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## Cognitive Differences Between High and Low Responders of a Tier II Reading Intervention

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COGNITIVE DIFFERENCES BETWEEN HIGH AND LOW  
RESPONDERS OF A TIER II READING INTERVENTION

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## ABSTRACT

### **Cognitive Differences Between High and Low Responders of a Tier II Reading Intervention**

by

Jill Cohen

Most educational researchers would agree that early intervention is a key factor in remediating reading difficulties and can prevent a lifetime of literacy problems due to lack of foundational skills (Lyon, 1998; Lyon et al., 2001). However, understanding cognitive characteristics that may influence responsiveness to these interventions is critical. Students who are unresponsive to typical evidence-based interventions may need treatment more targeted to their specific cognitive deficits. This study evaluated a population of young students with potential reading disabilities who had not responded to intensive interventions after 20-30 weeks and addressed the following questions: Are there cognitive differences between students who respond well to an intense Tier II reading intervention and those who make little progress? If so, which cognitive skills best discriminate between high and low responders? Are certain cognitive skills predictive of progress in specific areas of reading (e.g. phonemic awareness, fluency)?

De-identified data was collected from 171 struggling readers in 1<sup>st</sup> through 3<sup>rd</sup> grade who participated in a large western school district's Reading Skills Development project from October 2012 to May 2013. From this population, *high-responders* and *low-responders* were identified based on progress in total reading score reports from Istation, a computer-based progress monitoring tool. After controlling for English proficiency level, high and low responders were compared on several reading-related cognitive skills measured by the Woodcock-Johnson III Test of Cognitive Abilities. Differences between

high and low responders were found on Auditory Working Memory and Retrieval Fluency. Additionally, Auditory Working Memory was found to best discriminate between the high and low responder groups and was most predictive of overall reading growth. No differences were found between groups on Vocabulary, Sound Blending, or Rapid Picture Naming. These results confirm and add to previous findings regarding the impact of working memory on learning and academic progress. Furthermore, they support the growing body of literature on using an assessment-based approach to inform interventions targeted to specific cognitive deficits, especially those deficits found to be predictive of progress such as working memory and long-term retrieval.

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## CHAPTER 1—INTRODUCTION

### **Background**

My current focus is on integrating Response to Intervention (RTI) with assessment and identification of cognitive strengths and weaknesses for students who may have a reading disability. One of the most common referrals for assessment is difficulty with reading acquisition. Estimates show 5% of children have a reading disability and that 80% of students with a specific learning disability (SLD) suffer their greatest academic problems in reading (Fiorello, Hale, & Snyder, 2006). While these difficulties start with simple word identification and meaning in the early grades, reading fluency and comprehension become an increasingly significant deficit in the later grades as students must read to learn new information in all subjects (Fuchs, Fuchs & Compton, 2004). Across the country, the risk for reading problems ranges from 20 to 80 % of all children. The 2011 data from the National Assessment of Educational Progress shows that 34 % of students in fourth grade do not have the basic reading skills needed to complete grade-level coursework. This number is even higher (45%) for large urban cities.

Among the literature, various causes of reading failure have been identified including environmental factors, such as lack of educational experiences, and biological or cognitive factors, such as language comprehension, phonemic awareness, verbal working memory, rapid automatic naming, long term retrieval, and processing speed (Fiorello et al., 2006; Flanagan, Ortiz, Alfonso, & Dynda, 2006; Hale, Kaufman, Naglieri, & Kavale, 2006; Royer & Walles, 2007). The many potential factors involved in reading acquisition necessitate comprehensive evaluations that can accurately identify

and treat reading problems. However, the current lack of consensus about how a reading disability is identified and how assessment should be incorporated into evaluations has led to approaches that may not serve those with reading deficits most effectively.

### **Learning Disabilities**

A specific learning disability (SLD or LD) is defined by the Individuals with Disabilities Education Act (IDEA; 2004) as a “disorder in one or more of the basic psychological processes” which manifests itself as an unexpected difficulty in one of seven areas of achievement, but most commonly in the area of reading. Because LD is recognized as an unexpected difficulty to learn, the main identification model used for years was a discrepancy between intelligence and achievement. Thus to be considered eligible for special education services, a child must score significantly higher on an IQ test than on an achievement test.

This model of identification became problematic because the use of varying discrepancy formulas and test instruments often identified different students (Bradley, Danielson, & Hallahan, 2002; Fletcher & Denton, 2003). Furthermore, research shows that underlying deficits in reading may occur regardless of discrepancy between intelligence and achievement (Fuchs et al., 2004; Stage, Abbot, Jenkins & Berninger, 2003). In fact, intelligence tests are often comprised of skills that measure cognitive processing and efficiency, so a student with a learning disability (i.e. dysfunction in neurological processing per the definition) may likely score low on *both* IQ and achievement tests. In reaction to the many voiced concerns, IDEA 2004 repealed the mandatory use of a discrepancy and authorized an alternative method of identification, Response to Intervention (RTI).

## **Response to Intervention (RTI)**

The shift from an ability-achievement discrepancy model to an RTI model for diagnosis and intervention is rapidly becoming the norm for many schools across the country, and especially in Nevada. RTI, which has been a special focus of IDEA 2004 due to the No Child Left Behind Act, uses a problem-solving approach that incorporates multi-tiered evidence-based interventions and preventative services such as universal screening and regular progress monitoring of all students. The RTI model for diagnosing a learning disability evaluates a child's response to general instruction and then increasingly targeted interventions that have been shown to be effective for most students. While there is no absolute definition of what RTI looks like, the following is a typical description of its three-tiered model.

Students in Tier I receive universal evidence-based instruction and get periodically screened to detect struggling learners. These at-risk children who have been identified receive research-based instruction, sometimes in small groups, sometimes as part of a class-wide intervention. Students who are not making progress with those interventions move to Tier II where they receive more intense instruction (e.g. 30-45 minutes in small groups above the general instruction) to meet their needs and are monitored more frequently on performance measures. If the student is able to make progress, they may move back to Tier 1. Alternatively, students who still do not respond adequately to interventions begin to receive Tier III interventions, which are more individualized and intense to help remediate existing problems and prevent more severe problems. Students in Tier III might have an hour or more outside of general instruction and be referred for evaluation of special education services if not making progress.

The intent is to reduce referrals to special education by distinguishing between students who have performed poorly due to inadequate prior instruction and students who truly have a disability in learning and need more intensive instruction (National Joint Committee on Learning Disabilities, 2005). Proponents of RTI insist it is an improvement from the highly criticized discrepancy model (sometimes called the “wait to fail” model) because interventions can be implemented immediately for underachieving students instead of waiting for students to exhibit a severe enough discrepancy between cognitive ability and academic achievement (Dunn, 2010; NJCLD, 2005).

Most educational researchers would argue that early intervention is paramount. Lyon and colleagues (2001) insisted that early identification and prevention programs could reduce the number of students with reading problems by up to 70%. Vellutino, Scanlon, Small, and Fanuele (2006) found that initiating two 30-minute small group reading interventions per week for students in kindergarten resulted in 84% of the at-risk children performing in the average range by the end of third grade. It’s been suggested that failure to acquire basic reading skills by age nine (when services typically begin) predicts a lifetime of illiteracy; without intervention, almost 75 % of children at-risk for reading failure will continue to have reading difficulties in high school (Lyon, 1998). From this perspective, RTI offers a promising approach to remediating reading deficits because it targets at-risk students early on through universal screening and implementation of interventions within general education.

Coupled with its support from field-based research, the wide adoption into educational policy has made RTI the new “it” tool for early intervention and disability identification. Indeed its problem-solving practices are useful in providing scientifically-

based instructional methods for all students regardless of disability status and in preventing over-identification of learning disabled students. Since many school districts are adopting the use of RTI as a comprehensive tool in determining whether a child has a learning disability, school psychologists are tasked with the duty to recommend evidence-based interventions and then see to it that they are implemented with fidelity. Successful implementation of RTI depends on many factors including administrative and district support, investment in resources, and professional development for teachers to gain skills in effectively delivering interventions (Fuchs & Deshler, 2007).

However, RTI alone is not a perfect model. There is a lack of procedural guidance which makes treatment integrity and progress monitoring problematic, especially since they rely on teachers' subjective reports (Reynolds and Shaywitz, 2009). Additionally, there is no true positive in an RTI model; using a "did respond/did not respond" method to identify students with a learning disability is essentially *diagnosis by default* (Fiorello et al., 2006; Hale & Brackenson, 2013), which is neither informative nor empirically sound. Furthermore, even with flawless implementation of the highest quality general education instruction and application of our current methods of broad early reading interventions to all who need them, estimates of non-responders still range from 2 to 6 % (National Research Center on Learning Disabilities, 2002; Torgesen, 2000). While this number is significantly lower than the percentage of *all* students who struggle in reading, RTI clearly does not capture everyone, i.e. "No Child Left Behind." This imperfection in the model suggests a need for better understanding of why these children are not responding to generalized interventions and what needs to change in order to adequately serve these students with severe reading disabilities.

## **Integrating Cognitive Assessment**

Supporters of the RTI model consider cognitive testing unnecessary and insist that the multi-tiered instructional process yields all relevant information about the student's academic needs (Bradley, Danielson, & Hallahan, 2002; Reynolds & Shaywitz, 2009). The opposing view is that a comprehensive assessment is crucial for identifying impaired versus intact cognitive processes that are relevant to unexpected underachievement which is (by definition) the essence of SLD. While the two opposing sides have often been promoted as mutually exclusive, several educational theorists disagree and hope to remediate the controversy by combining the seemingly disparate approaches into a balanced model. Many renowned researchers in the field (Compton, Fuchs, Fuchs, Lambert, & Hamlett, 2012; Flanagan, Fiorello & Ortiz, 2010; Flanagan, Ortiz, Alfonso, & Dynda, 2006; Fuchs & Deshler, 2007; Hale, Kaufman, Naglieri, & Kavale, 2006; Hale, Wycoff, Fiorello, 2010; Hale et al., 2010; Reynolds & Shaywitz, 2009; Royer & Walles, 2007) now contend that while RTI has many promising characteristics, alone it should not be relied on as a sufficient method of disability identification; instead RTI should incorporate cognitive assessment data that is necessary to 1) identify specific learning deficits in non-responders and 2) guide the development of individualized interventions for these students.

While looking for discrepancies in IQ and achievement may not be a theoretically sound method of SLD identification, intelligence tests themselves offer useful information for a school psychologist. In addition, Flanagan et al. (2006), Flanagan et al. (2010), and Hale et al. (2006) demonstrate that current cognitive assessment is well grounded in psychometric theory. While originally IQ was conceptualized as a single “g”



factor that was meant to represent global intelligence, the most recent and widely used IQ tests developed in the last 15 years have been centered on theoretical perspectives that emphasize multi-dimensional cognitive processes and factors.

The Cattell-Horn-Carroll (CHC) theory has been the basis for most of the major cognitive assessment batteries such as the Woodcock-Johnson III Tests of Cognitive Ability (WJ III-COG; Woodcock, McGrew & Mather, 2001), the Stanford-Binet Intelligence Scales, Fifth Edition (SB5; Roid, 2003), the Kaufman Assessment Battery for Children, Second Edition (KABC-II; Kaufman & Kaufman, 2004) and the Differential Ability Scales, Second Edition (DAS-II; Elliot, 2006). In addition, the neo-Lurian Planning, Attention, Simultaneous, and Successive (PASS) model was used in the development of cognitive tests that include neuropsychological processes of executive functioning such as the Cognitive Assessment System (CAS; Naglieri & Das, 1997) and the NEPSY-II (Korkman, Kirk, & Kemp, 2007). The authors explain how assessments based on the CHC and PASS theory can identify students' cognitive strengths and weaknesses and provide insight as to why certain instructional methods may be ineffective for particular students (Flanagan et al., 2006; Flanagan et al., 2010; Hale et al., 2006). Additionally, by using assessments based on these theories, school psychologists can gather information about cognitive strengths and weaknesses from clusters of tests and even individual subtests that measure specific abilities, rather than give the whole cognitive battery.

A critical theme noted by several authors in the field has been that the RTI model provides little guidance as to what to do *after* a child fails to respond because it does not delineate which specific components require intervention (Hale et al., 2006; Flanagan et

al., 2010; Reynolds & Shaywitz, 2009). In reading, for example, does the student exhibit weakness in phonological awareness, decoding fluency, vocabulary, orthographic processing, attention or something else entirely? Without a comprehensive assessment that examines these processes, the answer will remain unknown. Therefore, these authors claim that the most optimal match of a child's individual needs with specific intervention components requires a full profile of cognitive strengths and weaknesses.

While there are strengths to both an RTI and cognitive assessment approach to serving children with learning disabilities, research clearly demonstrates the need for an integrated model that combines both. RTI can identify students at risk for reading failure and deliver immediate services, but it alone cannot specify what the deficit entails and instead leads to a generic "learning problem" or in this case "reading problem" category (Hale et al., 2006). Similarly, Reynolds and Shaywitz (2009) argue that "elimination of an evaluation of cognitive abilities and psychological processes seems to revert to a one-size-fits-all mentality where it is naively assumed that all children fail for the same reason" (p. 140).

Current theorists support an alternative "third method" approach for understanding and evaluating a learning disability. This integrated approach uses a Cognitive Hypothesis Testing model that has both diagnostic and instructional implications. While more comprehensive assessments may be time-consuming, in the end multi-disciplinary teams actually *save* time. The logic here is that precious time and resources are not wasted on compensatory strategies that are ineffective for students unlikely to benefit from a generalized intervention because their deficits are biological in nature. Instead these comprehensive assessments can help determine which intervention

methods will be the most effective for unresponsive students who need more specialized services to target specific deficits.

This viewpoint is illustrated by the models presented in Hale et al. (2006) and Flanagan et al. (2010). Both articles discuss the relevance of Naglieri's (1999) Discrepancy/Consistency Model and Hale and Fiorello's (2004) Concordance-Discordance Model which are part of a broader Cognitive Hypothesis Testing approach to assessment based on a model of neuropsychological processes. These models show relationships between academic performance and cognitive measures with correlations between processing weaknesses and academic deficits (concordance/consistency) and significant differences between processing strengths and academic deficits (discordance/discrepancy). Use of a hypothesis testing approach to identifying and providing services for those with learning disabilities within these theoretical models has practical implications for the collection and interpretation of data in light of the individual's needs. In addition, it allows practitioners to evaluate students' strengths and weaknesses and develop individualized intervention strategies to improve learning.

### **Theoretical Framework behind Cognitive Assessment**

The current practice of school psychology demands that cognitive assessment be based on strong theoretical foundations. As previously mentioned, one of the most empirically supported and widely accepted theories of intelligence is the Cattell-Horn-Carroll (CHC) theory, which is the basis for many modern psychometric measures. The CHC theory is a fusion of the two most prominent theoretical models of intelligence, the Cattell-Horn fluid-crystallized (*Gf-Gc*) theory and Carroll's three-stratum theory of cognitive abilities (Flanagan, Ortiz, Alfonso, & Mascolo, 2006; McGrew, 2005).

