and Confidentiality

A proposal for this study was submitted and accepted by the Western Connecticut State University Internal Review Board (Appendix E). A letter of permission from the building principal (Appendix B) and the deputy superintendent (Appendix A) outlining rationale, procedures, and a timeline was secured. Scientific Learning had agreed to fund the study as a pilot program for the school. Participation and input from the company was limited to a two-hour training workshop for the teachers selected to supervise the students.

Permission to participate in this study was provided by parents/guardians of all students selected for the sample. Informed consent forms were sent to the parents/guardians of the participants (Appendix C) selected for the study and only those participants with signed consent participated. To maintain confidentiality, scores were reported in group format. Students in the control group will have the option of participating in the program at a later date.

CHAPTER FOUR: ANALYSIS OF DATA

This study examined the impact of Fast ForWord on the phonological awareness and rapid naming skills of students who had failed to meet the proficiency goal on the Connecticut Mastery Test in Reading. In addition, the study examined the relationship between Fast ForWord program completion, Connecticut Mastery Test in Reading scores, and posttest phonological awareness scores and the relationship between Fast ForWord program completion, Connecticut Mastery Test in Reading scores, and posttest rapid naming scores. The three research questions addressed in this study were:

1. Is there a significant difference in phonological awareness and rapid naming skills for students who participate in the Fast ForWord intervention and those who do not?
2. To what extent and in what manner can variation in the phonological awareness composite posttest scores be explained by the percentage of completion of the Fast ForWord program and state scores on the Connecticut Mastery Test in Reading?
3. To what extent and in what manner can variation in the rapid naming posttest scores be explained by the percentage of completion of the Fast ForWord program and state scores on the Connecticut Mastery Test in Reading?

This chapter presents the results of the study. It begins with a description of the data used followed by three sections that are organized according to the sequence of the research questions as well as the following: (a) pretest data preparation, (b) pretest data analysis, (c) posttest data preparation, (d) posttest data analysis. Section 2 pertains to research question 2 and includes the following: (a) descriptive statistics of the data and

(b) data analysis. Section 3 pertains to research question 3 and includes the following: (a) descriptive statistics of data and (b) data analysis. The chapter concludes with a summary of the results.

Description of the Data

This study utilized interval data from The Comprehensive Test of Phonological Processing (CTOPP), the Connecticut Mastery Test in Reading, and completion scores generated by the Fast ForWord program. The CTOPP yielded separate composite scaled scores for each of the following constructs: phonological awareness, rapid naming, and phonological memory. Each composite score had a mean of 100 and a standard deviation of 15. The current study examined the composite scaled score of phonological awareness and the composite scaled score of rapid naming.

The Connecticut Mastery Test (CMT) in Reading is made up of two subtests: the Degrees of Reading Power (DRP) and reading comprehension. The total reading score for each student was calculated by adding the raw score from the DRP to the weighted raw score from reading comprehension, with each subtest accounting for 50 percent of the total score. The CMT utilized scaled scores that ranged from 100 to 400, with five performance and descriptive categories for each grade level. For example, according to state criteria, third-grade students with scaled scores between 279 and 400 were in the advanced category while students with scores between 235 and 278 were meeting goal. Students with scores between 217 and 234 were in the proficient range while students with scores between 202 and 216 were in the basic range. Finally, students with scores between 100 and 201 were in the below-basic range.

Fast ForWord consists of a series of programs. Language is the first in the series and is followed by an advanced language program that builds on the same skills as the first. Each program generates a percentage complete score for each student. The percent complete score is an average of the total number of levels the student has mastered across individual games in the program, with a range from 0% to 100%. When a student achieves a percent complete score of 80% or higher, Scientific Learning considers the program to be complete and recommends that the student be switched to the next program in the series (Scientific Learning Corporation, 2009). In this study, if students completed the first program (either language or literacy) during the course of the study, they were switched to the second program (either language to reading or literacy advanced). Of the 28 students in the treatment group, 20 students completed the first program and began the second program. The average completion rate for the second program was 32% with a range from 4% to 64%. The data analysis for the current study only included the percentage complete score for the first program.

Research Question 1: Pretest Data Preparation

Pretest data preparation. Research question 1 examined the impact of phonological awareness and rapid naming skills for students who participated in the Fast ForWord intervention and those who did not. Pretest data were collected to examine differences between the treatment and control groups previous to the intervention.

Data from the Comprehensive Test of Phonological Processing were examined for their appropriateness. Data entry was checked for accuracy and there were no missing cases. One case from the treatment group was removed because of an error in the school data base that had identified the subject as having a Connecticut Mastery Test Reading scaled score that qualified for the target group. However, the student did, in fact, meet the standard for reading proficiency. An evaluation of data from the remaining sample (n = 55) was conducted. The Statistical Package for the Social Sciences (SPSS) (Nie, 1968) was used, and descriptive statistics, stem-and-leaf graphs, and histograms were analyzed.

The same data set was used to examine each of the three research questions. To avoid an inflated Type I error risk, a Bonferroni adjustment was made. The alpha level of .05 was divided by 3, resulting in an alpha level of .016 (Huck, 2004). The alpha level of .016 was used for all statistical tests. Pretest data were examined to ensure that the mean composite score for phonological awareness for the treatment and the control group were equal. Data were also examined to ensure that the mean composite scores for rapid naming for the treatment and the control groups were equal.

Descriptive statistics for pretest data. The mean pretest composite scores for phonological awareness and the mean pretest composite scores for rapid naming were examined. Based on a distribution with a mean of 100 and a standard deviation of 15 (Wagner, Torgesen, & Rashotte, 1999), the mean score for pretest phonological awareness for the treatment (n = 27, m = 81.22) and control (n = 28, m = 84.68) groups fell in the below-average range. An examination of pretest rapid naming composite scores for both treatment (n = 27, m = 96.74) and control (n = 28, m = 94.43) groups were within the average range.

Outliers and data normality. An evaluation of univariate and multivariate outliers was conducted to assess data normality. For research question 1, the distribution of pretest phonological awareness composite scores was examined for the treatment and the control groups. The distribution of pretest rapid naming composite scores was also examined for the treatment and the control groups. Stem-and-leaf plots and histograms for phonological processing were examined. Extreme values were found in the treatment group. Stem-and-leaf plots and histograms for rapid naming were examined. Extreme values were found in both treatment and control groups.

