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Executive Functions and Word Reading Fluency: A Brief Intervention With Economically Disadvantaged Secondary Students

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EXECUTIVE FUNCTIONS AND WORD READING FLUENCY: A BRIEF INTERVENTION WITH ECONOMICALLY DISADVANTAGED SECONDARY STUDENTS

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Dissertation Approval

This is to certify that the thesis presented to us by **Vanessa S. Kim** on the **14th** day of **September**, **2016**, in partial fulfillment of the requirements for the degree of Doctor of Psychology, has been examined and is acceptable in both scholarship and literary quality.

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Abstract

This study evaluated the use of a brief intervention that was designed to assist economically disadvantaged secondary students increase their capacity for attention to orthography and increase their ability to shift between rapid sight word recognition and decoding of unknown words in order to improve their word reading accuracy and fluency. The participants (N = 14) were eighth and ninth grade students enrolled in an urban public high school and receiving special education services. The study used analysis of variance for repeated measures and paired measures t-tests to analyze pre- and post-test data. The results indicated significant findings ($p < 0.5$) in the students' improvements in their sight word reading fluency and their ability to inhibit impulses and shift cognitive sets with accuracy and speed following the 8-week reading intervention. The findings suggest that exposure to repeated word fluency drills that target attention to orthography and shifting from sight word recognition to decoding may have influenced the students' self-monitoring skills and offer further support regarding the hypothesized role of executive functions in the act of reading.

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Chapter 1: Introduction

Learning disabilities are a result of psychological processing deficits that are neurologically based (National Association of School Psychologists, 2011). There is evidence that academic performance is influenced by lower order and higher order cognitive constructs such as phonological and orthographic processing, oral-motor functioning, language abilities, verbal and non-verbal reasoning abilities, immediate memory, working memory, and retrieval from long-term storage (Anderson, 2002; Berninger & Richards, 2002). Executive functions that regulate inhibiting impulsive responding, focusing and sustaining attention, planning, organizing, and generating and implementing strategies also are involved in both academic learning and production (Berninger & Richards, 2002; McCloskey & Perkins, 2012; McCloskey, Perkins, & Van Divner, 2009).

The development of executive functions occurs over a developmental continuum from infancy through early adulthood, with self-regulation executive functions typically becoming more fully developed during an individual's late 20s. Without adequate development and engagement of executive functions, learning disabled students demonstrate difficulty performing academic tasks consistent with expectations (Blakemore & Choudhury, 2006).

Executive functions can greatly impact a student's ability to learn and achieve, especially in the case of reading (Berninger & Richards, 2002; McCloskey & Perkins, 2012; McCloskey et al., 2009). Executive functions have been hypothesized to be part of an underlying cognitive framework that allows learning to occur and that enables the consistent utilization of learned skills (McCloskey & Perkins, 2012). Furthermore, students who persistently experience academic problems despite having average intelligence and the absence of learning disabilities or psychological processing deficits are likely to be demonstrating executive function weaknesses that contribute to the academic struggles (Denckla, 1996).

Reading, as a whole, is an intricate task that relies on multiple cognitive processes, abilities, and skills. Successful learning and achievement in the area of reading requires a student to possess adequate executive functions to maintain attention, manage time, sustain motivation, organize information, manage impulses, and monitor and manage the use of word decoding and comprehension skills (Joseph, 2006; Maricle, Johnson, & Avirett, 2010). Effective reading requires students to use their reasoning abilities in order to understand text, formulate categorical relationships, and develop inferences (McCloskey & Perkins, 2012).

For the purposes of this study, the specific skills involved in word reading was the focus. Word reading encompasses word recognition and identification. Word recognition is defined as the immediate recall of sight words, whereas word identification requires the reader to identify and blend the sounds corresponding with the letter combinations to formulate words that are a part of oral language (Cooper, Chard, Kiger, 2006; Joseph, 2006). Proficient readers apply word identification skills successfully when they encounter unfamiliar words. They often read multiple types of texts accurately and fluently for various purposes, such as for enjoyment or for gaining information. Conversely, novice readers struggle with applying literacy skills effortlessly and spend less time engaging in reading activities (Joseph, 2006).

Reading problems continue to be as one of the most common learning disabilities educators encounter in the classroom (Costa, Edwards, & Hooper, 2016; Joseph, 2006). According to the National Center for Learning Disabilities, 42% of the 5.7 million school-age students receiving special education services are identified with a learning disability (Cortiella & Horowitz, 2014). Furthermore, it is estimated that students with reading disabilities comprise 80% of the school-age population identified with learning disabilities. Due to the growing needs of struggling readers, evidenced-based literacy programs are being developed and implemented in classrooms to address strategies and techniques for word reading, including instruction in phonics and fluency interventions (Joseph, 2006).

There is a rising need to assess, identify, and intervene with students presenting with difficulties in reading, along with identifying the cognitive constructs that are contributing to these academic challenges (Joseph, 2006). In addition, it is important to consider other factors that may impact student success. For example, poor school achievement is more prevalent within culturally diverse populations and urban communities. African American and Latino students demonstrate academic progress significantly lower than Caucasian students. They are also overrepresented in the population of students receiving special education services (Cortiella & Horowitz, 2014). Specifically, Latino students had a dropout rate of 10.7% in 2014, which was higher than Caucasian students at 4.4% and African American students at 7.9% (Kena et al., 2016). Students from low-socioeconomic groups are four times more likely to drop out of high school than students from middle-class families. Additionally, there are more students with learning disabilities in impoverished households, and homeless children are twice as likely to be identified with a learning disability (Cortiella & Horowitz, 2014; Kaylor & Flores, 2007).

Other considerations in addition to the economic disadvantages associated with poverty including lack of resources, limited exposure to pre-academic skills, cultural influences, linguistic diversity, mental health problems, poor self-determination, and stressful home, family, and community dynamics, which all contribute to the disparity (Joseph, 2006; Kaylor & Flores, 2007). It is important to consider the various factors which affect culturally and linguistically diverse students. Consideration should be given to other aspects that may be linked to poor achievement. More often than not, executive function deficits are the common cognitive weaknesses that influence academic success, especially in the area of reading (Joseph, 2006; McCloskey & Perkins, 2012).

Statement of the Problem

Students with executive function deficits often fail to apply their abilities adequately to perform effectively within their learning environments. Due to these challenges, students with executive function deficits require explicit instruction and modifications in order to succeed (Marlowe, 2000). Equally, effective and concrete techniques to integrate executive skills training within the academic curriculum are necessary for student success. Despite the many advances that have been made in instructional program development in recent years, reading intervention programs typically do not include specific techniques for improving the use of the executive functions that are needed to cue and direct the effective use of reading skills (McCloskey & Perkins, 2012). Although there is great interest in improving reading and executive functions separately, there has been minimal focus applied to the application of executive functions to reading in the context of learning and academic achievement in the classroom. With the increase in research and popularity of understanding and assessing executive functions comes the growing need for resources and interventions to assist professionals in intervening, accommodating, and applying this construct in response to the educational and behavioral needs of students (McCloskey & Perkins, 2012; McCloskey et al., 2009).

Purpose of the Study

A review of literature found limited research that examined the relationship between executive functions and reading interventions. The available literature places emphasis on reading programs or interventions for executive functions as separate responses to the problems encountered by struggling readers. This study sought to evaluate the effectiveness of a brief intervention that was designed to help economically disadvantaged high school-age struggling readers increase their executive function capacity for directing attention to orthography, as well as increase their ability to use executive functions to shift between rapid sight word recognition and decoding of unknown words, in order to improve their word reading accuracy and fluency.

Research Questions

The following question is addressed in this research study:

Research Question #1: Will struggling high school-age students improve their word reading and word decoding fluency and accuracy when they are exposed to a reading intervention program that teaches word reading and word decoding skills and that utilizes techniques intended to increase students' executive function capacity for attention *to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?*

Additionally, this research study addresses the following questions related to students' cognitive abilities and academic skill acquisition:

Research Question #2: Will students improve their reading level when they are exposed to a reading intervention program that teaches word reading and word decoding skills and that utilizes techniques intended to increase students' executive function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?

Research Question#3: Will students improve their performance of a color-word interference task that requires executive function direction of orthographic processing after exposure to a reading intervention program that utilizes techniques intended to increase students' executive function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?

Research Question #4: Will students improve their performance of a rapid automatic switching task that requires executive function direction of orthographic processing after exposure to a reading intervention program that utilizes techniques intended to increase students' executive function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?

Research Question #5: What insights can be gained about student participation in the reading intervention by examining each student's background and their individual profile of pre- and post-test scores?

Chapter 2: Review of the Literature

Introduction

This literature review examines the constructs of executive functions and reading, and their neuropsychological underpinnings. Furthermore, methods of assessment and types of interventions are explored to provide greater understanding of the relationship between executive functions and reading as they relate to this study.

Executive Functions

The term executive functions has gained popularity in the educational and psychological fields in the last few decades. Like many complex psychological constructs, executive functions have been defined and discussed in many different ways in the professional literature. For example, Stuss and Benson (1986) refer to executive functions as one of the most significant capacities of the human frontal lobes. In their model, executive functions are responsible for directing and integrating other brain systems, such as memory, attention, language, emotion, sensory, motor, and higher-level cognitive abilities. These systems are organized and interrelated, as they function in a hierarchical manner that increases in complexity and abstraction.

Executive functions as described by Stuss and Benson (1986) are represented as an executive controller, which assumes operational mediation over lower level processes in order for higher mental systems to take precedence. This process is reflected in metacognitive skills, such as planning, motivation, organization, goal-setting, and self-monitoring. As the executive controller consistently activates cognitive-based functions needed for novel or non-routine tasks that require problem solving and learning, the responses and activities eventually become routinized and overlearned, allowing for automaticity of skill development (Stuss & Benson, 1986).

Gioia, Isquith, Guy, and Kenworthy (2000) refer to executive functions as a collection of cognitive processes that are responsible for problem-solving, cuing, guiding, and managing goal-directed behaviors and cognitive and emotional functions specifically during novel tasks. Executive functions can be construed as an overarching mechanism controlling, supervising, and self-regulating various basic and domain-specific cognitive processes used to direct and organize neurological functions, overt behaviors, and emotional responses (Isquith, Crawford, Andrews Espy, & Gioia, 2005).

Dawson and Guare (2010) identify executive functions as high-level cognitive skills used to meet challenges and accomplish goals. Executive functions assist in organizing behavior in order to inhibit impulses, plan and organize activities, sustain attention, persist to the completion of tasks, and manage and regulate emotions and behavior. In order to accomplish a goal or task, Dawson and Guare (2010) noted executive functions assist in two ways: problem solving and guidance. In order to problem solve a task, planning, organization, time management, working memory, and metacognition skills are used. Once a plan has been outlined, additional executive functions are utilized to guide behavior in order to execute the plan and achieve the goal. These additional executive functions include response inhibition, emotional control, sustained attention, task initiation, flexibility, and goal directed persistence (Dawson & Guare, 2010).

Barkley (2001) defines executive functions as the linkage between self-regulation and inhibition, which he refers to as "self-control." Response inhibition is viewed as a prerequisite to self-regulation, which functions to alter instrumental, purposive, and intentional behaviors to meet immediate and delayed outcomes. Barkley (2001) views self-control as requiring actions that are often counter to, or in opposition with, immediate self-interests but necessary in order to delay gratification and achieve a future desired outcome. The executive functions guide self-control by increasing the perception and value of future outcomes over immediate outcomes. When this is consistently repeated, a cognitive shift occurs involving the simultaneous weighing of alternative responses and their proximal and distal outcomes during judgments and decision making (Barkley, 2001).

Barkley's (2001) conceptual model consists of covert operant learning-to-the-self by linking behavioral inhibition to four major executive functions. Behavioral inhibition is defined as involving the delay of responses, the interruption of ongoing responses, and the control of interference (Barkley, 2001). The four major executive functions identified are nonverbal working memory, verbal working memory, self-regulation of affect/motivation/arousal, and reconstitution. Nonverbal working memory involves the use of mental representations of possible future events to serve as symbols of event response outcomes. The mental icon is crucial for self-control, as it provides a template (sensory-motor representation) of an act to be constructed and planned (Barkley, 2001).

Verbal working memory activates cortical aspects of speech used in planning and problem solving. This is observed as self-talk, which assists in self-reflection, monitoring, problem solving, self-instruction, and self-questioning (Barkley, 2001). The self-regulation of affect/motivation/arousal results from the engagement of nonverbal and verbal working memory. Self-regulation of this type encompasses the emotional and motivational aspects experienced during the engagement of future-directed behaviors that are intrinsically-based.

Finally, reconstitution is described as fluency, flexibility, and generativity. It allows previously used behavioral patterns to be analyzed and synthesized to form new processes in order to solve increasingly complex problems. Reconstitution is involved when novel actions are required to overcome obstacles in order to attain a goal successfully. It requires the ability to sustain mental referents from previous instruction or experiences in order to manipulate them as a means to achieve goals in multiple ways (Barkley, 2001).

Lezak (1995) refers to executive functions as interrelated capacities of cognitive and behavioral skills that allow an individual to successfully carry out independent, purposeful, goal-directed actions that include self-direction and self-regulation. Lezak, Howieson, Loring, Hannay, and Fischer (2004) conceptualize executive functions as having four components: volition, planning, purposive action, and effective performance. These distinct activity-related behaviors are necessary for self-regulation and are socially responsible as well as self-serving.

Volition is referred to as the capacity for intentional behavior. It is the process by which individuals determine their needs and wants in addition to conceptualizing a goal (Lezak, 1995; Lezak, Howieson, Loring, Hannay, & Fisher, 2004). Planning is described as identifying and organizing the steps and components needed to fulfill a goal or to meet the initial intentions. Planning requires conscious thought, monitoring, and reflection in order to conceptualize changes from present circumstances. This includes the ability to identify alternative choices and consider sequential and hierarchical ideas as the basis of the framework to execute the plan (Lezak, 1995; Lezak et al., 2004). Purposive action occurs as intentions and plans lead to a self-serving action that requires the use of initiating, maintaining, shifting, and inhibiting behaviors sequentially in order to carry out the plan effectively. Effective performance results from the ability to monitor, self-correct, and regulate the qualitative aspects of the self-serving action (Lezak, 1995; Lezak et al., 2004).

Denckla (1996) considered executive functions as an umbrella construct that includes central control processes, such as integrating cognition and inhibiting, initiating, shifting, planning, organizing, preparing and maintaining actions and behavior. The term "executive function" is used to refer to self-regulatory behaviors needed to select, sustain, and guide actions within the context of goals or rules (Mahone et al., 2002). It is suggested that executive functions should not be perceived or utilized as the neuropsychological equivalent of intelligence theorists' *g*, due to the multiple dimensions of executive control (Denckla, 1996).

Furthermore, executive functions direct, and are supported by, cortical and subcortical neural networks (Denckla, 1996). These neural networks support functions related to "how and when" during lower and higher level problem solving tasks. Executive functions are considered to be critical when compensating for deficits in cognitive domains, such as language or visual-spatial processes (Denckla & Reiss, 1997).

Stuss and Alexander (2000) expanded on the view of Stuss and Benson (1986) by conceptualizing executive functions as a set of multiple directive capacities that coordinate with each other in order for an individual to engage in organizing, strategizing, and self-regulating his or her behavior. Emphasis is placed upon the specific processes related to different regions within the frontal lobes, indicating that executive functions are not a unitary trait. Rather, executive functions are distinct neural capacities that are unified by the general concept of an overarching control system that supervises all aspects of perception, emotion, cognition, and action (Stuss & Alexander, 2000). Higher level cognition requires the use and integration of various executive functions to support the complexity of affective responsiveness, social and personality development, self-awareness, and consciousness (Stuss & Alexander, 2000).

