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# Examining the Effectiveness of an Orthographic-Based Intervention for Children with Reading Disabilities

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Examining the Effectiveness of an Orthographic-Based Intervention for  
Children with Reading Disabilities

by

S. Mitchell Colp

A THESIS

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## **Abstract**

It has been well-documented that combined phonological awareness and word-identification training provide the most effective way of strengthening reading ability in children with Reading Disabilities (RDs). With that said, these findings are based on the assumption that all children with RDs represent a homogenous population and react similarly to specific intervention approaches. Recognizing the heterogeneity within the RD population, preliminary research has surfaced which challenges the combined approach in favor of techniques which address the relative deficit in either phonological or word-discrimination (orthographic) processes. Continuing in this line of research, a study was conducted to examine the effectiveness of an orthographic-based intervention design to improve reading ability for children with orthographic skill deficits. The study took place at a private, not-for-profit, school designed for children with a variety of Learning Disabilities. Through utilizing a single-case multiple-baseline research design, 12 children with RDs in grades 3 through 6 (3 students per grade) were matched on reading ability and intelligence prior to beginning the intervention. The results of this study will be discussed in relation to the importance of assessing and intervening for specific reading difficulties within RD populations.

## Table of Contents

Abstract	ii
Table of Contents	iii
List of Tables	v
List of Figures	vi
<b>CHAPTER ONE: INTRODUCTION</b>	<b>1</b>
The Problem	5
Present Study	6
<b>CHAPTER TWO: LITERATURE REVIEW</b>	<b>8</b>
Reading Disabilities	8
The Linguistic System	9
Phonological Awareness and Decoding	11
Orthographic Knowledge and Word-Identification	13
Deficits in Phonological Decoding and/or Orthographic Word-Identification	17
Declining Research and an Emerging Approach	19
Present Study	24
<b>CHAPTER THREE: METHOD</b>	<b>27</b>
General Research Design	27
The Intervention	28
Participants	30
Instructors	30
Students	30
Instruments	31
Oral Reading Ability	31
Linguistic Processes and Skills	31
Single-Case Multiple-Baseline Across-Participants Research Design	33
Procedure	34
Analytic Strategy for Research Questions	38
<b>CHAPTER FOUR: RESULTS</b>	<b>40</b>
Treatment Fidelity	40
Oral Reading Ability Outcomes	41
Grade 3	41
Participant 1	41
Participant 2	42
Participant 3	43
Grade 4	43
Participant 4	43
Participant 5	44
Participant 6	45
Grade 5	45
Participant 7	46
Participant 8	47

Participant 9	47
Grade 6	47
Participant 10	48
Participant 11	49
Participant 12	49
Linguistic Process and Skill Outcomes	50
Subtype-Specific Intervention Outcomes	51
Orthographic Word-Identification Deficit Subtype	51
Phonological Decoding Deficit Subtype	52
Mixed Phonological/Orthographic Deficit Subtype	52
<b>CHAPTER FIVE: DISCUSSION</b>	<b>54</b>
Implications	56
Limitations	58
Future Directions	59
Conclusion and Final Thoughts	61
<b>REFERENCES</b>	<b>63</b>

### **List of Tables**

Table 1. Student Participant Demographics _____	32
Table 2. Diagnostic Approach for Subtype Classification _____	37
Table 3. Baseline and Intervention Performance on Linguistic Skill Subtests _____	50
Table 4. Baseline Performance on PAL-II RW and Resultant Classifications _____	51
Table 5. Summary of GORT-4 and PAL-II RW Outcomes by Linguistic Subtype _____	53

### **List of Figures**

Figure 1. Sample Baseline and Intervention Schedule by Week _____	37
Figure 2. GORT-4 Baseline and Intervention Performance for Grade 3 by Week _____	42
Figure 3. GORT-4 Baseline and Intervention Performance for Grade 4 by Week _____	44
Figure 4. GORT-4 Baseline and Intervention Performance for Grade 5 by Week _____	46
Figure 5. GORT-4 Baseline and Intervention Performance for Grade 6 by Week _____	48

## CHAPTER ONE: INTRODUCTION

The ability to read represents a fundamental skill within today's modern society. As a culture, we interact with text in our educational, employment, and recreational settings to a degree in which has never been seen before. With current advancements in technology, the role of reading in our daily lives is increasing, and now represents a primary form of social interaction for many individuals (Cain, 2010). For example, the Canadian Wireless Telecommunications Association highlighted that Canadians sent 57 billion text-messages during the year of 2011 – that averages to be approximately 156 million messages per day (CWTA, 2011). Since technological trends which involve reading, such as text-messaging, are anticipated to continue at an exponential rate, the ability to gain mastery over the reading process becomes increasingly important for the academic development, job obtainment, social competence, and recreational lifestyle of children in present and future generations.

Understanding the vital nature of reading within society, educational researchers have worked for many years to understand how reading is developed, why some children fail to gain mastery, and what steps can be taken to inform intervention. This is a complex area of study, given that the successful development of reading ability involves a variety of cognitive and linguistic systems and reading difficulties may be the result of a number of diverse factors. Although appearing simplistic on the surface, Huey (1968) recognized that understanding the reading process would represent “the acme of the psychologist's achievements” (p. 6).

In working to identify the various processes and skills involved in reading, researchers have highlighted how both cognitive and linguistic systems play a significant role in reading development. For example, cognitive elements such as processing speed and working memory have been shown to impact the attainment of early reading skills, fluency, and extraction of



meaning from print (Berninger, Yates, & Lester, 1991; 2001). For clarity, processing speed impacts the rate in which children gather information from reading, while comprehension of what has been read relies on working memory (Swanson & Howell, 2001). Taken together, processing speed and working memory allow children to read quickly and encode useful information, while obtaining meaning from what has been read (Vellutino, Scalon, & Tanzman, 1991). Individuals with protracted reading abilities tend to demonstrate variety with respect to the presence and severity of processing speed and working memory impairments, when compared to their typically developing peers (Wagner & Muse, 2006, Wechsler, 2006). In addition to processing speed and working memory, a number of other cognitive processes have been examined in terms of their links to reading (e.g., attention, inhibition, rapid automatic naming) and have also been demonstrated to predict overall achievement (Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Vellutino et al., 1996; Wolf, 1997)

While it is important to examine the cognitive factors that may contribute to reading difficulties, emphasis should also be placed upon the child's linguistic system (i.e., oral language) and its contribution to the reading process. In fact, arguments could be made that the linguistic system is central to the successful development of reading ability (Fowler, 2011). Within modern theories of reading acquisition, linguistic systems provide a foundation or infrastructure in which literacy is believed to build upon (Fowler, 2011). When considering the linguistic system, two factors have been consistently identified to predict reading development among emergent readers – phonological decoding and orthographic word-identification (Berninger & O'Malley, 2011; Cunningham et al., 2001). For clarity, phonological decoding allows children to decipher unfamiliar words in text using individual sounds, while orthographic word-identification allow for the efficient recall of known words from memory (Berninger,

2007). Although it is believed by many researchers that orthographic word-identification finds seminal roots in phonological decoding (e.g., Ehri, 2000), there is also evidence to support that deficits in either skill area may exist independently of the other (e.g., Buttner & Shamir, 2011; Cunningham et al., 2001; Gustafson et al., 2011). That is, while related from a developmental perspective, phonological decoding and orthographic word-identification may represent separate factors within the reading process.

The distinction between these two linguistic skills may be of particular importance in the assessment and intervention for children with Reading Disabilities. For clarity, Reading Disabilities are commonly identified in children who experience protracted reading abilities which are unexpected in relation to their age, level of cognitive functioning, and the quality of teaching instruction they have received (Mather & Goldstein, 2001). There is initial evidence to support that these two areas (phonological decoding and orthographic word-identification) may differ in their degree of deficit within Reading Disability populations. Researchers have identified incidents in which children with Reading Disabilities have relatively little impairment in phonological decoding while experiencing significant orthographic word-identification deficits (e.g., Seymour & Evans, 1993), no impairment in orthographic word-identification while significant deficits in phonological decoding (e.g., Temple & Marshall, 1983), and mixed impairments which affect both phonological decoding and orthographic word-identification abilities (Fiorello et al., 2007).

As children with Reading Disabilities demonstrate variety in regards to their level of impairment in both phonological decoding and orthographic word-identification abilities, it is plausible that grouping children based on their primary area of deficit may be useful and help to inform intervention efforts. That is, grouping children with Reading Disabilities, based on their

primary area of linguistic deficit, may improve reading outcomes by allowing instructors to recommend specific interventions which target these weaknesses.

In the past, grouping children with Reading Disabilities into specific categories or “subtypes” based on their relative areas of deficit was fairly commonplace but, since 2000, has been declining within the educational literature. This decrease in subtype research has been the result of a number of factors. Foremost, there has been a lack of construct validation studies to confirm proposed subtypes within intervention settings, and limited support has been offered as to whether large grouping approaches (e.g., nine subtypes of Reading Disability; Morris et al., 1998) provides utility for intervention efforts.

Despite the decline of subtyping research in recent years, there are some indications that identifying children as having primary deficits in phonological decoding, orthographic word-identification, or both linguistic skills may be helpful in informing intervention decisions. First, as mentioned earlier, phonological decoding and orthographic word-identification represent two linguistic factors which have been consistently cited within the educational literature to be significant predictors of reading development (e.g., Berninger, Yates, & Lester, 1991; Buttner & Shamir, 2011; Stanovich, 1988; Torgesen, 2000). Second, initial work by Gustafson, Ferreira, and Ronnberg (2007) suggests that it is not only possible to group children according to their primary deficits in phonological decoding and orthographic word-identification, but that interventions may prove to be more efficacious when consideration is given to such groupings. In their research, Gustafson et al. (2007) found children with Reading Disability who were categorized as having a phonological decoding deficit subtype improved their reading ability to a greater extent when placed within a phonologically-based intervention, when compared to those placed within an orthographic-based intervention. Similarly, children who were identified as

having an orthographic word-identification deficit subtype improved their reading ability significantly more in the orthographic-based than a phonologically-based intervention. The implication here is that it may be plausible to create a new grouping system using these phonological and orthographic factors, particularly for children with Reading Disabilities.

### **The Problem**

Although identifying phonological decoding and orthographic word-identification deficit subtypes for children with Reading Disabilities has potential utility to inform intervention efforts, the empirical support for such a procedure is limited. The Gustafson et al. (2007) study mentioned above is one of few, if not only, studies to have examined the link between phonological and orthographic skills to intervention approaches. While encouraging with respect to the use of linguistic grouping systems, the study examined children from Sweden. Recent cross-linguistic studies have documented marked distinctions between Swedish and English-speaking readers, primarily in regards to their reliance on phonological decoding and orthographic word-identification. That is, Swedish-speaking children rely more heavily on orthographic word-identification than phonological decoding skill, with phonological decoding becoming an insignificant factor in reading competence past Grade One (Furnes & Samuelsson, 2010). In contrast, phonological decoding remains a significant predictor of reading development across the lifespan of English-speaking individuals (e.g., Lyon, Fletcher, & Barnes, 2003; Wagner & Torgesen, 1987). The vast differences between English and Swedish linguistic systems questions the degree to which the Gustafson et al. (2007) study is generalizable to the English language context. An additional limitation of Gustafson et al.'s (2007) study was with the design of the orthographic computer-mediated intervention. Specifically, the computer program would “sound-out” words when prompted by the participant. Through allowing the

computer program to decipher words for the participants upon request, the researchers created a mixed intervention which diminished the findings outlined for the orthographic word-identification deficit subtype.

### **Present Study**

Continuing from the initial work of Gustafson et al. (2007), the present study was conducted to examine the effectiveness of an orthographic knowledge intervention with English-speaking children categorized as having phonological decoding, orthographic word-identification, or mixed deficits. Utilizing a single-case multiple-baseline across-participants research design, the performance of 12 students with Reading Disabilities in grades 3 to 6 were examined when provided with a teacher-led orthographic knowledge intervention program. The students attended a private school designated for students with Learning Disabilities and were selected based on specific cognitive, diagnostic, and reading achievement inclusion criteria. Based on the previous work of Gustafson et al. (2007), it was predicted that children who were identified as having orthographic word-identification deficit subtypes would demonstrate the greatest reading gains within the orthographic knowledge intervention, whereas children who were identified as having a mixed or phonological decoding deficit subtype would make little to no overall improvement.

Following this introduction, Chapter Two begins with a description of Reading Disabilities and how the English linguistic system impacts the development of key factors involved in reading development. Chapter Two also outlines how the contemporary understanding of reading development has led to the creation of subtyping paradigms for children with Reading Disabilities, why such techniques have declined significantly within the educational literature, and concludes by discussing a subtyping approach based on phonological

decoding and orthographic word-identification skills. Chapter Three focuses on a description of the participants and selection criteria and instruments prior to discussing the specific orthographic knowledge intervention and role of single-case multiple-baseline across-participants research design within the present study. Chapter Four contains the results of the data analysis, and information regarding treatment integrity. Lastly, Chapter Five summarizes the findings pertaining to the impact of the orthographic knowledge intervention on reading ability for those participants involved in the study. Finally, the implications, limitations, and future directions of this research will be discussed.