Skewness (-.007) and kurtosis (-.639) values for pretest phonological awareness scores in the control group were within the ±1 range of data normality (Meyer, Gamst, & Guarino, 2006). In the treatment group, kurtosis (1.10) values for pretest phonological awareness scores exceeded the ± 1 range. Skewness (-1.34) and kurtosis (1.65) values for pretest rapid naming scores exceeded the ±1 range in the treatment group. Skewness (.041) for pretest rapid naming in the control group did not exceed the ± 1 range, but kurtosis (1.17) values did.

Data normality with outliers removed. To improve skewness and kurtosis outliers were identified. All data from two subjects in the control group and one subject in the treatment group were removed from the data set, which resulted in an equal sample size (n = 26) for each group. Descriptive statistics for the total sample with outliers removed (n = 52) are presented in Table 17. With outliers removed, kurtosis values for the pretest phonological awareness scores in the treatment group fell within the ± 1 range. Kurtosis values for the pretest rapid naming scores in both the treatment and control groups indicated values within the ± 1 range. The skewness value (-1.058) for the pretest rapid naming scores in the treatment group approximated the ± 1 range.

Table 17

Descriptive Statistics for Phonological Awareness and Rapid naming Pretest Scores with Outliers Removed

	Phonological awareness		Rapid naming	
	Treatment	Control	Treatment	Control
N	26.000	26.000	26.000	26.000
Mean	81.420	85.000	98.810	93.880
Std.Deviation	10.250	11.60	15.570	14.280
Skewness	-0.070	-.054	-1.058	-0.836
Kurtosis	0.955	-.644	0.816	0.504

The standard error of skewness for the treatment and control groups was .456.

The standard error of kurtosis for the treatment and control groups was .887.

To further evaluate normality, the Sharpiro-Wilk Test was conducted to compare the sample to a comparable normal distribution. Using an alpha level of .001 (Meyers, Gamst, & Guarino, 2006), results (Table 18) were nonsignificant and indicated the sample distributions did not deviate from normal. These results support the assumption of data normality required for the analysis.

Table 18

Sharpiro-Wilk Test of Normality with Outliers Removed

Pretest Composite Score	Group (n = 26)	Statistic	df	Significance
Phonological awareness pretest	Treatment	.959	26.00	.380
	Control	.971	26.00	.644
Rapid naming pretest	Treatment	.909	26.00	.025
	Control	.943	26.00	.160

$p < .001$ (Meyers, Gamst, & Guarino, 2006).

Homogeneity of variance. Homogeneity of variance was examined to check the assumption of equal variance across both treatment and control groups. A preliminary check found the Levene statistic was not significant, indicating equal variance in the groups (Table 19). Since the study utilized a multivariate analysis, the covariance between the dependent variables was examined with Box's Test of Equality of Covariance Matrices. Results (Table 20) indicated that the Box's Test of Equality of Covariance of Matrices was not significant (Box's M = .65, ns.), indicating that the assumptions of homogeneity were met and the matrices were equal.

Table 19

Levene's Test for Homogeneity of Variance with Outliers Removed

	Levene statistic	df	Sig. (2-tailed)
Phonological awareness pretest	.624	50	.433
Rapid naming pretest	.400	50	.530

Table 20

Box's Test of Equality of Covariance Matrices with Outliers Removed

Statistic	Value
Box's M	
F	
df1	
df2	
Sig.	

Note. Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups

Research Question 1: Pretest Data Analysis

Comparison of pretest means using a MANOVA. A MANOVA was conducted on pretest data to determine group differences prior to treatment. The MANOVA examined the intercorrelation between the two dependent variables—phonological awareness and rapid naming—for each level of the independent variable. Results indicated that there were no significant differences between the group means before treatment, where $F\ (2, 49) = .34$, ns., thus indicating that prior to the intervention, the phonological and rapid naming skills were the same for both the treatment and the control groups (see Table 21). This finding allowed for an analysis of posttest means to examine differences between phonological-awareness composite scores and rapid naming composite scores after treatment.

Table 21

Multiple Analysis of Variance Test to Determine if Groups Were Comparable before Treatment

Mulitvariate test	Value	F	Hypothesis df	Error df	Sig.
Wilks' Lambda	.96	1.12[a]	2.00	49.00	.34

[a] = Exact statistic.

Research Question 1: Posttest Data Preparation

Posttest data preparation. Research question 1 examined the effect on phonological awareness and rapid naming skills of students who participated in the Fast ForWord intervention and those who did not. Posttest data were collected after treatment to examine posttreatment differences between students who participated in Fast ForWord and students who did not. Data from the Comprehensive Test of Phonological Processing were examined for their appropriateness. Data entry was checked for accuracy, and there were no missing cases.

All data from the sample (n = 52) were screened using descriptive statistics, stem-and-leaf graphs, and histograms. Data were screened and checked for missing values, outliers, and violation of statistical assumptions.

Descriptive statistics for posttest data. Descriptive statistics for the total sample (n = 52) are presented in Table 22. Skewness and kurtosis values for both posttest phonological awareness and posttest rapid naming, across treatment and control groups, were within the ± 1 range (Meyer, Gamst, & Guarino, 2006).

Table 22

Descriptive Statistics of Posttest Phonological Awareness and Rapid naming Composite Scores with Outliers Removed

	Phonological awareness		Rapid naming	
	Treatment	Control	Treatment	Control
Mean	86.58	88.46	101.96	96.62
Standard Dev	13.12	11.72	10.90	13.75
Skewness	.28	-.20	-.22	-.99
Kurtosis	-.69	-.06	-.56	.84

The standard error of skewness for the treatment and control groups was .456.

The standard error of kurtosis for the treatment and control groups was .887

n = 26 in each group.

Outliers and data normality. An evaluation of univariate and multivariate outliers was conducted to assess data normality. The distribution of posttest phonological awareness composite scores and posttest rapid naming composite scores were examined for the treatment and the control groups. To further evaluate normality, the Shapiro-Wilk Test was conducted. Using an alpha level of .001 (Meyers, Gamst, & Guarino, 2006), results (see Table 23) were nonsignificant and indicated the sample distributions did not deviate from normal.

Table 23

Sharpiro-Wilk Test of Normality with Outliers Removed

Posttest Composite Scores	Group	Statistic	Significance
Phonological awareness	Treatment	.971	.647
	Control	.983	.923
Rapid naming	Treatment	.976	.780
	Control	.912	.029

Note. $p < .001$ (Meyers, Gamst, & Guarino, 2006).