The Cattell-Horn theory proposes that general intelligence is actually an accumulation of numerous abilities working together in various ways to bring out different intelligences. *Gf-Gc* theory separates these abilities broadly into two different sets of abilities: fluid intelligence, which Cattell describes as the ability to reason and solve novel problems, and crystallized intelligence, which is the ability to reason with previously learned information and develops largely as a function of education, experience, and language development (Kamphaus, Winsor, Rowe, & Kim, 2005). Carroll's three-stratum theory first divides general intelligence into eight broad categories, including fluid and crystallized intelligence, and then further divides those factors into more narrow abilities (McGrew, 2005).

The CHC theory of intelligence, an integration of these two models, claims that general intelligence is composed of 10 broad stratum abilities and over 70 narrow abilities. The 10 broad abilities are as follows: fluid intelligence (Gf), quantitative knowledge (Gq), crystallized intelligence (Gc), reading and writing (Grw), short-term memory (Gsm), visual processing (Gv), auditory processing (Ga), long-term storage and retrieval (Glr), processing speed (Gs), and decision speed/reaction time (Gt). Examples of narrow abilities are quantitative reasoning, lexical knowledge, working memory, spatial relations, associational fluency, reading speed, and spelling ability (Flanagan, Ortiz, Alfonso, & Mascolo, 2006).

The PASS cognitive processing theory provides another framework for evaluating cognitive strengths and weaknesses in children. This model is comprised of four executive processes: *Planning*, the ability to select and use efficient solutions to problems; *Attention*, the ability to selectively attend to some stimuli while ignoring

others; *Simultaneous Processing*, the visual-spatial ability to recognize patterns and integrate stimuli into groups; and *Successive Processing*, the ability to integrate information in a serial order (Naglieri, 2005). Assessments based off the PASS model have been used for identification and intervention of deficits associated with reading disabilities. Students who struggle in attention tend to have trouble focusing on important details when they read and miss relevant information. Simultaneous processing is critical for reading comprehension and deficits in successive processing lead to difficulty decoding sounds to make words and remembering words in order.

These theoretical models serve not only as a foundation for test development, but also as a tool in the selection and interpretation of tests of cognitive and academic abilities (Alfonso, Flanagan & Radwan, 2005). For example, the Cognitive Assessment System (CAS) is a measure of executive processes that includes 12 subtests for assessing each of the four PASS scales such as planned codes, expressive attention, nonverbal matrices, and word series (Naglieri, 2005). The Woodcock-Johnson Third Edition Test of Cognitive Abilities (WJ-III:COG) includes 20 subtests for measuring broad and narrow abilities such as Verbal Comprehension (Gc), Sound Blending (Ga), Memory for Words (Gf), and Visual Matching (Gs). The tests are organized into various CHC and clinical clusters for diagnostic interpretations.

Research has shown a relationship between the various cognitive abilities and processes that underlie the major areas of academic achievement, namely reading, math, and writing (Flanagan, Ortiz, Alfonso, & Mascolo, 2006). Therefore, recently, the CHC model has been used for 1) classifying achievement tests to organize assessments that are closely in line with referral information for individuals suspected of having a learning

disability, 2) facilitating interpretation of academic abilities, and 3) providing data that can be more readily linked to appropriate interventions (Flanagan et al., 2006; Alfonso et al., 2005).

### **Rationale**

The CHC and PASS models can be used as part of the Cognitive Hypothesis Testing approach to select specific cognitive and academic measures based on the presenting problem. Hypotheses can be made about the cognitive demands required to perform a given task and specific tests can be chosen based on these hypotheses. For example, according to the CHC model of intelligence, a child suspected of having a learning disability in reading could be given measures of narrow cognitive abilities related to reading such as phonological processing, lexical knowledge, and retrieval fluency. Academic assessment measures related to reading can also be given such as nonsense word decoding, letter and word recognition, and associational fluency (Flanagan et al., 2006). These models allow the examiner to interpret assessment data from a theoretical perspective; therefore, assumptions can be made about the cognitive weaknesses that contribute to the presenting problem.

Students with learning disabilities in reading often have unique cognitive profiles that differentially impact their reading achievement (Flanagan, Ortiz, Alfonso, & Mascolo, 2006) and may also affect their responsiveness to instruction. For example, one student may have deficits in phonemic awareness and could use further training in phonological processing. Another may have difficulty with decoding fluency and would benefit from repeated word exposure to build automaticity. Due to specific cognitive deficits, these students may not benefit from typical Tier II reading interventions, which

may look like 30 to 45 minutes in a small group; instead they may need more individualized instruction targeted to their specific deficits.

### **Purpose of the Study**

The purpose of this study was to investigate how using a theory-driven model of assessment could be used to identify strengths and weaknesses between students who have responded well and students who have poorly responded to Tier I and Tier II instruction. The following research questions are ones which were addressed.

### **Research Questions**

- 1) *Are there cognitive differences between students who respond well and students who do not respond to a Tier II intervention for struggling readers?*
- 2) *If so, what cognitive skills best discriminate between high-responders and non-responders?*
- 3) *Furthermore, do certain cognitive abilities predict progress in reading skills (e.g. fluency, phonemic awareness) during the Tier II intervention?*

Answers to these questions would provide insight into the heterogeneous nature of children's reading ability and how various cognitive skills can influence progress and outcomes. In addition, findings contribute to the growing body of research on the cognitive skills necessary for proficient reading. Finally, understanding students' particular strengths and weaknesses may help guide treatment planning so that students respond more effectively to interventions.

School psychologists are tasked with accurately identifying students with a learning disability and ensuring that the most effective interventions are being implemented for those students. In order to accomplish this task, it would be useful to

address both biological and environmental factors of learning difficulties (the first with comprehensive cognitive testing and the latter with RTI). Because this integrated approach is relatively new and debates continue to abound in the literature regarding the best method for conceptualizing and treating learning disorders, a clear need exists for further research that explores the link between cognitive processing and more effective learning.

### **Limitations of Previous Research**

Currently a limited amount research in the field integrates a cognitive assessment approach to reading deficits within an RTI framework. However, a theoretical movement in that direction will hopefully lead to better practice in the schools. By using cognitive measures based on CHC and PASS theories of reading ability to assess students who are at risk for reading failure and subsequent responsiveness to typical Tier II interventions, we may be able to identify consistent patterns of weaknesses that emerge among struggling readers. Furthermore, determining cognitive patterns of strengths and weakness can help pave the way for developing reading interventions that target those core deficits (e.g. phonological awareness, retrieval fluency, successive processing, working memory). To best serve struggling students, school psychologists should be able to quickly and efficiently discriminate between students who are likely to respond to a Tier II intervention and those who are not. This would help establish a better model of the cognitive patterns of strengths and weaknesses that contribute to reading success and allow students to receive the help they need right away. Only when we have insight into the underlying cognitive processes of reading failure can we truly individualize strategies to promote better reading and learning.



## CHAPTER 2—LITERATURE REVIEW

### Introduction

Many educational psychologists support a model of SLD identification that incorporates both a comprehensive assessment of cognitive abilities and responsiveness to high-quality instruction. Responsiveness is typically characterized by two different progress indicators: performance level and growth rate (Al Otaiba & Fuchs, 2002) with a dual discrepancy between students and peers showing the greatest promise in identifying non-responders (McMaster, Fuchs, Fuchs, & Compton, 2003). It is estimated that 20 to 30 % of children at risk for reading disabilities do not respond to generally effective interventions (McMaster et al, 2003; Al Otaiba & Fuchs, 2006). Although this means that some students' reading difficulties can indeed be remediated with interventions, it still begs the question as to how to better identify and serve students who need more intensive instruction. We need to understand the cognitive correlates for reading success and be better prepared to identify students' strengths and weaknesses as it impacts reading development. If this can be done *prior* to delivering Tier II intervention, rather than waiting until a student is classified as SLD by RTI criteria, school psychologists stand a better chance of identifying students who will not respond to generalized interventions due to cognitive deficits in certain areas. This in turn allows them to subsequently target those students' specific weaknesses and plan for more effective interventions.

While the RTI movement has made a great deal of headway in the search for a better method of classification and intervention, numerous researchers have indicated that inadequate treatment response may be an insufficient marker for identification of a learning disability (Bradley, Danielson, & Hallahan, 2002; Flanagan, Fiorello & Ortiz,

2010; Flanagan, Ortiz, Alfonso, & Dynda, 2006; Fuchs & Deshler, 2007; Hale, Kaufman, Naglieri, & Kavale, 2006; Reynolds & Shaywitz, 2009; Royer & Walles, 2007). To improve the process, Bradley et al. (2002) recommend further research on potential markers for early identification of students who are likely to be unresponsive to intervention. This suggests the need for an evaluation of cognitive processes that underlie learning deficits, particularly in reading.

### **Factors Underlying Reading Deficits**

One theme across the literature is the speculation that both biology and environment play a role in the display of reading deficits (Flanagan et al., 2006; Flanagan et al., 2010; Hale et al., 2006; Royer & Walles, 2007). Biological problems relate to neurological differences in the brain with examples including difficulties in: executive functions (e.g. attention, working memory and successive processing), phonetic coding and processing, long-term retrieval, perceptual speed, and language development (Flanagan et al., 2006; Hale et al., 2006; Royer & Walles, 2007). Environmental problems may include lack of appropriate instruction, lack of access to educational resources, or living in a low SES home in which there is little exposure to reading materials or practice with activities that promote lexical knowledge and phonological awareness such as letter identification, letter-sound association, and rhyming activities (Royer & Walles, 2007). Royer and Walles hypothesize that students whose difficulties are environmental in origin are likely to respond positively to conventional reading interventions, whereas students who have biological difficulties are likely to be resistant to these interventions.

While this hypothesis fits with the RTI model of identifying children through their lack of response, a further implication is that early detection of these treatment resisters could prevent time being wasted on generalized interventions that will result in little progress after 10-15 weeks. When using RTI alone, students who are unresponsive to treatment will eventually be diagnosed with a learning disability but only *after* a teacher has watched them fail for several weeks or months. Even then, without more comprehensive assessment, interventions will still not be targeted towards the student's actual weaknesses, thus hindering academic growth. In fact, Denton, Fletcher, Anthony, and Francis (2006) found that more intensive Tier III generalized interventions provided for students who were non-responsive to Tier II interventions did not help these children reach benchmark goals. It seems that "more of the same" is not an effective strategy for non-responders.

A prevailing assumption in the reading literature is that most poor readers have difficulties at the level of decoding individual words and that the central cause is a core phonological processing deficit (Al Otaiba & Fuchs, 2002; Nelson, Benner & Gonzalez, 2003; Royer & Walles, 2007; Shaywitz, 2003; Torgesen, 2000). Poor phonological processing is thought to inhibit the accurate encoding of the basic sounds of speech (phonemes) which negatively impacts normal language and reading acquisition (Shaywitz, 2003). Torgesen (2000) indicates that poor readers often struggle both in recognizing a word by sight and using phonetic cues to sound it out. This slow and/or inaccurate decoding weighs on valuable cognitive resources such as working memory, hindering higher level reading activities such as text comprehension (Royer & Walles, 2007).

## **Cognitive Characteristics of Non-Responsive Students**

In a review of the literature on characteristics of unresponsive students, Al Otaiba and Fuchs (2002) reported that the majority of children who were unresponsive to early literacy interventions demonstrated poor phonological awareness. However, other factors such as difficulties in rapid automatized naming, phonological working memory, verbal IQ, and attention and behavior problems have also been found to have significant and predictive relationships to inadequate response (Al Otaiba & Fuchs, 2002; Fletcher et al., 2011; Nelson, Benner, & Gonzalez, 2003; Stage, Abbott, Jenkins, & Berninger, 2003). Due to the findings of several contributors, Al Otaiba and Fuchs (2002) concluded that a “typical” non-responder is difficult to characterize because he or she is likely to have a complex profile of strengths and weaknesses which may be different than other non-responders. They suggested further research in aptitude-treatment interactions (ATIs) that would examine the effectiveness of differentially applied interventions to accommodate students’ particular strengths and weaknesses. This recommendation is consistent with the hypothesis that cognitive profiling of strengths and weaknesses could lead to more targeted interventions for individual students.

Nelson, Benner and Gonzalez (2003) extended the previous literature review by including meta-analytic techniques to determine the magnitude and relative contribution of learner characteristics to treatment effectiveness. They found several factors moderating response to treatment including: rapid letter naming, phonological awareness, problem behavior, alphabetic principle, memory, and IQ. Rapid letter naming had the highest magnitude of effect, followed by phonological awareness which is consistent with research that shows phonological processing deficits to underlie most reading problems

(Al Otaiba & Fuchs, 2002; Royer & Walles, 2007; Shaywitz, 2003; Torgesen, 2000).

These authors also noted that identifying learner characteristics that contribute to treatment response may lead to the development of more specialized interventions.

Stage, Abbot, Jenkins, and Berninger (2003) examined how cognitive characteristics such as Verbal IQ, reading-related language abilities, and attention ratings affected reading growth in low-achieving first-graders. Treatment consisted of 20-minute lessons offered 24 times over four months that combined instruction in the alphabetic principle, connections between written and spoken words, and practice in reading first-grade level books. Results showed that treatment groups improved significantly more than control groups in real-word reading and pseudo-word decoding. Individual growth analysis found phonological, orthographic, and rapid automatized naming (RAN) deficits to be unique predictors of response to early reading intervention, especially when students had double or triple deficits in these language skills. Single deficits were more likely to compromise growth in real-word reading, whereas double and triple deficits affected phonological decoding.

Consistent with previous outcomes, Stage and colleagues found RAN was the most frequent reading related language deficit. Attention was also a contributing factor to the effectiveness of these early interventions. Verbal IQ seemed to play only a small role and was the least relevant predictor, although this may be due to the use of only first-graders. Research shows that older students tend to be impacted more by verbal ability (Evans et al., 2001). Regardless, this study supports the notion that cognitive abilities play a role in response to early reading interventions and may help differentiate students for whom certain interventions will be most beneficial.

Fletcher et al. (2011) evaluated the following cognitive attributes between students who responded adequately and inadequately to a Tier 2 reading interventions: phonological awareness, rapid letter naming, oral language skills, processing speed, vocabulary, and nonverbal problem solving. These measures were selected either as correlates of inadequate response or constructs often associated with SLD. Students were grouped by impairments in fluency alone or decoding and fluency. These authors found cognitive differences between responders and non-responders for both the reading fluency and decoding/fluency groups; however there were no differences between the impaired groups. The contribution of phonological awareness and rapid letter naming skills to group separation supported previous findings as well (Al Otaiba & Fuchs, 2002; Stage et al, 2003). However, they did not conclude that additional cognitive assessments were justified in adding value to the identification process. The authors acknowledged that the low intensity of the interventions (8 to 16 weeks) used to identify responder status and limited cognitive tests (e.g. Kaufman Brief Intelligence Test) were limitations of their study and suggested use of the WJ III cognitive battery or CAS to better assess cognitive processes. Additionally, their definition of responders and non-responders involved only end of the year norm-referenced and criterion-referenced testing. They did not include progress on the interventions utilized, which may account for those students who started exceptionally low but did make relative progress on assessed skills and thus would be considered a responder. Therefore, further research using more appropriate cognitive test higher intensity interventions, and progress monitoring is warranted in order to better detect cognitive correlates of inadequate response.