Their hierarchical model of executive functions incorporates a tiered framework emphasizing self-awareness. The model consists of four tiers representing different levels of functioning: arousal-attention, perceptual-motor, executive mediation, and self-awareness. The model allows the ability to ascend and descend between the tiers based upon the type of task and whether adaptations, preferences, or limitations are present. The complexity and novelty of the tasks and skills are more prominent at the upper tiers (executive mediation and self-awareness). The executive mediation tier involves planning, behavioral inhibition, and problem-solving skills whereas the highest tier (self-awareness) incorporates memories from previous experiences, learned knowledge, and abstract thought to formulate future expectations (Stuss & Alexander, 2000).

Borkowski, Chan, and Muthukrishna (2000) identified information processing, monitoring, task analysis, strategizing, and planning as components of executive functioning within the metacognitive system. Metacognition focuses on the contributing factors of monitoring and controlling strategies in order to effectively carry out complex and novel tasks. Within the area of planning, self-regulation is viewed as a necessary factor for decision making. Emphasis is placed upon the motivational roles of these components as important processes that shape and maintain self-regulation (Borkowski & Burke, 1996; Borkowski et al., 2000; Borkowski & Muthukrishna, 1992).

Miyake, Friedman, Emerson, Witzki, and Howerter (2000) focused on three executive functions: shifting, inhibition, and updating. These are described as lower level functions and are generally used to complete multiple higher level executive tasks. Shifting is defined as the ability to switch back and forth between mental sets that are internally cued. It requires disengagement of one set and subsequent action of another relevant task. Shifting also requires the ability to perform new operations while exposed to interference (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000).

Inhibition as defined by Miyake et al. (2000) is the ability to deliberately suppress an automatic or dominant response when necessary. This type of inhibition should be viewed separately from reactive inhibition, which is often referred to as a decrease in activation levels and is an unintentional process. The third area of executive functions, updating, is closely related to working memory. Updating requires an individual to monitor and actively manipulate stimuli relevant to a task. This requires coding of information and replacing irrelevant content with newer or more meaningful material (Miyake et al., 2000).

Given the multiplicity of ways in which executive function is defined in the literature, it is not surprising that Jurado and Rosselli (2007) observed that “the concept of executive function is one that still awaits a formal definition” (p. 213). Consequently, the need to provide a comprehensive theory of executive functions that could integrate the many perspectives on executive function that are available in the professional literature has been acknowledged (McCloskey & Perkins, 2012; McCloskey et al., 2009).

The Holarchical Model of Executive Functions (HMEF) proposed by McCloskey and colleagues provides a multi-dimensional framework that can be used to define and understand executive functions. The theory includes five tiers of executive capacity: I. Self-Activation, II. Self-Regulation, III. Self-Realization and Self-Determination, IV. Self-Generation, and V. Trans-Self Integration (McCloskey & Perkins, 2012; McCloskey et al., 2009).

The Self-Activation tier refers to the neural processes involved in awakening from sleep. This focuses on the transition from an unconscious to a conscious state, involving the gradual increase of executive capacities as sleep inertia dissipates. The Self-Regulation tier is composed of at least 33 executive functions responsible for cueing, directing, and coordinating behaviors within four broad domains of functioning (Perception, Emotion, Thought, and Action). The 33 self-regulation executive functions are divided into seven clusters: Attention, Engagement, Optimization, Efficiency, Memory, Inquiry, and Solution. The Attention cluster is composed of Perceive/Aware, Focus/Select, and Sustain. This cluster addresses the cueing of perceiving for awareness and the focusing and sustaining of attention (McCloskey & Perkins, 2012; McCloskey et al., 2009).

The Engagement cluster cues and directs initiating tasks, applying effort, inhibiting impulses, stopping and interrupting behavior, and flexibility and shifting cognitive sets. The Optimization cluster focuses on overseeing accuracy, regulating intensity, revising errors, and stabilizing perceptions, emotions, thoughts, and actions. This cluster consists of the Modulate, Monitor, Correct, and Balance executive functions.

The Efficiency cluster forms the cues for monitoring the passage of time, regulating rate, organizing successions, and automaticity of tasks. This cluster houses the Sense Time, Pace, Sequence, and Execute set of executive functions. The Memory cluster cues and directs all aspects of the memory system, including initially registering and briefly holding specific information, manipulating information that is being held in mind, storing newly learned information, and retrieving previously stored information (McCloskey & Perkins, 2012; McCloskey et al., 2009).

The Inquiry cluster cues and directs efforts to gauge the difficulty of tasks; anticipate problems, needs, and consequences; estimate time; analyze information and situations; and compare and evaluate information. The Solution cluster cues and directs making associations, generating novel ideas, organizing, planning, prioritizing, and deciding within the context of solving problems.

Within the HMEF, the 33 self-regulation executive functions can be used to cue and direct within and across four broad, distinct but interrelated domains of functioning, labeled as Perception, Emotion, Thought, and Action (McCloskey & Perkins, 2012; McCloskey et al., 2009). The distinction among the domains of functioning accounts for the fact that self-regulation executive functions are not a unitary trait. The effective use of specific self-regulation executive functions can vary immensely across the four domains as well as within a single domain.

The third tier of the HMEF model is comprised of two subdomains: Self-Realization and Self-Determination. Self-Realization occurs when the unconscious use and activation of executive functions leads to greater self-awareness and conscious control. Frequent and consistent use of self-realization pathways increases self-control of the 33 self-regulation executive functions that are typically activated unconsciously. Self-Determination refers to long-term goal setting that extends beyond the short-term planning executive function of the Solution cluster. This subdomain engages higher self-control to formulate elaborate plans and execute actions successfully to achieve desired outcomes (McCloskey & Perkins, 2012; McCloskey et al., 2009).

The Self-Generation tier regulates the development of self-guiding principles that influence self-realization, self-determination, and self-regulation. This tier reflects an increase in inquiring and exploring the development of set ethical and moral principles to be used in guiding perceptions, feelings, thoughts, and actions. The final tier is the Trans-Self Integration tier, which refers to the ability to seek out experiences that promote unified cognizance and transcendence of the egoic self (McCloskey & Perkins, 2012; McCloskey et al., 2009).

An advantage of the McCloskey HMEF (McCloskey & Perkins, 2012; McCloskey et al., 2009) is that it makes an important distinction among the various ways in which executive functions can be used to cue, direct, and integrate perceptions, feelings, thoughts, and actions. The concept of Arenas of Involvement within the HMEF helps to account for another source of variation in the effective use of executive functions. The HMEF posits that executive function use can vary greatly depending on the arena within which executive functions are being used to direct perception, feeling, thought, or action. The four Arenas of Involvement proposed within the model are the Intrapersonal (individual self-direction), Interpersonal (direction of the self when in the company of others), Environment (direction of self in relation to natural and man-made surroundings), and Symbol System, also referred to as Academic (direction of self when engaged with reading, writing, math, and other forms of information used to communicate). An individual may experience difficulties in one or more arenas while demonstrating effective use of executive functions in the remaining arenas. Additionally, an individual may display more strengths or weaknesses in one or more subdomains of functioning in conjunction with one or more Arenas of Involvement (McCloskey & Perkins, 2012). Therefore, the model indicates that executive functions and the subdomains of functioning are not developed uniformly, and their use can vary based upon the given environment or arena.

Using the concept of Arenas of Involvement, McCloskey and Perkins (2012) propose that executive functions within the academic arena are used to cue, direct, and integrate various academic endeavors, such as reading, writing, and mathematics. Many students who present with learning disabilities also display executive function difficulties within the academic arena. These students' learning challenges often are compounded by the presence of underdeveloped executive functions which can impact the efficiency of new learning and, most notably, impact the demonstration of what has been learned and the completion of tasks (McCloskey & Perkins, 2012; McCloskey et al., 2009). For example, in the case of reading, students with a reading disability often receive good instruction and learn how to decode words and improve their ability to sound out words during instructional drills, but when reading connected text from a book for a prolonged period, these same students often do not make use of their learned word decoding skills. When reading connected text, these students often mispronounce words that they were able to decode during instructional drills. When a student's reading is monitored by a teacher and the teacher prompts him or her to return to a word to reread it, the student then applies decoding skills accurately. In these instances, the student now possesses the knowledge needed to decode words, but when reading, the student does not use executive functions effectively to monitor word level reading in order to recognize when to stop and shift from sight word reading to decoding when necessary. Observation of these types of reading errors contributed to the distinction between learning disabilities and producing disabilities (McCloskey et al., 2009). Learning disabilities involve process deficits that impede the student's ability to learn the requisite reading skills whereas producing disabilities involve the lack of use of executive functions to effectively engage skills that have been learned.

In addition to producing disabilities, students with learning difficulties may also experience deficits in working memory. Working memory is a complex construct that is referred to as the cognitive mechanism in charge of storing and processing information concurrently (Pena & Fuchs, 2016). Baddeley (1986, 1992, 2003) used the term "the central executive" to denote a control process within his neuropsychological model of working memory. In this model, the central executive is viewed as the component within a unified system that coordinates information processed through the phonological loop and visuospatial sketchpad (Baddeley & Hitch, 1974). Baddeley's conception of the central executive has greatly influenced subsequent models of executive functions such that working memory is routinely listed as a component of executive control.

According to Baddeley (1986, 1992, 2003), working memory functions to temporarily store and manipulate information involved in complex cognitive tasks, such as comprehension, learning, and reasoning. The central executive coordinates the verbal information (phonological loop) and mental images of visual and spatial features (visuospatial sketchpad) described by Engle (2002) as a system of working memory. In Baddeley's model, working memory is a cognitive capacity required to hold information for the purposes of completing tasks, and is considered a central aspect of executive functions (Baddeley, 1986, 1992, 2003).

As McCloskey has pointed out, however, working memory is a mental capacity that is distinguishable from executive functions, and is under the direct guidance of executive functions (McCloskey and Perkins, 2012). Therefore, it is possible for a person to have good working memory but poor executive control of these working memory resources; that is, to have a strong capacity for holding and manipulating information in the mind, but be unaware of when to cue the use of this working memory capacity. Conversely, a person can have good executive control over working memory, but have very little in the way of working memory capacity; that is, to be aware of when working memory capacities are needed for effective functioning, but to have little in the way of working memory resources to bring into play in these situations. In the former case, an individual with strong working memory may not produce as expected because he or she is unaware of the need to use working memory. In the latter case, an individual may recognize when working memory is needed and that he or she has little of it and, therefore, uses executive functions to develop strategies that could be used to compensate effectively for the lack of working memory capacity.

Based on further examination of the HMEF's Arenas of Involvement, McCloskey makes the distinction between learning disabilities caused by neuropsychological process deficits that impede new learning and producing disabilities based on the ineffective use of executive functions to apply what has been learned (McCloskey, Gilmartin, & Stanco, 2014; McCloskey & Perkins, 2012). Of particular interest in the current investigation is the involvement of executive functions in the act of reading. Due to the comprehensive nature of the HMEF model and its application to the academic arena, has been used to further understand and interpret the current research.

The Neuropsychology of Executive Functions

Prior to the use of the term executive functions, the cognitive capacities now described as executive functions were typically considered to consist of neural processing occurring in the frontal lobe of the brain. Luria (1966, 1973) offered a detailed perspective on what he believed to be the functions of the frontal lobe. Luria identified all of the following as mental or emotional states or behaviors associated with frontal lobe function: problem solving, intentionality, formulating goals, planning, sequencing, shifting, and evaluating. He described the frontal lobe as a structure governing the cortical functions responsible for regulating the attentional processes of the occipital, temporal, and parietal lobes (Luria, 1966, 1973). The frontal lobe assists in sustaining an adequate level of arousal and vigilance needed for selective attention and inhibition within the environment. The frontal lobe manages the synthesis of external information and determines the behaviors needed to carry out a plan. Using more recent terminology, the executive functions of regulating, programming, evaluating, questioning, strategizing, and self-monitoring all require the frontal lobe to acquire and master newly learned skills (Luria, 1966, 1973).

Stuss and Benson (1986) may have been the first to use the term “executive functions” to refer to some of the cognitive capacities typically associated with the pre-frontal cortex. They expanded on Luria’s views of the brain’s frontal lobe involvement in using executive functions when activated by the environmental settings or novel demands that require the use of problem solving skills. The neural pathways routed through the frontal lobe plays an intricate role in directing cognitive processes and emotions (Stuss & Benson, 1984). The neural systems which support executive functions are interrelated and multifaceted. The prefrontal cortex is dependent on efferent and afferent neuronal connections with the occipital, temporal, and parietal lobes in addition to the limbic system and other subcortical regions of the brain (Stuss & Benson, 1984). The afferent neuronal connections deliver sensory information to the frontal lobe. The efferent neuronal connections enable executive control of the other cortical and subcortical structures of the brain, including the cingulate gyrus, anterior temporal cortex, inferior parietal lobe, and subcortical regions of the hypothalamus (Stuss & Benson, 1984).

The frontal lobe integrates information from other regions of the brain in order to modulate and coordinate motor responses. In terms of sensory, perception, and construction functions, the frontal lobe is relevant in coordinating visuomotor processes, allocating attention, applying working memory, organizing tasks, and monitoring behavior. Stuss and Benson (1984) reported that individuals with frontal lobe damage were more likely to struggle with activities involving self-direction, planning, self-correction, and visuomotor coordination.

Impairments of attention are attributed to the frontal lobe as well. Stuss and Benson (1984) reviewed clinical observations of individuals with impaired alertness, arousal, distractibility, and deficient responses to testing as a result of frontal lobe damage. Two levels of attention were described: arousal and attending. Arousal reflects the ability to awaken, maintain wakefulness, and follow commands. Attending is the ability to maintain alertness, direct effort, and concentrate on a specific task for a defined period of time. Attention related disorders involve the frontal lobe and are conceptualized on three levels: activation of the reticular system to cue levels of arousal and alertness, shifting activation from the thalamus as it correlates with alertness, and activation of the frontal-thalamic gating system responsible for selective and directed attention (Stuss & Benson, 1984).

Inflexibility and perseveration are reported to occur in individuals following damage to the frontal lobe. Stuss and Benson (1984) speculated frontal lobe damage combined with external factors may contribute to motor perseveration, poor inhibition, and difficulty overcoming previously established response patterns on the Wisconsin Card Sorting Test (WCST). Individuals with frontal lobe damage had a tendency to perseverate on previous responses by replicating them. There appeared to be a dissociation between thoughts and actions, whereby these individuals were aware of the errors, but were unable to use that knowledge to modify their behaviors (Stuss & Benson, 1984). Challenges in problem solving and monitoring were evident along with deficits in coordinating behavior with planning. Furthermore, cognitive deficits, such as difficulties in attention, problems in planning, and impaired monitoring of performance, were more common in individuals with frontal lobe damage, when completing complex mental tasks that required multiple steps and when presented with multifaceted stimuli. These individuals were observed to respond impulsively and failed to analyze and execute steps required for effective problem solving (Stuss & Benson, 1984). Tasks such as block design, mazes, category sorting, Wisconsin Card Sorting Test, Tower of London, and the

Halstead Category Test revealed difficulties with numerous aspects of executive function, including organizing, planning, following rules, verbalizing abstract responses, shifting, programming, monitoring, maintaining effort, and providing self-feedback (Stuss & Benson, 1984).

Miller and Cummings (2007) have identified specific frontal lobe neural circuits whose functioning is thought to be reflective of executive functions. These frontal-cortical regions are linked to an intricate circuitry of subcortical structures. The behaviorally relevant cortical regions of the medial frontal cortex, orbitofrontal cortex, and dorsolateral prefrontal cortex each project to specific areas of the striatum. These striatal regions, in turn, distend to the subdivisions of the substantia nigra and globus pallidus (Miller & Cummings, 2007).