## CHAPTER TWO: LITERATURE REVIEW

This chapter provides a review of phonological awareness and orthographic knowledge development as it relates to the decoding and identification of words in print, and provides empirical evidence to support their combined importance in fostering reading acquisition. Next, the assumption that phonological awareness precedes orthographic knowledge will be discussed, as to propose an emerging concept that primary deficits in these areas may exist in isolation of one another. This assertion will be supported by examining contemporary research on selective impairments in phonological decoding and orthographic word-identification, and the success of targeted intervention approaches. This discussion begins with an introduction to Reading Disabilities.

### **Reading Disabilities**

According to the Learning Disabilities Association of Canada (LDAC), Learning Disabilities originate from a central processing deficit which may affect the gathering, organization, storage, and use of verbal and non-verbal information. These disabilities range in severity, persist across the lifespan of an individual, and interfere with the mastery of reading, oral language, written language, and/or mathematics. Of these domains, reading has been demonstrated to be the most prevalent difficulty area for children with Learning Disabilities. This subset of children, referred to as having Reading Disabilities, account for 80% of all those diagnosed with Learning Disabilities in Canada (LDAC, 2002).

Reading Disabilities manifest in children who present significant difficulties in reading, which are unexpected in relation to their age, level of cognitive functioning, and the quality of teaching instruction they have received. In addition, the discrepancy these children face in

reading cannot be attributed to a general developmental delay or sensory impairment (Lundberg & Høien, 2001; Mather & Goldstein, 2001).

Children with Reading Disabilities display inconsistency or ‘heterogeneity’ in regards to their ability to read high-frequency words (e.g., home), sound-out novel words (e.g., yacht), read quickly, and comprehend the meaning behind print (Johns & Lenski, 2001). That is, difficulties in these functional domains of reading (i.e., reading accuracy, rate, and comprehension) are commonly identified in children with Reading Disabilities. Through receiving early intervention, children with Reading Disabilities may gain reading proficiency to a level which is appropriate for their age and/or grade (Hulme & Malatesha, 1998). However, in many cases, reading accuracy, rate, and comprehension commonly remain primary areas of concern, and it is the persistence of such problems over time that assists in the differentiation of Reading Disabilities from the typical struggles faced by emergent readers (Gersten & Baker, 1999). It is undeniable that children with Reading Disabilities experience significant difficulty in gaining mastery over the reading process, and only through understanding the mechanisms of reading development can researchers hope to provide insight that can inform intervention efforts. Of all the systems explored by educational researchers, the linguistic system represents one area of investigation which has shed considerable light into our understanding of reading development and disability (Fowler, 2011).

### **The Linguistic System**

Linguistic systems are important to investigate when trying to understand reading acquisition and the development of Reading Disabilities. One modern belief is that humans are biologically adapted for oral language, whereas reading and writing are too new to have been shaped through evolution (Fowler, 2011). For example, oral language is universal across human



cultures and is nearly universally acquired, or developed, within cultures. Unless children are prevented by hearing loss or severe mental deficiencies, they learn to speak language without explicit instruction (Fowler, 2011). Unfortunately, reading proficiency develops in a much different fashion. Many human cultures lack a writing system, and within cultures, literacy is not universal. Children almost always need to be explicitly instructed to read, and many, even when given adequate instruction, fail to learn to read well (Lieberman, 1984).

While oral language appears to be an innately endowed in comparison to the more protracted and instruction-dependent process of learning to read, it is likely that oral language supports development of such reading mastery (Kavanagh & Mattingly, 1972). It has been demonstrated that the vast majority of children begin reading instruction when they are already competent users of oral language, and the language they read is typically the language they speak – albeit, sometimes of a different dialect (Fowler, 2011). There is evidence to suggest that beginning readers, who can learn to associate printed words to their oral representations, have potential to move closer to becoming fluent readers (Braze, McRoberts, & McDonough, 2011; Frost, 1998). This effect has been documented among readers of writing systems that vary considerably in the transparency with which words signal the pronounced form (Fowler, 2011). For example, English could be considered a transparent language because the majority of words, in printed form, provide cues to the reader as to how to pronounce or “decode,” and sentences are written to follow a logical order (e.g., noun followed by adverb). In contrast, Mandarin can be considered non-transparent due to the difficulty faced by readers to decode words, and the degree of irregularity found within the writing system. Thus, reading in transparent languages, which emphasize strong letter-sound correspondences, are more readily learned than non-transparent languages.

Within the English context, several linguistic skills appear to provide a foundation for the acquisition of reading ability. Factors such as phonological awareness, orthographic knowledge, semantics (i.e., word-meaning), and syntax (i.e., sentence structure) have been identified by researchers to strongly predict overall reading achievement in emergent readers (e.g., Berninger, & O'Malley, 2011; Dickinson & Tabors, 2002; Snow, Burns & Griffin, 1998). Of these factors, phonological awareness and orthographic knowledge have been identified as the primary contributors towards gaining reading mastery. Phonological awareness, which entails the ability to discriminate and manipulate the phonological units (e.g., sounds) of oral language, is often viewed as an intermediary between English oral and written language (Fowler, 2011). That is, the association of auditory units of spoken language to letters or groups of letters in print permits individuals access to the written code. This skill is commonly utilized by emergent or struggling readers as a primary strategy to access unfamiliar words in print. Alternatively, individuals may associate spoken words with visually precise images of such words or word parts, and forms what is called orthographic knowledge. This skill is akin to recognizing a common object, such as a ball, based on its physical attributes. Both phonological awareness and orthographic knowledge are viewed as vital to reading development and are described below, in terms of their development and contributions to the reading process.

### **Phonological Awareness and Decoding**

There is no topic within reading research which has gained as much attention over the past two decades as phonological awareness. Although definitions vary, phonological awareness can be generally described as the ability to discriminate and manipulate auditory (e.g., sound) units (Goswami, 2000; Sodoro, Allinder, & Rankin-Erickson, 2002). This learned process encompasses a child's ability to detect and utilize progressively finer units of sound within the

spoken word. When considering the English language, three established levels of phonological units exist: (1) syllables (e.g., /man/), (2) onset-rimes, which involve the breaking of syllables into two parts with the split occurring before the vowel (e.g., /m/ /an/), and (3) phonemes, which separates a syllable into its individual sound units (e.g., /m/ /ă/ /n/) (Harris & Hodges, 1995).

The ability to discriminate and manipulate phonological units is acquired developmentally, and initially consists of acquiring skills in the detection or isolation of sounds within a word. As children gain fluency in these detection or isolation skills, they can begin to manipulate the phonological units. Such tasks include the ability to blend two or more discrete sounds into a complete word (e.g., /m/ /all/ becomes /mall/), segment or break apart whole words into component sounds (/make/ becomes /m/ /ā/ /k/), or report what would be left of a word if one phonological unit was removed (e.g., /move/ without /m/ becomes /ove/) (Sodoro, Allinder, & Rankin-Erickson, 2002). Alphabetic insight, or the mastery of phonological awareness, is believed to occur when children recognize that alphabetic representations (e.g. letters) are directly linked to auditory stimuli (e.g. sounds) (Ehri, 2000; Snow, Burns, & Griffin, 1998).

Phonological awareness can be considered a linguistic process because it exists beneath the surface of observed behavior, and influences whether, or not, children gain reading mastery. When a child attempts to read a book and sound-out novel words that he or she encounters, this observed skill is called phonological decoding. Mastery of this skill is contingent upon the understanding of phonological awareness. That is, phonological decoding will utilize the learned knowledge obtained through phonological awareness, regardless of mastery, to decode words found in print (Ehri, 1995).

Although phonological awareness and decoding have more recently come into increased prominence with the National Reading Panel's (2000) meta-analysis, the relationship between

phonology and reading development and/or ability had been established for many years (Stanovich, 1988; Torgesen, 2000). Initial studies in the 1980s found activities that promoted phonological awareness, combined within instruction in the relationship between sounds and symbols, significantly increased reading and writing ability (Ball & Blachman, 1988; Bradley & Bryant, 1985; Hohn & Ehri, 1983). Later studies highlighted that the English language could be completely deconstructed into phonological units and, through utilizing this process, children learned to read at a much faster rate (Yopp, 1992). In 1994, Torgesen, Wagner, and Rashotte conducted a landmark study in the area of phonological awareness and decoding. In their longitudinal study, Torgesen and colleagues randomly sampled 288 kindergarten students from six elementary schools in the United States. Utilizing an expansive test-battery of 22 reading achievement and phonological tasks, the researchers followed their participants for a total of three years. The researchers concluded that deficits in phonological awareness and decoding strongly predicated future reading achievement for those children involved in the study. Since the publication of Torgesen et al. (1994) seminal article, numerous studies have continued to emerge and confirm the dominant theme that phonological awareness and decoding are critical elements for the prediction of reading ability in childhood (see Schumm, 2006 for review).

### **Orthographic Knowledge and Word Identification**

While phonological abilities are important to the development of reading mastery, there is growing empirical and clinical evidence to suggest that phonological awareness and decoding skills are not independently sufficient to facilitate the development of successful readers (Buttner & Shamir, 2011). In support of this view, evidence from intervention studies has demonstrated that not all struggling readers respond to phonological awareness intervention. For example, in the previously discussed Torgesen et al.'s (1994) study, the researchers made a secondary

conclusion that not all children who struggle with reading will respond to intensive phonological awareness intervention. This finding questioned the presence of phonology as the solitary construct which predicted reading ability.

Representing an emergent area of study, researchers have turned to an exploration of how words are stored and retrieved from memory to facilitate the development of skilled readers (e.g., Berninger, Yates, & Lester, 1991). Termed orthographic knowledge and word-identification, these two factors represent an important linguistic process which works alongside phonological awareness and decoding to foster overall reading ability (e.g., Berninger, 1995; Lonigan & Shanahan, 2009).

Orthographic knowledge can be described as a word-database or 'lexicon,' which collects visually precise, correctly-spelled, words-forms and stores them within long-term memory (Vellutino et al., 2004). While there is ongoing debate regarding the manner in which orthographic knowledge is acquired, Ehri (1995) has postulated that it is acquired developmentally, after gaining rudimentary proficiency in phonological awareness and decoding. Children initially begin by learning phonological awareness, before crafting their phonological decoding skills in real-life settings. Once children are able to phonologically decode, they begin acquiring words within their orthographic lexicon.

According to Ehri (2000), children move through a series of stages, becoming increasingly sophisticated at using phonological decoding to identify words in print. As children learn to recognize words, they first identify them holistically, as a single image or 'logograph.' For example, children at this stage of reading development may recognize words such as "look" through remembering features, such as the two letters o's which resemble eyes (Ehri, 1995). While the process of remembering anecdotal features, as in the previous example, resembles

growth in the orthographic lexicon, it is believed that these connections (e.g., two letters “oo” for eyes) represent a memory aid or “heuristic,” rather than a visually precise, correctly spelled, word form stored in long-term memory. With this in mind, this stage has been commonly referred to as the pre-alphabetic because children are using features, instead of letters and sounds, to aide in the identification of words (Stahl & Murray, 1994). As children continue to develop phonological decoding, they may begin to use some partial sound information to identify words. Ehri (2000) believes this time in development revolves around phonetic cues because children may substitute a word that begins with the same sound (e.g., /big/ may be replaced for /bug/).

In the full-alphabetic stage, children use all of the letters and sounds to identify words found in print (Ehri, 2000). At this time, the reading performance of children may appear laboured, due to their sole reliance on phonological decoding (Ehri, 1995). This is considered to be a threshold phase, which precedes the automatic identification of words based on the development of a well-formed orthographic lexicon. Thus, in the final stage, children are able to quickly identify words as a whole or through rapid recognition of chunks within words (Stahl & Murray, 1994). By this time, children are freely able to allocate attention and concentration towards gaining comprehension from what has been read, versus the effortful phonological decoding of all words within a given sentence (Chall, 1983).

Similar to phonological awareness, orthographic knowledge represents an important process which stores the necessary information for children to be successful in reading. With that said, children with Reading Disabilities may have significant difficulties in creating such visual representations, termed orthographic coding, and/or utilizing their orthographic knowledge within reading situations (Berninger, 1995; Berninger, et al., 1994; Castles, Riach, & Nicholson,

1994). According to Berninger (1995), the actual process by which children utilize their orthographic knowledge in real-life settings is called orthographic word-identification, and it represents a relatively novel area of investigation.