## **The Role of Assessment**

Many researchers maintain that data from cognitive evaluations can offer valuable information beyond the identification of a disability. Flanagan, Ortiz, and Alfonso (2008) point out that assessment data can be used to 1) give information about the cognitive or processing deficits that may be contributing to a child's learning difficulties; 2) understand why a particular Tier II intervention may not be effective for that child; 3) assist in the selection and development of new or modified interventions tailored to the child's unique pattern of cognitive strengths and weaknesses; 4) advise on strategies or accommodations that may help the child compensate for cognitive deficits while engaging in productive learning. Given the strong link between cognitive abilities and the development of reading skills, the value of conducting cognitive tests for identifying cognitive strengths and weaknesses to inform decisions about how best to intervene is apparent.

Lonigan, Allan, and Lerner (2011) discuss the degree to which different types of assessments can inform instructional decisions for pre-school literacy skills, which are often predictive of later success in reading. Traditional methods of determining the skills of preschool children often involve informal assessments by the teacher such as classroom observations, checklists, rating scales, or portfolios of children's work products. Some concerns for using informal measures like these, however, are that they typically do not use a standardized procedure so norms may not be available, and they may not provide specific information about areas of weakness in different domains of literacy. Standardized measures such as screening assessments and progress-monitoring assessments allow for more meaningful comparisons across children; they can be used to determine the need for additional instruction as well as the child's growth in specific

areas. However these assessments, often utilized in an RTI model of identification, are insufficient to allow the type of matching of instructional activities to children's educational needs that is required to improve children's educational outcomes.

For truly at-risk students, Lonigan et al. (2011) promote the use of diagnostic assessment, which allows for in-depth, determination of early literacy skills in which a child has strengths and weaknesses relative to the norm. These authors list examples of standardized diagnostic measures, including the Woodcock Johnson III Test of Cognitive Abilities (WJ III-COG), for the assessment of preschoolers' oral language, phonological processing, and print knowledge skills. With diagnostic information, teachers can make more valid educational decisions about what instructional activities or interventions are most likely to benefit the child.

### **Linking Cognitive Processes to Reading Achievement**

If examiners interpret assessment data from a theoretical perspective, assumptions can be made about the pattern of cognitive weaknesses that contribute to the presenting problem. Applying the Cattell-Horn-Carroll (CHC) conceptual framework, cognitive functioning can be divided into broad and narrow abilities that determine how a student processes, stores, retrieves and analyzes information, all of which directly influence academic performance. This theory has been the basis for most of the major cognitive assessment batteries and several of the cognitive processes measured have been linked to reading acquisition (Fiorello & Primerano, 2005; Flanagan, Fiorello & Ortiz, 2010; Flanagan, Ortiz, Alfonso, & Dynda, 2006; Konold, Jule, & McKinnon, 1999). The following are descriptions of the CHC broad abilities most associated with reading



achievement in the elementary school years and used in research that will be further discussed (Konold et al., 1999; Flanagan, Ortiz, Alfonso, & Mascolo, 2006).

*Auditory processing (Ga)* involves the understanding of auditory patterns such as recognizing similarities and differences between sounds. Phonemic awareness skills are important for language development and the acquisition of early reading. *Crystallized ability (Gc)*, also called comprehension-knowledge, consists of the application of knowledge-based reasoning and judgment to problem solving. While the relationship is somewhat weaker for younger students, the ability to draw inferences from prior knowledge has a large impact on reading comprehension as children get increasingly older. *Processing speed (Gs)* is the ability to work quickly and accurately through automatic cognitive tasks. When children have automaticity in decoding syllables and words, it allows greater attention to be placed on text comprehension. *Short-term memory (Gsm)*, involves the ability to take in and hold information for immediate use. Its relationship to reading skills increases with age as children must remember word links between letters and sounds, irregular spelling patterns, and recall recently read information. *Long-term retrieval (Glr)* involves the ability to store and retrieve information through association over longer periods of time. Fluency in retrieval, including rapid automatized naming skills (RAN), is linked to reading especially in younger grades.

Since underlying cognitive abilities are associated with academic achievement in school, current research has sought to investigate which specific links may be most important. Fiorello and Primerano (2005) explored literature on the application of Cattell-Horn-Carroll (CHC) based cognitive assessments to school psychology practice with a

focus on linking assessment to intervention design. Many studies have examined the relationship between theory-driven standardized measures of CHC cognitive abilities and standardized measures of achievement in reading, writing, and mathematics. From their review on the literature, Fiorello and Primerano maintain that specific cognitive abilities are important for understanding the development of specific academic skills. In addition, they note that when assessments are organized around the CHC theoretical model, specific abilities account for a significantly greater portion of the variance in reading achievement than overall intelligence (*g*). Some of the studies included in the review are discussed in further detail below.

Evans, Floyd, McGrew, and Leforgee (2001) investigated predictive relationships between the various CHC cognitive abilities and reading achievement during childhood and adolescence using the standardization sample from the WJ III. Rather than miss potential associations, these authors included all seven CHC factors from the WJ III (the five previously described plus visual-spatial thinking, *Gv*, and fluid reasoning, *Gf*) along with three additional clinical clusters that further measured phonemic awareness and working memory. Multiple regression analyses were conducted to reveal relationships between the cognitive clusters and scores on the WJ III-ACH Basic Reading Skills and Reading Comprehension clusters. Results showed moderate to strong relations of crystallized ability (*Gc*) with measures of reading achievement across childhood and adolescence. Whereas short term-memory (*Gsm*) has moderate relations to reading comprehension during this same period, its importance tends to decrease with age as reading becomes more automatic and requires less working memory capacity. Auditory

processing (*Ga*), long-term retrieval (*Glr*), and processing speed (*Gs*) displayed moderate relations with reading achievement during childhood, though not in adolescence.

Evans et al. (2001) found that *Gc*, which represents general knowledge and verbal reasoning, was the strongest predictor of both basic reading skills and reading comprehension. Though *Gc* may not be as relevant for early reading acquisition, this link becomes especially prominent after age 8 as reading for knowledge is increasingly necessary. Auditory processing was more strongly linked to Basic Reading Skills acquired from age 6 to 9 and less with Reading Comprehension. This is consistent with research showing phonological skills to be especially relevant during early reading acquisition. Interestingly, the phonemic awareness cluster, which measured the ability to perceive and manipulate units of speech, was also a significant predictor of Reading Comprehension during early school-age years and again in adolescence. This may be due to the higher complexity of some of the phonemic awareness tasks which involved overlapping constructs (i.e. *Ga* and *Gsm*), such as repeating a dictated word with a sound omitted (say “cart” without the /t/) or substituted (“say “sunny” but change /s/ to /f/).

Though this study by Evans et al. (2001) provides a foundational argument for the predictive relationship between cognitive abilities and reading achievement in children, the use of its normative sample of *all* children does not specifically account for differences in those with academic deficits. According to Hale and Backenson (2013), children with reading deficits don’t use the same area of the brain as typically developing children. They often compensate for their weaknesses by using other areas of processing. Therefore, it is important to also explore predictive relationships between cognitive

processes and reading achievement in a sample of struggling readers at risk for reading deficits.

The Center for the Improvement of Early Reading Achievement (Konold, Jule, and McKinnon, 1999) conducted an investigation of how children of various reading abilities performed on each of the CHC constructs associated with an underlying function or component of literacy acquisition (auditory processing, crystalized ability, processing speed, and short-term memory). Their intent was to develop an integrative model through cluster analysis of how these processes operate together among emergent readers. Konold et al. used a large standardized national sample to identify six individual normative profile types on measures of *Ga*, *Gc*, *Gs*, and *Gsm*. Then a multivariate analysis of variance (MANOVA) compared them across the four different literacy outcome measures (Letter-Word Identification, Word-Attack, Reading Vocabulary, and Passage Comprehension) that comprise the WJ III-ACH reading clinical clusters to determine which profiles were most associated with successful readers.

Not surprisingly, children with strengths in all four areas (auditory processing, crystalized ability, processing speed, and short-term memory) performed the best on reading outcome measures, whereas children with weaknesses in all four areas performed the worst. However, Konold and colleagues found that children with at least one secondary strength performed better than the flat average profile group, which suggests that successful readers benefit from having a strength in at least one area. In addition, a cognitive strength in auditory processing predicted higher achievement on Word Attack (a measure of pseudoword decoding) but an increased processing speed was not as important for Reading Vocabulary as the other three areas.

Morris et al. (1998) also considered the possibility of subtypes in reading LD, based on cognitive and language functions. These authors used a sample of elementary children who were identified as LD on measures of decoding, word recognition, and/or calculations or were identified as having attention-deficit/hyperactivity disorder (ADHD), typical development, or generalized low performance. Through cluster analysis, they identified nine reliable subtypes (two normally developing and seven LD) that represented 90% of the sample. Two of the seven LD subtypes had language deficiencies; four of the five specific LD subtypes exhibited weakness in phonological awareness, with variations in RAN and verbal short-term memory. The remaining subtype experienced difficulty in processing speed with verbal and nonverbal measures including rate and accuracy or oral reading. Results supported previous research that phonemic awareness is an important predictor of reading impairment with discriminative variability on other cognitive skills such as phonological processing and language ability.

Compton, Fuchs, Fuchs, Lambert and Hamlett (2012) recently examined profiles of cognitive and academic strengths and weaknesses in children with LD in reading and math. These authors took a developmental approach by considering how cognitive dimensions measured in third grade support academic growth over the next two years. Nonverbal problem solving, processing speed, concept formation, language, and working memory were assessed by a battery of cognitive measures that included tests from the WJ III and the Weschler Intelligence Scale for Children-III (WISC-III). Academic achievement in reading comprehension and word reading was assessed individually three times from third until fifth grade. Results showed that the cognitive profiles of students with a reading disability reflected specific impairments. For example, students with a

disability in reading comprehension were lower on language abilities including listening comprehension and oral vocabulary, whereas students with difficulties in word reading exhibited poor working memory and oral language skills. A distinctive cognitive strength for both groups was processing speed. Limitations for this study are its small sample size with respect to LD groups and its exclusion of other notable cognitive processes related to reading such as phonemic awareness and RAN.

This body of research reflects the importance of various cognitive processes in different reading achievement outcomes and suggests that unexpected underachievement associated with SLD in reading may be conceptualized in terms of cognitive profiles of strengths and weaknesses. Given the complex array of components implicated in successful reading, it makes sense that children would display diverse cognitive profiles that would differentially impact their ability to read. However, research has shown that similar patterns emerge in how these processes work together. The studies examining predictors of reading achievement and the work on cognitive profiles for students with a reading disability provide a framework for future research in this area. However, there are limitations to these studies in sample size, cognitive measures used, and skills assessed. Previous research has used large standardization samples collected for norming the Woodcock-Johnson test batteries or samples that included mostly typically developing and non-disabled students. While these samples provide structure for looking at typical reading development, there is a need to also evaluate a population of young students with potential reading disabilities and their response to intensive interventions.

## **Early Reading Interventions**

If school psychologists can adequately assess students at risk for reading failure and determine their cognitive weaknesses underlying the difficulty, they may be able to intervene with more targeted interventions earlier on. While not as complex and discriminating in the specific deficit matched to intervention approach that may be possible with a more comprehensive model, research has shown that assessment-to-instruction practices have been successful in improving reading performance.

Fisher, Lapp, Flood, and Moore (2006) describe a professional development initiative designed to 1) increase teachers' knowledge about assessment-to-instruction practices, 2) increase teachers' skills in administering and interpreting data, and 3) improve teachers' dispositions towards the benefits of linking assessment with instruction. Teachers were expected to create assessment profiles for struggling students in which they continuously assessed student growth, used the data to diagnose students' needs, and planned instruction based on their analyses. Out of hundreds of teachers who completed these courses, 25 were selected to interview and observe for this study's focus. Results from this study indicate that the initiative design for educating teachers in how to plan instruction based on literacy assessment information had a positive influence on teacher knowledge, skills, and disposition. In addition, students who were provided instruction by these teachers outperformed a control group of students by an additional reading growth of 6 months, which suggests that students also benefit from the assessment-to-instruction approach.

A longitudinal study by Hatcher, Hulme, and Snowling (2004) evaluated the effectiveness of three different structured methods of linking phonological awareness to

reading for children just entering school at the pre-kindergarten and kindergarten level. Participants were 410 children, aged 4- to 5-years old, in 20 urban UK classrooms. The children were assessed for cognitive ability and then divided into four matched groups based upon age, general IQ, letter identification, phonological awareness, early word reading scores, and other school-related factors such as amount of classroom support and number of years since teachers received training. The groups (5 classes each) were randomly assigned to one of three experimental teaching conditions: Reading with Rhyme, Reading with Phoneme, Reading with Rhyme and Phoneme, or to a taught control condition (Reading). Analyses were conducted for both children normally developing and children at-risk of reading failure. Results showed that in normally developing children, improvements in phonological skills through training did not translate into better literacy skills; therefore providing additional phonological training might be redundant for most normally developing children. However, for children identified early on as at-risk for reading failure, the additional training in phoneme awareness did improve progress in learning to read. In at least two-thirds of the at-risk group, the decline in reading skills was halted by the additional phonological training.

### **Addressing Gaps in the Literature**

These studies show the impact of assessment to intervention practices for students with varying developmental needs. Clearly there is a strong connection between cognitive processes and the development of reading skills. Additionally, research in how cognitive processes may affect responsiveness to intervention has provided evidence that students do not all respond to interventions in the same way. It is not fully understood, however, precisely how students who respond well to Tier II interventions differ from those who



do not. As previously stated, there are many reasons why a child may struggle with reading. Many of those children will improve when met with appropriate instruction and generalized evidence-based interventions. Unfortunately a significant amount of children will not respond to typical remediation and will need individualized intervention targeted at their specific deficits. As it stands, cognitive tests are often used after Tier II intervention has already been unsuccessful. Understanding the cognitive differences (e.g. deficits in processing speed, working memory, retrieval) that are likely to impair a child's ability to learn *before* spending weeks on ineffective Tier II instruction would allow for specialized interventions earlier in the game. Furthermore, the ability to predict a student's progress on different curriculum-based measures of reading has implications for treatment planning.