Once univariate outliers were examined, multivariate outliers were screened by computing the Mahalanobis distance. The Mahalanobis distance was computed using a chi-square criterion of 2 degrees of freedom at $p < .001$ confidence level (Meyers, Gamst, & Guarino, 2006), resulting in a critical value of 13.816. All Mahalanobis distance values fell below the critical value with no multivariate outliers observed. These results support the assumption of data normality required for the analysis.

Correlations. Meyers, Gamst, and Guarino (2006) suggest that a moderate correlation between variables is needed for multivariate analysis**;** therefore, an examination of the correlations between the dependent variables for each group participating in the MANOVA (phonological awareness posttest scores and rapid naming posttest scores) was conducted. Results of the correlations are presented in Table 24. These correlations suggest some variability in the dependent variable covariance which was assessed further with Box's M test.

Table 24

Pearson 2-tailed Intercorrelation Matrix between Phonological Awareness and Rapid Naming Posttest Scores for Treatment and Control Groups

Groups (n =26)	Rapid Naming Treatment	Rapid Naming Control
Phonological Awareness Treatment	-.216	
Phonological Awareness Control		.024

Correlations were ns.

Homogeneity of variance. Univariate and multivariate tests were used to examine the distribution of data. A preliminary check indicated that the Levene's statistic for phonological awareness (F (1, 50) = .527, ns), and for rapid naming (F (1, 50) = .294, ns), indicated equal variance in the groups. Results are presented in Table 25.

Table 25

Levene's Test for Homogeneity of Variance

	Levene statistic	df	Sig. (2-tailed)
Phonological awareness posttest	.527	50	.471
Rapid naming posttest	.294	50	.590

Tests for homogeneity of variance

Multivariate normality was checked with Box's Test of Equality of Covariance of Matrices. Results (see Table 26) indicated that Box's Test of Equality of Covariance of Matrices was not significant (Box's M = 2.48, ns) and indicated that the assumptions of homogeneity were met**,** and the matrices were equal. The posttest data for both the treatment and the control groups were found to be acceptable for the purposes of this study.

Table 26
Box's Test of Equality of Covariance Matrices

Statistic	Value
Box's M	2.48
F	.79
df1	3.00
df2	450000.00
Sig.	.50

Note. Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

Research Question 1: Posttest Data Analysis

Comparison of posttest means using a MANOVA. A Hotelling's T,^{2} or two-group, multivariate analysis of variance test (MANOVA) was conducted on the two dependent variables—post-phonological awareness composite scores and post rapid naming composite scores. The MANOVA examined the intercorrelation between groups and group differences. The Hotelling's T^2 was transformed to F values with four multivariate statistics. With two dependent variables, all four multivariate test statistics were the same. For purposes of this study, the Wilk's Lambda statistic was reported because it was the most reported statistic for this type of research (Meyers, Gamst, & Guarino, 2006). Results (Table 27) indicate no significant difference in the levels of independent variable, as defined by treatment and control group, where F (2, 49) = 1.27, ns. Univariate test results also indicated that there was no significant impact of group on either phonological awareness or rapid naming posttest scores (see Table 28).

Table 27

Multiple Analysis of Variance Test Comparing Treatment to Control Groups for Phonological Awareness and Rapid Naming

			Hypothesis		
Mulitvariate test	Value	F	df	Error df	p
Wilks' Lambda	.95	1.27[a]	2.00	49.00	.29

[a] = Exact statistic.

Table 28

Tests of Between-Subjects Effects

Source	Dependent variable	Type 111 sum of squares	df	Mean square	F	Sig
Group	Phonological post	46.17	1.00	46.17	.30	.59
	Rapid naming post	371.55	1.00	371.55	2.41	.13

Research Question 2: Data Preparation

The second research question examined the extent that variation in the phonological awareness composite posttest scores could be explained by the percentage of completion of the Fast ForWord program and the state scores on the Connecticut Mastery Test in Reading. Data analysis for research question 2 was limited to the treatment group (n = 26) since one of the predictor variables was the percentage of program completion.

Descriptive statistics. Descriptive statistics for the two predictor variables, percentage of program completion and the Connecticut Mastery Test in Reading scaled scores and the criterion variable, phonological awareness composite score, are presented in Table 29. The percentage of program completion refers to the total percentage of levels completed in the Language Program for students in grade 4 and 5 and the Literacy Program for students in grade 6 through 8. In the sample of 26 students, the average completion rate was eighty-five percent. The Connecticut Mastery Test in Reading scaled scores ranged from 122 to 219, with a mean of 185.

Table 29

Descriptive Statistics of Program Completion Percentages, Connecticut Mastery Test Reading Scores, and Posttest Phonological Awareness Composite Score for Treatment Group (n = 26)

	Program completion	CMT reading	Phonological awareness
Mean	85.690	185.310	86.580
Standard dev.	13.638	25.080	13.120
Skewness	-2.421	-.955	.280
Standard error	.456	.456	.456
Kurtosis	5.769	.277	-.690
Standard error	.887	.887	.887

An intercorrelation matrix for both the predictor variables (Connecticut Mastery Reading Test scaled score and percentage of program completion) and the criterion variable (phonological awareness) are presented in Table 30. The correlation between the two predictor variables (r = .22, ns.) fell below the recommended criteria of .70 (Meyers, Gamst, & Guarino 2006) and was an indication that collinearity does not exist. Collinearity refers to a strong correlation between two predictor variables that can distort the results in a multiple regression (Meyers, Gamst, & Guarino 2006).

Table 30

Pearson One-tailed Correlation Matrix for Treatment Group (n=26) for Connecticut Mastery Test Scores, Posttest Phonological Awareness Scores, and Program Percent Complete

	CMT score	Phonological awareness score
Phonological awareness score	.1	
Percentage complete	.2	.486*

* p < .01 level.

Multivariate outliers were screened by computing the Mahalanobis distance. The Mahalanobis distance was computed using a chi-square criterion of 2 degrees of freedom at p < .001 confidence level (Meyers, Gamst, & Guarino, 2006), resulting in a critical value of 13.816. All Mahalanobis distance values fell below the critical value with no multivariate outliers observed.