Stanovich and West (1989) were two of the first researchers to explore the contribution of orthographic knowledge and word-identification to understanding reading achievement. They conducted a study with 180 undergraduate students to determine how well an orthographic word-identification task predicted reading ability. This task involved the presentation of three words which were, phonetically identical, and the participant was asked to choose the correctly spelled word (e.g., was, wuz, whuz). They revealed that orthographic word-identification accounted for unique variance after controlling for the effects of phonological awareness and decoding. These findings were later replicated in studies conducted by Barker, Torgesen, and Wagner (1992).

In a longitudinal study, Cunningham et al. (2001) administered a battery of phonological decoding and orthographic word-identification tasks to a group of children in the first grade, and tracked their progress until their third grade. The researchers determined that even after variance attributed to phonological decoding in the first grade was partialled out, orthographic word-identification predicted significant variance in third grade word recognition scores. To Cunningham and his colleagues, it also appeared that phonological decoding and orthographic word-identification were important contributors to reading ability and, at minimum, demonstrated partial independence of one another.

Although it is believed by many researchers that orthographic knowledge and word-identification find seminal roots in phonological awareness and decoding (e.g., Ehri, 2000), there is also evidence in support of an emerging view that deficits in phonological decoding and orthographic word-identification skills may occur independently of one another in Reading

Disability populations (e.g. Buttner & Shamir, 2011; Cunningham et al., 2001; Gustafson et al., 2011).

### **Deficits in Phonological Decoding and/or Orthographic Word-Identification**

The recognition that deficits in phonological decoding and orthographic word-identification could occur in isolation of one another was first noted by Temple and Marshall (1983). In their case study, the researchers examined a 17-year-old girl who could read simple and complex words, but demonstrated great difficulty when tested using a phonological decoding task. The researchers highlighted that, although her word-identification abilities were intact, she appeared to have a ‘phonological decoding deficit’. Similar findings were also reported in later case-study experiments completed by Campbell and Butterworth (1985), Seymour and MacGregor (1984), and Snowling and Hulme (1989).

Around this same time, Coltheart et al. (1983) described a 17-year-old girl who demonstrated little difficulty in reading words phonetically, but struggled when she met irregular or ‘low frequency’ words, which do not necessarily follow the typical phonetic rules (e.g., yacht). While orthographic skills have only more recently been forwarded as a term, this early case study provided descriptions of reading difficulties which appeared consistent with what today could be considered an ‘orthographic word-identification deficit.’ Concurrent descriptions were noted in case studies by Job, Sartori, Masterson, and Coltheart (1984), Seymour (1986), and Seymour and Evans (1993).

In a series of studies employing multivariate cluster-analytic methods, Lyon and his colleagues (Lyon et al., 1981; 1982; Lyon & Watson, 1981) identified six subgroups of older students with Learning Disabilities (11 to 12 years old) and five subtypes of younger students with Learning Disabilities (6 to 9 years old), on measures assessing linguistic skills, visual-



perceptual abilities, and memory span. Similar to previous case studies, Lyon and his colleagues demonstrated that phonological decoding and orthographic word-identification were key features found in children with Reading Disabilities and impairments were demonstrated, primarily, in one area or the other.

In a follow-up study, Castles and Coltheart (1993) presented additional evidence that primary deficits could occur in phonological decoding and/or orthographic word-identification independent of one another. They followed 32 children with Reading Disabilities and compared their performance on a variety of phonological and orthographic tasks. Utilizing a regression analysis, Castles and Coltheart identified a significant discrepancy between phonological decoding and orthographic word-identification skills after examining a nonsense and word-choice task. They determined that 6 cases could be identified as having a primary orthographic word-identification deficit, 21 cases could be identified as having a primary phonological decoding deficit, and 5 cases were equally low in both domains (i.e. mixed deficit). Castles and Coltheart concluded that the primary phonological decoding and orthographic word-identification deficit patterns were relatively common among children with Reading Disabilities, and they could exist along a spectrum or continuum.

More recently, Fiorello, Hale, and Snyder (2006) utilized a discriminant function analysis to examine 128 children with Reading Disabilities and noted findings which were similar to those previously mentioned. According to Fiorello and her colleagues, classifications were created based on their participants' performance on a variety of phonological decoding, orthographic word-identification, and cognitive functioning tasks. The results indicated four possible subtypes, which were differentiated by having primary deficits in phonological decoding, orthographic word-identification, combined phonological decoding/orthographic

word-identification, or fluency/comprehension skills. In sum, phonological and orthographic skills have consistently been found to contribute to the reading process, with evidence suggesting that they may exist in isolation of each other.

### **Declining Research and an Emerging Approach**

Support for the identification of phonological decoding and orthographic word-identification as key, yet separate, factors in the reading process leads to the conclusion that such a distinction may be useful for the purposes of assessment and intervention. In particular, it is possible that these two linguistic skills could be used to identify three subtypes of Reading Disability that would respond differently to intervention approaches.

In the past, work to identify Reading Disability subtypes was fairly commonplace, with, for example, distinctions made between children who demonstrated impairments in reading accuracy versus reading rate (Lovett, 1984, 1987). However, research into specific Reading Disability classifications has been declining within the educational literature. Namely, since the early 21<sup>st</sup> century, larger emphasis has been given within the Reading Disability research to identifying a larger number of factors which contribute to individual difference in reading ability.

This decrease in subtyping research within the educational literature has been the result of a number of factors. Foremost, the decline has resulted from a lack of construct validation for the proposed subtypes, primarily within the realm of intervention (Lyon, Fletcher, & Barnes, 2003). Specifically, there has been limited empirical support for subtype-treatment interactions, in which specific remediation efforts prove more effective for one group over another. If each subtype represents an independent construct, the belief is that targeted intervention will primarily privilege one group – while individuals with the remaining subtypes demonstrate zero to marginal gains (Kerlinger & Lee, 1999). While proposed Reading Disability subtypes could be

validated using subtype-treatment interaction studies, the educational literature is limited with respect to such studies, and available evidence does not provide conclusive results (Hooper & Willis, 1989; Newby & Lyon, 1991; Lyon, Fletcher, & Barnes, 2003).

In one of the earliest approaches to Reading Disability subtyping classifications, Lovett (1984, 1987) utilized clinical judgement to dichotomise children with Reading Disabilities either as “accuracy” or “rate” disabled. Her subtyping approach represents one of the few techniques to have been explored utilizing a subtype-treatment interaction approach, and found marginal success for such a dichotomy (see Newby & Lyon, 1991 for a review). With that said, Lovett’s approach occurred at a time in which our understanding of reading development was in its infancy, and the importance of the linguistic processes which underlie reading were largely unrecognized. For researchers who have explored linguistic processes as they relate to the subtyping children with Reading Disabilities, the empirical findings are limited. This is primarily the case because researchers have utilized statistical techniques (e.g., Cluster Analysis) as a method of creating classification procedures, without examining the construct validity of such groupings within intervention settings.

In order to best inform intervention activities, the types of classification systems adopted must also be of ‘practical’ utility. That is, it may not be practical within a school setting to offer a wide range of interventions to address all the factors that impact reading success. As mentioned earlier, many contemporary researchers have focused more on individual differences and, in doing so, have identified a wide-range of factors which predict reading ability. Cognitive and linguistic factors, such as phonological skills, orthographic skills, processing speed, working memory, rapid automatic naming, attention, and memory, have all been implicated, in varying degrees, to significantly predict reading achievement (Adams, 1990; Ball & Blachman, 1991;

Barker, Torgesen, & Wagner, 1992; Berninger, Abbott, Thomson, & Raskind, 2001; Olson, Forsberg, & Wise, 1994; Wolf, 1997). While some researcher have worked to link such factors to particular interventions (see Berninger, 1994), these approach has also been limited by a lack of evidence to determine whether such techniques are effective (Foorman et al., 1997; Lyon, Fletcher, & Barnes, 2003). While multi-faceted models may be statistically predictive of reading mastery, the assessment and intervention of multiple factors can be both impractical and onerous within the school environment. That is, a multi-faceted classification system for children with Reading Disabilities places substantial stress upon teachers. Limited support has been offered to indicate whether such large models best inform intervention activities.

As detailed earlier, phonological decoding and orthographic word identification represent two linguistic factors which have been consistently cited within the educational literature to be significant predictors of reading mastery (e.g., Berninger, Yates, & Lester, 1991; Buttner & Shamir, 2011; Stanovich, 1988; Torgesen, 2000) and, as such, it may be plausible and practical to create a new classification system using these two factors. Utilizing phonological decoding and orthographic word-identification in this fashion represents a parsimonious assessment and intervention model. Its primary strength is that it considers the educational context, demands placed on teachers, and availability of interventions which can assist in the evaluation of subtype-treatment interactions. While there may be merit in larger models of classification, preliminary research has surfaced which supports the argument that identifying primary deficits in phonological decoding and orthographic word-identification may be sufficient to inform classroom intervention and predict reading success.

Preliminary support for a two-factor model (i.e., use of phonological and orthographic subtypes to inform assessment and intervention) comes from the work of Gustafson, Ferreira,

and Ronnberg (2007). Gustafson et al. examined two computer-based interventions tailored to improve phonological awareness or orthographic knowledge. Children with Reading Disabilities were initially assessed and grouped based on relative deficits in either phonological decoding or orthographic word-identification. In order to group the participants, the researchers utilized a median split approach in which they divided their participants' phonological decoding and orthographic word-identification scores at the sample median and thereby defined high and low groups. Participants who were marked as low for phonological decoding and high for orthographic word-identification were categorized as "phonological decoding deficit," and those who were placed in an opposite position were said to have an "orthographic word-identification deficit". Once this had been completed, the researchers randomly assigned children from each of the two groups into the phonological or orthographic intervention conditions.

Gustafson and his colleagues found that children with Reading Disabilities who presented with primary impairments in phonological decoding responded better to the reading intervention which addressed phonological awareness instruction; whereas children with primary orthographic word-identification difficulties performed best when provided orthographic knowledge supplementation. With respect to intervention that was incongruent with the primary linguistic skills, Gustafson et al. (2007) found that improvement in the less impaired area was not sufficient to increase overall reading ability. For example, children who demonstrated a primary deficit in phonological decoding did not significantly gain reading ability when their orthographic word-identification was increased.

The Gustafson et al. (2007) study is one of few, if not only, studies to have examined the link between phonological and orthographic skills with intervention approaches. While encouraging with respect to the use of linguistic classification systems, the study has a number of

limitations. First, Gustafson and his colleagues utilized a median-split selection technique, which turned continuous variables (e.g., phonological decoding, orthographic word-identification skill) into dichotomous, or dual-outcome, variables (Kerlinger & Lee, 2000). Through utilizing this process Gustafson and his colleagues did not allow for mixed deficits in phonological decoding and orthographic word-identification to be examined. This method conflicted with previous research, which had stated that deficits in phonological decoding and orthographic word-identification could exist along a spectrum or continuum (e.g., Castles and Coltheart, 1993; Fiorello, Hales, & Synder, 2006).

Second, there is question as to the integrity of the treatment approaches utilized by Gustafson and his colleagues. While the phonological awareness intervention appeared well-developed, the orthographic knowledge intervention demonstrated design issues which limit the generalizability of their research findings. That is, a computer-based intervention flaw allowed participants to click on a presented word and have it sounded out by the computer. Thus, the orthographic intervention became synonymous with a combined approach, rather than a singular technique.

Third, the research findings are limited with respect to their generalizability to English-speaking individuals. Specifically, the Gustafson, Ferreira, and Ronnberg's (2007) study was conducted with Swedish-speaking children. Recent cross-linguistic longitudinal studies have documented significant differences in phonological decoding and orthographic word-identification between Swedish and English speaking children with Reading Disabilities. Using a series of logistic regressions, Furnes and Samuelsson (2010) found that Swedish versus English speakers differed on the extent to which phonological decoding and orthographic word-identification were predictive of reading skills. Specifically, Swedish-speaking children relied

more heavily on orthographic word-identification than phonological decoding skill, with phonological decoding an insignificant factor in reading competence past Grade One. In contrast, English-speaking children relied heavily on phonological decoding skills until Grade Three – the point in which their study ended (Furnes & Samuelsson, 2010). As documented by many researchers, phonological decoding remains a significant predictor of reading development across the lifespan of English-speaking individuals (e.g., Lyon, Fletcher, & Barnes, 2003; Wagner & Torgesen, 1987).

### **Present Study**

The present study examines the effectiveness of an intervention which targets orthographic knowledge in a group of English-speaking children with Reading Disabilities, who present with primary phonological decoding, orthographic word-identification, or mixed deficit subtypes. The intervention selected for this study is Precision Reading. This intervention involves the repeated reading of grade-level passages for five minutes every day until a desired level of mastery is achieved (e.g., reduced reading errors, increased reading speed). Individual words which are mispronounced are recorded on a piece of paper and then said aloud to the student, without breaking the word into phonetic segments. Although the intervention has received limited empirical scrutiny, the foundational elements of repeated readings approach, coupled with one-on-one instruction, has been documented to increase the orthographic knowledge of struggling readers (Jong & Messbauer, 2011). The rationale behind the Precision Reading program is that the increased and systematic exposure to mispronounced words allows for the building of a visual representation of that word-form and storage within the orthographic lexicon.