The literature thus far presents a compelling argument for the need of a comprehensive approach in identifying and treating students with a reading disability. RTI is not useful as a diagnostic tool, and without cognitive testing to offer a better understanding of how cognitive deficits impact the responsiveness to intervention, many students may be left behind. However, there are gaps in the literature presenting a need for the current study. The cited studies are not necessarily based off a theoretically sound model of reading development and cognitive function. Limitations for previous studies include small sample sizes, often with respect to reading disability groups, limited cognitive measures used, and skills assessed. Previous research has used large standardization samples collected for norming the Woodcock-Johnson test batteries or samples that included mostly typically developing and non-disabled students. While these samples provide structure for looking at typical reading development, there is a need to

also evaluate a population of young students with potential reading disabilities and their response to intensive interventions.

Further limitations have been the low intensity of general intervention to determine responder status and insufficient criteria for adequate response. Most definitions of responders and non-responders have involved only end of the year norm-referenced and criterion-referenced testing. While this may be ecologically valid information, the exclusion of progress monitoring on the skills for which the interventions were utilized neglects an important and internally valid measure of how a student is responding to treatment. Criteria for response to intervention should include measures of how the student is making progress with *the actual intervention*. A child who does not reach grade-level benchmarks may still be making relative progress on those assessed skills and thus should be considered a responder. For example, doubling the number of words read in a minute from five to ten would still be considered significant improvement despite being only in the 12<sup>th</sup> percentile per say for oral reading fluency. Furthermore, criteria should include growth comparison to other students in the same intervention rather than solely to students of the same age. Finally, many studies have looked at the relationship between cognitive ability and achievement, but not cognitive ability and relative *growth* of reading achievement after intervention. This is an important distinction for Tier II approaches to serving students with potential reading disabilities. Understanding cognitive profiles of strengths and weaknesses that may assist or impede the learning process has implications for the RTI process.

Because of these limitations and the lack of research that adequately addresses the research questions presented, further research using more appropriate cognitive tests,

higher intensity interventions, and progress monitoring is warranted in order to a) better detect cognitive correlates of inadequate response and b) predict growth on curriculum-based reading measures. Due to the amount of time and effort that have been invested in the Response to Intervention solution to the No Child Left Behind Act, it is important to consider and plan for those students who will not benefit from generalized interventions even in a pull-out scenario.

The purpose of this research was to specifically evaluate a population of young students with potential reading disabilities who had not responded to intensive interventions after 20-30 weeks. For research with this smaller and more selective population the following questions were addressed: Can assessments based on the CHC theory be used to identify cognitive weaknesses in students at-risk for reading disabilities? Are there cognitive differences between students who respond well to an intense intervention and those who make little progress? Are certain cognitive skills predictive of specific progress in specific areas of reading (e.g. phonemic awareness, fluency, nonsense word decoding)? Most research has looked at how broader abilities impact achievement, however, according to Hale and Backenson (2013), subtests explain much more of the variance than either factors or global IQ scores. Although cognitive batteries do not predict much as a whole, subtests that can create homogenous subtypes highly predict achievement. Therefore, answers to these questions using a modern sample of struggling readers and subtest measures of narrow CHC abilities with better construct validity, will hopefully lead to a more precise model that can contribute to the theoretical knowledge of reading development and intervention in the early years.

For struggling readers to resist the all too common fate of lifelong literacy problems, it is important that they get the interventions they need early on. Students who are unresponsive to typical evidence-based interventions may need treatment more targeted to their specific cognitive patterns. Imagine how much more effective an intervention might be if it was matched to specific cognitive deficits *prior* to the onset of instruction. For example, a child with weak auditory processing and phonemic awareness should have practice with phoneme blending and segmentation, whereas this training would be redundant for children who have normal phonological skills. Another student with poor verbal-comprehension knowledge and long-term retrieval may benefit from vocabulary enhancing activities, but not necessarily decoding ones. Students who exhibit difficulties with sustained and shifting attention may be able to learn strategies to help maintain focus. According to Hale and Backenson (2013), good teaching actually changes brain functioning so it is important to understand the cognitive processes underlying deficits in reading in order to help a student better respond to teaching interventions. Knowing a child's pattern of strengths and weaknesses can inform decisions about whether generalized Tier II interventions will be sufficient or if a more customary method of intervention is needed. In the long-run, this approach can decrease time wasted and improve learning outcomes for struggling readers.

### **Educational Implications of an Assessment to Intervention Model**

Since the No Child Left Behind (NCLB) and Elementary and Secondary Education Act (ESEA) legislation, states have been required to develop standards that better align curriculum, assessment, and instruction. Furthermore, the reauthorization of the ESEA has strengthened accountability for gaps in student achievement and allowed

state funding to be allocated for developing and establishing the effectiveness of interventions for students with disabilities or at high-risk for disabilities (US Department of Education, 2010). The Response to Intervention (RTI) model has incurred widespread use because it offers a promising approach to targeting at-risk students early on through universal screening and implementation of interventions within general education. Most educational researchers would agree that early intervention is a key factor in remediating reading difficulties and can prevent a lifetime of literacy problems due to lack of foundational skills (Lyon, 1998; Lyon et al., 2001). NCLB and ESEA legislation, along with the Individuals with Disabilities Education Act (IDEA, 2004), has prompted much research in the effectiveness of early reading intervention strategies for improving decoding, reading fluency, and comprehension. However, understanding cognitive characteristics that may influence responsiveness to these interventions is critical.

The role for diagnostic cognitive assessments in explaining unresponsiveness and guiding interventions has significant implications for the practice of school psychology. Presently, assessing cognitive processes is controversial in the field due to the tainted history of the discrepancy model and arguments against the value of intelligence tests. In addition, some disagree that processing deficits should be used in the criteria for a learning disability with claims that methods to measure processing deficits are unclear and inadequate (Bradley et al., 2002). However, others suggest that cognitive assessments are well grounded in psychometric theory and measure cognitive processes quite efficiently, and cognitive processes are clearly related to achievement (Alfonso, Flanagan & Radwan, 2005; Flanagan, Ortiz, Alfonso, & Mascolo, 2006; Naglieri, 2005; Reynolds and Shaywitz, 2009). In addition, psychometrically sound cognitive assessments can be

useful for identifying specific patterns of strengths and weaknesses that contribute to reading proficiency. School psychologists can use CHT to interpret assessment findings in order to better make recommendations for programming and interventions.

Torgesen (1998) noted that an effective preventative intervention for students at-risk for reading failure must consist of “the right kind and quality of instruction delivered with the right level of intensity and duration to the right children at the right time” (p.34). The last part of that statement (“the right children at the right time”) reflects the need for accurate identification early enough in the process of reading development to remediate problems. A model that could provide insight into *who* exactly the “right children” are may lead to more appropriate methods of determining the “right kind and quality of instruction.” In addition, understanding cognitive deficits inherent in a reading disability may help educators place children in small group interventions with others having similar strengths and weaknesses. By incorporating diagnostic cognitive assessment earlier on, RTI would cease to be a “one-size-fits-all” model where students are given generalized reading interventions for their generalized “reading disability.” Instead, students grouped together with weaknesses (for example) in visual processing would be able to receive different interventions than students grouped together for verbal language deficits.

## CHAPTER 3—RESEARCH METHOD

### Research Questions

The general question that was explored with this research is: *Do cognitive abilities differ between responder and non-responder groups?* If so, identifying differences could help us understand why certain struggling readers do not make typical progress in a reading intervention even after 25 to 30 weeks. This broad question may be more specifically explored with the following research questions:

#### Research Question 1:

*Are there differences between high-responder and low-responder groups on cognitive skills such as comprehension-knowledge, working memory, processing speed, long-term retrieval, auditory processing? If so, skills in which cognitive area(s) best discriminate between the two groups?*

Based on the literature, it was hypothesized that there would be significant differences between the high-responder and low-responder groups in areas of working memory, processing speed, and long-term retrieval. It was further hypothesized that lower scores on the Woodcock-Johnson III (WJ-III) Retrieval Fluency and Auditory Working Memory subtests would be most predictive of membership in the low-responder category. This is because decoding skills require cognitive abilities such as retrieval from memory of letters to sounds and the ability to hold these sounds from the beginning of the word in short term memory while working on the remainder of the word.

Students who have deficits in these areas may struggle more with reading despite typical interventions that focus on building phonemic and orthographic awareness. Students who have cognitive deficits relative to other cognitive abilities may have

different brain processes that impact their ability to read/learn. Students with lower cognitive ability in certain areas may be unable to benefit from generalized interventions in the same way that students without deficits can. Tests that are predictive of responsiveness to intervention could provide valuable and time-saving information.

**Research Question 2:**

*For both high-responders and low-responders, is cognitive performance in certain areas predictive of progress on certain reading outcomes?*

Based on previous research, it was hypothesized that scores on certain cognitive measures (e.g. WJ-III Retrieval Fluency, Rapid Picture Naming, Auditory Working Memory) would predict percentage of progress on curriculum based reading measures (e.g. phonemic awareness, fluency). Specifically, it was hypothesized that WJ-III Sound Blending and Auditory Working Memory would significantly predict phonemic awareness; Retrieval Fluency and Rapid Picture Naming (a measure of RAN/processing speed) would significantly predict oral reading fluency; and that Rapid Picture Naming and Auditory Working Memory would contribute most to overall reading scores.

Different cognitive processes may play more or less of a role for separate areas of reading. For example, a student with weaknesses in processing speed may do poorly on fluency measures but not word identification. It is important to know whether certain cognitive abilities or deficits may impact performance and progress in a certain area of reading for more specialized intervention.

Answers to these questions can contribute to a model that may be able to explain impaired reading development and predict outcomes, which has clear implications for the practice of school psychology. Students may exhibit similar poor performance, but fail



for different reasons. If using cognitive assessment to identify strengths and weaknesses of a struggling reader can predict whether a student is unlikely to respond to typical interventions prior to the onset of instruction, this approach will save time and lead to better treatment planning. Additionally, understanding how certain cognitive impairments may impact progress for different reading outcomes has implications for a theoretical model of reading development in students with a learning disability. Once a model is established, follow-up research questions can investigate whether differential interventions would be effective for students depending on their cognitive strengths and weaknesses.

### **Methodology**

De-identified secondary data collected from various assessments that measure both literacy outcomes and cognitive components of reading were used to answer these research questions. In addition, statistical analyses were conducted that allowed the researcher to 1) select and sort students into groups of high-responders and low-responders according to their progress on curriculum-based measures, 2) analyze differences between groups on separate cognitive measures, and 3) examine the relationship between scores on selected cognitive assessments and percentage of progress on selected curriculum-based measures of reading. Next, the participants, instruments, procedures, and statistical analyses used to address the research questions will be discussed.

### **Participants**

Over 350 first-, second-, and third-grade students in six urban elementary schools in the southwestern United States participated in the Tier II reading intervention; however

only students who had adequate data to answer the research questions (i.e. WJ test scores and monthly ISIP progress reports) were included in this study. Therefore, the final sample consisted of 171 students from these six schools who received at least 20+ weeks of a Tier II reading intervention from October through May. Although specific cultural demographics were not included in the data obtained, the schools had a high minority and low socioeconomic population. Gender and grade characteristics of the students are as follows: 75 females, 96 males; 50 first-graders, 62 second-graders, and 59 third-graders.

### **Intervention Procedure**

During the 2012-2013 school year, six urban elementary schools participated in a district-wide Reading Skills Development project that focused on improving the reading performance of struggling readers by using precise diagnostic assessments, research-validated reading intervention strategies and small-group tutors. Students from each school were identified as having potential reading deficits by teacher referral and data collected from AIMSweb. Approximately 400 students were then selected to participate in a Tier II reading intervention that included three to four 50-minute instructional periods per week over the course of the school year. Each intervention period consisted of: 30 minutes of small group evidence-based strategic instruction in phonemic awareness and decoding skills by a trained tutor; and 20 minutes of an evidence-based computer program (Istation; Mathes, Torgesen, & Herron, 2011) that provided individual skill-based lessons in several core reading areas and continuous progress monitoring.

### **Assessments**

**AIMSweb.** AIMSweb (Pearson, 2012) is a standardized computerized assessment system used as a curriculum-based measure (CBM) of early literacy and reading skills for

kindergarten through eighth grade. Tests include measures of oral reading fluency (ORF), letter naming fluency (LNF), phoneme segmentation fluency (PSF), nonsense word fluency (NWF), and reading comprehension. AIMSweb assessments are typically given to all students by their classroom teachers as universal screeners and progress monitoring tools throughout the year. Scores that fell below the 25<sup>th</sup> percentile (according to the benchmark levels by grade and assessment period) on at least two subtests of this screening measure were used to identify students at-risk for reading deficits. AIMSweb data were then cross-referenced with teacher referrals of their lowest performing students and matches were considered candidates for further assessment and intervention in the Reading Skills Development project.

At-risk students identified by AIMS web and teacher referrals were further assessed using the Core Phonics Survey. Each survey presented lists of letters and words for the student to identify or decode. The lists included both real and pseudowords in a variety of consonant and vowel patterns. The inclusion of pseudowords requires the student to use decoding skills rather than memory to correctly pronounce these words. If the student was unable to decode a word, the examiner moved on to the next one and discontinued the subtest after three or more consecutive errors are made. Both AIMSweb and the Core Phonics Survey were administered by educators at the elementary school.

**Istation Indicators of Progress (ISIP™).** Istation Indicators of Progress Early Reading (ISIP™; Mathes, Torgesen, & Herron, 2011) is a computer-adaptive assessment that is tailored to the performance abilities of individual children. ISIP™ Early Reading measures progress in five critical domains: phonemic awareness, alphabetic knowledge

and skills, connected text fluency, vocabulary, and comprehension. The ISIP™ Total Reading Score was used to classify high and low responders. The Phonemic Awareness and Text Fluency subtests as well as the ISIP™ Total Reading Score were used as outcome measures of reading growth when determining if certain cognitive abilities were predictive of progress. The Phonemic Awareness subtest is comprised of two types of items: Beginning Sound, which assesses the student's ability to recognize an initial sound in an orally presented word, and Phonemic Blending, which assesses the ability to blend up to six phonemes into a word. Text Fluency measures the student's ability to read fluently with comprehension by leaving every fifth or sixth word blank so that the child must choose the correct word from a selection of three to complete the sentence. The ISIP Total Reading score is a composite of all subtests administered to the student and represents a good measure of overall progress.

**Woodcock-Johnson-III, Tests of Cognitive Abilities (WJ-III-Cog)** . The Woodcock Johnson III Test of Cognitive Abilities (WJ III-Cog; Woodcock, McGrew & Mather, 2001) is an individually administered norm-referenced test based on the Cattell-Horn Carroll (CHC) theory of cognitive abilities. Between 2012 and 2013, several subtests from the standard and extended battery were used to assess cognitive abilities of the selected participants that research has shown to be related to reading achievement. All subtests were administered by advanced graduate students in school psychology as part of the collaborative Reading Skills Development project. Below are brief descriptions of the factors/abilities and the subtests used to measure each (Mather & Woodcock, 2001; Shrank & Wendling, 2009).