Research Question 2: Data Analysis

The following is an examination of the relationship between phonological awareness, Connecticut Mastery Test in Reading scaled scores, and percentage of program completion. Data were analyzed using a multiple regression to examine the extent to which scaled scores from the Connecticut Mastery Test in Reading and percentage of program completion were predictors of posttest phonological awareness composite scores. Data were entered in the Statistical Package for the Social Sciences in a hierarchical approach because percentage of program completion had been found to have an impact on dependent variables in the literature (Borman, Benson & Overman, 2009). The percentage complete was entered in the first block, and the Connecticut Mastery Test in Reading scaled score was entered in the second block. The model summary presented in Table 31 indicates that in model one, the percentage of program completion accounted for 24% of the variation in posttest phonological awareness composite scores with CMT scores adding less than 1%.

Table 31

Multiple Linear Regression Model Summary for Phonological Awareness

Model	R	R^2	Adjusted R^2	Standard error of the estimate	F change	Sig. F change
1	.47(a)	.24	.20	11.70	7.43	.01
2	.49(b)	.24	.18	11.91	.173	.68

[a] Predictors: (Constant), percentage complete. [b] Predictors: (Constant), percentage complete, CMT scores

In predicting posttest phonological awareness composite scores, when program completion was entered, results (Tables 32) indicated that the set of variables for model 1 (F (1, 24) = 7.42, p < .02) did significantly predict the variation in scores. When CMT scores were added to the model, results indicated that the set of variables for model 2 (F 2, 23 = 3.67, ns.) did not significantly predict the variation in scores.

Table 32
Analysis of Variance for Phonological Awareness

Model		Sum of squares	Df	Mean square	F	P
1	Regression	1017.080	1.00	1017.080	7.426	.012[a]
	Residual	3287.26	24.00	136.97		
	Total	4304.35	25.00			
2	Regression	1041.58	2.00	520.80	3.67	.041[b]
	Residual	3262.78	23.00	141.85		
	Total	4304.35	25.00			

[a] Predictors: (Constant), percentage complete. [b] Predictors: (Constant), percentage complete, CMT score.

An examination of the standardized coefficients (Table 33) indicates that the percentage of program completion made a significant contribution to predicting posttest phonological awareness scores but the addition of the Connecticut Mastery Test in Reading scaled scores did not.

Table 33

Coefficients of the Regression model with Phonological Awareness Composite Scores as the Criterion

	Unstandardized coefficients		Standardized coefficients		
	B	Standard error	Beta	t	Sig.
(Constant)	40.42	21.05		1.92	.07
percentage complete	.45	.18	.47	2.51	.02
CMT level	.04	.10	.08	.416	.68

Research Question 3: Data Preparation

The third research question examined the extent that variation in the rapid naming posttest scores could be explained by the percentage of completion of the Fast ForWord program and scores on the Connecticut Mastery Test in Reading. Data analysis for research question 3 was limited to the treatment group (n = 26) because one of the predictor variables was the percentage of program completion.

Descriptive statistics. Descriptive statistics for the two predictor variables, percentage of program completion and the Connecticut Mastery Test in Reading scaled scores and the criterion variable rapid naming composite score are presented in Table 34.

Table 34

Descriptive Statistics of Program Completion Percentages, Connecticut Mastery Test Reading Scores, and Posttest Rapid naming *Composite Scores for Treatment Group*

	Program completion	CMT reading	Rapid naming
Mean	85.69	185.31	101.96
Standard dev.	13.63	25.08	10.90
Skewness	-02.42	-00.96	-00.22
Standard error	00.46	00.46	00.46
Kurtosis	05.77	00.28	-00.57
Standard error	00.89	00.89	00.89

n = 26

An intercorrelation matrix for both the predictor variables (Connecticut Mastery Test in Reading scaled scores and percentage complete), and the criterion variable (rapid naming) are presented in Table 35. The correlation between the two predictor variables ($r = .20$) fell below the recommended criterion of .70 (Meyers, Gamst, & Guarino 2006) and is an indication that collinearity does not exist.

Multivariate outliers were screened by computing the Mahalanobis distance. The Mahalanobis distance was computed using a chi-square criterion of 2 degrees of freedom at the $p < .001$ confidence level (Meyers, Gamst, & Guarino, 2006), resulting in a critical value of 13.816. All Mahalanobis distance values fell below the critical value with no multivariate outliers observed.

Table 35

Pearson One-Tailed Correlation Matrix for Treatment Group (n=26) for CMT Scores, Posttest Rapid naming Scores, and Program Percentage Complete

	CMT score	Posttest rapid naming score
Posttest rapid naming score	.104	
Percentage complete	.224	-.383*

Note. $p < .05$

Research Question 3: Data Analysis

The following is an examination of the relationship between rapid naming, Connecticut Mastery Test in Reading scaled score, and the percentage of program completion. Data were analyzed using a multiple regression to examine the extent to which the Connecticut Mastery Test in Reading's scaled score and the percentage of program completion were predictors of posttest rapid naming composite scores. Data were entered into the Statistical Package for the Social Sciences using a hierarchical method because previous studies had indicated that percentage of program completion was found to have an impact on posttest measures. The percentage completed was entered in the first block, and Connecticut Mastery Test in Reading scaled score was entered in the second block.

The model summary presented in Table 36 indicates that the model was not successful in predicting post rapid naming scores. The percentage of program completion accounted for only 15% of the variation in posttest rapid naming composite scores with CMT reading scores adding 3%. In predicting post rapid naming composite scores, when program completion was entered, results indicated that the set of variables for model 2 (F (1, 24) = 4.14, ns.) did not significantly predict the variation in scores (see Table 37).

Table 36

Multiple Linear Regression Model Summary for Rapid Naming

Model	R	R^2	Adjusted R^2	Standard error of the estimate	F Change	Sig. F Change
1	.38[a]	.15	.11	10.27	4.14	.05
2	.43[b]	.19	.11	10.25	1.06	.31

[a] Predictors: (Constant), percentage complete. [b] Predictors: (Constant), percentage complete, CMT scores

Table 37

Analysis of Variance for Rapid Naming

Model		Sum of squares	Df	Mean square	F	P
1	Regression	436.31	1.00	436.31	4.13	.05[a]
	Residual	2532.64	24.00	105.52		
	Total	2968.96	25.00			
2	Regression	548.36	2.00	274.17	2.60	.10[b]
	Residual	2420.60	23.00	105.25		
	Total	2968.96	25.00			

[a] Predictors: (Constant), percent complete. [b] Predictors: (Constant), percent complete, CMT scores.