The dorsolateral prefrontal cortex is thought to be responsible for the following executive functions: Adjust/Stop, Monitor, Implement, Program, Plan/Recall, and Volition. These prefrontal components are conceptualized as a series of hierarchical functions, with the lowest level involved in the direction of motor actions, the second level involved in contextual premotor selection, and the third level involved in episodic control in volitional acts. Moreover, executive functions are dependent on intact functioning of mental capacities such as language, memory, praxis, perception, and visuospatial processing (Miller & Cummings, 2007).

With respect to the specific executive functions associated with the dorsolateral prefrontal cortex, volition results in judgment, initiation, suppression of habitual responses, and fluency. Planning and recalling involve generating strategies, retrieving information, and maintaining mental control. Programming includes selecting, implementing, and inhibiting motor responses in addition to spatial planning. Implementation is mediated by the frontal motor cortex and is relevant in tasks requiring psychomotor speed. Monitoring requires vigilance and the ability to attend to tasks in the presence of distractions. The final component, adjusting and stopping, enables the avoidance of perseverative behaviors (Miller & Cummings, 2007).

Eliot (1999) indicated that young children resemble adults with frontal lobe damage as displayed by their poor sense of time, brief attention span, and lack of self-control. The frontal lobe's latent maturation imposes limitations on a child's effective use of his or her cognitive abilities. Developmentally, the frontal lobe region is the last to form fissures *in utero*. Post birth, the frontal lobe forms and synaptic pruning occurs slowly, with synaptic density peaking at 7 years old and then declining gradually until stability is reached in late adolescence. The anterior cingulate mediates conscious awareness and plays an important role in regulating emotions. Imaging studies indicate activation of the anterior cingulate when an individual is engaged in a challenging task requiring significant attention. When a novel task is overlearned and becomes automatic, the anterior cingulate activity declines. Further evidence supports the role of the anterior cingulate in decision making, self-awareness, and attending to environmental and external factors (Eliot, 1999).

Stuss and Alexander (2000) concur that frontal processes are activated when control over automatic processes is needed. This occurs when the complexity of the task requires old information to be processed in an alternative manner, resulting in novel problem solving. Regardless of the model employed, executive functions are associated with many different regions of the frontal lobe and appear to be distributed over a large cerebral network rather than represented by a single neural pathway that is used to control all aspects of perception, emotion, thought, and action.

Several studies of patients with focal frontal lobe lesions and their performances on various tasks related to memory, attention, affective responsiveness, and self-awareness were reviewed. The findings suggested that pathology in the left frontal lobe affects encoding, whereas the right frontal lobe is more involved in retrieval. Regarding the types of memory recalled, the medial-temporal areas correlate with explicit recall and frontal functions significantly correlate with implicit memory. The right prefrontal regions are essential for organization of episodic memory, emotional associations, and future planning. The right dorsolateral frontal area is necessary for monitoring behavior, whereas the left dorsolateral frontal areas are required in verbal processing. Both of these areas, in addition to the superior medial frontal lobe, are activated in tasks that require cognitive shifting. The inferior medial frontal area appears to facilitate certain aspects of inhibitory behavior (Stuss & Alexander, 2000; Stuss et al., 2002).

Stuss and Alexander (2000) posit a model of self-awareness based on brain functioning. The model includes four operational levels: arousal-attention, perceptual-motor, executive mediation, and self-awareness. The executive mediation and self-awareness levels are instantiated in the frontal lobes and are cued by the external environment. The executive mediation level is limited primarily to the ventrolateral and dorsolateral frontal regions. It integrates planning, inhibition, and facilitation of parietal-temporal association cortices and working memory capacities. The neural circuits connecting the frontal lobe to the basal ganglia and cerebellum provide higher level planning along with self-awareness emerging from emotions and abstract memory (Stuss & Alexander, 2000).

Royall et al. (2002) discussed specific executive control neural circuits involving the frontal lobe, basal ganglia, and thalamus. Three important circuits were identified: the dorsolateral prefrontal circuit, lateral orbitofrontal circuit, and anterior cingulate circuit. The dorsolateral prefrontal circuit receives information from the parietal and temporal cortices and is involved in goal selection, planning, sequencing, response set formation, set shifting, verbal and spatial working memory, self-monitoring, and metacognition. The lateral orbitofrontal circuit receives input from visual and auditory processing areas in the occipital and temporal lobes in addition to input from limbic centers, such as the amygdala and superior and inferior temporal gyri. This circuit is involved in the initiation of social and internally driven behaviors and the inhibition of inappropriate responses. The anterior cingulate circuit receives input from the hippocampus, amygdala, and paralimbic cortex. It is important in monitoring behavior and self-correcting errors (Royall et al., 2002).

Collette et al. (2005) conducted a study using positron emission tomography (PET) to explore cerebral areas activated by three executive processes: updating, shifting, and inhibiting. The results showed increases in activity during the executive tasks in the left superior parietal gyrus, right intraparietal sulcus, and left middle front gyrus. Specifically, updating tasks showed an increase in the bilateral activation of anterior and posterior areas, shifting tasks activated the parietal lobe and left middle and inferior frontal gyri, and inhibitory tasks were associated with activation of the right orbitofrontal gyrus, but produced less activation than shifting and updating tasks. These findings suggest that the parietal areas play a critical role in carrying out the executive tasks that are being directed by the frontal lobe (Collette et al., 2005).

Leung, Skudlarski, Gatenby, Peterson, and Gore (2000) conducted a study to assess the activation of frontal and anterior cingulate structures elicited by the Stroop color word interference task (Stroop, 1935 as cited in Leung, Skudlarski, Gatenby, Peterson, & Gore, 2000). The Stroop task requires the individual to name the ink color in the presence of a discrepant color name. The individual must inhibit an automatic behavior of reading the word in order to name the color of the ink in which the word is printed. Leung et al. (2000) used the Stroop task in a functional magnetic resonance (fMRI) study to determine the neural circuits activated during this executive task. The results indicated the anterior cingulate gyrus was strongly activated while completing the Stroop task. It plays a role in guiding the execution of the correct response by monitoring performance, suppressing the inappropriate responses, selecting the correct response, and coordinating the decision to the motor systems. Temporally, the inferior part of the anterior cingulate gyrus appeared to be activated at a slightly later time, indicating its involvement in vocalization and emotional judgment. Within the frontal cortex, the middle frontal, inferior frontal, and medial wall frontal regions were activated during the Stroop task. The inferior frontal regions were associated with selective retrieval and verbal inhibition; the medial wall frontal regions participated in motor preparation and planning; and the middle frontal regions were related to task monitoring and problem solving (Leung, Skudlarski, Gatenby, Peterson, & Gore, 2000).

Executive Function Assessment

The assessment of executive functions should specify the strengths and weaknesses demonstrated by the student. Ideally, this leads to the application of interventions to address concerns identified in assessment. Most of the comprehensive assessments designed to assess executive functions have focused mainly on the roles of cueing and directing perception, cognition, and action as they apply within the academic arena. As a result, there is a lack of executive function assessments used to address social, emotional, and adaptive functioning within the Intrapersonal, Interpersonal, and Environment Arenas. Due to these limitations, it may be best to utilize a multidimensional and multi-method approach when assessing executive functions. This can best be accomplished by using both direct and indirect approaches involving formal and informal assessment techniques (McCloskey & Perkins, 2012).

The direct formal approach involves the use of norm-referenced tests (McCloskey & Perkins, 2012). This method includes standardized assessments such as the Delis-Kaplan Executive Functions System (D-KEFS; Delis, Kaplan, & Kramer, 2001), the Neuropsychological Test-Second Edition (NEPSY-II; Korkman, Kirk, & Kemps, 2007), and the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993).

The D-KEFS is an assessment battery that consists of nine subtests used to assess executive functions. It is used to assess student concerns within the areas of reasoning, visual processing, retrieval fluency, graphomotor processing, visuospatial processing, long-term retrieval, and orthographic processing (Delis et al., 2001). The D-KEFS can be administered as a full battery for a comprehensive assessment, or the subtests can be administered individually or in combination for a cross–battery or process oriented approach (McCloskey & Perkins, 2012). The NEPSY-II offers six subtests used to measure executive functions. These subtests are similar to the tasks of the D-KEFS, with the addition of working memory. The NEPSY-II subtests are the Animal Sorting, Auditory Attention and Response Test, Clocks, Design Fluency, Inhibition, and Statue (Korkman et al., 2007). The WCST is a measure that assesses executive functions using stimulus cards to complete different sorting patterns based upon corrective feedback. The results of the WCST yields T-scores and percentages relative to the individual's performance in planning strategies, organizing task demands, using feedback to solve problems, motivating initiatives to complete goals, and modulating impulses. The information obtained from the WCST can assist practitioners in determining the effectiveness of executive direction of concrete and abstract thinking abilities in individuals under ambiguous learning conditions, and can assist in identifying prefrontal lobe dysfunction (Heaton et al., 1993).

The indirect formal approach involves collecting information from others who have directly observed individuals' behaviors while using executive functions when completing tasks. Indirect formal assessment methods include the use of standardized behavior rating scales with parents and teachers, in addition to self-report scales (McCloskey & Perkins, 2012). An example of this assessment approach is the Behavior Rating Inventory of Executive Functions (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000). The BRIEF is a rating scale that consists of parent, teacher, and self-report forms. The parent and teacher rating forms can be used with students between the ages of 5 and 18, and self-report rating scales can be used with students between the ages of 11 and 18.

Each rating scale provides three indices, which are the Behavior Regulation Index, Metacognition Index, and Global Executive Composite. Within these indices are individual Clinical Scales: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor. The raters are required to draw upon their recollections of the student's behavior while completing the rating scale (Gioia et al., 2000; McCloskey & Perkins, 2012).

Executive Function Interventions

Interventions for executive functions can be developed through a case conceptualization model. Case conceptualization requires addressing three important issues that impact the effectiveness of intervention efforts. The first issue is that the observed executive function difficulties are the result of the lack of optimal functioning of specific neural mechanisms. It is important that parents and professionals involved with the student recognize that the problems being observed are not the result of a conscious desire on the part of the student to avoid work or challenging situations. Rather, the difficulties have an organic basis in brain function. This perspective is likely to engender the patience needed to work with unmotivated students who are experiencing executive function difficulties (McCloskey, et al., 2009; McCloskey, Gilmartin, & Stanco, 2013).

The second issue is to avoid attributing the executive function difficulties to brain damage that cannot be corrected. When such thinking occurs, a fixed mindset ensues (Dweck, 2006), which makes it much less likely that proper attention and effort will be devoted to intervention. Instead, it is better to adopt a growth mindset that assumes that the investment of time, energy, and effort eventually will result in improved functioning.

The third issue is whether the observed difficulties are resulting from a lack of awareness of executive functions and how they cue and direct behavior or are due to a slow rate of maturation. When difficulties result only from a lack of awareness of how to engage and use executive functions, interventions are likely to produce noticeable changes in a relatively short amount of time. Conversely, when difficulties present as maturational delays, intervention efforts are likely to require much more time, effort, and patience for improvements to be realized (McCloskey et al., 2013; McCloskey et al., 2009).

Interventions should incorporate techniques to teach students to consciously and unconsciously activate their neural networks based upon the task. The students should be exposed to an environment that allows for frequent contact with teachers or specialists, and promotes the occurrence of effective modeling of strategies. An intervention plan should be developed that focuses on making the student aware of the specific functions needed to achieve the goals and to provide opportunities to learn how to engage the required executive functions (McCloskey et al., 2013).

Intervention strategies can be organized into four general categories or stages: orienting, external control, bridging, and internal control. Orienting strategies are designed to increase awareness of executive capacities and the difficulties one may be experiencing. These strategies assist in establishing goals by demonstrating or modeling the behavior in a concrete manner and should be revisited periodically to aid in progress monitoring and clarification of the purpose of intervention efforts. In order to increase awareness, education should be provided about what executive functions do and how they can be used to accomplish tasks and achieve goals. Awareness can be increased by discussing individual strengths and challenges, and shifting focus to an internal locus of control to highlight positive thinking and autonomy in the student (McCloskey et al., 2013).

External control interventions act as executive function substitutes for the student. They involve direct guidance that is provided by a parent, teacher, or professional that serves as a substitute for the cueing and directing that would be done by the student. Intervention strategies for external control can include structuring the classroom environment, providing time management tools and assistance, providing prompts and cues for the processing of information or the completion of work projects, using behavioral interventions involving rewards and punishments, and prescribing pharmacological treatment. All of these can be considered substitutes for internal self-regulation. Ideally, external control strategies should be used in a very limited manner with the goal of transitioning away from these external control mechanisms and toward internal self-regulation. The shift from external control to internal self-regulation can be achieved through the use of bridging strategies (McCloskey et al., 2013). Bridging strategies are cognitive routines that can be taught to and practiced by students to increase their capacity for self-direction. These strategies include one or more of the following tasks: reflective questioning, providing corrective feedback, modeling, practicing and rehearsing, teaching specific executive function skill routines, using verbal mediation, using verbal and nonverbal labeling, teaching self-talk strategies, aligning external demands with internal desires, and teaching internal control strategies (McCloskey et al., 2013).

Internal control strategies reflect effective self-direction and successful use of executive functions to cue and direct perceptions, feelings, thoughts, and actions.

Internal control strategies can be taught to students to enable them to increase their self-direction capacities. These strategies include internal feedback, self-administered rewards, and self-monitoring. Individuals can use internal imagery to guide their perceptions, thoughts, feelings, and actions to accomplish goals (McCloskey et al., 2013).

Reading

The National Assessment of Educational Progress (NAEP, 2015) defines reading as "an active and complex process that entails understanding written text, developing and interpreting meaning, and using meaning as appropriate to type of text, purpose, and situation" (National Assessment Governing Board, 2015). The basis of NAEP's definition for reading takes into account the reader's ability to integrate individual skill components in order to read successfully. The individual skill components identified by the National Reading Panel (2006) include Phonemic Awareness-Decoding, Oral Reading Fluency, and Comprehension. Each skill component is essential for reading; however, individually, they are insufficient in the overall process of reading. A proficient reader would demonstrate adequate skills in each of these components. A deficit or underdevelopment in any of these individual skill components would pose challenges for successful literacy.

According to NAEP's 2015 National Assessment results, 37% of 12th grade students scored at or above the proficiency level in reading. This percentage decreased by 1% from the previous assessment results from 2013. Prior to 2015, the 2013 assessment results indicated 38% and the 1992 assessment results indicated 40% of 12th grade students scoring at or above the proficient level in reading. This indicates an overall slight decline in reading performance since 1992. The NAEP defines the proficient achievement level as demonstrating solid academic performance (National Assessment of Educational Progress, 2015). Since the No Child Left Behind Act (NCLB) of 2001, there has been an increase in mandating evidence-based reading interventions and instruction to promote literacy development (Joseph & Schisler, 2006).

Learning to read begins with early literacy skills typically developed within the pre-school years. At this time, phonics and phonemic awareness are taught through basic alphabetic principles (Armbruster, Lehr, & Osborn, 2001). During first and second grade, students are taught decoding skills that enable reading words accurately and fluently (Meisinger, Bloom, & Hynd, 2010). As reading progression continues, students develop comprehension skills and the notion of reading as a means to learn new information and vocabulary, and further higher order abstract reasoning skills becomes instilled. This typically emerges in fourth grade and continues to progress as the student advances academically (Meisinger et al., 2010).