WJ-III Verbal Comprehension, a test used to measure crystallized knowledge (Gc) or verbal ability, the store of acquired knowledge that develops largely as a function of educational experiences and the ability to verbally communicate that knowledge. Verbal Comprehension is comprised of four subtests that measure lexical knowledge and language development: Picture Vocabulary, Synonyms, Antonyms, and Verbal Analogies. These tasks require the student to semantically relate a concept to another concept via an association.

WJ-III Sound Blending measures an important component of auditory processing (Ga), the ability to process and synthesize language sounds. After listening to a series of syllables or phonemes, the student is asked to blend the sounds into a word. This requires the student to hold and match the sequence of phonological elements to stored lexical knowledge.

Working memory, a component of the factor of short-term memory (Gsm), is the ability to retain information in immediate awareness and then mentally manipulate that information. This narrow ability is implicated in many phonemic awareness tasks as well. WJ-III Auditory Working Memory is a complex mental task in which students listen to a series containing words and digits, and then reorder the information in order to repeat back the sequence of objects followed by the sequence of numbers.

Retrieval Fluency measures naming facility and automaticity of long-term retrieval (Glr). The subtest consists of three timed tasks in which students must name as many examples as possible of a given category (e.g. animals) in one minute. Rapid Picture Naming, also called Rapid Automated Naming (RAN), measures efficient recall of information from acquired knowledge. This subtest requires students to name pictures

of common objects as quickly as possible within two minutes and is considered a measure of processing speed (Gs). These abilities been shown to relate to reading achievement and may give valuable information about underlying processes contributing to reading deficits.

### **Determination of Intervention Response**

De-identified assessment and intervention data described above were analyzed for the current study. With regards to RTI, different criteria constitutes response to intervention, but usually some cutoff line can be established. A child may show some improvement but not enough to be considered satisfactory response so this line separates adequate responders from inadequate or non-responders. It is not well understood how these Tier II responders differ from non-responders and for students who fall just barely on either side of the cutoff line, there may not be much of a difference. Thus for purposes of this study, it would be helpful to compare students who fall at more extreme ends of the response continuum (i.e. high-responders and low-responders). This increases ecological validity in that selected students for the study are representative of those in other settings who would be very likely to respond to generalized interventions and those who would be very unlikely to respond.

*High-responders* were separated from *low-responders* to the Tier II Reading Skills Development intervention by evaluating pieces of data collected from the 2012 to 2013 school year. Istation Indicators of Progress (ISIP™; Mathes, Torgesen, & Heron, 2011) reports for all students who participated in the Reading Skills Development intervention project were examined. The Istation software delivers monthly reports on different variables of the Istation intervention (e.g. Phonemic Awareness,

Comprehension, Text Fluency, Vocabulary, and Total Reading). Monthly scores for ISIP Total Reading from October 2012 to May 2013 were compared to get a growth variable for each of these students. Those students whose progress over the intervention period fell in the top and bottom 33<sup>rd</sup>% of growth were identified as candidates for comparison.

*Low-responders* were operationally defined as students who fell in the bottom third (33<sup>rd</sup>%) of growth in ISIP™ Total Reading (among students in the Center). Rather than categorically including everyone that does not fall into the low-responder group as a responder, for purposes of comparison, *high-responders* were defined as students who fell in the top third (33<sup>rd</sup>%) of growth in ISIP™ Total Reading. Not all students in the Center were included in the sample; only those students who were present for at least 20 weeks of the Reading Skills intervention (or 6 months of progress scores) and had data that fell in one of the two categories. Identifying individuals that fall at the ends of the response spectrum allows for a better comparison between achievement and cognitive skills of these students. Furthermore, this method of using both criterion-referenced tests and individual progress monitoring was able to identify students who are truly not responding to intensive intervention rather than falsely include students who have made significant progress but are still below grade level standards.

### **Statistical Analyses**

This study explored whether cognitive differences existed between the high-responder and low-responder groups and whether specific cognitive subtests could predict progress on certain reading measures. Statistical procedures were selected based on the nature of the data collected and the appropriateness for each research question, both of which will be discussed in more detail below.

Research Question 1: *Are there differences between the high-responders and low-responders in specific cognitive areas related to reading achievement? If so, which cognitive skills are most predictive of group membership (high vs. low-responders)?*

**MANOVA/MANCOVA.** A preliminary multivariate analysis of variance (MANOVA) was used to determine main effects of the independent variable of interest (high/low responder group) along with three other possible moderating variables (English proficiency level, gender, grade) on cognitive performance. A secondary multivariate analysis of covariance (MANCOVA) was used to compare group performance across the five cognitive variables (WJ-III Verbal Comprehension, Auditory Working Memory, Sound Blending, Rapid Picture Naming, and Retrieval Fluency) with English proficiency level as a covariate. While there were expected correlations between each cognitive variable contributing to an overall dependent variable, the post-hoc analyses of variance (ANOVAs) were used to determine which subtests accounted for the most difference or best discriminated between high-responder and low-responder status. Based on the literature, it was predicted that there would be significant differences between the groups on Retrieval Fluency, Auditory Working Memory, and Rapid Picture Naming.

**Discriminant Analysis.** Because significant differences were present between groups, discriminant analysis was used to determine the extent to which the cognitive variables predict membership into high-responder and low-responder groups. Variables were entered into the discriminant analysis using a stepwise method to add or remove variables from the model if they passed the statistical criteria that increases the differentiation between the groups.

Post-hoc ANOVAs were a starting point for the stepwise method of variable selection, choosing those variables which were significantly different between groups.



The discriminant analysis allowed the researcher to determine which variable or combination of variables had the strongest individual relationship with the dependent variable categories (high-responders and low-responders), which may be predictive of successful response to reading intervention. It was hypothesized that lower scores on the Retrieval Fluency, Rapid Picture Naming and Auditory Working Memory subtests would be most predictive of membership in the low-responder category. Decoding skills require cognitive abilities such as processing speed, RAN, retrieval from memory of letters to sounds and the ability to hold these sounds from the beginning of the word in short term memory while working on the remainder of the word.

Research Question 2: *Do scores on certain cognitive measures (e.g. WJ-III Retrieval Fluency, WJ-III Auditory Working Memory) predict percentage of progress on curriculum based reading measures (e.g. phonemic awareness, fluency)?*

**Multiple Regression.** Multiple regression is a statistical approach that uses one or more explanatory variables to predict a linear dependent variable. In this case, multiple regression analyses were used to develop a model of the predictive relationship between selected cognitive variables and amount of progress on specific literacy measures. Predictor variables were scores on the WJ-III Auditory Working Memory, Sound Blending, RPN, and Retrieval Fluency subtests. These subtests were chosen because of research in links between working memory, processing speed and retrieval from long-term memory in reading achievement. Outcome measures were the growth between October and May scores on ISIP assessments (Istation Phonemic Awareness and Total Reading) as well as progress on AIMSweb Oral Reading Fluency assessments. Linear relationships were analyzed based on the literature and earlier significant test findings.

The purpose of this analysis was to further look at how cognitive skills may impact students' progress on an individual skill level rather than simply overall response to the Reading Skills Development Tier II intervention. For example, strength in processing speed may contribute to the performance of a student who has significantly increased his reading fluency, despite continuing to be low in reading comprehension. If performance on short cognitive subtests could predict the amount of progress a struggling reader would make on specific target goals given generalized interventions, this would be time well spent on the front end. A student who is unlikely to make adequate progress given certain cognitive deficits could benefit from more specialized interventions targeted to his or her specific deficit.

### **Summary of Procedures**

To summarize the methodology involved in the current study, a step-by-step of procedures will be reviewed. First, de-identified data were collected from approximately 200 struggling readers in 1<sup>st</sup> through 3<sup>rd</sup> grade who participated in the school district's Reading Skills Development project for a minimum of 20 weeks. From this population, *high-responders* and *low-responders* were identified based on monthly progress scores collected in Istation reports. Next, statistical the following procedures were selected based on the nature of the data: multivariate analysis (MANOVA/MANCOVA), multiple regression, and discriminant analysis. MANOVA was used to compare group performance across the five cognitive variables (WJ-III Verbal Comprehension, Auditory Working Memory, Sound Blending, Rapid Picture Naming, and Retrieval Fluency). Post-hoc analyses of variance (ANOVA) then determined which subtests accounted for the most difference. Additionally a discriminant analysis was conducted to see which of the

cognitive variables used best discriminated between high-responder and low-responder status. Finally, a series of multiple regressions explored how the predictor variables (WJ-III Auditory Working Memory, Sound Blending, Processing Speed, and Retrieval Fluency subtests) related to the progress on AIMSweb Oral Reading Fluency, and ISIP™ Phonemic Awareness, and Total Reading.

## CHAPTER 4—DATA ANALYSIS

The purpose of this study was to evaluate a population of young students who have not responded to a Tier II reading intervention to determine how cognitive skills may have impacted their progress overall and on individual reading skills. This study analyzed data collected as part of a Reading Skills Development project aimed at improving interventions for struggling readers in first, second, and third grade. The following sections present the demographics of the participants, types of data analysis, specific findings, and significance of those findings.

### **Demographics**

Data were collected on 194 students, however, only 171 students who had all five WJ-III cognitive subtests and at least six monthly Istation Indicators of Progress (ISIP™) scores between October and May were included in the sample. Of the 171 students, 44% were female (n=75); 56% were male (n=96); 30% were 1<sup>st</sup> graders (n=50); 36% were 2<sup>nd</sup> graders (n=62); and 34% were 3<sup>rd</sup> graders (n=59). The mean age was 7 years, 10 months. While cultural demographics of the sample were not provided, the cultural demographics of the school district from which the sample was taken are as follows: 28% Caucasian, 44% Hispanic/Latino, 11% Black/African American, 7% Asian, and 10% biracial or other. However, the six schools included in the sample were in lower than average socioeconomic areas and had a larger than average Hispanic population. The English proficiency levels (EPL) were coded according to Language Assessment Scale codes used by the district and categorized in the following way: AA = non-proficient; AB/BB = limited proficiency; CC/no code = full proficiency. For purposes of this study, the EPLs of the sample were as follows: 18% were considered non-proficient in English (n=31);

48% had limited English proficiency (n=82); and 34% were considered fully proficient in English (n=58). Some analyses were performed on the entire sample (N=171) and some were performed on a subset as explained below.

### **High vs. Low Responder Groups**

Response to intervention was measured using monthly Istation Indicators of Progress (ISIP™) Total Reading scores between October and May. A total growth variable *GrT* was computed for 171 students in SPSS by calculating month to month changes in ISIP Total Reading score for each month between October and May. This resulted in 7 scores (or a minimum of 6) which were then summed to estimate total ISIP growth (*GrT*). This resulted in a normal distribution of *GrT* that ranged from -27.48 points to 47.63 points ( $M = 11.76$ ,  $SD = 12.04$ ). Negative points represent negative progress (i.e. lower scores at the end of the intervention).

This *GrT* variable was used to divide students into high-responder and low-responder groups. Students whose progress was in the top third (33%) of ISIP™ Total Reading growth were considered high-responders (HR) and students whose progress was in the bottom third (33%) of ISIP™ Total Reading growth were considered low-responders (LR). The *GrT* variable was transformed into a new responder group (*RG*) variable in SPSS using cut scores of less than 7.556 (33<sup>rd</sup> percentile) for low-responders and greater than 16.817 (67<sup>th</sup> percentile) for high-responders. This subset of the sample presented in Table 1 (N=112) had the following characteristics: 46% were female and 54% were male; 26% were first graders, 37% were second graders, and 37% were third graders; 21% were non-proficient in English, 48% had limited proficiency in English, and 31% were fully proficient in English.

Table 1					
<i>Descriptive Statistics for Total Reading Growth Scores (GrT) in High and Low Responder groups by Gender, Grade, and English Proficiency Level</i>					
	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>Min</u>	<u>Max</u>
<b>High Responders</b>	56	24.32	6.31	16.82	47.63
Gender					
Male	25	24.42	6.01	17.47	41.78
Female	31	24.25	6.63	16.82	47.63
Grade					
First	18	25.10	5.71	17.37	37.01
Second	24	25.45	7.57	16.82	47.63
Third	14	21.38	3.41	17.08	27.50
English Proficiency					
Non	14	27.54	8.33	17.37	47.63
Limited	22	23.04	4.03	16.82	32.03
Full	20	23.49	6.27	17.08	41.78
<b>Low Responders</b>	56	-1.46	7.87	-27.48	7.48
Gender					
Male	36	-.58	5.93	-14.07	7.04
Female	20	-3.03	10.50	-27.48	7.48
Grade					
First	11	-.60	6.29	-12.04	6.92
Second	18	-4.14	9.70	27.48	6.23
Third	27	-.02	6.83	-17.49	7.48
English Proficiency					
Non	9	-.18	6.37	-12.04	6.92
Limited	32	-2.03	8.58	-27.48	7.48
Full	15	-.95	6.27	17.08	41.78
<b>Total Sample</b>	171	11.76	12.04	47.63	-27.48

A chi-square test of independence was performed to detect differences in expected and actual values between the high-responder and low-responder groups for gender, grade, and English proficiency. Significant differences were found between groups for gender ( $X^2=4.356$ ,  $df=1$ ,  $p=.037$ ) and grade ( $X^2=6.669$ ,  $df=2$ ,  $p=.036$ ), but not

for English proficiency ( $X^2=3.933$ ,  $df=2$ ,  $p=.140$ ). There were more females in the high-responder group and more males in the low-responder group than would be statistically expected. Additionally, there were more third graders and fewer first or second graders than would be statistically expected in the low-responder group. Finally, non-proficient, limited proficiency, and fully proficient students were proportionally spread as expected among the high and low-responder groups.

### **Multivariate Analyses**

Research Question 1: *Are there differences between the high-responders and low-responders in specific cognitive areas related to reading achievement? If so, which cognitive skills are most predictive of group membership (high vs. low-responders)?*

The dependent variables of interest in the research question were WJ-III subtest performance on Vocabulary (VC), Sound Blending (SB), Auditory Working Memory (AWM), Retrieval Fluency (RF), and Rapid Picture Naming (RPN). Overall means, standard deviations, range values and statistics of normality for high and low responders are presented in Table 2.

Initially all of the variables except Sound Blending met the assumption of normality, which was defined by skewness and kurtosis within the acceptable range ( $\pm 1.5$ ). Outliers were screened for by visually scanning the histogram plot of the data and then running tests for extreme values. Two outliers were found and replaced by the next lowest/highest values plus or minus one unit (e.g. 25 was replaced by a score of 73; 156 was replaced by a score of 148). The removal of these outliers normalized the data by lowering the kurtosis value to within the acceptable range while maintaining almost the same mean score (within two-tenths of a point) and standard deviation (within one point).