When CMT scores were added to the model, results indicated that the set of variables for model 2 (F 2, 23 = .2.60, ns.) did not significantly predict the variation in scores. An examination of the standardized coefficients (Table 38) indicates that neither the percentage of program completion nor the Connecticut Mastery Test in Reading scaled score made a significant contribution to predicting posttest rapid naming scores. Although neither variable made a significant contribution, the percentage of program completion made a larger, but negative, contribution (t = -2.03) compared to the Connecticut Mastery Test in Reading scaled scores (t = 1.03).

Table 38

Coefficients of the Regression Model with Rapid Naming as the Criterion

	Unstandardized coefficients		Unstandardized coefficients		
	B	Standard error	Beta	t	Sig.
(Constant)	115.22	18.13		6.35	0.00
Percentage complete	-.34	.15	-.42	-2.22	0.04
CMT level	.09	.08	.20	1.03	0.31

Summary

A two-group MANOVA and two multiple regression procedures were conducted for this research. The data examined in the MANOVA were obtained from posttest composite scores on the Comprehensive Test of Phonological Processing (Wagner et al., 1999). In research question 1, a comparison of means between students who participated in the Fast ForWord program and those who did not was conducted. Results of the multivariate analysis of variance (MANOVA) indicated that there was no significant difference between the treatment or control groups for either phonological awareness or rapid naming composite scores.

Research question 2 utilized a multiple regression analysis using the composite scores of phonological awareness as the criterion, with the percentage of program completion and the Connecticut Mastery Test in Reading scaled scores as predictors. Results indicated that in model 1, percentage of program completion was successful in predicting posttest phonological awareness but model 2 was not significant, indicating that the combination of percentage of program completion and CMT scores did not predict posttest composite scores. Research question 3 utilized a multiple regression analysis using the composite scores of rapid naming as the criterion, with the percentage of program completion and the Connecticut Mastery Test in Reading scaled scores as predictors. Results indicated that the model was not successful in predicting rapid naming posttest composite scores.

CHAPTER FIVE: SUMMARY AND CONCLUSIONS

Chapter 5 will begin with a summary of the first four chapters. Following the summary, a description of the study will be presented. Next, the results for each research question are described. These results include: a discussion relating these results to findings outlined in the literature review; limitations that emerged as a result of the data analysis; implications of the research; and suggestions for additional research.

Overview of the Current Study

The current study addressed the topic of instruction for students who struggle with reading. National reading scores since 1992 have indicated that between 20% and 40% of the students who have participated in national reading assessments lack the reading skills needed to master grade level text (The Nation's Report Card, 2007), a problem that has been attributed to ineffective instruction (Torgesen, 2002; Shaywitz, Lyons, & Shaywitz, 2006). Torgesen (2002) estimated that the number of students who struggle with reading could be reduced with effective instructional programs that: (a) target specific skills, (b) are individualized, and (c) are implemented in a systematic manner. Reading research has isolated processing skills needed for reading and has indicated that phonological processing plays a prominent role in the development of word reading and subsequent comprehension skills (Vellutino, et al. 2004).

The literature supports a causal relationship between phonological processing and word reading. Two specific subcomponents of phonological processing—phonological awareness and rapid naming—have been identified as markers for reading problems; and poor skills in either have been found to place a student at-risk for reading problems (Wolf, 2007). The current study examined an instructional program, Fast ForWord, that was designed to improve the underlying auditory processing skills required for phonological processing (Tallal, 2004). Fast ForWord incorporates the instructional components recommended by Torgesen (2002) in that it targets specific skills, is individualized, and is presented in a systematic format. These factors suggest that it would be a viable and effective option for struggling readers.

Previous studies have found that Fast ForWord has not had a significant impact on language and reading skills (Borman, Benson, & Overman, 2009; Cohen, Hodson, & O'Hare, 2005; Gillam et al., 2008; Porkoni, Worthington & Jamison, 2004; Rouse & Kruger, 2004), but findings have indicated it has had an impact on phonological skills (Cohen, Hodson, & O'Hare, 2005; Gaab et al., 2007; Gillam et al., 2008). Therefore, the researcher designed this study to investigate the impact of Fast ForWord on the phonological awareness and rapid naming skills of struggling readers. The study was also used to examine the predictive nature of program completion and Connecticut Mastery Test in Reading scaled scores, on the posttest composite scores for phonological awareness and on the posttest composite scores for rapid naming, respectively.

The researcher conducted the study in an urban district in southern Connecticut. The target population (n = 78) consisted of all students in Grades 4 through 8 who were considered at-risk because they scored below the proficiency level on the state reading assessment. Each student in the target population was asked to participate in the study**,** and permission was secured for a total of 56 students who made up the sample.

Two subscales of the Comprehensive Test of Phonological Processing were used to assess pretreatment and posttreatment phonological awareness and rapid naming skills. Pretesting was conducted for all 56 students. To ensure an equal representation of

Connecticut Mastery Test in Reading scores across both treatment and control groups, students were assigned to groups using a stratified random assignment procedure. Students with scaled scores that fell in the below-basic level (n = 36) were assigned to either treatment or control groups using a computerized random table of numbers. The same procedure was used for students with scaled scores that fell in the basic level (n = 20). The treatment and control group had the same proportion of CMT scaled scores represented in the sample with a total of 28 students per group.

The treatment group was scheduled to participate in the Fast ForWord Language Program for 50 minutes a day, five days a week, for approximately 12 weeks. In all, a total of 37 sessions were held. The students in Grades 4 and 5 attended an average of 34 sessions, with a range from 29 to 37 days. The students in Grades 6, 7, and 8 attended an average of 30 sessions, with a range from 21 to 37 days. Members of the control group maintained their usual schedule. Posttest evaluations were completed at the end of the treatment session. Previous to data analysis, outliers were identified, and this resulted in the removal of four cases. The final data analysis was conducted on 52 cases—26 from the control group and 26 from the treatment group.

The study was designed to answer three research questions using two quantitative research designs and one sample (n = 56) group. In research question 1, a pretest and posttest design was used in the analysis of post treatment differences between groups. Research question 1 examined whether or not there was a difference between the posttest phonological awareness and posttest rapid naming scores of students who participated in the Fast ForWord treatment and those who did not. The independent variable in this design was the type of instructional program, with two levels—Fast ForWord treatment and the regular curriculum. The dependent variables were phonological awareness and rapid naming. A multivariate analysis of variance (MANOVA) was conducted to determine the relationship of the independent variable on the posttest composite scores.