This study utilizes a single-case multiple-baseline across-participants research design and examines the performance of 12 students from a private school designated for students with Learning Disabilities in a large urban center. Through selecting only those who meet specific cognitive, diagnostic, and reading achievement inclusion criteria, each student serves as his or her own control condition to monitor changes in reading during the intervention program. According to Anderson et al. (2004), this type of research design offers flexibility and strong conclusions within school settings, in comparison to parametric approaches, when sample sizes are small.

The research questions and hypotheses are as follows:

1. Does the orthographic knowledge intervention impact oral reading ability, and its composite skills (i.e., accuracy, rate, and comprehension), of participants identified as having Reading Disabilities?

H1 The orthographic knowledge will improve the oral reading ability, and its composite skills (i.e., accuracy, rate, and comprehension), of participants identified as having Reading Disabilities?

2. Does the orthographic knowledge intervention impact the linguistic skills (i.e., phonological decoding and orthographic word-identification) of participants identified as having Reading Disabilities?

H1 The orthographic knowledge intervention will improve the orthographic word-identification skills of participants identified as having Reading Disabilities.



H2 The orthographic knowledge intervention will not improve the phonological decoding skills of participants identified as having Reading Disabilities.

3. Does the orthographic knowledge intervention impact oral reading ability, and its composite skills (i.e. accuracy, rate, and comprehension), differently depending on the linguistic subtype demonstrated?

H1 The orthographic knowledge intervention will improve reading accuracy, rate, and comprehension for participants identified as having an orthographic word-identification deficit subtype.

H2 The orthographic knowledge will mildly improve reading accuracy, rate, and comprehension for participants identified as having a phonological decoding deficit subtype.

H3 The orthographic knowledge intervention will moderately improve reading accuracy, rate, and comprehension for participants identified as having a mixed phonological/orthographic deficit subtype.

## CHAPTER THREE: METHOD

This chapter provides a description of the research design, participants, instruments, and intervention guidelines, as well as, outlines the specific procedures taken to complete this study. Consideration is also given within this chapter to the analytical methods used in the differentiation of participants into linguistic subtypes and determination of research questions previously outlined.

### General Research Design

The investigation utilized a single-case multiple baseline across-subjects design to evaluate the effectiveness of an orthographic knowledge intervention to increase the oral reading ability, and its composite skills (i.e. accuracy, rate, and comprehension), among a small sample of students with Reading Disabilities from a school in a large urban center. The orthographic intervention, termed Precision Reading, has been employed by the school for the past number of years, but has never received a thorough program evaluation of its effectiveness for their student population. Recognizing the importance of research-informed practice, a school representative contacted the primary investigator to assist in a program evaluation, and this study represents a partial component of this overall project. Student participants, from grades 3 to 6, were randomly assigned to a 3-week, 6-week, or 9-week waitlist condition (i.e., baseline phase) prior to the provision of a reading intervention program (see below “Intervention” section). The baseline phase consisted of 2 to 4 visits by the primary researcher to collect assessment information regarding reading accuracy, rate, and comprehension. This information provided a control condition by which the subsequent effects of the daily intervention sessions could be compared. This type of research allows for changes in reading ability to be easily monitored, relative to baseline, within and between subjects.

## **The Intervention**

Precision Reading is an intervention program that targets the building of reading vocabulary (i.e., orthographic knowledge), through the repeated exposure and direct instruction of unknown words found in print (Freeze, 2006). Precision Reading was developed by Dr. Rick Freeze in 2001, and is currently being utilized by elementary and secondary schools within Alberta and Manitoba, Canada (Freeze, 2002). The program requires students to read the same passage aloud to an instructor for one minute every day for seven to ten school days. At the end of the one-minute reading, the instructor graphs the results and provides the student with corrective feedback with respect to their performance on the passage and the specific errors made. The words which the student pronounces incorrectly are written on a piece of paper and said aloud to the student, without phonetically segmenting, by the instructor. In order to progress through the program and access new passages, students must demonstrate reading to two pre-set criteria.

The first criterion is that students must read, at least, twice as many words correctly as they had on their first attempt. A second criterion is for the students' reading errors to be reduced to two or less errors per passage. If students are able to meet both of these criteria by their seventh reading, the repeated readings of that passage is concluded and a new passage is begun. If students are unable to reach the necessary criteria by their tenth reading, the instructor moves on to a new passage at the same level of difficulty.

The program provides graded reading passages drawn from a variety of grade-level specific materials, such as novels and textbooks, while also providing the tools needed to create individualized passages. The reading passages used in this study were taken from the resource manual. In addition, the format of Precision Reading passages is modified to ensure that pages

appear less intimidating (e.g., font size and style, images removed, margins adjusted). Again, it is important to note that word difficulty is not reduced within the grade-level passages, but rather the appearance of the passage is modified to assist with the visual processing of involved students.

Precision Reading is an amalgamation of two well-researched approaches to reading intervention and instruction – repeated readings (Samuels, 1979) and precision teaching (White, 1989). The philosophy of repeated readings is that when reading becomes automatic, comprehension naturally follows. This concept posits that rereading passages provides the necessary practice to make reading automatic, enabling the student to pay closer attention to comprehending the passage, and ignore traditional word decoding (e.g., phonics). As repeated readings represents an effective intervention technique in its own right, precision teaching was augmented to provide the reinforcement for this success. Precision teaching involves the continuous self-monitoring of performance through the utilization of graphical methods. This visual approach is based upon operant conditioning theory, and believes that the ongoing visual demonstration of success provides a reinforcing factor which drives continued performance by the individual reader. Thus, within the repeated readings framework, precision teaching offered a precise, authentic, direct, and daily measurement method for student to track their performance, obtain reward, and improve fluency (West, Young, & Pooner, 1990; White, 1986).

Although repeated reading and precision teaching represent two well-documented approaches which can assist with the intervention of children with Reading Disabilities, their amalgamated form within Precision Reading has received limited empirical investigation. To date, one case-study has been published which speaks to the efficacy of Precision Reading to remediate reading difficulties in children with Reading Disabilities. In their study, Updike and

Freeze (2001) monitored the progress of Abe, a 10 year-old boy, who demonstrated persistent reading difficulties and was diagnosed with a Reading Disability. Throughout his nine sessions of Precision Reading, Abe made significant gains in his reading accuracy and rate, and was not assessed for overall comprehension. Thus, the ability of Precision Reading to effectively remediate reading achievement in children with Reading Disabilities is relatively unexplored within the current literature.

### **Participants**

**Instructors.** A total of four instructors were individually assigned to one of the four grades under investigation (i.e. grades 3-6). The responsibilities of these participants were to deliver daily intervention and maintain an intervention log, which recorded the number of sessions by each participant and ongoing student performance. Since this study was in partial fulfilment of a program evaluation project undertaken by the school, the instructors delivered the orthographic intervention as part of their assigned classroom requirements. The intervention facilitators had, on average, 10.5 years of teaching experience ( $SD = 7.05$ ), coupled with 3 years of specialized experience delivering this orthographic knowledge intervention ( $SD = 2.31$ ).

**Students.** The study participants consisted of 12 students from grades three to six, totaling three children per grade. Participants were nominated, by the school, to receive the orthographic intervention on the basis of obtaining the lowest scores on a teacher-led reading assessment (i.e., GORT-4, see below for details). While intervention services were provided to all students who were nominated by the school, a subset of students was selected for inclusion in this study. Selection was based on the ability to match three participants per grade on relative oral reading skill, cognitive functioning, and the presence of confirmed Reading Disability diagnoses by a Registered Psychologist. Although attempting to be rigorous with participant

selection criteria, 5 of the 12 selected participants presented with comorbid DSM-IV diagnoses. Of these, Attention Deficit Hyperactivity Disorder was most common (4 participants), followed by Disorder of Written Expression (3 participants) and Mathematics Disorder (1 participant). Demographic information for these participants has been presented in Table 3.1 on the following page.

### **Instruments**

**Oral reading ability.** To screen the initial student body and track ongoing performance in reading, the *Gray Oral Reading Test - 4<sup>th</sup> Edition* (GORT-4; Wiederholt & Bryant, 2001) was utilized. The GORT-4 provides scores for students' oral reading accurate, rate, and comprehension, and an overall quotient which can be compared against other measures of academic and cognitive functioning. The test consists of two parallel forms, each containing 14 developmentally sequenced reading passages with 5 comprehension questions following each passage. The GORT-4 was normed on a sample of more than 1,600 students aged 6 through 18 years. The normative sample was stratified to correspond to key demographic variables including race, gender, ethnicity, and geographic region within the United States. The GORT-4 demonstrates reliability coefficients for internal consistency and test-retest to be  $\alpha = .90$  or above. Similar to reliability, the GORT-4's construct validity has been examined against other well-known measures of reading ability (e.g., Woodcock Reading Mastery Tests – Revised) and has displayed moderate to high correlations throughout ( $r = .45$  to  $.82$ ) (Wiederholt & Bryant, 2001).

**Linguistic processes and skills.** The *Process Assessment of the Learner – 2<sup>nd</sup> Edition: Diagnostic Assessment for Reading and Writing* (PAL-II RW; Berninger, 2007) was utilized to examine phonological decoding and orthographic word-identification deficits. The PAL-II RW is a

Table 1.

*Student Participant Demographics.*

Variable	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Age	8	8	8	9	9	9	10	11	10	11	11	11
Grade	3	3	3	4	4	4	5	5	5	6	6	6
YOPA	2011	2011	2011	2011	2010	2011	2010	2010	2011	2008	2011	2008
Cognitive Functioning												
Full-Scale Intelligence	LA	LA	A	LA	LA	A	A	A	LA	A	A	A
Verbal Comprehension	B	LA	A	A	A	B	A	HA	A	A	HA	A
Perceptual Reasoning	A	A	A	A	LA	A	LA	HA	A	A	A	HA
Working Memory	A	LA	LA	LA	A	A	LA	LA	A	B	A	LA
Processing Speed	A	LA	A	LA	B	A	B	LA	LA	HA	A	A
Comorbid Diagnoses												
Behavioural	-	ADHD-C	-	ADHD-C	ADHD-I	ADHD-C	-	-	-	-	-	-
Academic	-	DWE	-	-	-	DWE	-	-	-	-	DWE	-
						MD						

*Note.* P = participant, YOPA = year of psycho-educational assessment, EL = extremely low range, B = borderline range, LA = low average range, A = average range, HA = high average range, DWE = disorder of written expression, MD = mathematics disorder, ADHD-I = attention deficit/hyperactivity disorder – primarily inattentive type, ADHD-C = attention deficit/hyperactivity disorder – combined type.

standardized and norm-referenced measure designed to assess the processes and skills related to reading and writing development from kindergarten through Grade 6. Since the PAL-II RW has an expansive test-battery, only specific subtests relating to orthographic word choice and phonological decoding were selected. To measure orthographic word-identification, the Word Choice task and two related process subtests were utilized (Receptive Coding and Expressive Coding). For phonological decoding, the Pseudoword Decoding task and three related process subtests (Phonemes, Syllables, and Rimes) were utilized. This measure has demonstrated test-retest and split-half reliabilities ranging from  $\alpha = .72$  to  $.88$  on the above mentioned subtests. The construct validity of the PAL-II RW was examined using three cognitive ability and neuropsychological tests, the Differential Abilities Scales–Second Edition (DAS-II; Elliot, 2007), the Wechsler Nonverbal Scale of Ability (WNV; Wechsler & Naglieri, 2006), and the NEPSY–Second Edition (NEPSY-II; Korkman, Kirk, & Kemp, 2005). Correlation coefficients were generally low because the PAL-II RW was developed to measure different theoretical constructs (e.g.,  $r = .30$  or lower).

### **Single-Case Multiple-Baseline Across-Participants Research Design**

This study employed a single-case multiple baseline research design, which has become a popular way to incorporate single-case research within the classroom environment. Kucera and Alexrod (1995) stated that multiple baseline approaches are particularly well-suited for literacy research because they are, relatively, unobtrusive to the daily workings of a classroom and provide ongoing feedback to inform best-practice interventions. The authors also maintain that multiple baseline techniques can help examine new approaches and strategies to determine whether or not they demonstrate effectiveness. This technique is the preferred design when it is



not possible for students to return to original baseline levels. For example, once a student has learned a new strategy for decoding words it is not desirable, and in many cases possible, to have that student unlearn a new skill. There are three types of single-case multiple baseline approaches commonly utilized within educational settings: across behaviors, subjects, and settings. Based on the research questions of this study, the across participants technique is most appropriate and will be discussed in detail.