	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>Min</u>	<u>Max</u>	<u>Skewness</u>	<u>Kurtosis</u>
<b>High Responders</b>							
Vocab Comp (VC)	56	83.80	12.21	60	108	.099	-.661
Sound Blending (SB)	56	113.57	16.90	74	147	.101	-.385
Aud Working Memory (AWM)	56	104.29	12.18	66	129	-.809	1.412
Retrieval Fluency (RF)	56	91.20	12.86	66	123	-.061	-.282
Rapid Picture Naming (RPN)	56	90.64	14.85	58	120	-.361	.017
<b>Low responders</b>							
Vocab Comp (VC)	56	82.68	11.19	57	111	.205	.029
Sound Blending (SB)	56	108.43	15.40	73	145	-.098	-.231
Aud Working Memory (AWM)	56	93.34	16.19	46	120	-.799	.614
Retrieval Fluency (RF)	56	84.30	18.01	31	113	-.803	.870
Rapid Picture Naming (RPN)	56	86.89	12.99	60	117	-.030	-.361

To determine whether covariates needed to be added to the primary analysis, an initial four-way multivariate analysis of variance (MANOVA) examined WJ-III subtest performance on Vocabulary (VC), Sound Blending (SB), Auditory Working Memory (AWM), Retrieval Fluency (RF), and Rapid Picture Naming (RPN) across gender, grade, English proficiency level, and responder group. Although not part of the original research question, these potentially moderating variables needed to be tested for their impact on performance. See Table 3 for statistical values across all possible main effects and interactions for the four variables.



<u>Variable Effects</u>	<u>Wilks' Lambda</u>	<u>F</u>	<u>df</u>	<u>Significance</u>
Responder Group	.834	3.094	5	.013
English Proficiency	.730	2.659	10	.005
Gender	.981	.306	5	.908
Grade	.877	1.059	10	.398
Responder Group x EPL	.901	.839	10	.592
Responder Group x Gender	.919	1.382	5	.240
Responder Group x Grade	.874	1.083	10	.379
EPL x Gender	.850	1.325	10	.221
EPL x Grade	.783	.993	20	.470
Gender x Grade	.799	1.848	10	.057

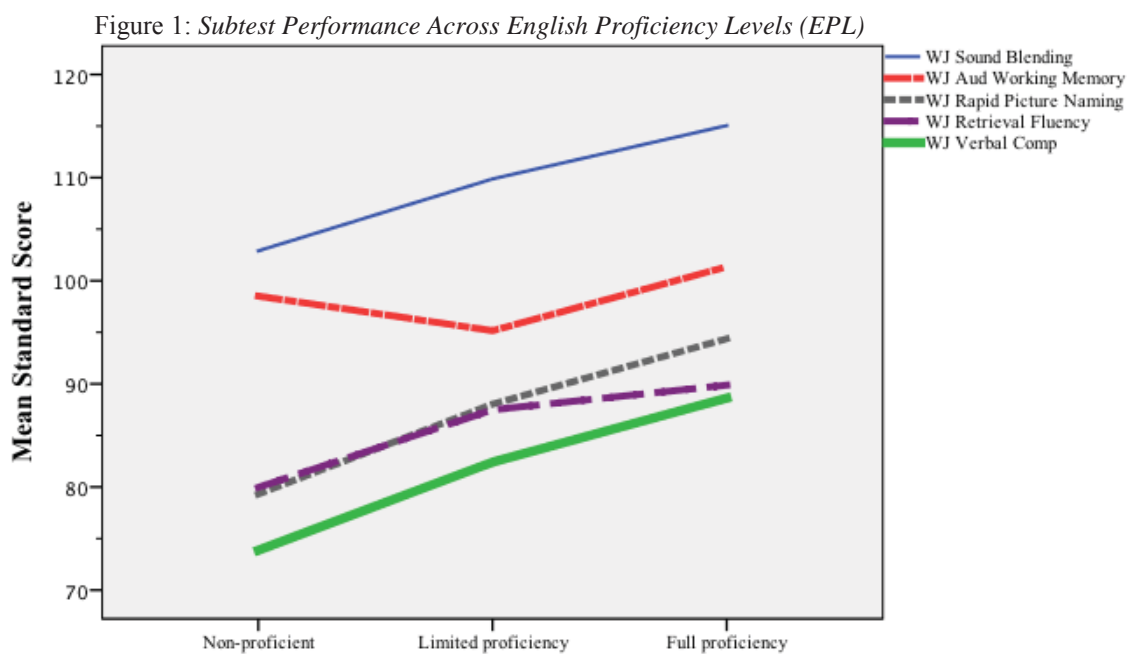
Non-significant differences were found on the multivariate analysis between grades (Wilks'  $\lambda = .884$ ;  $p=.453$ ) and gender (Wilks'  $\lambda = .981$ ;  $p=.911$ ) so these variables were removed from the analysis. However, significant differences were found for English proficiency level (Wilks  $\lambda = .738$ ;  $p=.007$ ) and responder group (Wilks'  $\lambda = .844$ ;  $p=.020$ ). All interactions between the four variables were non-significant ( $p >.05$ ). Univariate results found significant differences between the English proficiency groups on VC ( $F =17.627$ ;  $p<.001$ ), SB ( $F =6.00$ ;  $p<.01$ ), RF ( $F =3.824$ ;  $p<.05$ ), and RPN ( $F =14.086$ ;  $p<.001$ ), but not on AWM ( $p >.05$ ).

Table 4 displays overall means, standard deviations, range values for high-responders and low-responders divided by EPL (non-proficient, limited proficient, and fully proficient in English). All subtest variables met the assumption of normality, which was defined by skewness and kurtosis within the acceptable range ( $\pm 1.5$ ).

Table 4:  
*Descriptive Statistics for WJ-III Subtests Across Responder Group and English Proficiency Level*

<u>EPL</u>	<u>N</u>	Low Responder (n = 56)					High Responder (n = 56)				
		<u>Mean</u>	<u>SD</u>	<u>Min</u>	<u>Max</u>	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>Min</u>	<u>Max</u>	
Responder Group											
Non-Prof.											
VC	9	72.67	9.487	57	86	14	79.64	12.351	61	108	
SB	9	101.11	13.550	77	117	14	109.14	15.427	84	142	
AWM	9	95.78	14.438	64	117	14	106.86	15.256	66	129	
RF	9	67.67	25.065	31	105	14	90.14	13.364	66	114	
RPN	9	77.67	10.782	64	96	14	85.71	14.520	62	107	
Limited Prof.											
VC	32	83.34	10.924	65	107	22	79.18	9.806	60	97	
SB	32	111.19	14.669	73	138	22	109.86	16.797	74	141	
AWM	32	89.44	16.898	46	116	22	100.77	9.258	72	118	
RF	32	87.41	13.730	57	113	22	88.77	15.433	67	123	
RPN	32	88.25	12.697	60	113	22	88.23	16.133	58	120	
Full Prof.											
VC	15	87.27	9.407	75	111	20	91.80	10.763	66	108	
SB	15	106.93	17.215	82	145	20	120.75	16.367	94	147	
AWM	15	100.20	13.749	78	120	20	106.35	12.326	74	122	
RF	15	87.67	16.885	56	113	20	94.60	8.562	75	112	
RPN	15	89.53	13.147	62	117	20	96.75	11.942	74	117	

Based on Levene's  $F$  tests, error variances were equal across the groups for all five dependent variables ( $p < .05$ ) which satisfied the homogeneity of variance assumption. Means plots (see Figure 1) and follow-up tests revealed significant linear relationships between English proficiency level and subtest scores on Verbal Comprehension, Sound Blending, Retrieval Fluency and Rapid Picture Naming. However there was no significant relationship for EPL and Auditory Working Memory.



Post-hoc Bonferonni tests indicated that students with full English proficiency had significantly higher subtest scores than non-English proficient students on VC ( $p = .000$ ), SB ( $p = .004$ ), RF ( $p = .021$ ), and RPN ( $p = .000$ ). The proficient group also had significantly higher subtest scores than the limited proficiency group, who in turn had higher scores than the non-proficient group, on VC and RPN.

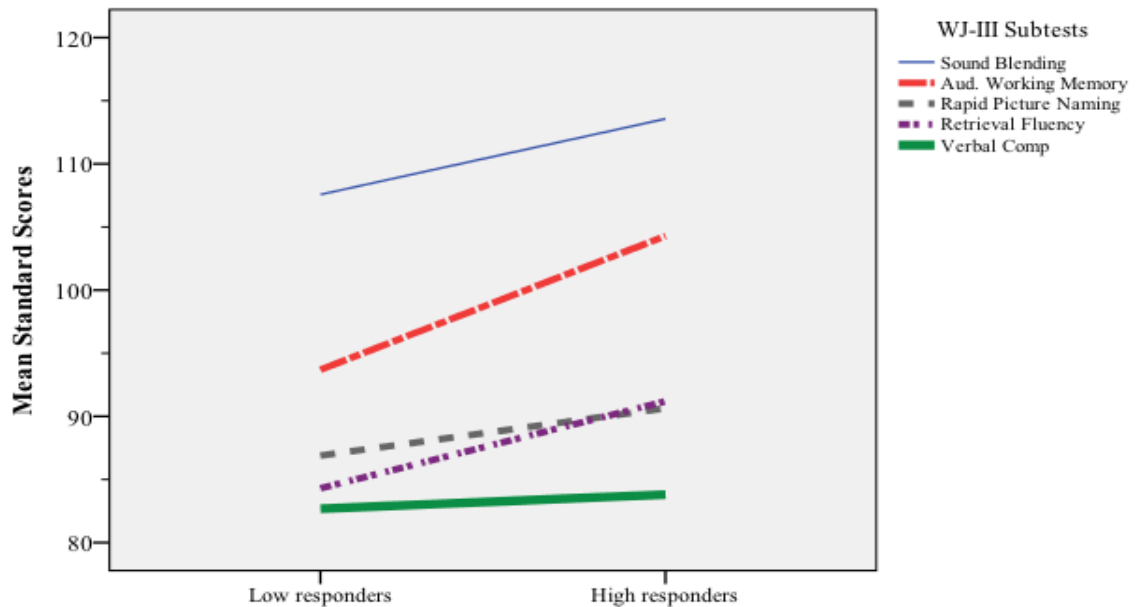
Because it was suspected that English proficiency level (EPL) might contribute to differences on WJ-III subtest performance and impact the relationship between the

responder groups and performance, a multivariate analysis of covariance (MANCOVA) examined group performance (low-responder vs. high responder) across the five WJ-III subtest dependent variables using EPL as a covariate. The Box's M value of 27.932 was associated with a p value of .032, which was interpreted as non-significant based on Huberty and Petoskey's (2000) guideline (i.e.  $p < .005$ ). Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANCOVA.

The macro-level multivariate test indicated that both responder group (Wilks'  $\lambda = .840$ ;  $p = .002$ ) and English proficiency level (Wilks'  $\lambda = .818$ ;  $p = .001$ ) were significantly related to WJ-III subtest scores. The Wilks' Lambda represents the amount of variance in the DV not explained by the IV. For this analysis, responder group accounted for 16% of the variance and EPL accounted 18.2% of the variance among subtest scores. Linear relationships (shown in Figure 2) were found between the WJ-III subtests when controlling for English proficiency group. The univariate test results show significant differences between the low-responder and high-responder groups on AWM [ $F(1,110) = 15.267$ ,  $p = .019$ ] and RF [ $F(1,110) = 5.676$ ,  $p = .019$ ] which partially confirmed the hypothesis that AWM, RF, and RPN would be significantly different between groups.

The high responder-group performed significantly better than the low-responder group on Auditory Working Memory and Retrieval Fluency tasks. The multivariate effect size was estimated at .123 for AWM and .049 for RF, which implies that 12.3% of the variance in the auditory working memory skills and nearly 5% of the variance in retrieval fluency skills were accounted for by responder group membership. There were no significance differences between responder groups on the other cognitive subtests.

Figure 2: Subtest Performance Across High and Low Responders



### Discriminant Analyses

Discriminant analysis (or discriminant function analysis, DFA) can be performed as a follow up to build upon the findings of a significant MANOVA and determine which variables are showing the largest group differences. Since DFA allows us to use significant variables to predict membership into two or more mutually exclusive groups, it was employed to answer part two of this research question. Because the previous MANCOVA found Auditory Working Memory (AWM) and Retrieval Fluency (RF) to be different between high-responder and low-responder groups, these variables were entered into the discriminant analysis using a stepwise method. This procedure is based on minimizing the Wilks' lambda after each new variable has been entered and requires a minimum of  $F > 3.84$  by default. In this case, the discriminant analysis used only AWM as a predictor of group variance and removed RF from the analysis. However, the Chi-square test was significant for this one variable (Wilks'  $\lambda = .871$ , Chi-square = 15.173, canonical correlation = .360,  $p < .001$ ). See Table 5 below.

Table 5						
<i>Ability of WJ-III Subtests to Discriminate between Responder Groups</i>						
<b>Variables Entered</b>	<b><u>Wilks' <math>\lambda</math></u></b>	<b><u>Chi-Square</u></b>	<b><u>Eigenvalue</u></b>	<b><u>Canonical Correlation</u></b>	<b><u>F</u></b>	<b><u>Sig.</u></b>
Auditory Working Memory (AWM)	.871	15.173	.149	.360	16.349	.000
<b>Variables Not Entered</b>						
Verbal Comp (VC)	.998				.258	.612
Sound Blending (SB)	.975				2.832	.095
Retrieval Fluency (RF)	.953				5.435	.022
Rapid Picture Naming (RPN)	.982				2.023	.158

Results from the SPSS extracted function accounted for approximately 13% of the variance between high and low responders. Additionally the model accurately classified 65.2% of all cases into their respective categories. Typically discriminant functions use several variables to accurately predict group membership, however it should be noted that these values represent just one variable. While RF was not found to significantly add to the model, the results from the discriminant analysis show that AWM can predict group membership, which partially confirmed the hypothesis.

### **Multiple Regression:**

Research Question 2: *Do scores on certain cognitive measures (e.g. WJ-III Retrieval Fluency, WJ-III Auditory Working Memory) predict percentage of progress on curriculum based reading measures (e.g. phonemic awareness, fluency)?*

Multiple regression is a statistical approach that uses two or more independent variables to predict a single linear dependent variable. In this case, three separate multiple regression analyses were used to determine whether a predictive relationship existed

between four selected cognitive variables and amount of progress on three specific literacy measures. Predictor variables were scores on the WJ-III Auditory Working Memory, Sound Blending, Processing Speed, and Retrieval Fluency subtests and outcome variables were the growth between October and May scores on ISIP assessments (Istation Phonemic Awareness and Total Reading) as well as progress on AIMSweb Oral Reading Fluency assessments. The three separate regression analyses were conducted as follows: 1) SB, AWM, RF, and RPN as predictor variables for October to May growth on ISIP Phonemic Awareness; 2) SB, AWM, RF, and RPN as predictor variables for winter to spring growth of the AIMSweb Oral Fluency; 3) SB, AWM, RF, and RPN as predictor variables for October to May growth on ISIP Total Reading.