The researcher employed a correlational design with multiple linear regression for the second and third research questions to explain the shared variance in posttest phonological awareness and rapid naming scores, respectively. For research question 2 and 3, data from the treatment group were analyzed. Research question 2 examined the extent of the relationship between phonological awareness, Connecticut Mastery Test in Reading scaled scores, and percent of program completion. The criterion variable for research question 2 was the posttest phonological awareness composite score. The predictors were the scaled scores on the Connecticut Mastery Test in Reading and percentage of completion of the Fast ForWord program. Research question 3 examined the extent of the relationship between rapid naming, Connecticut Mastery Test in Reading scaled scores, and percent of program completion. The criterion variable for research question 3 was the posttest rapid naming composite score. The predictors were the scaled scores on the Connecticut Mastery Test in Reading, and percentage of completion of the Fast ForWord program. The *Statistical Package for the Social Sciences version 13.0* (Nie, 1968) was utilized for the MANOVA and the multiple regression analyses.

Results and Conclusions

This section includes a presentation of the results and findings from the statistical analysis performed for each of the three research questions, a comparison of results to previously discussed issues in the literature, implications of the current results, and suggestions for future research.

Research question 1: Results of Pretest Data Analysis

Is there a significant difference in phonological awareness and rapid naming skills for students who participate in the Fast ForWord intervention and those who do not? Research question 1 utilized a pretest and posttest design. Pretest data were collected from a sample population of students (n = 56) who had scored below the proficient level on the Connecticut Mastery Test in Reading. Data were collected to ensure that the means for the phonological awareness and rapid naming scores were statistically equivalent for both treatment and control groups prior to the treatment. Data consisted of the phonological awareness and rapid naming composite scores on The Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999), a standardized instrument that yields standard composite scores (M = 100, SD = 15). Data preparation resulted in the removal of four cases. Data analysis was conducted (n = 52) and indicated that there were no significant differences between the group means before treatment, indicating that prior to the intervention, the phonological and rapid naming skills were the same for both the treatment and the control groups.

Although the primary purpose for the collection of pretest data was to examine group differences before treatment, an examination of the descriptive statistics for the pretest data revealed three unexpected findings. These findings are discussed in the context of the current study because they support the literature and have practical implications for schools. The first finding indicated 80% of the students in the sample had phonological awareness scores that were at least one standard deviation below the average test mean. This is consistent with research that has indicated most poor readers have weaknesses in phonological processing (Shaywitz, Lyon, & Shaywitz, 2006).

The second finding indicated poor readers could be grouped according to their scaled scores on the phonological awareness and rapid naming composite scores. Scores that fell below one standard deviation from the mean (M = 100, SD = 15) were considered to be below average. In examining the pretest phonological awareness and rapid naming scores of students in the current sample (n = 52), 80% of the student's had scores that followed one of three patterns: 55% of the students had below average phonological scores but average rapid naming scores, 14% of the students had below average rapid naming scores but average phonological scores, and 11% of the students had below average scores on both measures. The remaining 20% had scores that fell within one the average range on both measures. This finding was consistent with results from studies that had found poor readers can be grouped according to their scores on measures of phonological awareness and rapid naming (Lovett, Steinbach, & Frijters, 2000; Wolf & Bowers, 1999; Morris et al.,1998).

The third finding indicated that, in contrast to the moderate, positive correlation found between phonological awareness and rapid naming constructs in samples considered to represent the normal population (Wagner, Torgesen, & Rashotte, 1999; Schatschneider et al., 2002), a negative correlation between pretest phonological awareness and rapid naming scores ($r = -.248$, $p < .05$) was found in the current sample ($n = 52$). The negative correlation suggests that that in this sample of struggling readers, the relationship between phonological awareness and rapid naming differs from what would be expected in the normal population.

Research Question 1: Posttest Data: Results and Conclusions

In analyzing the first research question, a MANOVA was used to assess the effect of the independent variable on the two dependent variables. The independent variable was the processing skill intervention, with two levels—Fast ForWord treatment and no treatment instruction. The dependent variables included phonological awareness and rapid naming and were assessed using the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999). Results of the multivariate analysis indicated no significant difference in the levels of the independent variable, as defined by the treatment and control groups. Univariate test results also indicated a nonsignificant difference between groups on the measures of phonological awareness and rapid naming. Results indicated that Fast ForWord did not have a significant impact on the phonological awareness and rapid naming skills of struggling readers. This finding is in keeping with independent studies that have failed to find large impacts of Fast ForWord on outcome measures related to language and reading (Borman, Benson, & Overman, 2009; Cohen, Hodson, & O'Hare, 2005; Gillam et al., 2008; Porkoni, Worthington, & Jamison, 2004; Rouse & Kruger, 2004).

Research question 2: Results and Conclusions

To what extent and to what manner can variation in the phonological awareness composite posttest scores be explained by the percentage of completion of the Fast ForWord program and state scores on the Connecticut Mastery Test in Reading?

To answer this question, data were analyzed using a multiple regression to examine the extent to which scaled scores from the Connecticut Mastery Test in Reading and percentage of program completion were predictors of posttest phonological awareness composite scores. The correlation between the scaled scores on the Connecticut Mastery Test in Reading and posttest phonological scores was small and nonsignificant ($r = .18$). The correlation between the level of program completion and posttest phonological scores was moderate and significant ($r = .49$, $p < .02$).

Data were entered in SPSS in a hierarchical approach to explore a predictive model. Percentage complete was entered in the first block, and Connecticut Mastery Test in Reading scaled score was entered in the second block. Results from the multiple regression analysis did not indicate a contribution towards the variance between posttest phonological awareness scores, scaled scores on the Connecticut Mastery Test in Reading, and percentage of completion of Fast ForWord. Results from the simple linear regression indicated that percentage of program completion did contribute towards the variance in posttest phonological scores.

Research question 3: Results and Conclusions

To what extent and in what manner can variation in the rapid naming posttest scores be explained by the percentage of completion of the Fast ForWord program and state scores on the Connecticut Mastery Test in Reading? To answer this question, data were analyzed using a multiple regression procedure to examine the extent to which scaled scores from the Connecticut Mastery Test in Reading and percentage of program completion were predictors of posttest rapid naming composite scores. The correlation between the scaled scores on the Connecticut Mastery Test in Reading and posttest rapid naming scores was positive but nonsignificant ($r = .10$). A negative but nonsignificant correlation was found between the level of program completion and posttest rapid naming scores ($r = -.38$).