Unfortunately, reading challenges may be the result of a learning disability, executive dysfunction, working memory deficits, weaknesses in processing, lack of motivation, or limitations in higher order reasoning skills (Baker, Gersten, & Grossen, 2002). Often overlooked are the sociocultural risks factors that plague poor readers. These factors include lack of early exposure to print and slow development of crystallized knowledge, being an English Language Learner (ELL), poverty and low socioeconomic status (SES), residing in an urban community, exposure to trauma and crime-ridden environments, and being an ethnic or racial minority (Rouse & Fantuzzo, 2006). Early and cumulative exposure to positive adult models and community influences demonstrates benefits in later achievement, as well as being favorably associated with literacy skills (Anderson, Leventhal, & Dupèrè, 2014).

Furthermore, ELLs experience significant difficulties in school achievement. With the growing diversity in communities and schools, there is an increased population of ELLs who experience challenges with literacy. This contributes to the achievement gap and poses obstacles for educators. National legislation requires schools to identify these students and holds schools accountable for their progress (Meisinger et al., 2010). These challenges contribute to the achievement gap between ELLs and native English speakers. It further poses obstacles for teachers to provide best practices to support ELLs in the classroom. Due to the NCLB of 2001, there is an expectation for ELLs to master academic skills similar to their native English speaking peers (Howard, 2012). The results of this legislation have pressured school systems to monitor academic achievement and language acquisition of ELLs with minimal support in providing interventions and accommodations to address these needs.

Ultimately, students who experience difficulties with reading may further experience obstacles in other academic subject areas and often become frustrated, less motivated, and avoidant of tasks involving reading. Negative long-term effects of poor reading can contribute to students developing behavior, academic, and social problems, truancy, and limitations in daily living and vocational skills as adults (Meisinger et al., 2010). Poor readers often have deficiencies in decoding and word recognition, in addition to fluency, which is a strong predictor of reading achievement (Hudson, Pullen, Lane, & Torgesen, 2009).

Phonemic Awareness-Decoding

Phonemic awareness is an individual's ability to be alert to phonemes in specific words and the ability to manipulate the individual sounds in words. Phonemic awareness includes phoneme identification, blending, segmentation, deletion, substitution, and addition. Phoneme identification is based upon identifying sounds within the beginning, middle, and end of words. The combination of sounds to formulate whole words is called phoneme blending. Phoneme segmentation is taking a whole word and dividing it into segmented sounds for articulation. Phoneme deletion occurs when the reader deletes a sound from a given word and replaces the sound with a substitution to create a different word. Phoneme addition commonly occurs in the presence of prefixes and suffixes (Joseph & Schisler, 2006).

Phonemic awareness is rooted in the alphabetic principle, which refers to the knowledge of a relationship between individual letters and sounds. When readers take into account the foundations of the alphabetic principle and phonemic awareness, they can generate sequential decoding. The blending of sounds to formulate words is the basis of decoding (Joseph, 2006). Decoding is described as the ability to apply letter-sound correspondence and orthographic patterns in order to accurately pronounce words. Skills in decoding transitions a reader from the phonological awareness of sounds in words to identifying and accessing words efficiently based on orthography (Joseph, 2006).

The National Reading Panel (2006) examined the effects of phonemic awareness instruction. The results were significant, indicating that teaching manipulation of sounds in words is effective across all literacy domains. Instruction that focuses on phonemic awareness through manipulation of sounds yields greater progress than skilled teaching. Even better results were seen with the use of blending and segmentation in instruction.

Oral Reading Fluency

Oral reading fluency is the ability to read words and passages with accuracy and efficiency. It demonstrates the automaticity of reading when a student can attend to the text and fluidly read whole words with prosody (Joseph & Schisler, 2006). Oral reading fluency is a multicomponent process that includes morphology, phonemic awareness, letter knowledge, blending and segmentation, word recognition, semantics, syntax, accuracy, and speed (Bashir & Hook, 2009; Pikulski & Chard, 2005). By increasing word recognition and accuracy, students read more fluently. Students who have difficulty with oral reading fluency often read passages slowly and focus overly on each individual word in the text. This can increase frustration and contributes to poor comprehension (Joseph, 2006).

There are two instructional approaches to enhance oral reading fluency: guided oral reading and independent silent reading. Guided oral reading refers to the process during which a student reads aloud and receives guidance and feedback from a teacher. Independent silent reading is when a student reads silently and receives minimal to no guidance or feedback (The National Reading Panel, 2006). It is suggested that oral reading fluency exercises should be incorporated into daily classroom lessons until students are able to read approximately 135 words per minute with 97% accuracy using reading material at the fourth-grade level. Adequate oral reading fluency is reported to be a reliable predictor of a student's reading comprehension performance. Fluency allows the student greater ability to comprehend the text and aids in reducing frustration resulting from slower patterns of reading (Joseph, 2006).

Comprehension

Comprehension is crucial in the development of reading skills. Reading comprehension is viewed as an active process that requires higher order cognitive thinking skills. It requires the student to be thoughtful and intentional in his or her application of previous background knowledge. Students' ability to apply reading comprehension strategies is correlated highly with their overall academic achievement, and it is the ultimate goal of reading (National Reading Panel, 2006; Shapiro, 2004).

The National Reading Panel (2006) reviewed research data on reading comprehension and identified three dominant themes. The first theme is relative to the cognitive process and the immersion of complex skills in which reading comprehension takes place. The second theme addresses the development of reading comprehension based upon interactive strategies. The final theme indicates the need to prepare teachers with better skills to facilitate instruction of reading comprehension (National Reading Panel, 2006). Mercer and Mercer (2001) identified five areas of reading comprehension: vocabulary, understanding explicit information, inferential comprehension, critical reading, and emotional sensitivity.

Teaching comprehension strategies should motivate and instruct readers to utilize skills necessary for reading. Strategies such as recall, generating questions and answers, and summarization of texts can lead to student gains in performance on comprehension-based standardized tests. These strategies are multileveled and require active involvement and motivation, in addition to direct teacher involvement, for a high success rate (National Reading Panel, 2006).

Neuropsychology of Reading

The cerebellum, basal ganglia, and cortex operate in a parallel fashion during most adaptive activities. Koziol and Budding (2008) suggest that dysfunction of the cerebellum is involved in learning disabilities, primarily in the area of reading. The brain creates systems by building upon previously acquired brain functions. The most important brain functions utilized for reading are sensory, motor, oral language, memory, and executive control. Each of the above-mentioned functions undergo further development in order for adequate learning and acquisition to occur in a systematic manner (Berninger & Richards, 2002).

The task of reading involves creating representations in one's mind from the visual information presented in the form of written text. Generally, beginning readers utilize a preexisting system for extracting visual information. This system then branches into specific areas for written language. This prompts the processing of orthographic language by encoding written words with spoken words. The letters formulate sound codes that are stored and represented as orthographic word forms that eventually develop into written language and reading (Berninger & Richards, 2002).

Neurologically, the initial visual exposure activates both sides of the occipital lobe in the primary visual and striatal areas and the posterior medial extrastriatal association cortex (Berninger & Richards, 2002; Bookheimer, Zeffiro, Blaxton, Gaillard, & Theodore, 1995). Beyond the initial processing stage, the continued processing of visual information recognized as orthography occurs in the left inferior occipital temporal cortex. This region is where written symbols are initially linked to language; however, there is limited research as to whether lexical and pre-lexical symbol associations for orthographic processing of reading occur in the fusiform gyrus or the lingual gyrus (Berninger & Richards, 2002).

The specialized function of coding words phonologically rather than semantically appears to result from the activation of several areas of the brain. The superior temporal sulcus is activated by speech more than by auditory tones. The superior temporal sulcus is uniformly sensitive to real words and pseudowords, indicating its role in phonological rather than the semantic features of words (Berninger & Richards, 2002; Binder et al., 2000). This suggests the superior temporal sulcus to be the center for the formations of phonological representations of words. Overall, speech sounds are mostly activated within the superior temporal gyrus and superior temporal sulcus, indicating both regions play a role in receptive phonological word forms. The three regions that have the strongest activation for real words rather than pseudowords are the posterior inferior temporal gyrus, the angular gyrus, and the area between the posterior middle and inferior temporal gyri. These regions function in the coding of semantic phonological word forms (Berninger & Richards, 2002). The phonological, semantic, and syntactic processes are individually separated within the brain. The development of language requires the integration of the individual processes. Single words presented orally activate the auditory cortex and upper left temporal lobe. The extraction of the meaning of the word, however, occurs in the pars triangularis and in the left temporal gyrus and sulcus (Berninger & Richards, 2002).

In relation to learning and automaticity, the cerebellum plays a significant role. When learning novel items, the left frontal and anterior cingulate cortices and the right cerebellum are active. The bilateral sylvian insular cortex is less active during novel stimuli, but the circuits increase post practice, which is related to speed of response and automaticity. It is thought that the cerebellum is active for learning tasks and deactivates after rehearsal, indicating that the process has been automatized (Berninger & Richards, 2002). Mishkin and Appenzeller (1987) provided further insight into the concept of learning and automaticity in relation to the cognitive and behavioral pathways. The cognitive pathway supports the connection between schemas and the amygdala, which houses opiate neurotransmitters and acts as a gatekeeper. This allows emotion-based information from the hypothalamus to influence the information individuals perceive and learn. This pathway processes the emotionally-laden content that is salient in learning and further incorporates additional cognitive sets that are interrelated and important to the initial information presented. The behavioral pathways represent overlearned responses and functions through the caudate nucleus and putamen, which make up the striatum. This pathway receives signals from various points of the cortex and exports it to the globus pallidus and substantia nigra in order to execute motor routines to perform the learned task (Berninger & Richards, 2002; Mishkin & Appenzeller, 1987).

Language development and reading can affect the pattern of activation in the frontal lobes. The left frontal regions are activated when attention is placed upon words, whereas increased activation in the left posterior regions occurs when attention is placed upon sentences (Abdullaev & Posner, 1998; Berninger & Richards, 2002). Research indicates sensory coded stimuli are recoded linguistically in the superior temporal regions when determining whether letter strings are real words with meanings. The left prefrontal cortex is involved in the executive control of reading processes (Berninger & Richards, 2002). Linguistically recoded sensory information is stored in two separate lexicons, which are organized by word forms: phonological, the sound of the word, and orthographic, the visual form of the word. The reading of real words and pseudowords is dependent on how word forms are represented in memory. Real words have orthographic, phonological, and semantic coding, whereas pseudowords have only orthographic and phonological codes. Real words activate the fusiform gyrus and pseudowords activate the left inferior frontal regions (Berninger &Richards, 2002; Herbster, Mintun, Nebes, & Becker, 1997).

The beginning stage of reading is known as the decoding stage (Chall, 1979), where lexicons for orthographic word forms are developed and connections to written and oral language are formed. During the decoding stage, individuals rely on episodic, short-term, and explicit long-term memories. From this initial stage, individuals progress to the fluency stage, where the practice of reading becomes reorganized and processed through the cognitive pathway to the behavioral pathway (Mishkin & Appenzeller, 1987) for functional reading (Berninger & Richards, 2002). The functional reading system reorganizes during this stage of reading development to formulate oral reading fluency and silent reading fluency. Silent reading fluency allows the reader to automatically access orthographic and phonological lexicons, allowing working memory to be reserved for the process of reading comprehension (Berninger & Richards, 2002). As readers achieve fluency, their coordination of a functional reading system with other brain systems involved in learning allows for expansion of knowledge (Berninger & Richards, 2002; Chall, 1979).

Reading Assessment

Reading assessments are essential for educators to develop differentiated instruction and interventions to meet the presenting needs of students. These assessments are used to determine students' reading abilities in the areas of decoding, fluency, and comprehension. Due to the complexity of the reading process, it can be challenging to determine appropriate measures that will provide reliable and valid data. There are different types of assessments that can be used. Some of these assessments are standardized norm-referenced tools and curriculum-based measurements.

Standardized norm-referenced tools are formal assessment measures, such as the Gray Oral Reading Test, Fifth Edition (GORT-5; Wiederholt & Bryant, 2012), the Process Assessment of the Learner, Second Edition Diagnostic Assessment for Reading and Writing (PAL-II RW; Berninger, 2007), the Test of Word Reading Efficiency, Second Edition (TOWRE-2; Torgesen, Wagner, & Rashotte, 2012), and the Wechsler Individual Achievement Test, Third Edition (WIAT-III; Wechsler, 2009). These tools are used to assess various areas of reading and yield standard scores in order to make comparisons of students' performances with age-based national norms.

The GORT-5 (Wiederholt & Bryant, 2012) is a norm-referenced standardized assessment that can be used to assess reading accuracy, rates, and comprehension by having the student read passages based upon his or her grade level. Three primary scores are derived from this assessment: Fluency, Comprehension, and an overall composite score called the Oral Reading Quotient.

The PAL-II RW (Berninger, 2007) is designed to measure skills related to processes of reading and writing. The PAL-II RW contains 22 subtests used to measure phonological coding and decoding, orthographic coding, morphological decoding, syntactic coding, silent reading fluency, verbal working memory, rapid automatized naming, and rapid automatic switching.

The TOWRE-2 (Torgesen et al., 2012) can be used to assess word reading and decoding fluency. The TOWRE is a standardized norm-based assessment that contains two subtests: Sight Word Efficiency (SWE) and Phonemic Decoding Efficiency (PDE). The SWE measures the student's ability to read a number of real words accurately within a 45 second time limit. The PDE subtest assesses the number of nonsense words that are accurately decoded within a 45 second time limit.

The WIAT-III (Wechsler, 2009) is a standardized assessment battery used to measure achievement skills. The Reading Composite is comprised of the Early Reading Skills, Reading Comprehension, Word Reading, Pseudoword Decoding, and Oral Reading Fluency subtests. The Reading Comprehension subtest measures literal and inferential reading comprehension skills using a variety of passage and question types that resemble those used in a school setting. The Word Reading subtest is designed to measure speed and accuracy of single word reading. The Pseudoword Decoding subtest measures the ability to decode nonsense words. The Oral Reading Fluency subtest is designed to measure oral reading fluency of expository and narrative passages.

Curriculum-based measurements are used in assessing students' academic growth in response to their instruction. They are often used by teachers to effectively monitor progress in a time efficient manner (Hosp & Suchey, 2014). Curriculum-based measures include the Dynamic Indicators of Basic Literacy Skills (DIBELS) Next (Good & Kaminski, 2011), the Scholastic Phonics Inventory (SPI; Scholastic Inc., 2009a), and the Scholastic Reading Inventory (SRI; Scholastic Inc., 2001).

The DIBELS Next progress monitoring techniques can be used to assess a student's performance over time. The progress monitoring data assist teachers, reading specialists, and school psychologists in determining whether the instructional supports are adequately addressing the student's reading needs and if modification of the interventions is needed to promote further growth towards goal attainment. The progress monitoring techniques involve ongoing assessment of the student's skills in Nonsense Word Fluency (NWF) and Oral Reading Fluency (ORF; Good & Kaminski, 2011). NWF is defined as a short measure of the alphabetic principle and basic phonics. The NWF assesses the student's knowledge of basic letter sounds and the ability to blend letter sounds, consonant-vowel-consonant (CVC), and vowel-consonant (VC) words. The test items used on the DIBELS Next are make-believe nonsense words which require the student to utilize his or her knowledge of sound-blending and letter-sound correspondence. It requires the student to apply grapheme-phoneme knowledge in the decoding of the non-words (Good & Kaminski, 2011). There are two different scores obtained from the NWF: Correct Letter Sounds (CLS) and Whole Words Read (WWR). The CLS is determined by assessing the number of correct letter sounds produced within 1 minute. The WWR is determined by assessing the number of correct nonsense words read correctly without sounding out individual phonemes. The DIBELS ORF is a measure of accurate and fluent reading skills utilizing advanced phonics and word-attack. The student is given three unfamiliar grade-level texts and is asked to read each text aloud for 1 minute. Errors are noted while the student reads aloud. The score is the median number of words correctly read and the median number of errors noted on all three passages.