Similarly to the *GrT* variable, growth measures for ISIP Phonemic Awareness were calculated in SPSS by computing a new variable (*GrPA*) that totaled the sum of differences between October 2012 scores and May 2013 scores ( $M=11.17$ ,  $SD=15.44$ ). Additionally an AIMSweb growth measure for Oral Reading Fluency (*GrORF*) was calculated by subtracting winter scores from spring scores ( $M=18.17$ ;  $SD=13.08$ ). Winter scores were used in place of fall scores due to the low number of students who had fall AIMSweb data. Growth measures for other areas of the ISIP progress reports (e.g. Comprehension, Vocabulary) were also calculated; however these variables were not evenly distributed and means were close to zero showing little overall progress in these skill areas. Therefore, only the computed growth variables (*GrT*, *GrPA*, and *GrORF*) were used as the outcome measures for the regression analysis.

Table 6 below reflects means and standard deviations of the three growth measures used: ISIP Phonemic Awareness ( $M=11.17$ ,  $SD=15.44$ ); ISIP Total Reading

( $M=11.76$ ;  $SD=12.04$ ); AIMSweb Oral Reading Fluency ( $M=18.17$ ;  $SD=13.08$ ). These outcome variables were normally distributed, defined by skewness and kurtosis in the acceptable range ( $\pm 1.5$ ).

	<u>N</u>	<u>Mean</u>	<u>SD</u>	<u>Skewness</u>	<u>Kurtosis</u>
<i>Phonemic Awareness (GrPA)</i>	101	11.17	15.44	.360	1.254
<i>Oral Reading Fluency (GrORF)</i>	128	18.17	13.09	.113	.759
<i>Total Reading (GrT)</i>	171	11.76	12.04	-.317	.881

Individual regression analyses were performed for each of the aforementioned outcome growth variables using four WJ-III subtests (SB, AWM, RF, RPN) as potential predictors. Specifically, it was hypothesized that WJ-III Sound Blending (SB) and Auditory Working Memory (AWM) would significantly predict phonemic awareness (*GrPA*); Retrieval Fluency and Rapid Picture Naming would significantly predict oral reading fluency (*GrORF*); and that Rapid Picture Naming and Auditory Working Memory would contribute most to overall growth (*GrT*).

Independent variables (SB, AWM, RF, RPN) were added into the multiple regression model in SPSS first using a forward method that only allowed variables to enter if they were significant ( $p < .05$ ), then using a forced entry option that allowed all the variables to enter at the same time regardless of significance levels. The latter method was done to obtain the actual (non-significant) statistic values for the regression. Results from the first two regression analyses (shown below in Table 8) indicated that none of the predictor variables were significantly related to progress in Phonemic Awareness ( $R^2 = .028$ ,  $F(5,95) = .956$ ,  $p = .867$ ) or Oral Reading Fluency ( $R^2 = .043$ ,  $F(5,122) = 1.098$ ,



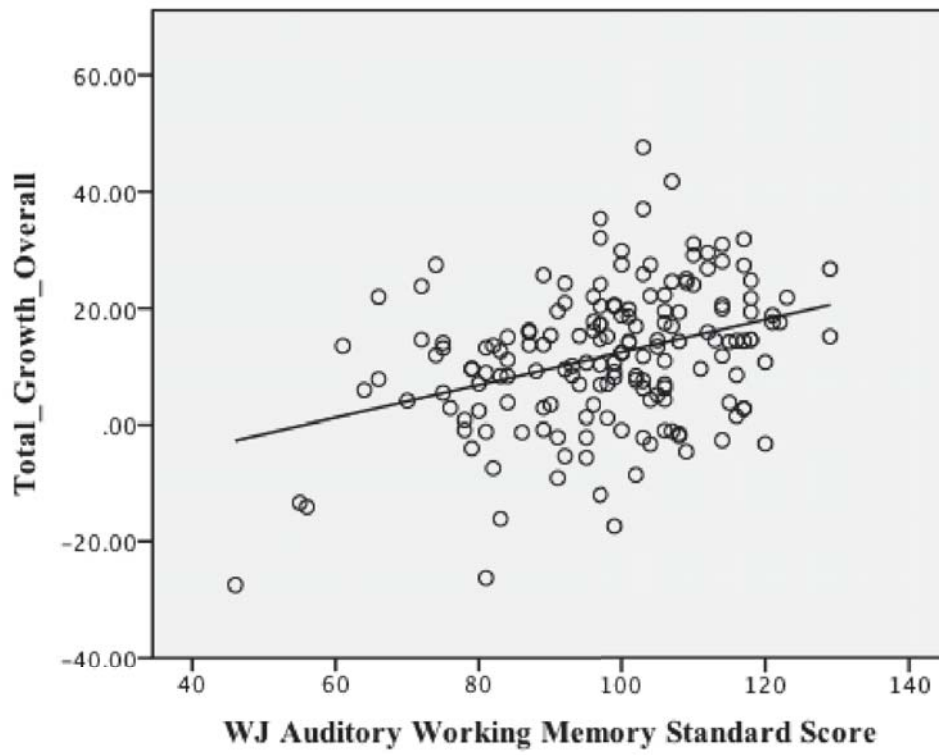
$p=.365$ ); therefore the null hypothesis could not be rejected for either regression model.

A third multiple regression analysis used a forward option to test if any of the cognitive subtests significantly predicted Total Reading growth (*GrT*). The forward method entered variables one at a time based on the designated significance ( $p \leq .05$ ) to enter. Results indicated that AWM was significantly related to total reading growth ( $\beta = .343, p < .001$ ), and explained 11.8% of the variance ( $R^2=.118, F(1,169)=22.511, p < .001$ ).

Table 7				
<i>Predictive Relationships Between WJ-III Subtests and Growth Measures</i>				
Model 1: Phonemic Awareness ( <i>GrPA</i> )				
<u>Variables Entered</u>	<u>R</u>	<u>R<sup>2</sup></u>	<u>F</u>	<u>Sig.</u>
SB, AWM, RF, RPN	.138	.019	.463	.762
Model 2: Oral Reading Fluency ( <i>GrORF</i> )				
<u>Variables Entered</u>	<u>R</u>	<u>R<sup>2</sup></u>	<u>F</u>	<u>Sig.</u>
SB, AWM, RF, RPN	.192	.037	1.171	.327
Model 3: Total Reading ( <i>GrT</i> )				
<u>Variables Entered</u>	<u>R</u>	<u>R<sup>2</sup></u>	<u>F</u>	<u>Sig.</u>
AWM	.343	.118	22.511	.000

A scatterplot was produced in SPSS (Figure 3) that illustrates the regression model between Auditory Working Memory and Total Reading progress. A model fit line was incorporated to show the positive relationship between the two and this upward slope indicates that AWM is significantly predictive of progress in overall reading.

Figure 3: *Linear Relationship of GrT & AWM*



## CHAPTER 5—DISCUSSION

### Summary

Since the No Child Left Behind (NCLB) and Elementary and Secondary Education Act (ESEA) legislation, states have been required to develop standards that better align curriculum, assessment, and instruction. The Response to Intervention (RTI) model has incurred widespread use because it offers a promising approach to targeting at-risk students early on through universal screening and implementation of interventions within general education. Most educational researchers would agree that early intervention is a key factor in remediating reading difficulties and can prevent a lifetime of literacy problems due to lack of foundational skills (Lyon, 1998; Lyon et al., 2001). However, understanding cognitive characteristics that may influence responsiveness to these interventions is critical. Students who are unresponsive to typical evidence-based interventions may need treatment more targeted to their specific cognitive patterns. Therefore, it would be helpful to understand these cognitive differences earlier in the intervention process so that time is not wasted on interventions that are not likely to be effective.

The purpose of this investigation was to use a theory-driven model of assessment to identify strengths and weaknesses between students who have responded well and students who have poorly responded to Tier I and Tier II instruction in the area of reading. This study evaluated a population of young students with potential reading disabilities who received 6 months or more of intensive interventions through a Reading Skills Development program. These students were chosen to participate in the reading program based on teacher referrals and scores far below average on national reading

measures. The study addressed the following questions: Are there cognitive differences between students who respond well to an intense Tier II reading intervention and those who make little progress? Are certain cognitive skills predictive of progress in specific areas of reading (e.g. phonemic awareness, fluency, total reading)?

### **Discussion of Results**

De-identified data was collected from approximately 170 struggling readers in 1<sup>st</sup> through 3<sup>rd</sup> grade who participated in the school district's Reading Skills Development project for a minimum of 20 weeks. A new variable was computed based on the top and bottom 33<sup>rd</sup>% of growth in Total Reading as measured by Istation reports. This total growth variable was used to identify *high-responders* and *low-responders*. Chi-square analyses examined whether there were differences in gender, grade, and English proficiency level between high and low responders. Results indicated that there were more girls than statistically expected in the higher responder group and more boys in the low-responder group. Additionally there were more third-graders in the low-responder group than statistically expected.

The gender difference may be due to the increased risk for reading disabilities among boys. A study by Yoshimasu et al. (2010) found a higher prevalence of reading disabilities among males than females in a population-based cohort of over 5,700 children. While children with ADHD had equal likelihoods of a comorbid reading disability diagnosis, boys without ADHD were twice as likely to have reading deficits than girls. The proportional difference in the current study is not quite that high, but it is reasonable to expect that there would be more male low-responders (i.e. boys at risk for a reading disability) than females.

Regarding the difference in grade level between responder groups, it is not surprising that there are significantly more third graders in the low-responder group. For reading and language-based skills, the younger the child, the easier it is to correct a problem. Research on brain plasticity and child development shows that there are critical or sensitive periods in which the brain is most susceptible to growth and change, and this is when optimal learning and intervention take place, especially for students with reading deficits (Burns, 2013; Shaywitz, 2003). This may explain why first and second graders (who are closer in age to the sensitive periods of cognitive development) made more progress during the reading interventions than third graders. These results are consistent with researchers who maintain that early intervention is essential because by third and fourth grade, deficits are much more difficult to remediate (Lyon et al., 2001, Lyon 1998). This is because after a child has experienced a few years of school, remediation requires reconstruction of established neural processes, which is a much harder task.

To answer the first research question, high and low responders were compared across five WJ-III subtests (Vocabulary Comprehension, Sound Blending, Auditory Working Memory, Retrieval Fluency and Rapid Picture Naming) using multivariate and follow-up univariate analyses. Because it was suspected that other variables might contribute to differences in subtest scores, a preliminary analysis examined the multivariate relationship using gender, grade, and English proficiency level in addition to responder group, which was the main variable of interest.

Subtest scores did not vary by gender and grade, so these variables were dropped from the primary analysis; however, a linear relationship was found between English proficiency level and four of the WJ-III subtests (Verbal Comprehension, Sound

Blending, Retrieval Fluency and Rapid Picture Naming). This is not unexpected because English language skills are required on those subtests (e.g. identifying picture vocabulary, choosing synonyms for a word, blending phonemes to identify an English word, quickly listing food items, rapidly naming pictures); whereas Auditory Working Memory utilizes numbers and letters rather than knowledge of English words.

Due to the positive relationship, EPL was entered into the analysis as a covariate to control for these effects. Results from the multivariate analyses indicated that after controlling for EPL, students who responded well to the Tier II Reading intervention differed from students who did not respond well in the areas of Auditory Working Memory and Retrieval Fluency. High responders performed better than low responders on both tasks suggesting that working memory and retrieval fluency are related to growth in reading skills, especially for struggling students. Additionally Auditory Working Memory was found to be a significant predictor of whether or not a student would respond well to generalized intervention, accounting for approximately 12% of the variance between groups. No other subtests were found to be significantly predictive of responder group status. This may be due to some of the limitations of the study such as sample size and insufficient cognitive measures, which will be discussed in further detail.

A multiple regression model was used to determine whether various cognitive subtests could predict growth in specific areas (phonemic awareness, oral reading fluency, and overall reading scores). These areas were chosen due to their high impact on reading ability. Research shows that phonological skills are especially relevant during early reading acquisition and deficits in phonemic awareness have been implicated as a reason for reading failure. Oral reading fluency (i.e. being able to recognize words

quickly and efficiently) is an important contributor to success in reading because it reflects automaticity, the ability to do things without thinking about them. Students with higher automaticity in reading are able to expend less cognitive energy on decoding words, thus leaving more brainpower for comprehension and learning.

It was predicted that cognitive abilities such as sound blending and auditory working memory would contribute most to growth in phonemic awareness; retrieval fluency and rapid automatized naming skills (RAN) would contribute most to growth in oral reading fluency, and auditory working memory and RAN would contribute most to growth in overall reading scores. Results indicated that none of the subtests predicted progress in phonemic awareness and/or oral reading fluency over the course of the intervention. However, auditory working memory (but not RAN) was found to be predictive of total reading growth, accounting for approximately 13% of the variance.

It is not surprising that auditory working memory was found to be significantly related to whether or not students made reading progress during the Tier II intervention. Research has shown working memory to be a reliable indicator of which students will have difficulties in the classroom. In a longitudinal study, Alloway, Gathercole, Kirkwood and Elliott (2009) tested more than 3,000 elementary and junior high students in the UK and then followed up six years later. Results indicated that 98% of students with deficits in working memory had very low standardized tests scores in reading comprehension and math. Additionally, they found that that working memory in five-year olds was a better predictor of reading and math achievement six years later than was IQ (Alloway & Alloway, 2010).

Long-term retrieval reflects an additional aspect of memory. Retrieval fluency is the efficiency with which previously learned information is called to mind, so there should be no surprise that this skill was also found to be higher among students who made more progress during the reading intervention. Retrieval of phonological information from long-term memory is expressed in how the child remembers pronunciations of letters, word segments, or entire words. Efficient retrieval of this phonological information is required when readers attempt to decode unfamiliar words; therefore deficits in this area often result in difficulties with reading fluency. Though it was not found to be predictive of growth in oral reading fluency as hypothesized, it still accounted for some of the variance between high and low responders.

### **Limitations**

While the study was able to answer the research questions, there were some unfortunate weaknesses to the design of this study that may limit its ability to find more significant results or generalize to different populations. The first limitation was its homogenous and non-randomized sample since students were specifically selected from six Title 1 schools in only one school district. This was a convenience factor as the study paralleled an ongoing research project on the effectiveness of an assessment to specialized interventions approach and schools had already been selected as participants. In addition, many of the low-performing students were English Language Learners (ELL) which may have confounded some of the data due to lack of English proficiency. It should be noted, however, that the use of English proficiency level as a covariate should have lessened the impact of this factor.



Another limitation was the inability to get accurate attendance data for students who participated in the intervention program. Attendance and amount of time spent receiving interventions is an important variable that may contribute to differences in progress made. Students used Istation for half of every intervention period and Istation reports recorded how often each student logged onto the system, so these reports were used as a general estimate for the amount of intervention time each student received. Additionally, only students who had 20+ weeks of Istation report data, October and May Total scores, and at least four more monthly progress scores in between October and May (total of six data points) were included in the sample. However, this data is only an estimate because accurate attendance records were not kept for each student and so precise tutoring time could not be used as a covariate.