Data were entered in SPSS in a hierarchical approach to explore a predictive model. Percentage complete was entered in the first block, and Connecticut Mastery Test in Reading scaled score was entered in the second block. Results from the multiple regression analysis did not support a relationship between posttest rapid naming scores, scaled scores on the Connecticut Mastery Test in Reading, and percentage of completion of Fast ForWord. Neither program completion nor Connecticut Mastery Test in Reading scaled scores were found to predict posttest rapid naming scores.

Limitations of the Study

The first limitation was related to the research design. The sample size was small, which in combination with the alpha level and anticipated small effect size, limited the overall power of the study. Also, the statistical model did not test whether or not subjects made pretest to posttest gains. Three additional limitations associated with conducting a research study within a school setting are discussed.

One limitation was related to chance factors inherent in data collection procedures. Pretest and posttest data were collected by trained staff using a valid and reliable instrument, but staff availability and scheduling constraints made it impossible to have the same examiner assigned to the same student for both pretest and posttest administration. Doing so would have reduced the chance factors related to differences in examiner style and student rapport.

The second limitation was related to environmental conditions within the school. Pretest and posttest administrations took place in quiet rooms within the building, and extraneous factors such as noise level and unexpected interruptions were controlled. Controlling for extraneous factors during the treatment program was more difficult.

Snow days; school vacations; special events; fire drills; staff and student absences; and technological problems with the computers made it difficult to adhere to the recommended five-day-a-week protocol. These implementation problems were consistent with findings in the literature (Borman, Benson, & Overman, 2008; Rouse & Krueger, 2003).

Another limitation was related to difficulties with program completion. Previous studies have found that the majority of students who participated in Fast ForWord failed to complete the program. In contrast to these studies, 93% of the older students, in grades 6 through 8, and 84% of the younger students, in grades 4 and 5, completed at least one program during the intervention period, but achieving this level of completion rate required a great deal of effort and commitment on the part of both students and teachers. Informal feedback from the teachers involved suggested that students needed more individual attention than expected for a computer-generated program. It is suspected that the high levels of program completion in the current study were related to a combination of small sample size, student motivation, level of staff supervision, and involvement of the primary researcher. The small sample size made it easier to provide the students with the individual attention needed to maintain program compliance and motivation. In addition, the researcher had previous experience administering the Fast ForWord program, and the skill and knowledge base related to this experience may have had an impact on the level of teacher commitment.

The ability to generalize beyond the current study was limited because of threats to external validity. The study took place in an urban elementary school that had a high population of poor minority students. The target group included students who performed below the proficient level on a state reading test but individual reading assessments were not administered. The lack of individualized reading assessments risked identifying students who may have performed poorly for reasons other than reading skills and the impact of an experimenter effect needs to be considered in terms of generalization beyond the sample group.

Implications

The researcher intended to present the results of this study to school and district level administrators who were interested in interventions that targeted students who had failed to reach the proficiency goal on a state reading assessment. The researcher also wanted to expand on findings in the literature that indicated Fast ForWord had an impact on phonological skills. This section will begin with a discussion of the implications related to the pretest data, followed by implications pertaining to the research questions.

An examination of the pretest data had two practical implications for school and district level administrators. The first is that in a random sample of students who failed to reach proficiency on the Connecticut Mastery Test in Reading, 80% had phonological processing weaknesses. These students were older and in grades where phonological skills are typically not assessed or addressed. The implication was that phonological weaknesses in older students may be overlooked. Assessing the phonological awareness and rapid naming skills of students who fail to reach proficiency goals on state assessments could help educators identify students with phonological processing weaknesses.

A second practical implication was that scores on phonological and rapid naming assessments could be used to differentiate student need. Consistent with Wolf and

Bowers's (1999) findings, in the current sample, 55% of the students had poor phonological scores but average rapid naming scores**;** 14% of the students had poor rapid naming scores but average phonological scores**;** and 11% of the students had poor scores on both measures. The instructional strategies for each of these three groups would differ. Those with poor phonological skills would need direct instruction in phonological processing, those with poor rapid naming skills would need instruction designed to improve fluency and those with weaknesses in both would need the most intense intervention (Wolf & Bowers, 1999). Using phonological awareness and rapid naming scores to group students would help educators identify students according to their reading needs.

Three additional implications are discussed. One, in contrast to other independent studies, the majority of students in this sample completed at least one program, but this required a commitment on the part of staff and students. While the adaptive features of Fast ForWord provided individualized instruction in a group setting, the program placed a high demand on student engagement and required a great deal of sustained attention and focused effort on the part of the student. In order to maintain attention and effort, many students required individual attention during the session. The implication for school leaders is that even though the program is computer-generated, teacher feedback and interaction are necessary for students to complete the program. This implication is important to consider, especially given the demands that Response to Intervention places on individualized instruction. Computer generated programs may provide a way to individualize instruction but this study suggested that teachers remain an important factor in the overall success of the intervention.

Second, the percentage of program completion was found to significantly predict posttest phonological scores. This finding implies that completing the program does have an impact on posttest phonological scores and underscores the importance of program fidelity. Third, although Connecticut Mastery Test in Reading scores did not predict posttest phonological or rapid naming scores, the CMT may be an instrument that educators could use to screen students for phonological weaknesses. An examination of the pretest data indicated that 80% of the students in the sample, made up of students who had scored below the proficient level on the state test, had below-average phonological skills. This finding suggests that the CMT scores may help educators target students who need further assessment.

Suggestion for Future Research

It is suggested that future research continue to examine the impact of Fast ForWord on phonological processing. Future studies, designed to detect small effect sizes, emphasize high completion rates and examine the possible impact of Fast ForWord on post-treatment instruction in phonological processing and/or reading are needed. The literature supports improvements on phonological measures at posttest and at six months post (Cohen, Hodson & O'Hare, 2005; Gaab et al., 2007; Gillam et al., 2008). Findings related to improvements over time raise the question of whether or not Fast ForWord may improve some facet of processing, which in turn, increases the ability to access phonological information and/or instruction after treatment. Exploring effects over time may offer additional insight. Future studies that examine the extent to which scores on the Connecticut Mastery Test in Reading predict phonological skills are also recommended. The current study found that 80% of the students in the sample had below-average phonological awareness skills. Phonological weaknesses can be masked by accurate but inefficient decoding skills (Shaywitz et al., 1999) and, without formal assessment, may go unnoticed. If the Connecticut Mastery Test in Reading scaled scores are found to predict phonological skills, these scaled scores could be used to identify students who need formal assessments in the area of phonological processing.