The multiple baselines across participant's research designs allow researchers to examine the impact of an intervention program (e.g., Precision Reading) on an outcome variable (e.g., reading ability) for individual participants over time. Once a baseline has been established for the outcome variable, the intervention is then applied to one of the participants. During this time, baseline is maintained for all other participants. Once a set period of time or improvement is seen for the first participant, the intervention is started with a second individual, and so on. The reasoning behind this design is that if one participant shows improvement when intervention is started, it is possible that improvement is due to the intervention. If gains were reflected in the other participants while they were still at baseline, a conclusion could not be made that the intervention was the most probable reason for this observed change.

### **Procedure**

After obtaining consent from University of Calgary and the participating school, the primary researcher accessed reading achievement (accuracy, rate, and comprehension) scores that were on file for all students in grades 3 through 6. The reading scores were from a standardized reading assessment called the *Gray Oral Reading Tests – 4<sup>th</sup> Edition* (GORT-4), which had been administered by their classroom teacher in mid-October of the current academic year. While all students who achieved a standard score within the Poor (70-79) or Very Poor

(<70) range on the GORT-4 receive intervention services ( $n=21$ ), a subset of students were selected for inclusion in this study. Selection was based on the ability of the primary investigator to match three participants from each grade on oral reading performance within in the Very Poor or Poor range. This process allowed for a relatively homogenous participant sample ( $n=14$ ) in terms of oral reading ability, prior to the utilization of further selection criteria.

Parental consent forms were sent home, via the 14 students, to allow permission for the primary investigator to review the psychoeducational reports within each student's cumulative file. Specifically, psychoeducational reports were reviewed as to ensure that all participants had a Low Average to Above Average Full Scale Intelligence Quotient, as measured by the *Wechsler Intelligence Scale for Children – 4<sup>th</sup> Edition* (WISC-IV; Wechsler, 2003), and to confirm whether a Reading Disability diagnosis was made by a Registered Psychologist. The knowledge of whether a Reading Disabilities was diagnosed by a Registered Psychologist represented a significant elimination factor, which excluded two participants from the final sample. Again, it is important to note that the excluded participants still received intervention services, but their reading performance trends were not examined within the present study.

The resulting sample of participants ( $n=12$ ) were sent home with consent forms, which outlined the nature of the study and inquired regarding their willingness to have their child participate in the orthographic knowledge intervention, and requested an additional reading assessment using seven subtests from the *Process Assessment of the Learner – 2<sup>nd</sup> Edition: Diagnostic Assessment of Reading and Writing* (PAL-II RW). This additional assessment provided information about the participants' strengths and weaknesses with phonological decoding and orthographic word-identification. Testing was conducted by the primary investigator, on an individual basis, and took approximately 35 minutes per student. In order to

differentiate participants based on the level of deficit in phonological decoding or orthographic word-identification, the PAL-II RW Pseudoword Decoding and Word Choice task scaled scores were converted into their corresponding z-score values. The distance between scores was then examined, so as to differentiate which linguistic skill was most impaired or whether a mixed impairment was present. On the following page, Table 2 provides a visual representation of this categorization process.

The intervention was delivered in a manner consist to that previously outlined in the Intervention section. In addition to the core program, the teachers were asked to keep an Intervention Log, in which they recorded information regarding the number of sessions held with each student and the specific passages they worked on throughout. In alignment with the selected multiple baseline design, the three participants within each grade were assigned to one of three waitlist conditions – 3 weeks, 6 weeks, or 9 weeks. By examining more than one baseline, the effects of confounds from other variables were reduced (e.g. undocumented reading interventions) and a more definitive conclusion could be reached in regards to observed change as a consequence of the targeted intervention (Barlow, Nock, & Hersen 2009).

Participating students were administered the GORT-4 by the primary researcher every three weeks, following the initial teacher conducted assessment (Week 0). This process began the first week of November and continued for a total of 24 weeks. The exception to this was a six week span between Weeks 18 and 24, owing to a conflict with in-school achievement testing. In order to minimize practice gains, the GORT-4 was administered in alternating formats (e.g., Form A, and Form B). Through utilizing this process, the reliability of assessment could be improved while minimizing practice effects. Data collection ended on the 24<sup>th</sup> week and students were re-administered the GORT-4 and two subtests from the PAL-II RW–Pseudoword Decoding

and Word Choice. Please refer to Figure 1 for a graphical representation of the assessment schedule, which specifically includes information regarding baseline, intervention start times, and GORT-4 measurement.

Table 2.

*Diagnostic Approach for Subtype Classification*

Diagnostic Category	Critical Z-Score Difference
Phonological Decoding Deficit Subtype	$Z_{difference} \geq 1$ PW < WC
Mixed Phonological/Orthographic Deficit Subtype	$Z_{difference} < 1$ PW $\approx$ WC
Orthographic Word-Identification Deficit Subtype	$Z_{difference} \geq 1$ WC < PW

Note. PW = pseudoword decoding scaled score, WC = word choice scaled score.

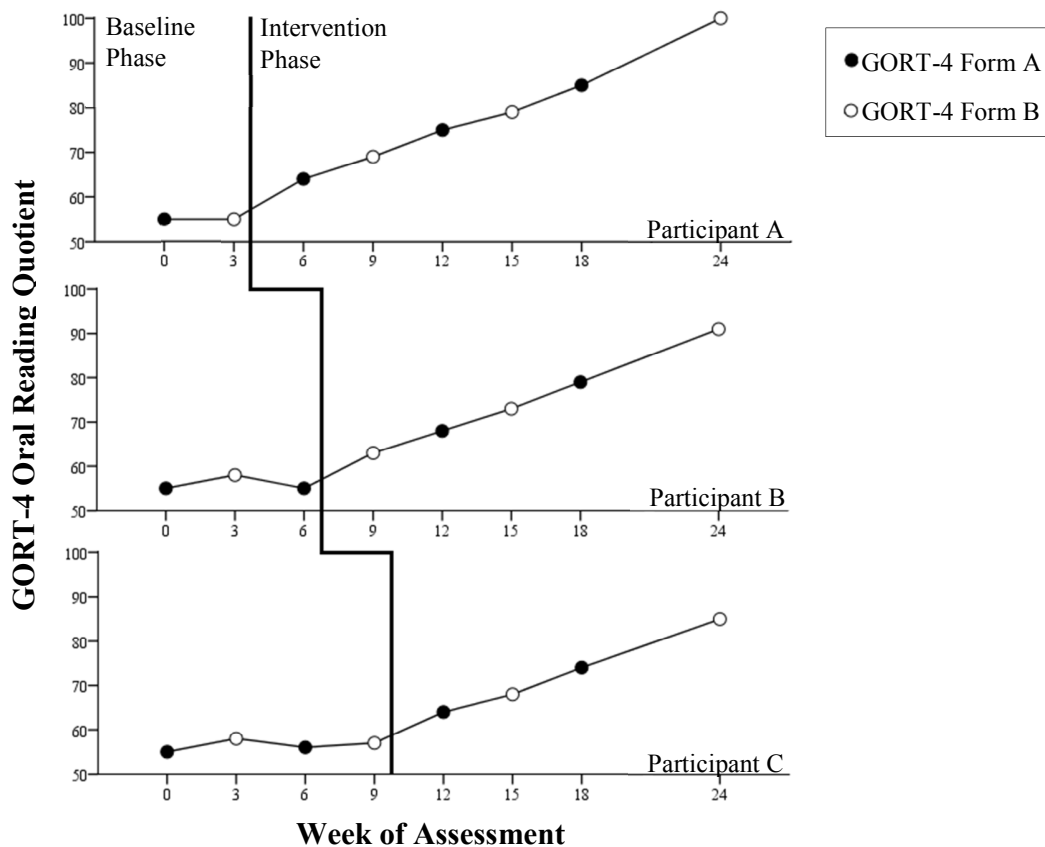


Figure 1. Sample Baseline and Intervention Schedule by Week.

Following the completion of intervention activities, the primary researcher retrieved the intervention logs and conducted a semi-structured interview with each teacher. The purpose of the interview was to confirm each instructor's familiarity with the technique, and whether they implemented the program in alignment with the Precision Reading manual. It is important to note that prior to the collection of intervention data, the school had implemented a number of Precision Reading refreshment activities aimed at ensuring consistency between instructor staff.

### **Analytic Strategy for Research Questions**

The primary data analysis strategy used for this type of design was visual inspection, and this technique represents a standard practice within most single-case multiple-baseline research design (Hayes, Barlow, & Nelson-Gray, 1999; Kazdin, 2003). Changes in reading ability were examined by visually inspecting the patterns of change in the level, slope, and stability of the overall Oral Reading Quotient (ORQ), as provided by the GORT-4. Changes that were large in magnitude, temporally related to the baseline-to-intervention phase change, consistent throughout the intervention phase, and similar across participants allowed for the strongest conclusions to be drawn about the relationship between the intervention and observed reading improvement (Hancock & Mueller, 2010).

Single-case research designs provide practical utility within school environments, but are often scrutinized because visual inspection is used as the primary technique and statistical analyses are often difficult to employ, due to sample size. With that said, Jacobson, Follette, and Revenstorf (1984) believe that assessment of statistically reliable change between baseline and post-intervention performance of individual participants may provide additional validity to such visual inspection techniques. This form of calculation is often referred to as a reliable change index (RCI) and it helps demonstrate whether measurement error may be the reason for observed

development between baseline and intervention conditions (Jacobson & Truax, 1991; Maassen, 2004). Thus, after concluding the visual inspection process, a RCI was calculated to determine whether changes in the GORT-4 subscales (accurate, rate, and comprehension), and the omnibus Oral Reading Quotient. Baseline RCI scores were also compared to intervention RCI scores to determine if measured changes were more significant during the intervention period. Utilizing the same technique, the PAL-II RW Pseudoword Decoding and Word Choice tasks were also examined. The equation can be represented as

$$RCI = \frac{Intervention_{post} - Intervention_{pre}}{S_{diff}}$$

wherein, the reliable change index is calculated by subtracting the post-intervention score from the pre-intervention score and the result is divided by the standard error of differences (Christensen & Mendoza, 1986; Ferguson, Robinson, & Splaine, 2002; Jacobson & Truax, 1991). If the product is larger than the z-score level of significance, in this case 1.96 ( $p < .05$ ), then the change can be considered to be beyond that of chance variation. The formula uses the standard error of the mean, which was calculated using the standard deviations and reliability coefficients of the normative sample – all of which were statistically sound for the GORT-4 and PAL-II RW.

## CHAPTER FOUR: RESULTS

This chapter explores the reading ability and linguistic development encountered by the twelve students selected to participate in the orthographic knowledge intervention. Each grade will be examined holistically through visual inspection, prior to an in-depth look at individual participants through interpreting trends and reliable change indexes. To conclude, this chapter will outline exploratory findings regarding the utility of identifying linguistic subtypes to inform intervention efforts.

### **Treatment Fidelity**

With all intervention-based studies, it is important to assess treatment fidelity in order to examine the generalizability of research findings. As mentioned in Chapter Three, treatment fidelity information was examined by gathering the Intervention Logs and conducting a semi-structured interview with each intervention facilitators. The log review and interview were completed to gather information regarding the intervention-specific administration and frequency of treatment. Through this process, it was identified that all intervention facilitators offered the orthographic intervention in a manner consistent with the manual, but varied in the frequency of treatment. Facilitators highlighted that variety existed due to time constraints, sick days, student motivation, or absenteeism. For participants who were placed in the 3 week waitlist condition, they had on average 49.50 sessions ( $SD=13.82$ ), followed by the six week ( $M=39.75$ ,  $SD=15.56$ ), and finally the nine week waitlist condition ( $M=33.00$ ,  $SD=12.96$ ). The exact number of sessions experienced by each participant will be discussed in the grade-specific outcome sections to follow.

### Oral Reading Ability Outcomes

In order to examine whether the Precision Reading program had an impact on oral reading ability, grade level performance was examined by visually inspecting the patterns of change in the level, slope, and stability of the overall Oral Reading Quotient (ORQs), as provided by the GORT-4. At which point, reliable changes index (RCI) scores were calculated to corroborate visual inspection techniques and determine the probability of such growth in oral reading ability occurring by chance (Research Question 1). It is important to stress that the utilization of visual inspection and RCI procedures offers an exploratory examination of development during the orthographic intervention, and in no means is meant to infer prediction or causation relationships. To begin, each grade was examined in a holistic fashion prior to an in-depth exploration of the individual participants.

**Grade 3.** Through visually examining the multiple-baselines for the Grade 3 classroom, overall gains were observed in the Oral Reading Quotient (ORQ) for 2 of the 3 participants, when comparing baseline to intervention conditions. Please refer to Figure 2, on the following page, for a visual depiction of ORQ trends.