The NWF and ORF scores are plotted on a graph over time to determine whether the student is making progress based upon the scores falling above or below the aimline. Standard DIBELS end-of-the year benchmark goals and timeframes for grade specific benchmarks are used to determine the target goals for the student. Progress monitoring data is reviewed regularly to make decisions regarding instruction to improve student outcomes. If three consecutive data points fall below the aimline, it is recommended that the school-based team meet to consider modifying the instruction (Good & Kaminski, 2011).

The SPI is used to measure phonological decoding and sight word fluency. Phonological decoding is assessed by the accuracy and speed of decoding nonsense words, whereas sight word fluency measures the accuracy and speed of reading high frequency words. This measure is intended to identify students between grades 3 and 12 who struggle with decoding and are unable to recognize sight words with speed and accuracy. The SPI takes 10 minutes to administer individually through a computer-based program. The level of difficulty is adjusted throughout the assessment based upon the student's performance. The results of the SPI are used to place students who need additional instruction in foundational phonological decoding skills through programs such as System 44 (Scholastic, Inc., 2009a).

The SRI measures reading comprehension and reports current reading levels in students between kindergarten and grade 12. The SRI takes 25 minutes to administer individually through a computer-adapted assessment, which adjusts the level of difficulty in the questions based upon the student's performance. The student is required to answer fill-in-the-blank or cloze questions drawn from over 5,000 test items extracted from fiction and non-fiction texts. The results of the SRI determine the student's reading level reported in Lexiles. This guides the selection of books the student can read at an independent level and is used in conjunction with the READ 180 program (Scholastic, Inc., 2001).

Reading Interventions

Effective reading instructions and interventions should be adopted to ensure that the programming, teaching techniques, and curriculum lessons are meeting students' needs. Interventions for oral reading fluency focus on the importance of repeatedly reading aloud. Repeated reading engages the student in rereading the same text over time in order to increase the rate and accuracy of oral reading fluency. Repeated reading should include immediate corrective feedback, guidance, and modeling by teachers (Algozzine, Marr, Kavel, & Dugan, 2009). The amount of time spent in the classroom focusing on oral reading instruction and practice leads to greater student progress in reading fluency compared to silent recreational reading alone (Armbruster et al., 2001). Oral reading fluency interventions should incorporate explicit instruction strategies, such as repeated reading, word drills, modeling, previewing, scaffolding, reading from predictable texts, actively engaging students, providing corrective feedback, choral reading, and using reinforcement strategies to maintain motivation (Algozzine et al., 2009; Begeny & Martens, 2006; Joseph & Schisler, 2006).

Corrective feedback is a technique used by teachers to provide the student with prompts and corrections while the student is demonstrating skill building. Scaffolding is an instructional method that uses guided practice to link concepts together and gradually fade supports as the student demonstrates adequate skill level. Reinforcement strategies are often used in the classroom in the form of verbal praise and tangible rewards to increase students' positive behaviors relative to learning. Teachers should provide their students with opportunities to practice their reading skills by allowing them to engage in each specific area, including fluency, vocabulary, comprehension, and decoding. By routinizing reading with repetition, the skills of reading become automatic (Joseph & Schisler, 2006).

The use of modeling allows students to listen and follow the text while it is being read aloud prior to the students engaging in independent reading. Modeling allows students to observe reading behavior prior to demonstrating the behavior themselves. Active student engagement places emphasis on students' ability to reciprocate and participate in classroom activities. This allows students to develop meaningful experiences and active involvement during learning (Joseph & Schisler, 2006).

Traditional reading drills use flashcards to teach students to read novel words at a rapid rate. The student is required to read each word printed on the flashcard one after the other. The flashcards are shuffled between the drills and feedback is provided to the student after the word is read. This method is often used by teachers due to its time-efficiency and effectiveness in increasing word recognition (Joseph, 2006). Incremental rehearsal is a reading strategy that uses drill rehearsal techniques to address the reader in learning new words (MacQuarrie, Tucker, Burns, & Hartman, 2002). This technique incorporates 90% of unknown words interspersed with 10% of known words to maintain motivation and to gradually increase the student's ability to acquire and retain word recognition to improve reading fluency (Joseph & Schisler, 2006).

Repeated reading is used to improve oral reading fluency in connected texts. Students are required to repeatedly read the same passage until mastery is achieved. This technique encourages readers to read words in passages accurately, quickly, and with expression. Once students meet criterion level, a more difficult passage is introduced and the procedure is repeated until the skill is met (Joseph, 2006).

Orton-Gillingham based reading instruction interventions utilize multi-sensory, sequential, systematic phonics-based techniques to instruct reading in an explicit manner. Students are instructed in phonological awareness, sound-symbol correspondence, semantics, syllables, syntax, and morphology. One of the key components of Orton-Gillingham instruction is that it is multi-sensory, utilizing visual, auditory, and kinesthetic learning. The instruction in the Orton-Gillingham model requires the student to develop mastery with the use of repetition to develop over learning of the material prior to advancing on to new material. It requires the use of progress monitoring information and is individualized to the specific needs of the student (Ritchey & Goeke, 2006).

The READ 180 program is designed for students in grades 4 through 12 whose reading achievement is below proficiency levels. The program aims to address skill gaps through the use of small group teacher-directed instruction and independent computer work. The program specifically addresses comprehension skills, and data are recorded based upon the SRI Lexile scores achieved on the computer program (Scholastic Inc., 2005).

The System 44 program is designed for students in grades 3 through 12 who have difficulty with decoding. The program is a combination of teacher-led and software-based instruction intended to focus on phonemic awareness. The SPI collects data on the students' decoding accuracy and fluency. Students receive explicit instruction and modeling of sound-symbol correspondences, comprehension word attack strategies, decoding fluency, and increasing knowledge of nonfiction content through text (Scholastic Inc., 2009b).

Executive Functions and Reading

As noted earlier, McCloskey et al. (2009; 2012) and Berninger and Richards (2003) note that executive functions are used to cue, direct, and integrate various academic endeavors, such as reading, writing, and mathematics. Most learning-disabled students will display executive function difficulties within the academic arena (McCloskey & Perkins, 2102; McCloskey et al., 2009). These students' learning difficulties are compounded by the presence of underdeveloped executive functions, which affect the efficiency of new learning and, most notably, impact production and the completion of tasks (McCloskey & Perkins, 2012; McCloskey et al., 2009). Reading difficulties, therefore, can result from or become exacerbated by poor or inconsistent use of a student's executive functions. Maricle, Johnson, and Avirett (2010) discussed the use of executive functions in managing impulses, maintaining focus, organizing, self-monitoring, time management, and problem solving during the act of learning. Reading requires students to use executive functions to cue, direct, and integrate the use of phonological and orthographic processing, oral-motor functioning, sight word recognition, decoding, reading fluency skills, receptive and expressive language use, reasoning with verbal information, and retrieval of word and content knowledge from long-term storage (McCloskey & Perkins, 2012; McCloskey et al., 2009).

Specifically, executive functions such as focusing, sustaining attention, monitoring, inhibiting, and shifting are required to coordinate the use of word recognition and decoding skills at the word processing level (McCloskey & Perkins, 2012). Reading comprehension is the most complex reading skill that requires the use of executive functions, to focus and sustain attention, coordinate and integrate word level reading with higher order thinking skills, retrieve information from long-term storage, and direct the use of working memory to sustain thought processing as long as reading continues. Due to the complexity of the act of reading, a weakness in any of the processes, skills, abilities, memory functions, or executive functions involved can result in poor reading comprehension (McCloskey & Perkins, 2012).

Shifting is one of the executive functions on which fluent reading relies. Shifting is known as the ability to switch attention or to transition between strategies or sets. It is described as the discontinuation of the use of one cognitive construct and the subsequent activation of a more appropriate one in its place (van der Sluis, de Jong, & van der Leij, 2004). Inhibition is the suppression of the activation of a cognitive construct so that a different construct can be activated and used. Shifting and inhibition are important skills associated with naming-speed tasks relative to basic reading skills. The rapid recognition and retrieval of visually presented stimuli, such as words and letters, are associated with phonological processing and fluency. Students who have deficits in shifting and inhibition also have been found to have decoding and reading fluency weaknesses (van der Sluis et al., 2004). The self-regulatory factors of executive functions are involved in cueing and directing reading skills, such as word recognition, decoding, focusing attention, perceiving orthographic images correctly, inhibiting impulsive responses, and self-monitoring. The ability to read fluently encompasses all of these constructs and it is necessary to elicit executive functions in order to read well (McCloskey & Perkins, 2012; McCloskey et al., 2009).

Decoding of real words and pseudowords requires the reader to segment words into individual phonological units and then reassemble the units. Real words that eventually become familiar are read by accessing stored representations of the assembled phonological units by directly accessing previously stored word forms. The coordination of these processes requires participation of executive control (Berninger & Richards, 2002). This coordinates the system for linking orthographic codes to language and relies upon multiple memory stores for phonology, semantics, and morphology. According to Berninger and Richards (2002), the executive systems link the reading lexicons with incoming stimuli and previously represented visual information and oral language systems by activating higher order cognitive sets to reason about information that is being read.

Summary

It is evident that when individuals engage in reading activities, skills such as decoding, fluency, vocabulary, comprehension, and phonological awareness are needed in order to read successfully. In addition to these specific reading skills, the literature supports the hypothesis that executive functions are needed to cue, direct, prompt, coordinate, and integrate the use of the various processes, abilities, skills, and knowledge bases needed to perform the act of reading effectively. It is clear that components of reading and executive functions share similar neurological features and brain-based mechanisms. One would assume that in order for an individual to develop effective and successful reading skills, the individual would need to possess adequate executive functions. Although there are numerous reading intervention programs and, more recently, the introduction of executive function interventions, no specific interventions that target improvement of the use of executive functions in order to improve the efficiency of the act of reading had been developed until recently (McCloskey, 2015).

The intervention proposed by McCloskey (2015) involves the use of word reading drills that emphasize attention to the specific letter configuration of each word in order to avoid word reading errors. The hypothesis underlying the intervention is that a student with executive function difficulties is more likely to confuse the letter configurations of words that are unknown with the letter configurations of words that are known, resulting in the student substituting the pronunciation of a known word for an unknown word. The reason for this substitution is a lack of effective use of executive functions to carefully monitor reading at the word level to recognize when letter configurations comprise an unknown word and shift to decoding mode to sound out the unknown word instead of substituting a known word (McCloskey, 2015).

The use of an executive function-based intervention targeting reading fluency that can be supplemented with preexisting reading programs targeted for students with learning disabilities would be beneficial. Hypothetically, such a program would engage students in practicing a word reading routine that strengthens the use of executive functions in their role of cueing fast and accurate sight word recognition.

The current study evaluated pre- and post-intervention data obtained from the performance of a group of high school-age, severely disabled readers who underwent word reading drills based on the McCloskey (2015) concept of improving attention to the letter configurations of words that are being read in order to improve the use of monitoring and shifting executive functions, to discriminate accurately between known and unknown words and to cue the use of decoding skills to sound out unknown words in order to pronounce them correctly. The study also tested the notion that engaging in this intervention would improve students' abilities to use executive functions to control the processing of orthography when completing tasks such as the D-KEFS Color-Word Interference task and the PAL-II Rapid Automatic Switching task.

Chapter 3: Method

Overview

This study examined archival pre- and post-test data collected during the implementation of an intervention used to strengthen attention to orthography and the shifting between rapid sight word recognition and decoding of unknown words to improve oral reading fluency and accuracy of struggling readers. This study investigated whether improvement is noted in the pre- and post-test data collected on word reading accuracy and fluency, decoding accuracy and fluency, inhibitory control, and cognitive shifting.

Data Source

The source of data for this study is shelf data collected over the course of the implementation of an 8-week intervention conducted during the 2014-2015 academic year. The shelf data were collected on 1 ninth grade and 13 eighth grade students who were identified previously as having an educational disability and were receiving special education services at the time of the study. The students were selected by their reading specialist to participate in the study based upon their performance on the SRI. The students attained an SRI Lexile score below 100 within the Beginning Reader (BR) level. Performance within the BR level indicates the student is lacking foundational skills in reading by displaying pre-decoding skills. The students who attain a Lexile BR level are in need of additional reading interventions. Based on the clinical observations of the reading specialist, all students referred for the intervention exhibited difficulties with knowing when to apply decoding skills when reading words. For example, these students tended to call out a word similar to the word to be read and did not realize that they had misread the word.

Description of the Intervention Program Used with Students

The intervention took place in an urban public high school located in southeastern Pennsylvania with a population of approximately 2,400 students enrolled in eighth and ninth grade. The 14 students were grouped together in the same reading class in order to receive instruction using the System 44 curriculum. The intervention was implemented twice per week as a supplement to the students' reading instruction in their learning support classroom. The 14 students were selected by their reading specialist to participate in the intervention program as part of their supplemental learning support curriculum. The students were selected based upon their SRI Lexile scores and reading errors patterns. All the students obtained a Lexile score within the 1st percentile indicating they were at the BR level and required intensive instruction at the foundational level of reading. The intervention included the use of the READ 180 and System 44 reading programs, in addition to word fluency drills developed based on the McCloskey (2015) model for an executive functions-based word reading intervention.

The READ 180 program focuses on building background knowledge prior to reading, providing opportunities to hear examples of fluent reading as instructional models, giving explicit instruction in vocabulary, presenting lessons in writing skills, and providing differentiated instruction in phonics, spelling, reading fluency, and reading comprehension. Students who are receiving READ 180 instruction are monitored using the SRI, the results of which are reported as Lexile scores (Scholastic Inc., 2005). The System 44 uses SPI assessment to identify students who are lacking decoding skills that also are impeding their reading comprehension. Once students can demonstrate proficiency in decoding, they progress to an alternative reading intervention, such as READ 180 (Scholastic Inc., 2009b).

The word fluency drill technique instructed students to rapidly read words presented to them one at a time. The word fluency drill was an individual practice drill involving one student and a monitor who administered the list and recorded correct and incorrect responses. Words on the drill list were presented to the student one at a time for 1 second on an index card or on a PowerPoint slide. The drill list was created by interspersing known and unknown words in varying proportions. The drill was intended to increase individual engagement and to naturally produce a reinforcing effect when known words were accurately identified (Joseph, 2006). The words used in the fluency drills were derived from the System 44 curriculum. The ratio and pattern of words used in each drill varied, but the same ratios and patterns were used with all participants to maintain consistency and for ease of use of the technique with a relatively large number of students that had to be assessed individually each week.

The 14 students were placed in the same reading group for instruction. They participated in the System 44 program, which included teacher instruction 3 days per week and READ 180 computer-based instruction 2 days per week. In addition to the teacher and computer-based instruction, the students received the word fluency drills as an intervention paralleling the System 44 curriculum content two times per week for 8 weeks. The word fluency drills were developed by the school psychologist who met with the reading specialist at least once per week to review the lesson plans in preparation for the intervention. Throughout the study, the school psychologist observed the students during their System 44 instruction, noted the specific words, letter sounds, and blends that were being practiced in the classroom, and noted areas which the reading specialist placed more emphasis on due to the group's presenting needs. This information was used to assist the school psychologist in selecting the words and letter patterns used in the fluency drills.

The words used in the fluency drills coincided with the System 44 lessons presented each week. The words were selected, grouped, and organized in a specific sequence based upon their orthography. This allowed the students to be exposed to slight letter changes between known and unknown sight words. The order in which the words were presented functioned as a visual cue for the students to attend to the rapid orthographic changes, as a method to improve their oral reading fluency and accuracy.