Summary

The current study examined the impact of Fast ForWord on the phonological awareness and rapid naming skills of struggling readers. An examination of the pretest data revealed that 80% of the students in the sample (n = 52), had below average phonological awareness skills, a finding that has practical implications for administrators. Screening struggling readers for phonological weaknesses may offer schools a method to assess and address their needs.

Results from the current study indicated that students who participated in the Fast ForWord program did not have significant differences in phonological awareness or rapid naming when compared to students who did not participate. This finding is in keeping with other researchers who failed to find significant program effects on language and reading skills. It is possible that the small sample size limited the power of the current study to detect change.

The current study indicated that the majority of students could complete Fast ForWord in a school setting but achieving this required a commitment on the part of students and teachers. Program completion has been associated with treatment effects in other studies, and current results support this finding. In the current study, the percentage of program completion was found to predict posttest phonological scores. Understanding the importance of program completion, and anticipating the level of student support needed to achieve program completion were considered to be important factors in maintaining program fidelity during the study.

Future studies that examine the impact of Fast ForWord on phonological skill need to have the power to detect small effects, the majority of students need to complete the program, and change over time should be measured to explore possible interactions between Fast ForWord and reading instruction.

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APPENDIXES

APPENDIX A

DISTRICT CONSENT FORM

Department of Education and Educational Psychology

181 White Street
Danbury, CT 06810

November 29, 2008

Dear Ms.:

As a doctoral student in Instructional Leadership at Western Connecticut State University I am requesting permission to conduct a study investigating the efficacy of Fast ForWord, an intervention program designed to improve foundation skills correlated with language development and reading.

The purpose of my research is to examine the effect Fast ForWord has on processing skills specific to phonological awareness, memory, and rapid naming. The target population will include students in grades three through eight who scored at the basic or below basic level on the 2008 CMT reading test. The study will be a randomized design that will compare two groups of students. When one group has completed the program, the other group will be able to use the Fast ForWord program.

Scientific Learning, the company that produces Fast ForWord, has agreed to provide access to the program during the study and will not have any other involvement other than data analysis that is part of the program protocol and provided to the school.

Upon district approval, the dissertation proposal will be reviewed by Western Connecticut State University's Institutional Review Board. The purpose of this process is to insure confidentiality and protection of participants. The goal is to begin the study in January and complete data collection by June. Results of the study will be made available for district use and consideration.

Sincerely,
Barbara Boller, Ed.S

Research study approved pending IRB determination

Signature________________________________

Date________________

APPENDIX B

PRINCIPAL CONSENT FORM

WESTERN CONNECTICUT STATE UNIVERSITY

Department of Education and Educational Psychology
181 White Street
Danbury, CT 06810

November 29, 2008

Dear Mr.:

I am currently a doctoral candidate at Western Connecticut State University. I am preparing to conduct my doctoral research project and I have obtained the permission from the superintendent of schools. I am seeking permission to carry out my study at the elementary level at your school.

The study is designed to examine the efficacy of a program called Fast ForWord which is designed to improve processing skills related to reading and language development. The target population will include regular education students in grades three through eight who scored at the basic or below basic level on the 2008 CMT reading test. The study will be a randomized design that will compare two groups of students. When one group has completed the program the other group will be able to participate in the Fast ForWord program.

I will be available to work with you and your staff to design and implement procedures that will fit within your school structure, provide training for staff and provide information sessions for parents.

If you have any questions, please feel free to contact me.

Sincerely,

Barbara Boller, Ed.S

APPENDIX C

PARENT CONSENT FORM

WESTERN CONNECTICUT STATE UNIVERSITY
Consent Form for Student Participation in a Research Project

Dear Parent or Guardian,

I am currently enrolled in the doctoral program for Instructional Leadership at Western Connecticut State University. This program requires that I design and implement a dissertation research study.

I am looking at a program called Fast ForWord, a computer program that is designed to help students develop skills that are important to reading. Students who participate in the study would play a series of computer games for 40 minutes a day, five days a week for approximately twelve weeks. The games are designed to improve listening skills, comprehension and memory. The principal and his teachers will help to schedule students so they don't miss out on classroom instruction.

There will be two groups of students, one group will begin the games in January and the other group will begin either in late spring or September. The students will be given a brief fifteen minute test at the beginning and the end of the program. The names of individual students will not be reported to the district or impact your child's reading grade. Student names will be coded and remain confidential throughout the study. Reports from the study will be reported in group format.

Participation in this study is completely voluntary. You are free to withdraw your child from the study at any time. The students will not be graded and there is no risk involved. It is hoped that students who participate will improve skills that will help them become better readers. All information is completely confidential.

This research study has been reviewed and approved by Western Connecticut State University's Institutional Review Board. It is hoped that the results of this study will help the teachers and school administrators make decisions about which programs help develop reading skills.

If you agree to have your child participate in this study, please sign the attached statement and return it to your child's classroom teacher____________________________ by _________________.

Sincerely,
Barbara Boller, Ed.S

I, ____, the parent/legal guardian of student below, acknowledge that the researcher has explained to me the purpose this research study, identified any risks involved, and offered to answer any questions I may have about the nature of my child's participation. I voluntarily consent to my child's participation. I understand all information gathered during this project will be completely confidential.

Student/Minors's Name: ____

(Please Print)

Signature of Parent or Guardian: ____

Printed Name of Parent or Guardian____

Date____________________________

APPENDIX D

STUDENT CONSENT FORM

WESTERN CONNECTICUT STATE UNIVERSITY
Student Information Form to Participate in a Reading Project

Dear Student,

My name is Mrs. Boller. I go to school at Western Connecticut State University. I am doing an exciting research study. I would like you to be a part of my study. I will send a permission slip home with you. But first, I would like you to know about my study.

The study is to see if playing special computer games will help you become a better reader.

I will ask you to complete a short test that involves word games. You will take the test in the beginning of the study and at the end. The test will help tell if the computer games worked.

When the study is over I will let you know what I learned. If the games helped you in any way, your teachers may want other students to play.

I will not use your name in the study. I will use numbers instead of names. The tests we use will have nothing to do with report card grades. All of the information will be kept private.

You will be a volunteer for this study. If you have questions, please ask me.

If you would like to be in my study, please write your name here:

Signature____Date_______________

Printed Name____

Thank you,
Mrs. Boller