**Participant 1 (P1).** On the Gray Oral Reading Tests – 4<sup>th</sup> Edition (GORT-4), P1's Oral Reading Quotient (ORQ) score remained constant during the three-week baseline period and reflected performance in the Very Poor range ( $M=62.5$ ,  $SD=1.5$ ). Immediately following the baseline phase, an upward shift of was observed. Although demonstrating some variability during the baseline phase, P1's scores trended steadily upward towards the final assessment. The RCI value for the baseline phase represented that no reliable improvement occurred during this timeframe ( $RCI < 1.95$ ). However, with the implementation of the intervention phase, a significant improvement in reading ability, as measured by the ORQ. ( $RCI > 1.96$ ) occurred.



When this trend was further examined using the individual subscales of the GORT-4, reading accuracy, rate, and comprehension all demonstrated marked improvement ( $RCI > 1.96$ ). By the end of intervention, P1 had been administered 64 sessions of intervention and achieved an ORQ within the Poor range (70-79).

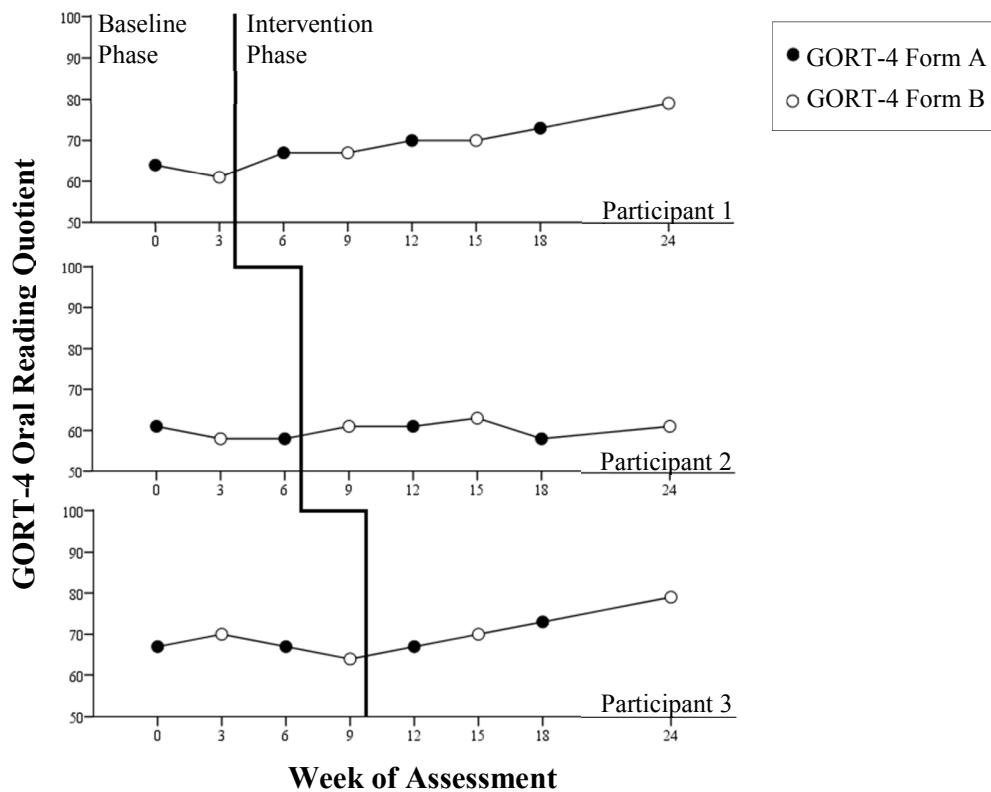


Figure 2. GORT-4 Baseline and Intervention Performance for Grade 3 by Week.

**Participant 2 (P2).** The ORQ score for P2 remained fairly constant during the six-week baseline period, and reflected performance within the Very Poor range ( $M=59, SD=1.73$ ). Participating in the intervention phase did little to change ORQ values, as this flat trend continued throughout the intervention phase. The RCI value for the baseline phase represented that no reliable improvement occurred during this timeframe ( $RCI < 1.95$ ). Similarly, from the averaged baseline to final assessment, the RCI denoted no significant improvement in reading

ability, as measured by the ORQ and individual subscales ( $RCI < 1.96$ ). By the end of intervention, P2 had been administered 41 sessions of intervention and remained within the Very Poor range ( $< 70$ ) for ORQ.

**Participant 3 (P3).** During the nine-week baseline phase, the ORQ scores for P3 remained constant and reflected performance within the Very Poor range ( $M=67, SD=2.45$ ). Immediately following the baseline phase, P3 demonstrated an upward shift in reading ability. The RCI value for the baseline phase represented that no reliable improvement occurred during this timeframe ( $RCI < 1.95$ ). However, from the averaged baseline to final assessment, the RCI denoted significant improvement in reading ability, as measured by the ORQ ( $RCI > 1.96$ ). When this trend was further examined using the individual subscales of the GORT-4, reading rate and accuracy demonstrated marked improvement ( $RCI > 1.96$ ), while reading comprehension did not significantly change from baseline levels ( $RCI < 1.96$ ). By the end of intervention, P3 had been administered 45 sessions of intervention and achieved an ORQ within the Poor range (70-79).

**Grade 4.** Through visually examining the multiple-baselines for the Grade 4 classroom, overall gains were observed in the Oral Reading Quotient (ORQ) for 2 of the 3 participants, when comparing baseline to intervention phase conditions. Please refer to Figure 3, on the following page, for a visual depiction of ORQ trends.

**Participant 4 (P4).** The ORQ score for P4 remained fairly constant during the three-week baseline phase, and during the baseline phase, and reflected performance within the Poor range ( $M=77.5, SD=1.50$ ). Participating in the intervention phase did little to change ORQ values, as this flat trend continued throughout the treatment timeline. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ).

From the averaged baseline to final assessment, the RCI denoted no significant improvement in reading ability, as measured by the ORQ and individual subscales ( $RCI < 1.96$ ). By the end of intervention, P4 had been administered 54 sessions of intervention and achieved an ORQ within the Below Average range (80-89).

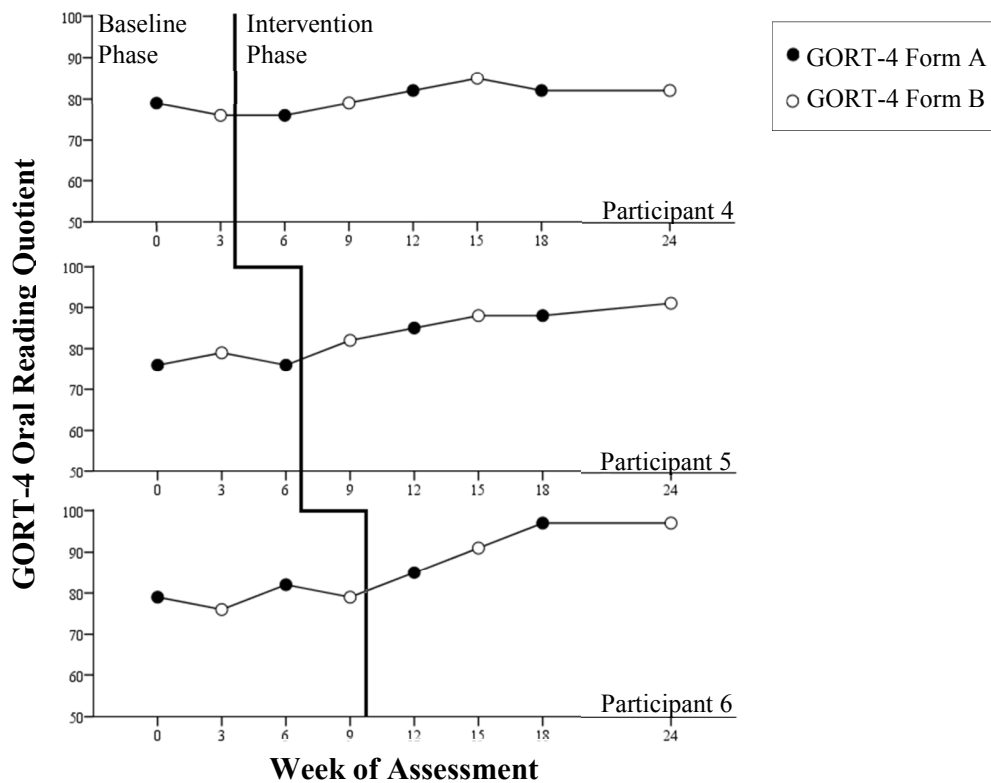


Figure 3. GORT-4 Baseline and Intervention Performance for Grade 4 by Week.

**Participant 5 (P5).** During the six-week baseline phase, the ORQ score remained constant and reflected performance in the Poor range ( $M=77.00$ ,  $SD=1.73$ ). Immediately after completing the baseline phase, an upward shift was observed. Although demonstrating some variability during the baseline phase, P5’s scores trended steadily upward towards the final assessment. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). However, from the averaged baseline to final

assessment, the RCI denoted significant improvement in reading ability, as measured by the ORQ ( $RCI > 1.96$ ). When this trend was further examined using the individual subscales of the GORT-4, reading accuracy and rate demonstrated marked improvement ( $RCI > 1.96$ ), while reading comprehension did not significantly change from baseline levels ( $RCI < 1.96$ ). By the end of intervention, P5 had been administered 59 sessions of intervention and achieved an ORQ within the Average range (90-100).

**Participant 6 (P6).** The ORQ score for P6 remained fairly constant during the nine-week baseline period, and reflected performance within the Poor range ( $M=77.50$ ,  $SD=2.12$ ). Immediately after completing the baseline phase, an upward shift was observed. Although demonstrating a degree of variability during the baseline phase, P6's scores trended steadily upward before plateauing at the 18<sup>th</sup> week of assessment. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted statistically significant improvement in reading ability, as measured by the ORQ ( $RCI > 1.96$ ). When this trend was further examined using the individual subscales of the GORT-4, reading accuracy, rate, and comprehension all demonstrated marked improvement ( $RCI > 1.96$ ). By the end of intervention, P6 had been administered 43 sessions of intervention and achieved an ORQ within the Average range (90-100).

**Grade 5.** Through visually examining the multiple-baselines for the Grade 5 classroom, overall gains were observed in the Oral Reading Quotient (ORQ) for 2 of the 3 participants, when comparing baseline to intervention phase conditions. Please refer to Figure 4, on the following page, for a visual depiction of ORQ trends.

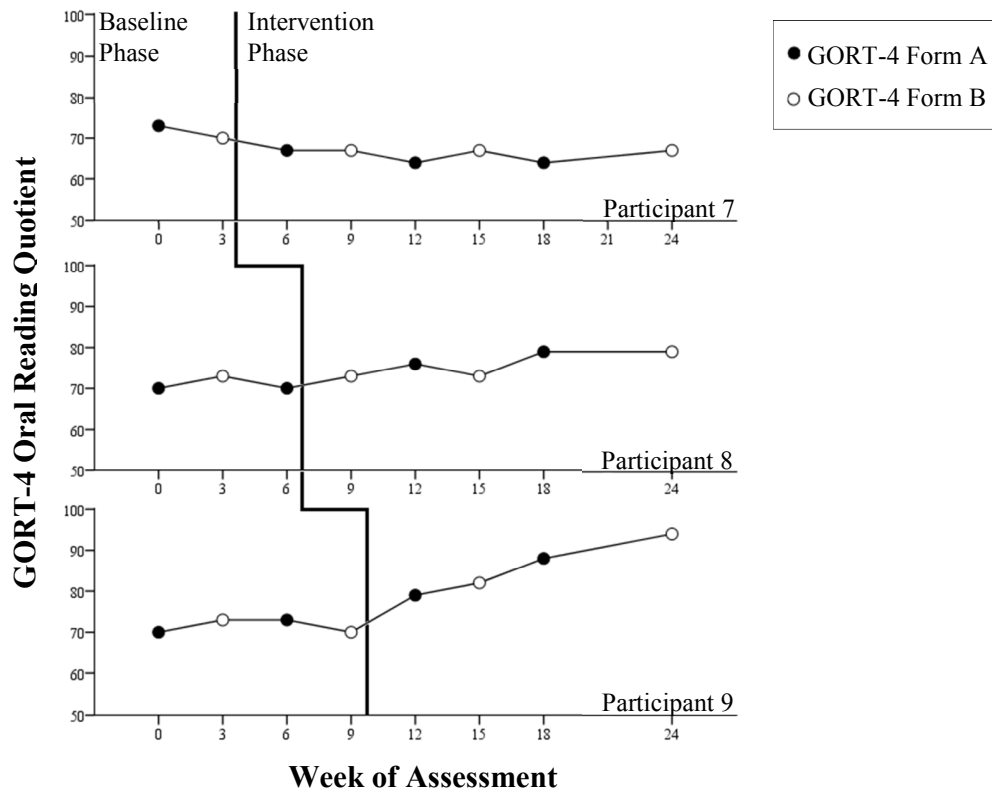


Figure 4. GORT-4 Baseline and Intervention Performance for Grade 5 by Week.