Prior to the start of the intervention, the students were administered the pre-tests for the SRI; the SPI Sight Word Accuracy, Sight Word Fluency, Nonsense Word Accuracy, and Nonsense Word Fluency; the D-KEFS Color Word Interference Test's (CWT) Word Reading, Inhibition, and Inhibition/Switching conditions; and the PAL-II Rapid Automatic Switching (RAS) subtests. The intervention took place inside the learning support reading classroom, where students were pulled out individually to participate in the word fluency drills presented twice per week for 8 weeks by the school psychologist. The drills were presented as a PowerPoint slide with one word listed per slide. The slides were set to change automatically at a rate of 1 second between slides. At the end of each session, the school psychologist provided corrective feedback and praise to the students individually. Each week, the word lists were updated to reflect the weekly lessons. The sequence of the words changed weekly to introduce new words or letter patterns, and to remove specific words that a majority of the group had mastered.

Following the conclusion of the intervention at the eighth week, the students were administered the SRI post-tests; SPI Sight Word Accuracy, Sight Word Fluency, Nonsense Word Accuracy, and Nonsense Word Fluency; the D-KEFS CWT's Word Reading, Inhibition, and Inhibition/Switching conditions; and the PAL-II RAS subtests. One month after the intervention ended, a second post-test consisting of the SPI Sight Word Accuracy, Sight Word Fluency, Nonsense Word Accuracy, and Nonsense Word Fluency were administered to determine whether the students were able to demonstrate maintenance of the skills in the absence of the intervention.

Measures Used to Evaluate the Effectiveness of the Intervention

Delis-Kaplan Executive Function System (D-KEFS). The D-KEFS is a standardized assessment battery used to assess executive functioning skills in children and adults from ages 8 to 89 years. The D-KEFS consists of nine subtests that measure a vast range of verbal and nonverbal executive functions. Each of the subtests is designed to be used as a stand-alone instrument that can be administered individually or with other D-KEFS subtests (Delis et al., 2001). For the purposes of this study, the D-KEFS Color-Word Interference task was used to gather pre- and post-test measures on the executive functioning skills of inhibition and shifting. In terms of test-retest reliability, completion time on the second testing of the Word Reading subtest was the same for individuals between the ages of 8- and 19-years-old. The scores were slightly higher on the second testing of the Inhibition and Inhibition/Switching subtests, suggesting improved performance in completion time after initial exposure (Delis et al., 2001).

The D-KEFS Color Word Interference test is modeled after the classic Stroop test. This test has four conditions: (a) Color Naming, (b) Word Reading, (c) Inhibition, and (d) Inhibition/Switching; however, only Word Reading, Inhibition, and Inhibition/Switching were used for this study. The Word Reading condition required students to read the names of colors (red, blue, green) printed in black ink as quickly as possible. The words were presented on a single easel page of six rows of words with 10 words in each row. Task performance is translated into a score that represents the amount of time required to complete the task and a score that represents the number of naming errors that are made.

The Inhibition condition required students to read the color of the ink in which each word was printed rather than reading the word (for example, saying “red” when presented with the word “blue” printed in red ink). The words were presented on a single easel page of six rows of words with 10 words in each row. This task requires the use of executive control of word reading to inhibit the natural tendency to read the word and, instead, say the color of the ink. Task performance is translated into a score that represents the amount of time required to complete the task and a score that represents the number of naming errors that are made.

The Inhibition/Switching condition required students to switch back and forth between naming the dissonant ink colors and reading the color-words. This condition requires the students to use their inhibition and shifting skills simultaneously based upon the rules of this task. As with the Inhibition condition, the students were required to name the color of the ink in which the word was printed rather than read the word; however, when the word is written inside a box (rectangle), the student is required to shift and read the word instead of naming the ink color, and then shift back to naming the ink color for the next unboxed word (Delis et al., 2001). The words are presented on a single easel page of six rows of words with 10 words in each row. Task performance is translated into a score that represents the amount of time required to complete the task and a score that represents the number of naming errors that are made.

Process Assessment of the Learner Second Edition Diagnostic Assessment for Reading and Writing (PAL-II RW). The PAL-II RW is designed to measure reading and writing skills and related processes in children in kindergarten through grade 6. For the purposes of this study, only the PAL-II RAS subtest was used. The RAS requires the student to fluently shift mental sets as they rapidly name letters and numbers presented in a random order (Berninger, 2007). The words and numbers are presented on a single easel page of four rows with 12 words and numbers in each row. The PAL-II is normed on students in kindergarten through grade 6. Due to the students being in eighth and ninth grade at the time of the study, their raw scores were converted to scaled scores using the PAL-II RW sixth grade norms. The raw scores were converted to scaled scores in order to make direct comparisons between the other assessment measures used for this study and to make comparisons among the students in the study. Task performance was translated into a score that represents the amount of time required to complete the task and a score that represents the number of naming errors that were made.

Scholastic Phonics Inventory (SPI). The SPI is designed to measure phonological decoding and sight-word reading fluency in students in grades 3 through 12. The SPI can assist educators in determining whether students are lacking foundational reading skills that are contributing to their challenges in reading comprehension. It is used as a guide to determine placements for students needing intense intervention in foundational and basic phonological decoding skills. There are five SPI subtests: Letter Names Accuracy, Sight Words Accuracy, Sight Words Fluency, Nonsense Words Accuracy, and Nonsense Words Fluency. For the purposes of this study, the results of the Sight Words and Nonsense Words Accuracy and Fluency percentages were used. Essentially, the results of the SPI produce scoring trends where educators can directly associate a low Lexile score with low decoding skills in addition to low percentages in word fluency skills (Scholastic Inc., 2009a).

Scholastic Reading Inventory (SRI). The SRI is an adaptive computer assessment used with students in grades kindergarten through grade 12 to determine their reading comprehension level. The SRI uses a Lexile (L) scale to report scores. The Lexile scores indicate the text level at which a student can read and comprehend with at least 75% accuracy before reaching frustration. The scale ranges from less than 100L (Beginning Reader) to 1500L. The SRI assessment is used to identify struggling readers, plan for instructional interventions, monitor progress, and establish goals in reading (Scholastic, Inc., 2001).

Data Analysis

The SPI pre- and post-test 1 and 2 data were analyzed using analyses of variance (ANOVA) for repeated measures to determine whether the students improved their word reading and decoding accuracy and fluency skills. A paired measures *t*-test was used to analyze the pre- and post-test data measures of the students' SRI Lexile scores; D-KEFS Color Word Interference Test Word Reading Speed and Errors, Inhibition Speed and Errors, and Inhibition/Switching Speed and Errors; and the PAL-II RAS. Comparisons were made to determine whether the students improved their overall reading comprehension skills and whether improvements in inhibitory control and shifting were made when presented with tasks that required cognitive flexibility.

Chapter 4: Results

Overview

The primary outcomes included the students' individual performances on the pre- and post-test of the SRI reported as Lexile level scores; SPI Sight Word and Nonsense Word Accuracy and Fluency; D-KEFS Color Word Interference Test's Word Reading Speed and Total Errors, Inhibition Speed and Total Errors, and Inhibition/Switching Speed and Total Errors subtests; and the PAL-II RAS Speed and Total Errors.

Descriptive Statistics

The sample consisted of 13 students in grade 8 and one student in grade 9. Of the 14 students, 6 were female and 8 were male; 12 students were Latino, 1 student was Caucasian, and 1 student was Multiracial. Descriptive statistics for the participants are included in Table 1. All of the participants had been identified previously as students with educational disabilities who were receiving special education services in a public high school. The participants had a history of difficulty with basic reading skills. They struggled with decoding, oral reading accuracy, and fluency. Several participants had dual educational classifications and/or comorbidity of two mental health diagnoses.

Table 2 provides a review of the participants' performance on the reading component of the Pennsylvania System of School Assessment (PSSA) for the past 3 years. Two of the participants, Students 5 and 13, opted-out of taking the PSSAs. The PSSAs were not applicable to Student 3 during the 2014-2015 school year, because he was enrolled in ninth grade. Students 3, 4, and 14 moved into the district from out of state in 2013-2014, resulting in PSSA scores being unavailable for the 2012-2013 school year.

Table 1

Demographic Characteristics of Sample

	n	%
Grade		
8th Grade	13	92.9
9th Grade	1	7.1
Gender		
Females	6	42.9
Males	8	57.1
Ethnicity/Race		
Caucasian	1	7.1
Hispanic/Latino	12	85.7
Multiracial	1	7.1
Age		
13 years-old	4	28.6
14 years-old	6	42.9
15 years-old	3	21.4
16 years-old	1	7.1
Mental Health Diagnosis		
Attention-Deficit/Hyperactivity Disorder	5	35.7
Conduct Disorder	1	7.1
Major Depressive Disorder	4	28.6

Educational Classification		
Autism	1	7.1
Emotional Disturbance	1	7.1
Intellectual Disability	1	7.1
Other Health Impairment	2	14.2
Speech or Language Impairment	1	7.1
Specific Learning Disability	12	85.7
Educational Placement		
Learning Support	13	92.9
Life Skills	1	7.1
Economically Disadvantaged	14	100
English Language Learner	7	50

Table 2

Participants' PSSA Reading Scores

Participant	2012-2013	2013-2014	2014-2015
1	Below Basic 919	Below Basic 807	Below Basic 774
2	Below Basic 824	Below Basic 996	Below Basic 802
3	Unavailable	Below Basic 946	Not Applicable
4	Unavailable	Below Basic 839	Below Basic 793
5	Opt-out	Opt-out	Opt-out
6	Below Basic 824	Below Basic 973	Below Basic 810
7	Below Basic 824	Below Basic 973	Below Basic 731
8	Basic 1187	Below Basic 924	Below Basic 973
9	Below Basic 946	Below Basic 898	Below Basic 810
10	Below Basic 946	Below Basic 730	Below Basic 784
11	Below Basic 877	Below Basic 730	Below Basic 819
12	Below Basic 877	Below Basic 1060	Below Basic 802
13	Opt-out	Opt-out	Opt-out
14	Unavailable	Below Basic 973	Below Basic 802

Table 3 shows the participants' school attendance history for the past three years. It includes the number of absences and tardiness. Students 3, 4, and 14 moved into the district from out of state in 2013-2014; therefore, attendance history for that year is unavailable. Table 4 indicates whether the participants have a history of grade retention and the number of years retained (if applicable), in addition to the length of time the participants had received special education services when the study took place.

Results Related to Research Questions

Research question #1. *Will high school-age students improve their word reading and word decoding fluency and accuracy when they are exposed to a reading intervention program that teaches word reading and word decoding skills and that utilizes techniques intended to increase students' executive function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?*

Tables 5 through 10 show the pre- and post-test score data used to answer Question 1. The measures used included the SPI assessments for Sight Word Accuracy, Sight Word Fluency, Nonsense Word Accuracy and Nonsense Word Fluency. Analyses of variance for repeated measures were conducted for each SPI measure to test for statistical significance. Sight Word Fluency was found to be statistically significant, $F(2, 26) = 3.92$, $p < .05$, partial $\eta^2 = .23$ (See Table 9). The means and standard deviations of the measures analyzed using ANOVA repeated measures are provided in Table 10.

Research question #2. *Will high school-age students improve their reading level when they are exposed to a reading intervention program that teaches word reading and word decoding skills and that utilizes techniques intended to increase students' executive*

Table 3

Participants' School Attendance History

Participant	2012-2013		2013-2014		2014-2015	
1	Absent 8	Tardy 5	Absent 11	Tardy 4	Absent 6	Tardy 27
2	Absent 9	Tardy 4	Absent 12	Tardy 8	Absent 13	Tardy 15
3	Unavailable		Absent 21	Tardy 0	Absent 19	Tardy 0
4	Unavailable		Absent 1	Tardy 2	Absent 2	Tardy 3
5	Absent 4	Tardy 0	Absent 1	Tardy 0	Absent 8	Tardy 57
6	Absent 9	Tardy 6	Absent 7	Tardy 31	Absent 16	Tardy 43
7	Absent 12	Tardy 38	Absent 5	Tardy 2	Absent 15	Tardy 6
8	Absent 4	Tardy 3	Absent 11	Tardy 3	Absent 12	Tardy 43
9	Absent 5	Tardy 3	Absent 3	Tardy 14	Absent 22	Tardy 24
10	Absent 3	Tardy 5	Absent 6	Tardy 1	Absent 1	Tardy 1
11	Absent 8	Tardy 7	Absent 17	Tardy 1	Absent 7	Tardy 12
12	Absent 8	Tardy 6	Absent 11	Tardy 1	Absent 10	Tardy 1
13	Absent 8	Tardy 0	Absent 5	Tardy 0	Absent 1	Tardy 1
14	Unavailable		Absent 1	Tardy 17	Absent 2	Tardy 1

Table 4

Participants' Grade Retention and Special Education Enrollment History

Participant	Number of Years Retained	Number of Years in Special Education
1	Not Applicable	6
2	1	6
3	1	10
4	1	3
5	1	7
6	Not Applicable	4
7	Not Applicable	8
8	Not Applicable	6
9	1	5
10	1	5
11	Not Applicable	3
12	Not Applicable	7
13	1	2
14	Not Applicable	5

Table 5

Participating Students' Scholastic Phonics Inventory Pre- and Post-test Sight Word Accuracy Scores (N = 14)

Student	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
1	60%	43%	63%	-17%	+3%
2	50%	57%	63%	+7%	+13%
3	77%	67%	90%	-10%	+13%
4	80%	93%	83%	+13%	+3%
5	63%	70%	70%	+7%	+7%
6	67%	87%	70%	+20%	+3%
7	57%	63%	53%	+6%	-4%
8	80%	80%	60%	0%	-20%
9	70%	77%	67%	+7%	-3%
10	60%	83%	83%	+23%	+23%
11	43%	47%	53%	+4%	+10%
12	53%	63%	57%	+10%	+4%
13	33%	17%	53%	-16%	+20%
14	80%	80%	87%	0%	+7%

Table 6

Participating Students' Scholastic Phonics Inventory Pre- and Post-test Sight Word Fluency Scores (N = 14)

Student	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
1	3%	20%	10%	+17%	+7%
2	3%	27%	20%	+24%	+17%
3	13%	17%	37%	+4%	+24%
4	37%	47%	30%	+10%	-7%
5	10%	20%	27%	+10%	+17%
6	17%	7%	17%	-10%	0%
7	13%	27%	7%	+14%	-6%
8	23%	27%	17%	+4%	-6%
9	43%	37%	40%	-6%	-3%
10	20%	47%	33%	+27%	+13%
11	7%	10%	13%	+3%	+6%
12	23%	27%	27%	+4%	+4%
13	3%	7%	13%	+4%	+10%
14	30%	30%	40%	0%	+10%

Table 7

Participating Students' Scholastic Phonics Inventory Pre- and Post-test Nonsense Word Accuracy Scores (N = 14)

Student	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
1	70%	33%	67%	-37%	-3%
2	73%	43%	60%	-30%	-13%
3	40%	43%	57%	+3%	+17%
4	80%	87%	80%	+7%	0%
5	60%	40%	43%	-20%	-17%
6	87%	97%	93%	+10%	+6%
7	47%	67%	67%	+20%	+20%
8	30%	60%	33%	+30%	+3%
9	67%	47%	33%	-20%	-34%
10	40%	47%	63%	+7%	+23%
11	57%	40%	70%	-17%	+13%
12	60%	50%	50%	-10%	-10%
13	43%	30%	37%	-13%	-6%
14	73%	73%	80%	0%	+7%

Table 8

Participating Students' Scholastic Phonics Inventory Pre- and Post-test Nonsense Word Fluency Scores (N = 14)

Student	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
1	17%	27%	10%	+10%	-7%
2	7%	23%	17%	+16%	+10%
3	17%	13%	13%	-4%	-4%
4	37%	33%	37%	-4%	0%
5	13%	30%	7%	+17%	-6%
6	17%	17%	30%	0%	+13%
7	0%	30%	10%	+30%	+10%
8	3%	3%	0%	0%	-3%
9	23%	10%	27%	-13%	+4%
10	40%	33%	33%	-7%	-7%
11	13%	33%	10%	+20%	-3%
12	20%	37%	13%	+17%	-7%
13	7%	10%	17%	+3%	+10%
14	27%	43%	27%	+16%	0%

Table 9

Tests of Within-Subjects Effects for Repeated Assessments Using the SPI Sight Word and Nonsense Word Decoding Measures

SPI Measure	Type II Sum of Squares	df	Mean Square	F Value	Significance Level	Partial Eta Squared η^2
Sight Word Accuracy	.023	2	.012	1.366	.273	.095
Sight Word Fluency	.045	2	.022	3.921	.032*	.232
Nonsense Word Accuracy	.026	2	.013	0.865	.433	.062
Nonsense Word Fluency	.044	2	.022	3.274	.054	.201

*Statistically significant at the .05 level

Table 10

*SPI Sight Word and Nonsense Word Decoding Measure Pre-test and Post-test Group Means and Standard Deviations**

	Pre-Test		Post-Test 1		Post-Test 2	
SPI Measure	Mean	SD	Mean	SD	Mean	SD
Sight Word Accuracy	.62	.15	.66	.20	.68	.13
Sight Word Fluency	.18	.13	.25	.13	.24	.11
Nonsense Word Accuracy	.59	.17	.54	.20	.60	.19
Nonsense Word Fluency	.17	.12	.24	.12	.18	.11

*The SPI percent scores were converted to proportions for these analyses.

function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?