AIMSweb fall scores and CORE Phonics data were not collected for all students participating in the Reading Skills Center, so unfortunately these pieces of information could not be included in the regression analysis. It would have been interesting to see if students improved over the intervention on teacher-given curriculum-based measures as well as computer-based measures. While Istation has extensive research behind its interventions and progress monitoring, it is difficult to determine if students are truly engaging in the interventions and motivated to try their best when not individually supervised or assessed by a teacher. More extensively recorded AIMSweb and CORE Phonics data could have added to the picture of growth among students who received the generalized Tier II interventions in the Reading Skills Development Center.

Finally the amount of assessment in order to measure the key cognitive components and literacy outcomes used in this study might be considered a limitation.

Students were pulled from classrooms, specials, or small group interventions to complete the testing which means they missed out on some instructional time. The pilot phase of cognitive testing during the consultation project initially included 14 WJ-III subtest measures that assessed the broad CHC factors of Comprehension-Knowledge (*Gc*), Long-Term Retrieval (*Glr*), Auditory Processing (*Ga*), Processing Speed (*Gs*), and Short-Term Memory (*Gsm*). The use of all 14 measures gave a more accurate representation of cognitive ability factors associated with reading acquisition. However, the amount of testing required to measure the five broad factors (typically 90 minutes per student) was considered prohibitive and was eventually reduced to 5 subtests (one per factor). This abbreviated version of the WJ-III battery (approximately 30 minutes per student) was a vast improvement in efficiency but may have reduced the validity of the factors/abilities being measured.

For example, Sound Blending was used as a measure of auditory processing and phonemic awareness; however it is only one type of phonemic skill and does not account for segmentation, deletion, substitution or rhyming. An additional phonemic subtest, Sound Awareness, comprised of multiple tasks, added qualitative value and strengthened the measure; however, it was cut from the project due to its length (20 minutes). Rapid Picture Naming was used as a processing speed task as considered by the WJ-III manual; however RAN is often thought to measure retrieval fluency/naming facility so this may have muddled the specificity of this measure. The use of an additional visual processing speed task would have added to the construct validity of the processing speed measure. In general, the lack of significance for some of the hypothesized variables may be due to this reduced specificity of the factors.

## **Educational Implications**

There is a profound saying that people often use when discussing life goals: “*It’s not the destination that matters, but the journey.*” This life lesson could be applied to the nature of the present study in how it differs from previous research that has typically focused on the link between cognitive ability and reading achievement instead of looking at individual growth in reading after generalized interventions have been implemented. In other words, rather than focus solely on the reading destination (i.e. end scores), this study highlights the reading journey (growth made over time). Other studies often emphasize end of the year nationally-normed reading measures as the outcome for whether students have made progress, but this often overlooks general progress made on the actual skills that have been taught through the intervention (e.g. alphabetic principles, decoding, text fluency). The preferred outcome of most reading interventions is to improve overall reading skills, not the ability to take a standardized reading assessment. Students who start off elementary school with lower reading skills are not likely to surpass their higher achieving peers but they can still be high-responders, i.e. students who make significant progress on reading goals after intervention. In fact some of the lowest achieving students initially had the highest total reading growth. This is because deficits in reading for high-responders are likely to be environmental rather than biological in nature.

Cognitive skills tend to remain stable over time, although research has shown that improvement can be made on certain skills when specifically addressed. If certain cognitive skills can impact a student’s ability to learn, these skills may have to be remediated before true reading progress takes place. This study found working memory

skills to somewhat moderate the effectiveness of the reading interventions. This is not surprising since researchers have shown working and short-term memory deficits to be correlated with and significantly predictive of academic achievement in reading, spelling, and math (Roberts et al., 2014). Reading is an intensive cognitive process in which learners are able to apply cognitive resources to broader levels of meaning as they develop automaticity with basic decoding. The ability to recognize words quickly and efficiently reflects automaticity, which is an important contributor to success in reading. Students who struggle to achieve automaticity in decoding must dedicate substantial working memory resources to this task, which makes these resources unavailable for higher order processes involved in comprehension (Royer & Walles, 2007). Even when phonemic awareness is intact, working memory can also impact the ability to apply phonetic coding skills to new words or to remember sight-word vocabulary for words that have irregular spellings (Roberts et al, 2014). It seems that working memory skills are especially important in the early years of school. For students who are just learning to decode, limits in working memory make it difficult for them to allocate resources to higher-level processes such as reading comprehension (Gathercole, Alloway, Willis, & Adams, 2006). This can often be observed in children who manage to decode all of the words in a sentence but fail to understand the meaning.

Because working memory acts as a bottleneck for learning in classroom activities, researchers have suggested that children with poor working memory skills will have difficulties in meeting the demands of many structured learning activities that are common in the classroom (Gathercole et al., 2006). Therefore, training in working memory would ideally improve reading and overall learning. Loosli, Buschkuehl, Perrig,

and Jaeggi (2012) investigated the effectiveness of a working memory intervention in typically developing children aged 9 to 11. They found that performance improved on both the trained working memory task and subsequent reading measures. Their study not only provides evidence for shared processes between reading and working memory, but that interventions to improve working memory can indeed generalize to reading achievement for young students.

The current study found only working memory and retrieval fluency to be different between high and low responders, however trimming the amount of assessment may have obscured some potentially interesting findings related to other cognitive factors. Either way, this study can add to the growing body of research on cognitive profiles of low-responders to Tier II interventions and using an assessment to intervention approach for differentiated instruction. Many RTI procedures utilize individualized diagnostic assessments after students are nonresponsive to Tier II intervention for a prolonged period of time. Unlike these procedures, this study has implications for utilizing diagnostic reading and cognitive assessments for students who are determined to be at the highest risk for ongoing reading difficulties prior to delivery of Tier II intervention. A diagnostic reading and cognitive assessment battery will add specificity to information available from existing CBM measures, (e.g. number of words read correctly per minute, word reading accuracy, and reading comprehension).

The goal of assessment is to identify specific weaknesses related to reading, such as decoding and comprehension, and determine if these weaknesses are accompanied by one or more foundational cognitive deficits, such as phonemic awareness, working memory, processing, or cognitive fluency. This information can be used to group

students together who are experiencing similar difficulties, adding efficiency to intervention planning and tutoring. Students need differentiated, high-quality focused instruction in order to keep on level and move forward. Furthermore, designing reading interventions based on diagnostic reading and cognitive assessments is consistent with a Cognitive Hypothesis Testing approach to assessment, which has been advocated for use in problem solving processes that address academic learning difficulties (Flanagan, Fiorello & Ortiz, 2010; Hale, Kaufman, Naglieri, & Kavale, 2006).

In her presentation on a cross-battery approach to assessment for intervention in SLD referrals, Flanagan (2014) asserted that it does not make sense to do more intense interventions without finding out *why* that intervention wasn't effective in the first place. Flanagan advocated for an assessment to intervention approach because different cognitive ability profiles suggest different interventions. Following their research on manifestations of cognitive ability weaknesses, colleagues Mascolo and Flanagan (2012) developed empirically-based recommendations and interventions for specific deficits. For example a student with a deficit in phonetic decoding requires remediation in phoneme-grapheme correspondence (e.g. what sound "sh" makes); whereas a student with speech/language deficits would benefit from interventions in orthographic development and fluency such as *Read Naturally* and *RAVE-O*. Their recommendations for students with poor verbal and working memory include interventions focused on building sight-word vocabulary, using chunking strategies, and learning mnemonics. Specific evidence-based instructional programs include *Text-Talk*® and *Word World*®.

## **Recommendations**

The current study provides further evidence for cognitive differences between responders and non-responders and has implications for an assessment to intervention approach; however further research should be conducted to address its limitations. The present study only found that auditory working memory and retrieval fluency (both aspects of memory) to be significantly different between students who responded well and students who responded poorly to the intervention. Additionally only working memory was found to be a significant predictor of overall reading growth. These results are consistent with previous research on the importance of memory and yet they fail to confirm hypotheses based on the literature that other subtests such as phonemic awareness (as measured by sound blending) and processing speed/RAN are important predictors of reading deficits and lack of progress. As previously mentioned, trimming the tests may have masked significant differences between groups because they limited the construct validity of the measures in that they didn't fully assess all aspects of the cognitive factors of interest. Therefore, future research may want to incorporate more subtests for each factor to increase the content validity of each cognitive ability in question. This approach requires more testing, but it may be considered worth it to learn about the student's deficits and potential response to Tier II instruction in order to plan more targeted interventions.

Clearly both short-term and long-term memory play an important part in learning. In the current study, short-term or working memory was measured with only one subtest, which utilized letters and numbers (non-meaningful information). While AWM was still significantly related to progress, it would be advantageous to incorporate more

meaningful information (e.g. memory for words) or visual information since both are required for reading. Examples include WJ-III Memory for Words, WRAML2 Story memory and Sentence memory, and WRAML2 Visual learning. Additionally, long-term retrieval (*Glr*) was measured only with a retrieval fluency task; however a subtest that also measures associative memory and learning such as the WJ-III Visual Auditory Learning and Delayed subtests or the WRAML Verbal learning subtest would provide valuable information as well and may reveal a stronger relationship with response to intervention. It is recommended that an additional subtest be added for phonemic awareness and auditory processing skills that includes segmentation, deletion, substitution or rhyming skills such as the WJ-III Sound Awareness, or various CTOPP-2 subtests (eg. Elision, Sound Matching, Segmentation). The use of a single task for each cognitive factor may not provide an adequately valid, reliable, or sensitive measure. Thus in future work, it will be important to include multiple measures of each factor to attain more robust information.

This study was not able to obtain accurate attendance data from the reading specialists who administered the Tier II interventions as part of the Reading Skills Development project. Future research on this topic should make recording attendance for all students a priority so that this can be used as a covariate for monitoring progress. Additionally

The intention of the study was to use the entire group (close to 400 students) participating in the Reading Skills Development project and receiving Tier II interventions. This larger sample would have allowed for more power to find significant differences and a greater ability to generalize to a population of struggling readers. Future



studies should increase the size of the sample by allocating more resources for testing and data collection from the students. A more diversified sample would also increase external validity of the results in areas with broader demographics.

The importance of this research in light of the growing prevalence of struggling readers should not be overlooked. The role for diagnostic cognitive assessments in explaining unresponsiveness and guiding interventions has significant implications for the practice of school psychology. Practitioners are tasked with the duty to recommend evidence-based interventions for struggling students and this is often after they have failed to respond to traditional interventions. School psychologists could greatly benefit from access to useful research that allowed them to easily identify why certain interventions may be ineffective for students and/or administer brief cognitive subtests to gain more information. Understanding cognitive deficits inherent in a reading disability may help educators place children in small group interventions with others having similar strengths and weaknesses. Ideally, RTI would incorporate cognitive assessment data that is necessary to 1) identify specific learning deficits in non-responders and 2) guide the development of individualized interventions for these students. Only when we have insight into the underlying cognitive processes of reading failure can we truly individualize strategies to promote better reading and learning.

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## CURRICULUM VITAE

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#### EDUCATION

- University of Nevada, Las Vegas**  
Ph.D. in Educational Psychology— Specialization in School Psychology 2014  
Dissertation: *Cognitive Differences Between High and Low Responders of a Tier II Reading Intervention*  
Current 4.0 GPA
- University of Nevada, Las Vegas**  
M.S. in Educational Psychology 2009  
Graduated with a 4.0 GPA
- University of California, Santa Barbara**  
B.A. in Psychology; Communication 2004  
Dean’s List, Honor’s Program  
Graduated *summa cum laude* with a 3.9 GPA

#### TEACHING EXPERIENCE

- University of Nevada, Las Vegas**  
Instructor: “Intro to Educational Psychology” (Undergraduate) 2011-2013  
Teaching Assistant— “Assessment for Teachers” (Graduate) 2011  
Teaching Assistant— “Qualitative Methods” (Graduate) 2010-2011
- Centennial Academy—Las Vegas, NV**  
Teacher: 4<sup>th</sup> grade 2008-2009  
Teacher: Spanish 2008-2010  
Performing Arts Director 2008-2010
- Ribet Academy College Preparatory—Los Angeles, CA**  
Teacher: 4<sup>th</sup> grade 2004-2005  
Teacher: Algebra/Pre-Algebra) 2006-2007
- Clark County School District—Las Vegas, NV**  
Long Term Guest Teacher 2007-2008

#### RELATED EXPERIENCE

- Baltimore City Public Schools**  
School Psychologist Doctoral Intern 2013-2014
- Spring Mountain Treatment Center**  
Case Manager/Therapist 2011-2013
- UNLV School Psychology Clinic (PRACTICE)/Education Advocacy Clinic**  
School Psychology Practicum Student 2009-2013

**Rhodes Elementary/Parsons Elementary**  
School Psychology Practicum Student 2009-2010

**University of Nevada, Las Vegas**  
Graduate Research Assistant—in Center for Research, Evaluation,  
and Assessment 2011-2013

Graduate Research Assistant—in Family Research and Services Lab 2011-2012

#### LEADERSHIP POSITIONS

**University of Nevada, Las Vegas**  
Chair, Student Coordinating Committee 2011-2012

Vice Chair, Student Coordinating Committee 2010-2011

Representative, Student Association of School Psychologists (SASP) 2012-2013

#### PUBLICATIONS AND PRESENTATIONS

Lei, S. A., Cohen, J. L., & Russler, K. M. (2010). Humor on learning in the college classroom: Evaluating benefits and drawbacks from instructors' perspectives. *Journal of Instructional Psychology, 37*(4): 326-331.

Cohen, J. (February, 2012) Promoting Academic and Social Competence through Executive Function Development. Paper presented at the annual meeting of the National Association of School Psychologists, Philadelphia, PA.

Cohen, J., Boggs, J., Marchand, G., Reynolds, R. E., & Hall, G. (April, 2012) Principal Change Facilitator Style and Student Learning: Effects of Teacher Efficacy and Curriculum Satisfaction. Poster presented at the annual meeting of the American Educational Research Association, National Conference, Vancouver, Canada.

Cohen, J., Urgelles, J., & Donohue, B. (2012, April). Factors related to the implementation of an empirically supported method for managing emergencies within the context of drug abuse and child neglect. In J. Urgelles (Chair), *Empirical development of a method for managing emergencies within the context of drug use and child neglect*. Symposium conducted at the annual convention of the Western Psychological Association, San Francisco, CA.

Cohen, J., Reynolds, R., Boggs, J. (2013, April) Strategy instruction and metaphorical comprehension in children. Paper presented at the annual meeting of the American Educational Research Association, National Conference, San Francisco, California.

Cohen, J. Stohlberg, P. (2013, August). Academic impact of different cognitive processes for LD and ADHD populations. Poster accepted for presentation at the annual meeting of the American Psychological Association, Honolulu, Hawaii.

Cohen, J. (in progress) Cognitive Differences Between High and Low Responders of a Tier II Reading Intervention. Dissertational research defended April 2014.

Boggs, J., Cohen, J., Marchand, G. (in progress). The effects of doodling on recall ability.