**Participant 7 (P7).** During the three-week baseline period, the ORQ scores for P7 remained constant and reflected overall performance within the Poor range ( $M=71.5.50$ ,  $SD=2.12$ ). Participating in the intervention did little to change ORQ values, and a flat trend continued throughout the intervention phase. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted no significant improvement in reading ability, as measured by the ORQ and individual subscales ( $RCI < 1.96$ ). By the end of intervention, P7 had been administered 49 sessions of intervention and demonstrated oral reading performance within the Very Poor range ( $< 70$ ).

**Participant 8 (P8).** The ORQ score for P2 remained constant during the six-week baseline period, and reflected performance within the Poor range ( $M=71.50$ ,  $SD=2.12$ ). Participating in the intervention did little to change ORQ performance, as recognized by a slight upward shift. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted no significant improvement in reading ability, as measured by the ORQ and individual scales ( $RCI < 1.96$ ). By the end of intervention, P8 had been administered 38 sessions of intervention and achieved an ORQ within the Poor range (70-79).

**Participant 9 (P9).** During the nine-week baseline phase, the ORQ scores for P9 remained constant and reflected performance within the Poor range ( $M=71.50$ ,  $SD=2.12$ ). Immediately after completing the baseline phase, P9 demonstrated an upward shift in reading ability. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted significant improvement in reading ability, as measured by the ORQ ( $RCI > 1.96$ ). When this trend was further examined using the individual subscales of the GORT-4, reading accuracy, rate, and comprehension all demonstrated marked improvement ( $RCI > 1.96$ ). By the end of intervention, P9 had been administered 25 sessions of intervention and achieved an ORQ within the Average range (90-100).

**Grade 6.** Through visually examining the multiple-baselines for the Grade 6 classroom, overall gains were observed in the Oral Reading Quotient (ORQ) by all participants, when comparing baseline to intervention phase conditions. Please refer to Figure 5, on the following page, for a visual depiction of ORQ trends.

**Participant 10 (P10).** The ORQ score for P10 remained fairly constant during the six-week baseline period, and reflected performance within the Very Poor range ( $M=55.50$ ,  $SD=3.54$ ). Participating in the intervention did little to change ORQ performance, as recognized by an upward shift of low magnitude. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted no significant improvement in reading ability, as measured by the ORQ and individual scales ( $RCI < 1.96$ ). By the end of intervention, P10 had been administered 31 sessions of intervention and remained within the Very Poor range ( $< 70$ ) for ORQ.

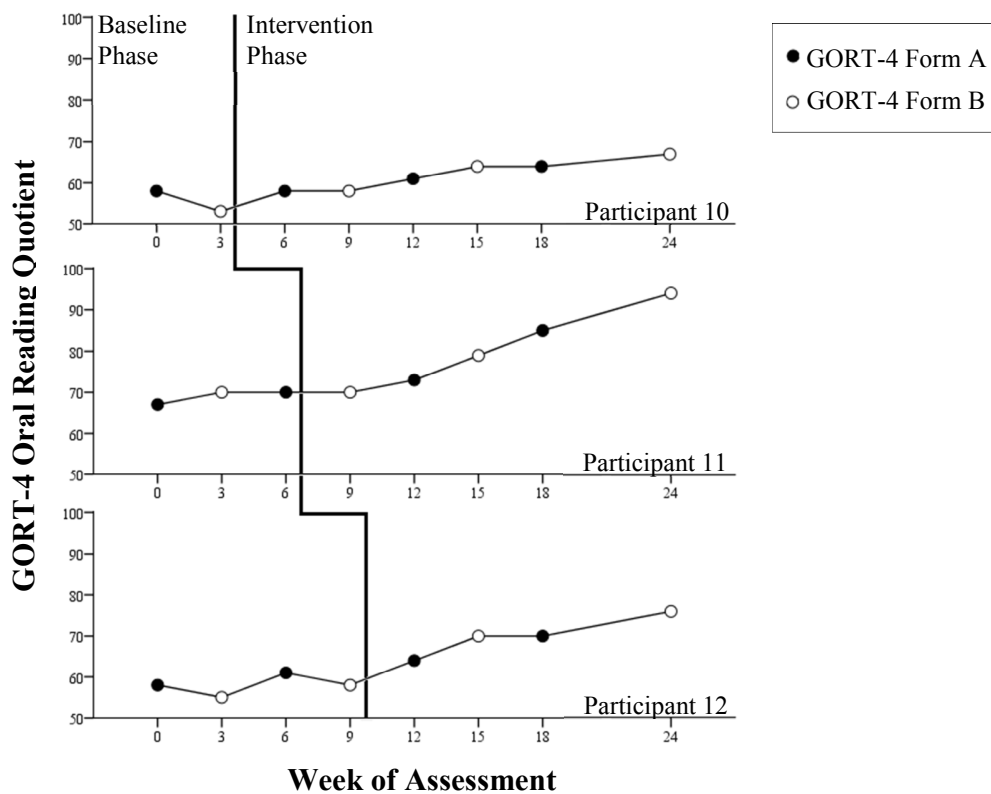


Figure 5. GORT-4 Baseline and Intervention Performance for Grade 6 by Week.

**Participant 11 (P11).** During the six-week baseline period, the ORQ scores for P11 remained constant and reflected performance within the Very Poor range ( $M=68.50$ ,  $SD=2.12$ ). Once completing the baseline phase, P11 demonstrated an upward shift in reading ability. Following some variability during the early weeks of intervention, P11's scores trended steadily upward towards the final assessment. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted significant improvement in reading ability, as measured by the ORQ ( $RCI > 1.96$ ). When this trend was further examined using the individual subscales of the GORT-4, reading accuracy, rate, and comprehension all demonstrated marked improvement ( $RCI > 1.96$ ). By the end of intervention, P11 had been administered 21 sessions of intervention and achieved an ORQ within the Average range (90-100).

**Participant 12 (P12).** The ORQ score for P12 remained fairly constant during the nine-week baseline period, and reflected performance within the Very Poor range ( $M=56.50$ ,  $SD=2.12$ ). Participating in the intervention phase resulted in an upward shift in the ORQ. The RCI value for the waitlist period represented that no significant improvement occurred during the baseline phase ( $RCI < 1.96$ ). From the averaged baseline to final assessment, the RCI denoted statistically significant improvement in reading ability, as measured by the ORQ ( $RCI > 1.96$ ). When this trend was further examined using the individual subscales of the GORT-4, reading accuracy and rate demonstrated marked improvement ( $RCI > 1.96$ ), while reading comprehension did not significantly change from baseline levels ( $RCI < 1.96$ ). By the end of intervention, P12 had been administered 19 sessions of intervention and achieved an ORQ within the Poor range (70-79).



### Linguistic Process and Skill Outcomes

In addition to examining the effects of the intervention on oral reading outcomes (e.g., accuracy, rate, and comprehension), the impact of the intervention on improving linguistic processes was also examined (Research Question 2).

The Pseudoword Decoding and Word Choice subtests from the PAL-II RW were administered at the beginning and end of the intervention to measure phonological decoding and orthographic word-identification development, respectively. Of the 8 participants who experienced oral reading ability growth during the intervention phase, 6 participants demonstrated parallel gains on the Word Choice task ( $RCI < 1.96$ ), while no one made gains in Pseudoword Decoding. Please refer to Table 3 for a graphical representation of baseline and post-intervention PAL-II RW scaled score performance on the Word Choice and Pseudoword Decoding subtests.

Table 3.  
*Baseline and Intervention Scaled Score Performance on Linguistic Skill Subtests.*

Participant	Baseline Word Choice	Intervention Word Choice	Sig .	Baseline Pseudoword Decoding	Intervention Pseudoword Decoding	Sig
P1	1	5	*	5	5	
P2	1	3		1	2	
P3	2	5	*	3	3	
P4	6	7		2	2	
P5	6	6		3	3	
P6	2	6	*	2	3	
P7	3	4		3	3	
P8	6	6		5	5	
P9	3	6	*	7	6	
P10	5	6		2	3	
P11	5	9	*	8	7	
P12	6	10	*	5	5	

Note. "\*" signifies reliable change, based on RCI calculations

### Subtype-Specific Intervention Outcomes

**Classification Procedure.** As described in the Chapter Three, participants were classified as having one of three possible subtypes: phonological, orthographic, or mixed deficit. The differentiation of Reading Disability subtypes was based on the assessed level of impairment in phonological decoding or orthographic word-identification. Utilizing scaled scores from the baseline Pseudoword Decoding and Word Choice tasks from the PAL-II RW, the distance between scores was then examined through z-score differentials. Table 4 provides a breakdown of initial PAL-II RW performance and the specific classification each participant was given prior to intervention. As demonstrated in the table, not all grades had one participant identified as having an orthographic, phonological, and mixed phonological/orthographic deficit subtype. Although not ideal, many grades did not offer distinct variety in regards to linguistic deficits after initial screening procedures were completed.

Table 4.

*Baseline Scaled Score Performance on PAL-II RW and Resultant Classification*

Participant	P1	P6	P9	P11	P4	P5	P10	P2	P3	P7	P8	P12
Subtype Class	OD	OD	OD	OD	PD	PD	PD	MD	MD	MD	MD	MD
Z Difference	1.33	1.66	1.33	1	1.33	1	1	0	.33	.33	.33	0
PAL-II RW Subtests												
Pseudoword Decoding	5	7	7	8	2	3	2	1	3	4	5	5
Word Choice	1	2	3	5	6	6	5	1	2	3	6	6
Phonemes	4	5	8	8	2	3	3	2	1	4	5	6
Syllables	6	6	7	9	3	4	2	4	3	4	7	7
Rimes	5	6	8	9	1	3	2	4	3	2	6	6
Receptive Coding	9	11	10	8	9	8	8	2	10	6	5	10

*Note.* P = participant, OD = orthographic word-identification deficit subtype, PD = phonological decoding deficit subtype, and MD = mixed phonological/orthographic deficit subtype.

**Orthographic Word-identification Deficit Subtype.** A total of four participants were classified as having an Orthographic Word-Identification Deficit Subtype and demonstrated great variety in the level of their linguistic and oral reading impairment. Participants identified with

this subtype had baseline oral reading performance, on average, within the Poor range based on aggregated ORQ data ( $M = 70.0$ ,  $SD = 6.48$ ). All participants within this domain demonstrated growth in reading ability during the intervention phase (P1, P6, P9, and P11). Beyond visual inspection, RCI scores supported that development in ORQ and were beyond that of chance. When this trend was closely examined using the individual subscales of the GORT-4, reading accuracy, rate, and comprehension all demonstrated marked improvement ( $RCI > 1.96$ ) for this group. By the end of treatment, this group had been administered, on average, 38.25 sessions of intervention ( $SD = 19.65$ ), and achieved an ORQ score of 91.0 ( $SD = 8.12$ ) which fell within the Average range (90-100).

***Phonological Decoding Deficit Subtype.*** A total of three participants were classified as having a phonological decoding deficit subtype and demonstrated great variety in the level of their linguistic and oral reading impairment. Participants identified with this subtype had baseline oral reading performance, on average, within the Poor range based on aggregated ORQ data ( $M = 71.0$ ,  $SD = 11.36$ ). Two participants within this domain demonstrated growth in reading ability during the intervention phase (P4 and P5). Beyond visual inspection, RCI scores supported that development in ORQ was beyond that of chance. When this trend was closely examined for P4 and P5 using the individual subscales of the GORT-4, reading rate was acknowledged as the main contributor to this overall improvement ( $RCI > 1.96$ ). By the end of treatment, this group had been administered, on average, 48.0 sessions of intervention ( $SD = 14.93$ ), and achieved an ORQ score of 80.0 ( $SD = 12.12$ ) which fell within the Below Average range (80-89).

***Mixed Phonological/Orthographic Deficit Subtype.*** A total of five participants were classified as having a mixed phonological/orthographic deficit subtype, and demonstrated variety

in regards to their degree of oral reading and linguistic impairment. Participants identified with this subtype had baseline oral reading performance, on average, within the Very Poor range based on aggregated ORQ data ( $M = 65.80$ ,  $SD = 6.23$ ). Two participants within this domain demonstrated growth in reading ability during the intervention phase (P2 and P12). Beyond visual inspection, RCI scores supported that development in ORQ and were beyond that of chance. When this trend was closely examined for P2 and P12 using the individual subscales of the GORT-4, reading accuracy and rate demonstrated marked improvement ( $RCI > 1.96$ ). By the end of treatment, this group had been administered, on average, 38.40 sessions of intervention ( $SD = 11.61$ ), and achieved an ORQ score of 72.40 ( $SD = 8.05$ ) which fell within the Poor range (70-79). Table 5 provides a visual summary of the oral reading and linguistic skill gains experienced by participants within each of the Reading Disability subtypes.