Table 11 shows the pre-test and post-test Lexile Level scores obtained from the SRI. These scores were used to answer Question 2. A paired measures *t*-test was conducted for the Lexile Level scores to test for statistical significance. Table 12 shows the results of the paired measures *t*-test. The means and standard deviations of the measures analyzed using the repeated measures *t*-test are provided in Table 13.

Research question #3. *Will students improve their performance of a color-word interference task that requires executive function direction of orthographic processing after exposure to a reading intervention program that utilizes techniques intended to increase students' executive function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?*

Tables 14 through 19 show the pre-test and post-test scores for speed and accuracy obtained from the D-KEFS Color Word Interference Subtest for the Word Reading, Inhibition and Inhibition/Switching Conditions. These scores were used to answer Question 3.

A series of paired measures *t*-tests were conducted for each of the D-KEFS scores to test for statistical significance. The Inhibition Time Scaled Score was found to be statistically significant, t (13) = 2.96, p <.05, d =.56, as was the Inhibition Errors Scaled Score, t (13) = 3.20, p <.01, d =.96. In addition, the Inhibition/Switching Time Scaled Score was found to be statistically significant, t (13) = 5.15, p <.01, d =.84, along with

Table 11

Participating Students' Scholastic Reading Inventory Pre- and Post-test Lexile Levels (N=14)

	Lexile Level		
Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	235	51	-184
2	0	0	0
3	188	212	+24
4	270	117	-153
5	108	290	+182
6	0	446	+446
7	120	124	+4
8	446	491	+45
9	197	253	+56
10	555	504	-51
11	35	213	+178
12	0	0	0
13	0	0	0
14	261	183	-78

Table 12

Results of the Paired Measures t-test for SRI Lexile Level Scores

SPI Measure	Mean Difference	df	Pooled SD	t-Value	Significance Level	Cohen's *D*
Lexile Level	33.5	13	174.48	0.79	.438	.19

Table 13

SRI Lexile Level Score Pre-test and Post-test Group Means and Standard Deviations

	Pre-Test		Post-Test	
SPI Measure	Mean	SD	Mean	SD
Lexile Level	172.5	172.77	206.0	176.17

Table 14

Participating Students' Delis-Kaplan Executive Function System Color Word Interference Test Word Reading Speed Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	7	9	+2
2	7	8	+1
3	8	9	+1
4	11	12	+1
5	1	1	0
6	11	10	-1
7	8	9	+1
8	3	3	0
9	9	8	-1
10	3	6	+3
11	6	7	+1
12	8	8	0
13	1	1	0
14	9	8	-1

Table 15

Participating Students' Delis-Kaplan Executive Function System Color Word Interference Test Word Reading Errors Pre- and Post-test Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	100%	100%	0%
2	20%	2%	-18%
3	100%	100%	0%
4	100%	20%	-80%
5	2%	2%	0%
6	25%	100%	+75%
7	100%	100%	0%
8	100%	100%	0%
9	100%	100%	0%
10	1%	100%	+99%
11	100%	25%	-75%
12	1%	20%	+19%
13	1%	1%	0%
14	100%	2%	-98%

Table 16

Participating Students' Delis-Kaplan Executive Function System Color Word Interference Test Inhibition Speed Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	6	11	+5
2	4	7	+3
3	6	9	+3
4	10	10	0
5	1	1	0
6	10	11	+1
7	6	9	+3
8	1	7	+6
9	11	12	+1
10	3	7	+4
11	4	5	+1
12	11	9	-2
13	7	7	0
14	9	9	0

Table 17

Participating Students' Delis-Kaplan Executive Function System Color Word Interference Test Inhibition Errors Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	3	8	+5
2	1	5	+4
3	11	9	-2
4	6	7	+1
5	1	5	+4
6	11	9	-2
7	7	12	+5
8	2	8	+6
9	12	8	-4
10	2	9	+7
11	5	9	+4
12	6	8	+2
13	1	6	+5
14	1	8	+7

Table 18

Participating Students' Delis-Kaplan Executive Function System Color Word Interference Test Inhibition/Switching Speed Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	6	9	+3
2	3	9	+6
3	9	10	+1
4	10	12	+2
5	1	2	+1
6	7	11	+4
7	7	10	+3
8	3	5	+2
9	9	9	0
10	6	8	+2
11	1	7	+6
12	9	10	+1
13	1	5	+4
14	9	10	+1

Table 19

Participating Students' Delis-Kaplan Executive Function System Color Word Interference Test Inhibition/Switching Errors Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	1	10	+9
2	2	5	+3
3	11	13	+2
4	8	9	+1
5	5	8	+3
6	4	11	+7
7	8	11	+3
8	1	7	+6
9	10	7	-3
10	7	8	+1
11	5	11	+6
12	8	4	-4
13	6	6	0
14	1	3	+2

the Inhibition/Switching Errors Scaled Score, t (13) = 2.65, p <.05, d =.81. See Table 20 for the results of the paired measures *t*-tests. The means and standard deviations of the measures analyzed using the repeated measures *t*-test are provided in Table 21.

Research question #4. *Will high school-age students improve their performance of a rapid automatic switching task that requires executive function direction of orthographic processing after exposure to a reading intervention program that utilizes techniques intended to increase students' executive function capacity for attention to orthography and their executive function capacity for shifting from rapid sight word recognition to decoding when necessary?*

Tables 22 and 23 show the pre- and post-test scores for speed and accuracy obtained from the PAL-II Rapid Automatic Switching Subtest. These scores were used to answer Question 4. Paired measures *t*-tests were conducted for the PAL-II Rapid Automatic Switching Time Scaled score and the Number of Errors Raw Score to test for statistical significance. Table 24 shows the results of the paired measures *t*-tests. The means and standard deviations of the PAL-II Rapid Automatic Switching scores analyzed using the repeated measures *t*-tests are provided in Table 25.

Research question #5. *What insights can be gained about student participation in the intervention by examining each student's background and their individual profile of pre- and post-test scores?*

All of the participants were influenced by the intervention in various ways. Below is a summary of the participants' educational backgrounds, performances during the intervention, and possible suggestions as to how their results may have been related to their history.

Table 20

Results of the Paired Measures t-test for the D-KEFS Color-Word Interference Subtest Conditions Score

D-KEFS Subtest Condition	Mean Difference (Post – Pre)	df	Pooled SD	t-Value	Significance Level	Cohen's *D*
Word Reading Time Scaled Score	.50	13	3.31	1.61	.131	.16
Word Reading Errors Proportion	-.06	13	0.48	-0.39	.703	.13
Inhibition Time Scaled Score	1.79	13	3.17	2.96	.011*	.56
Inhibition Errors Scaled Score	3.00	13	3.14	3.20	.007*	.96
Inhibition/Switching Time Scaled Score	2.57	13	3.07	5.15	.000*	.84
Inhibition/Switching Errors Scaled Score	2.57	13	3.17	2.65	.020*	.8

*Statistically significant at the .05 level

Table 21

D-KEFS Color-Word Interference Subtest Condition Scores Pre-test and Post-test Group Means and Standard Deviations

D-KEFS Subtest Condition	Pre-Test		Post-Test	
	Mean	SD	Mean	SD
Word Reading Time Scaled Score	6.57	3.35	7.07	3.27
Word Reading Errors Proportion	0.61	0.48	0.55	0.47
Inhibition Time Scaled Score	6.36	3.48	8.14	2.83
Inhibition Errors Scaled Score	4.93	4.05	7.93	1.82
Inhibition/Switching Time Scaled Score	5.79	3.36	8.36	2.74
Inhibition/Switching Errors Scaled Score	5.50	3.37	8.07	2.95

Table 22
Participating Students' Process Assessment of the Learner, Second Edition Rapid Automatic Switching Speed Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	8	8	0
2	9	9	0
3	14	9	-5
4	12	14	+2
5	1	5	+4
6	15	11	-4
7	7	9	+2
8	7	7	0
9	10	10	0
10	11	5	-6
11	5	7	+2
12	11	8	-3
13	1	1	0
14	9	12	+3

*Sixth grades norms were used to convert raw scores to scaled scores

Table 23

Participating Students' Process Assessment of the Learner, Second Edition Rapid Automatic Switching Total Errors Pre- and Post-test Scaled Scores (N = 14)

Student	Pre-Intervention	Post-Intervention	Post-Pre Difference
1	1	0	-1
2	2	0	-2
3	0	1	+1
4	0	0	0
5	1	3	+2
6	0	0	0
7	1	0	-1
8	7	2	-5
9	2	2	0
10	1	1	0
11	3	1	-2
12	1	2	+1
13	14	6	-8
14	1	1	0

*Sixth grades norms were used to convert raw scores to scaled scores

Table 24

Results of the Paired Measures t-test for the PAL-II Rapid Automatic Switching Subtest Scores

PAL-II RAS Subtest Score	Mean Difference (Post – Pre)	df	Pooled SD	t-Value	Significance Level	Cohen's *d*
Rapid Automatic Switching Time	-.36	13	3.75	0.49	.669	.10
Rapid Automatic Switching Errors	-1.07	13	2.92	1.53	.149	.37

Table 25

PAL-II Rapid Automatic Switching Scores Pre-test and Post-test Group Means and Standard Deviations

PAL-II Subtest Score	Pre-Test		Post-Test	
	Mean	SD	Mean	SD
Rapid Automatic Switching Time	8.57	4.20	8.21	3.24
Rapid Automatic Switching Errors	0.61	0.48	0.55	0.47

Student 1. Student 1 was a 14-year-old eighth grade female at the time of the study. She was identified as an economically disadvantaged student and an ELL. She was initially referred for special education in second grade due to her difficulty with blending and decoding of words, poor reading comprehension, and limited gains in her DIBELS scores. She had been receiving special education services since second grade. She has an educational classification of Specific Learning Disability (SLD) in basic reading skills, reading comprehension, and oral reading fluency. She has performed consistently within the Below Basic range on the PSSA Reading assessment. At the time of the initial study, she participated regularly in a supplemental learning support placement for all of her major subject areas. Her teachers reported that she displayed inconsistencies in her classroom performance. She often appeared uninterested in classwork, as evidenced by leaning her head down on the desk and isolating herself in the classroom. Other times, Student 1 was observed as being overly active. This was demonstrated by her pacing, walking around in circles around the classroom, and her inability to sit in her seat for longer than a few minutes. She responded appropriately to teacher redirection and reminders, and participated in class when called upon. In terms of post-secondary transition, Student 1 indicated a goal of joining the military.

Student 1's results indicated an overall decrease in her SRI Lexile scores. A decline in performance was seen in her SPI Sight Word Accuracy during the first post-test; however, scores slightly improved during the second post-test. Her overall SPI Sight Word Fluency increased. Student 1's SPI Nonsense Word Accuracy did not improve. Her performance on the SPI Nonsense Word Fluency was inconsistent with improvements during the first post-test and then a regression during the second post-test.

Student 1's overall D-KEFS performance showed improvements in Word Reading Speed, Inhibition Speed and Errors, and Inhibition/Switching Speed and Errors. She maintained her performance of zero errors on the Word Reading subtest. Student 1 showed progress in her executive functions as measured by the D-KEFS. No progress was made within the RAS score. See Table 26 for an overview of Student 1.

Student 2. Student 2 was a 14-year-old eighth grade female when the intervention took place. Student 2 was born in Puerto Rico, where she also attended kindergarten and first grade prior to relocating to the northeastern United States. She repeated first grade when she moved into the district. The primary language spoken in her home is Spanish and she received ELL services. Student 2 was identified with an SLD in written expression, basic reading skills, reading comprehension, and oral reading fluency in second grade. Her PSSA results have reflected consistently Below Basic performance in reading. She was receiving supplemental learning support for all of her core subject areas. Her teachers reported she has difficulty maintaining her attention, is easily distracted, and fails to complete homework and make-up work when she is absent. Student 2 did not report having post-secondary goals at the time of the study.

Student 2's results show continued poor performance on the SRI Lexile Level with a score of zero. Nevertheless, increased performance was seen in her SPI Word Accuracy and Fluency consistently between pre-test, post-test 1, and post-test 2. In the area of SPI Nonsense Word Accuracy and Fluency, Student 2 did not show improvements in accuracy but speed increased consistently over time. Within the area of executive functions, there was a slight increase in her Word Reading Speed, but she made more frequent errors. Her overall ability to inhibit and shift improved. As her speed

Table 26

Pre- and Post- Intervention Score Profile for Student 1

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	235	51		-184	
SPI Sight Word Accuracy	60%	43%	63%	-17%	+3%
SPI Sight Word Fluency	3%	20%	10%	+17%	+7%
SPI Nonsense Word Accuracy	70%	33%	67%	-37%	-3%
SPI Nonsense Word Fluency	17%	27%	10%	+10%	-7%
D-KEFS Word Reading Speed	7	9		+2	
D-KEFS Word Reading Errors	100%	100%		0%	
D-KEFS Inhibition Speed	6	11		+5	
D-KEFS Inhibition Errors	3	8		+5	
D-KEFS Inhibition/Switching Speed	6	9		+3	
D-KEFS Inhibition/Switching Errors	1	10		+9	
PAL-II RAS Speed	8	8		0	
PAL-II RAS Errors	1	0		-1	

increased, she continued to maintain her attention to changes in the stimuli resulting in fewer errors. No improvements were seen in her RAS scores. See Table 27 for an overview of Student 2.