Table 5.  
*Summary of GORT-4 and PAL-II RW Outcomes by Linguistic Subtype.*

Linguistic Subtype	GORT-4 Assessment				PAL-II RW Assessment	
	ORQ	A	R	C	WC	PW
<b>Orthographic</b>						
Participant 1	*	*	*	*	*	
Participant 6	*	*	*	*	*	
Participant 9	*	*	*	*	*	
Participant 11	*	*	*	*	*	
<b>Phonological</b>						
Participant 4	*		*			
Participant 5	*		*			
Participant 10						
<b>Mixed</b>						
Participant 2						
Participant 3	*	*	*		*	
Participant 7						
Participant 8						
Participant 12	*	*	*		*	

*Note.* ORQ = oral reading quotient, A = accuracy subtest, R = rate subtest, C = comprehension subtest, WC = word choice subtest, PW = pseudoword decoding, and “\*” signifies reliable change, based on RCI calculation.

## CHAPTER FIVE: DISCUSSION

The current study was undertaken to examine the effectiveness of an orthographic-based intervention (i.e., Precision Reading) to remediate the oral reading ability of children with Reading Disabilities, and to provide preliminary insight regarding the utility of identifying linguistic-based subtypes to inform intervention efforts. In general, the results of this study provide some preliminary support for an orthographic knowledge intervention to impact the development of oral reading abilities for children within Reading Disabilities in grades three through six. Specifically, eight of the twelve participants within this study made gains in reading rate, six participants made gains in reading accuracy, and four made gains in reading comprehension over the intervention timeline. These individually reported gains translate to 67% of the entire participant sample demonstrating some form of improvement in oral reading ability – albeit, only 33% achieved reading levels within the Average range by the end of intervention, based on the GORT-4 normative data.

In addition to examining the improvements in reading ability through visual inspection and RCI techniques, the effectiveness of the orthographic intervention to improve the linguistic skills (i.e., phonological decoding and orthographic word-identification) of participants was also examined. The results indicated that reliable growth in orthographic word-identification had occurred in six of the twelve participants, over the intervention timeline. This suggests that the orthographic intervention has modest abilities to remediate the orthographic word-identification of children with Reading Disabilities

Offering marginal success at a global level, the orthographic intervention demonstrated greater effectiveness when examined using linguistic-based Reading Disability subtypes. For example, all participants who were identified as having an orthographic word-identification

deficit subtype demonstrated greater improvement in oral reading ability, and its composite skills, than participants identified with the alternative classifications (i.e., phonological decoding and mixed deficit subtypes). This initial finding appeared consistent with previous research by Gustafson et al., (2007), in that children gain reading proficiency to a greater extent when interventions are targeted to their area of specific linguistic deficit.

In addition to providing preliminary support for the benefit of orthographic interventions for individuals with orthographic-based deficit subtypes, the results from this study also suggests that the use of these types of interventions may be useful in remediating the oral reading abilities of individuals who present with phonological and mixed phonological/orthographic deficit subtypes as well. The oral reading gains experienced by the remaining participants occurred within the composite skills of rate (phonological decoding deficit subtype), or in combination of both reading rate and accuracy (mixed phonological/orthographic deficit subtype). While it is true that not all participants within the remaining subtype categories demonstrated improvement in oral reading abilities, it may be the case that unique combinations of linguistic, cognitive, and intervention-based factors mediated such performance.

For example, the ability of two participants with phonological decoding deficit subtypes to demonstrate improvements in reading rate, but not in reading accuracy and comprehension, may represent an interaction between the primary linguistic deficit and the specific method of the orthographic intervention utilized. To clarify, the repeat-readings framework, utilized within the intervention, likely assisted these students in adopting a faster rate of word reading. However, because the intervention did not address their primary area of linguistic deficit, phonological decoding, the intervention had negligible impact on their ability to read words accurately or obtain overall meaning from text. In Precision Reading, participants are required to re-read

passages and are verbally rewarded for consistent performance gains in reading accuracy and/or rate. During the GORT-4 testing, these two participants substituted known words for unfamiliar ones encountered in print. As an example, these participants would utilize the beginning or ends of words as visual cues and say the first word which appeared to match the reading context. Making numerous errors, these participants neglected their phonological decoding skills and increased their overall reading speed. Since reading rate directly impacts the oral reading quotient, the conclusion that oral reading gains occurred for this subtype of participants appears inaccurate.

For others that did not respond to this type of intervention, there may be a number of other factors beyond the primary linguistic deficit at work. For example, two participants within the mixed phonological/orthographic word-identification deficit subtype demonstrated gains in reading accuracy and rate, but lacked development in comprehension, which may be the result of cognitive functioning. Both these participants were assessed as having Low Average working memory skills. As noted in Chapter One, working memory strongly influences an individual's ability to be an active reader and extract meaning from print (Swanson, Ashbaker, & Lee, 1996; Vellutino et al., 1996). While it substantial gains were made when the intervention targeted individuals with orthographic word-identification deficit subtypes, these results provide initial insight into how an orthographic intervention may also be of benefit to individuals who present with the remaining hypothesized linguistic subtypes.

### **Implications**

While the intention of this study was to examine the utility of identifying linguistic subtype of Reading Disability for the purpose of intervention recommendation, this study also provided some initial, albeit limited, support for Precision Reading's effectiveness in

remediating the oral reading abilities of children diagnosed with Reading Disabilities. To date, Precision Reading has had limited scrutiny within the educational literature and only one publication had surfaced regarding its effectiveness within the Reading Disability population (see Updike & Freeze, 2001). When Precision Reading was closely examined using linguistic subtypes, the importance of matching intervention to linguistic deficit was highlighted and partially corroborated the work of Gustafson et al. (2007) within the English language context. While unpredicted results were obtained by participants who were identified as having phonological decoding and mixed deficit subtypes, this may have been the product of linguistic, cognitive, and intervention-specific factors.

In the past, researchers have created subtype classification systems based on variable combinations of cognitive and linguistic factors (e.g., Fiorello, 2006; Morris et al., 1998), but have generally neglected to examine the construct validity and feasibility of such classifications within intervention settings. That is, many subtype classification were created using advanced statistical techniques (e.g., cluster analysis) in absence of examining the subtype-interaction effects. While identifying a large number of factors which contribute to reading problems may be helpful from a theoretical perspective, it becomes limited with respect to its application with school environments. These issues, amongst others, have contributed to a general decline in amount of subtyping research within the educational literature. The results of this study provide preliminary evidence to suggest that subtyping based on linguistic deficit may be of benefit to intervention. While further research and study in this area is warranted, this study demonstrates the preliminary benefits of a parsimonious subtyping model of classification (e.g., phonological decoding, orthographic word-identification, and mixed deficit subtypes), and how it may be useful to clinicians and educators for the purpose of specific intervention recommendation.



Considering the nature constraints placed on teachers within classrooms environments, the process of assessing all the potential cognitive and linguistic factors which impact reading development is time-consuming, onerous, and may not necessarily provide practical information for the purpose of intervention.

In transitioning from an intervention viewpoint to a theoretical one, future research should examine the process by which Reading Disability subtypes are created. Gustafson et al. (2007) utilized a median split approach which dichotomized participants into phonological deficit or orthographic deficit subtype groups, while this study employed a z-score differential to create phonological, orthographic, and mixed subtypes. While both approaches have their strengths and weaknesses, some participants may not necessarily conform to categorical subtype placements. Rather, Reading Disability subtypes may represent a spectrum in which primary deficits in phonological decoding and orthographic word-identification are at either ends. In order to explore such a concept, a large number of participants with Reading Disabilities could be matched on reading and cognitive abilities, prior to being assessed using a linguistic process measure (e.g., PAL-II RW). At which point, a cluster analysis could be conducted to preliminarily determine whether such a spread in phonological decoding and orthographic word-identification abilities exists within Reading Disability populations.

### **Limitations**

Where there are several important implications resulting from this study, a number of limitations should also be noted. First, this study was conducted within a small, specialized urban school and, while it offered good treatment fidelity by utilizing instructors who were well-trained and employed the orthographic intervention on a regular basis, the student population was limited to which participants could be matched on specific academic, cognitive, and linguistic

variables. In the study, all participants were matched based on relative oral reading and cognitive abilities, but linguistic subtypes were not part of this process. Ideally, it would have been helpful to have three students with each of the three subtypes (phonological decoding, orthographic word-identification, and mixed deficit subtype) within each of the grades, but the limited student population did not allow for such measures. The inability to match based on linguistic-subtypes significantly diminishes the generalizability of these findings.

Another limitation of this study relates to the number of sessions each participant received during the intervention phase. As highlighted in the Precision Reading manual, the intervention was intended to be offered daily and require seven to ten school-days per passage. While overall mean values outline that participants assigned to the 3 week baseline conditions received more intervention than those assigned to 6 week and 9 week, the standard deviations were large. As an example, P3 and P12 were both assigned to a 9 week waitlist condition, but received 45 and 19 sessions of Precision Reading by the 24<sup>th</sup> week of intervention, respectively. There was no apparent relationship between the number of intervention sessions received and the degree to which oral reading development occurred. In fact, noticeable gains in reading ability were highlighted in participants who experienced 19 to 45 sessions of Precision Reading, and the inability to gain reading ability appeared more related to the linguistic subtype each participant was identified as having.

### **Future Directions**

This study provides preliminary support for both the use of an orthographic-based intervention and the identification of phonological decoding, orthographic word-identification, and mixed deficit subtypes of Reading Disability, which may be beneficial to inform intervention recommendations. While the effectiveness of the orthographic knowledge intervention was

modest, it is plausible that further gains could be achieved if a more intensive orthographic intervention was utilized. As noted in Chapter Three, Precision Reading has had limited empirical scrutiny of its effectiveness in remediating the reading abilities of children diagnosed with Reading Disabilities. While the utilization of repeat-readings within the Precision Reading approach offers a mechanism by which orthographic knowledge can be improved, the overall program emphasises reading rate as a synonymous predictor of intervention success. This emphasis on reading rate has the potential to demonstrate oral reading gains in the absence of actual orthographic knowledge growth. Through utilizing an orthographic intervention which values reading accuracy over reading rate, the fidelity of these proposed Reading Disability subtypes could be further examined.

In comparison to previous work, this study utilized a single-case multiple-baseline across-participants research design, which offered flexibility and utility within the school environment. This type of research design allowed for the consistent tracking of reading development over the intervention timeline, and allowed the primary investigator to monitor potential confounds through examining the individual trends and slopes. In previous work by Gustafson et al., (2007), the researchers examined subtype-interaction through a repeated measures ANOVA technique, but methodological oversights in regards to the orthographic intervention damaged the generalizability and internal validity of their findings.

While providing preliminary support for matching intervention services to linguistic-based deficit subtypes within the English language context, future research within this area should match participants on reading, cognitive, and linguistic ability prior to implementing subtype-interaction studies. Given the limited number of participants that can be identified with a specific linguistic subtype in an individual classroom, it may be necessary for further studies to

utilize a Hierarchical Linear Modelling (HLM) framework and involve multiple schools. This approach would allow for treatment effects to be controlled and examined at the individual participant, Reading Disability subtype, intervention facilitator, and/or school level. This process would allow future researchers to be more confident with the determined outcomes, when compared against single-case or repeated measures ANOVA techniques (Kerlinger & Lee, 2005; Stevens, 2009).

### **Conclusion and Final Thoughts**

It is the case that reading research appears focused on identifying the cognitive and linguistic elements which help explain reading development and disability. The exploration of such research directions will be key in helping inform educators and clinicians of what factors should be acknowledged when we wish to promote reading mastery through intervention efforts. The present research is somewhat divergent from this orientation, in arguing for a more simplified approach to the assessment and intervention for children with Reading Disabilities. Certainly, this study provides only initial support for this position, and further study and investigation is needed. An advantage to this approach is that it recognizes the complexity of today's classroom and limited resources within a classroom. For educators to assess all the salient cognitive and linguistic factors involved in the reading process, for each struggling student in their classroom, would place significant stress and remove valuable resources from the environment (e.g., one-on-one instruction, curriculum goals, etc.). While it may be the case that future research confirms that educators should add cognitive and linguistic assessments to their repertoire, this research documents how a more parsimonious model of intervention recommendation, utilizing linguistic-based subtypes, may provide a useful caveat when considering these classroom obstacles. Huey (1968) stated that understanding the reading process

would represent “the acme of the psychologist’s achievements” (p. 6), and, while current research is coming closer to understanding this multifaceted construct, it is important not to forget the final product of such efforts – intervention.

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