Student 3. Student 3 was a Caucasian male who was 16 years old and in a ninth-grade supplemental life skills program during the time of this study. He was diagnosed with autism and participates in two learning support classes per day, reading and pre-algebra. He shared an interest in attending vocational school after completing high school, with the ultimate goal of pursuing a career in industrial construction. He previously received early intervention services as a young child due to speech delays. He has a history of trauma and abuse, which caused him to move and change schools frequently. His educational records indicate he was retained in first grade. Student 3 enrolled in the district during the 2013-2014 school year after moving from Arkansas. He demonstrated adequate word recognition, but struggled with reading fluency and comprehension. His teachers indicated that he is impulsive, disorganized, and has difficulty shifting his intentions between known and novel concepts. He reportedly struggled to inhibit his impulsive responses to questions and tasks in the classroom without allowing his teacher to finish asking questions or giving directions. This would result in Student 3 making frequent careless errors that are reflected in his overall classroom performance.

Student 3's results demonstrated an increase in his SRI Lexile Level. He showed a decline in his post-test 1 performance on the SPI Sight Word Accuracy, but was able to improve his longstanding performance as measured by post-test 2. He continued to show improvements in his SPI Sight Word Fluency with a 20% increase

Table 27

Pre- and Post- Intervention Score Profile for Student 2

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	0	0		0	
SPI Sight Word Accuracy	50%	57%	63%	+7%	+13%
SPI Sight Word Fluency	3%	27%	20%	+24%	+17%
SPI Nonsense Word Accuracy	73%	43%	60%	-30%	-13%
SPI Nonsense Word Fluency	7%	23%	17%	+16%	+10%
D-KEFS Word Reading Speed	7	8		+1	
D-KEFS Word Reading Errors	20%	2%		-18%	
D-KEFS Inhibition Speed	4	7		+3	
D-KEFS Inhibition Errors	1	5		+4	
D-KEFS Inhibition/Switching Speed	3	9		+6	
D-KEFS Inhibition/Switching Errors	2	5		+3	
PAL-II RAS Speed	9	9		0	
PAL-II RAS Errors	2	0		-2	

between post-test 1 and post-test 2. Although his SPI Sight Word Accuracy post-tests were inconsistent, his Nonsense Word Accuracy improved. Student 3's SPI Nonsense Word Fluency decreased with consistent scores between post-test 1 and post-test 2. He may have slightly reduced his speed in order to increase his attention to the orthography of the nonsense words. Student 3's D-KEFS Word Reading Speed improved slightly, and he was able to maintain errorless performance. He demonstrated improvements in inhibition speed, but made more errors. He showed some progress in his ability to inhibit and shift based upon improvements in speed and fewer errors. He struggled with maintaining speed when shifting between letters and numbers on the RAS but showed a small increase in reducing his errors when shifting. See Table 28 for an overview of Student 3.

Student 4. Student 4 was a male ELL student who was 14 years old when he participated in the study. He moved to the district during the 2013-2014 school year from New York, where he initially received special education services. He was identified with an SLD in reading comprehension and basic reading skills. He was unable to read independently for more than 2 to 3 minutes. He demonstrated poor decoding and comprehension skills. Student 4 often skipped words or interchanged letter sounds while reading. In addition to an SLD classification, he was identified with a Speech or Language Impairment. He struggled with receptive and expressive language skills. His PSSA performance in reading fell within the Below Basic range. At the time of the initial study, he did not have difficulty attending school regularly based upon his attendance records. Student 4 did not identify a post-secondary career interest or goal at the time of the study.

Table 28

Pre- and Post- Intervention Score Profile for Student 3

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	188	212		+24	
SPI Sight Word Accuracy	77%	67%	90%	-10%	+13%
SPI Sight Word Fluency	13%	17%	37%	+4%	+24%
SPI Nonsense Word Accuracy	40%	43%	57%	+3%	+17%
SPI Nonsense Word Fluency	17%	13%	13%	-4%	-4%
D-KEFS Word Reading Speed	8	9		+1	
D-KEFS Word Reading Errors	100%	100%		0%	
D-KEFS Inhibition Speed	6	9		+3	
D-KEFS Inhibition Errors	11	9		-2	
D-KEFS Inhibition/Switching Speed	9	10		+1	
D-KEFS Inhibition/Switching Errors	11	13		+2	
PAL-II RAS Speed	14	9		-5	
PAL-II RAS Errors	0	1		+1	

Student 4's results revealed a decline in his SRI Lexile Level. Overall, he showed improvements in his SPI Sight Word Accuracy. He showed greater improvements during the first post-test of the SPI Word Fluency, and his performance declined by 10 points after a prolonged absence from the interventions, as measured by the second post-test. Student 4's SPI Nonsense Word Accuracy increased during the first post-test with a decrease in speed, but no differences were noted for both measures on post-test 2. In terms of the D-KEFS Word Reading, Student 4 showed a slight increase in speed, but a drastic decline in his error performance. When required to manage his impulses, no changes were seen in his Inhibition speed, but there was a slight improvement in his ability to regulate his impulses by demonstrating fewer errors. His results showed an increase in his Inhibition/Switching Speed and Error scores, which was consistent with his RAS Speed performance. No changes were noted in his RAS Error scores. Student 4 displayed an overall improvement in his ability to switch between stimuli. See Table 29 for an overview of Student 4.

Student 5. Student 5 was a multiracial female student identified with an SLD in basic reading skills, reading comprehension, and oral reading fluency. She was 13 years old and in eighth grade at the time of the study. Student 5 noted an interest in the field of nursing or social work as a post-secondary career. During the first-grade school year, she moved to the district from Connecticut. She was evaluated in first grade due to retention, and was found eligible for special education services. Her teacher reported that she struggles with fluency and has below average processing speed. She required extended time for of her in-class work, as well as for tests and quizzes. Her decoding skills were

Table 29

Pre- and Post- Intervention Score Profile for Student 4

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	270	177		-153	
SPI Sight Word Accuracy	80%	93%	83%	+13%	+3%
SPI Sight Word Fluency	37%	47%	30%	+10%	-7%
SPI Nonsense Word Accuracy	80%	87%	80%	+7%	0%
SPI Nonsense Word Fluency	0.37	0.33	0.37	-4%	0%
D-KEFS Word Reading Speed	11	12		+1	
D-KEFS Word Reading Errors	100%	20%		-80%	
D-KEFS Inhibition Speed	10	10		0	
D-KEFS Inhibition Errors	6	7		+1	
D-KEFS Inhibition/Switching Speed	10	12		+2	
D-KEFS Inhibition/Switching Errors	8	9		+1	
PAL-II RAS Speed	12	14		+2	
PAL-II RAS Errors	0	0		0	

subpar and she had significant difficulty with spelling and identifying new words and vocabulary.

Student 5's results indicated an increase in her SRI Lexile Level, with improvements in her overall SPI Sight Word Accuracy and Fluency. Within the area of SPI Nonsense Word Accuracy, she struggled to make progress with a continued regression in post-test 1 and post-test 2 scores. Her initial post-test performance on the SPI Nonsense Word Fluency increased, but declined after an extended absence from the intervention as measured by her post-test 2. No changes in performance were seen in Student 5's D-KEFS Word Reading Speed or Errors. She showed improvements in her Inhibition Errors, and maintained her initial speed from pre-test. She demonstrated an increase in her ability to shift quickly with fewer errors, as indicated in her Inhibition/Switching and RAS Speed and Error scores. See Table 30 for an overview of Student 5.

Student 6. Student 6 was 14 years old at the time of the study. He was born in Puerto Rico and resided in New York until he was 8 years old. He then moved to the district and was evaluated for special education services in fourth grade, and was found eligible with an SLD in reading comprehension. The primary language spoken in his home was Spanish and he was identified as an ELL student. He has diagnoses of attention-deficit/hyperactivity disorder (ADHD) and conduct disorder, and received psychopharmacological treatment during the study. Student 6 participated in supplemental learning support. His teachers reported he was a slow reader and struggled with classroom performance. Generally, he handed in incomplete assignments and refused to do class work. He performed within the Below Basic range in reading on the

Table 30

Pre- and Post- Intervention Score Profile for Student 5

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	108	290		+182	
SPI Sight Word Accuracy	63%	70%	70%	+7%	+7%
SPI Sight Word Fluency	10%	20%	27%	+10%	+17%
SPI Nonsense Word Accuracy	60%	40%	43%	-20%	-17%
SPI Nonsense Word Fluency	13%	30%	7%	+17%	-6%
D-KEFS Word Reading Speed	1	1		0	
D-KEFS Word Reading Errors	2%	2%		0	
D-KEFS Inhibition Speed	1	1		0	
D-KEFS Inhibition Errors	1	5		+4	
D-KEFS Inhibition/Switching Speed	1	2		+1	
D-KEFS Inhibition/Switching Errors	5	8		+3	
PAL-II RAS Speed	1	5		+4	
PAL-II RAS Errors	1	3		+2	

PSSAs. At the time of the study, Student 6 did not indicate a post-secondary career interest.

Student 6's outcomes indicated a substantial increase in his SRI Lexile Level. He showed improvements in his SPI Sight Word Accuracy, with post-test 1 being greater than his post-test 2 performance. With the increase in accuracy, his SPI Sight Word Fluency decreased during post-test 1 and remained the same as the pre-test during post-test 2. His total SPI Nonsense Word Accuracy and Fluency progressed. Although there was a slight decrease in his D-KEFS Word Reading Speed by one scaled score, his ability to reduce his errors increased drastically by 75 percent. His Inhibition speed increased, but he displayed more errors, resulting in a decline in his post-test. Student 6's Inhibition/Switching Speed and Errors improved during the course of the study. His ability to shift quickly between letters and numbers regressed on the RAS subtest. See Table 31 for an overview of Student 6.

Student 7. Student 7 was a 13-year-old eighth grade female participating in supplemental learning support when the study took place. She reported a post-secondary career interest in the area of nursing. She was evaluated initially in kindergarten for special education services and was identified with an education classification of SLD in basic reading skills and reading comprehension, in addition to Emotional Disturbance (ED). She has diagnoses of ADHD and major depressive disorder (MDD) and received therapy and psychopharmacological treatment at the time of the study. Student 7 experienced depression and anxiety at home and school. She reported concerns about her grades and being "nervous" before tests. She was anxious about her home life and family, likely due to her history of separation and abandonment. She reported

Table 31

Pre- and Post- Intervention Score Profile for Student 6

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	0	446		+446	
SPI Sight Word Accuracy	67%	87%	70%	+20%	+3%
SPI Sight Word Fluency	17%	7%	17%	-10%	0
SPI Nonsense Word Accuracy	87%	97%	93%	+10%	+6%
SPI Nonsense Word Fluency	17%	17%	30%	0	+13%
D-KEFS Word Reading Speed	11	10		-1	
D-KEFS Word Reading Errors	25%	100%		+75%	
D-KEFS Inhibition Speed	10	11		+1	
D-KEFS Inhibition Errors	11	9		-2	
D-KEFS Inhibition/Switching Speed	7	11		+4	
D-KEFS Inhibition/Switching Errors	4	11		+7	
PAL-II RAS Speed	15	11		-4	
PAL-II RAS Errors	0	0		0	

experiencing self-injurious ideations. She saw her school counselor on a regular basis. In terms of academics, Student 7 struggled with maintaining motivation, organizing school materials, following multi-step sequences, decoding, spelling words, and composing written sentences.

Student 7's scores indicated a small increase in her SRI Lexile Level. She initially made some progress on her SPI Sight Word Accuracy and Fluency at post-test 1, but then regressed slightly on post-test 2. Her overall performance increased on the SPI Nonsense Word Accuracy and Fluency measures. She improved her D-KEFS Word Reading Speed by one scaled score and continued to display errorless performance in this area between post-tests 1 and 2. Her Inhibition and Switching performances resulted in increased speed and reduction in errors. Student 7 demonstrated an ability to manage her impulses while attending to and shifting her responses to the changing demands on the tasks. Her speed on the RAS improved, but she made more errors. See Table 32 for an overview of Student 7.

Student 8. Student 8 was 14 years old when he participated in the study. He was originally referred for special education services in second grade. He had an educational classification of SLD in basic reading skills, reading comprehension, and written expression, and Other Health Impairment (OHI). He was diagnosed with ADHD and MDD. Student 8 was not actively receiving treatment during the time of the study. He was described as shy and timid. He struggled with maintaining attention, was forgetful of school assignments, and lacked motivation. He participated in a supplemental learning support placement with a low teacher-to-student ratio. He performed in the Basic to

Table 32

Pre- and Post- Intervention Score Profile for Student 7

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	120	124		+4	
SPI Sight Word Accuracy	57%	63%	53%	+6%	-4%
SPI Sight Word Fluency	13%	27%	7%	+14%	-6%
SPI Nonsense Word Accuracy	47%	67%	67%	+20%	+20%
SPI Nonsense Word Fluency	0%	30%	10%	+30%	+10%
D-KEFS Word Reading Speed	8	9		+1	
D-KEFS Word Reading Errors	100%	100%		0	
D-KEFS Inhibition Speed	6	9		+3	
D-KEFS Inhibition Errors	7	12		+5	
D-KEFS Inhibition/Switching Speed	7	10		+3	
D-KEFS Inhibition/Switching Errors	8	11		+3	
PAL-II RAS Speed	7	9		+2	
PAL-II RAS Errors	1	0		-1	

Below Basic range on the reading component of the PSSAs. In terms of post-secondary goals, Student 8 shared he would like to attend a vocational school for graphic design.

Student 8's outcomes showed some improvement in his SRI Lexile Level; however, no progress was noted in his SPI Sight Word Accuracy post-test 1. He regressed during post-test 2. A slight improvement was seen in his SPI Sight Word Fluency post-test 1, but it was not maintained for post-test 2. Student 8 made progress in his Nonsense Word Accuracy with greater improvements seen immediately following the intervention in post-test 1. Student 8 demonstrated minimal progress on the SPI Nonsense Word Fluency. His D-KEFS Word Reading Speed and Error scores were consistent between pre- and post-test. He made overall improvements in his Inhibition and Inhibition/Switching Speed and Error scores. His RAS speed remained the same; however, he made more errors during the post-test, resulting in a decline in his scores. See Table 33 for an overview of Student 8.

Student 9. Student 9 was a 15-year-old eighth grade male at the time of the study. He was identified with an SLD in basic reading skills, reading comprehension, and written expression in third grade after being retained. He was diagnosed with ADHD and was not receiving treatment when the study took place. Student 9 had deficits in working memory and struggled with planning and organizational skills. His previous PSSA performances indicated scores in reading within the Below Basic range. He has a history of poor school attendance due to family and housing problems. Student 9 shared an interest in joining the military once he completes high school.

Student 9's results showed an increase in his SRI Lexile Level. He demonstrated an initial increase in his SPI Sight Word Accuracy performance on post-test 1, but then

Table 33

Pre- and Post- Intervention Score Profile for Student 8

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	446	491		+45	
SPI Sight Word Accuracy	80%	80%	60%	0%	-20%
SPI Sight Word Fluency	23%	27%	17%	+4%	-6%
SPI Nonsense Word Accuracy	30%	60%	33%	+30%	+3%
SPI Nonsense Word Fluency	3%	3%	0%	0%	-3%
D-KEFS Word Reading Speed	3	3		0	
D-KEFS Word Reading Errors	100%	100%		0%	
D-KEFS Inhibition Speed	1	7		+6	
D-KEFS Inhibition Errors	2	8		+6	
D-KEFS Inhibition/Switching Speed	3	5		+2	
D-KEFS Inhibition/Switching Errors	1	7		+6	
PAL-II RAS Speed	7	7		0	
PAL-II RAS Errors	7	2		-5	

regressed on post-test 2. A decrease in performance was noted on the SPI Sight Word Fluency and Nonsense Word Accuracy measures. He declined initially on the SPI Nonsense Word Fluency post-test 1, but then improved slightly on post-test 2. His D-KEFS Word Reading Speed fell one scaled score, but his performance remained errorless. A small improvement was seen in his Inhibition speed, but he produced more errors. No differences were noted in his Inhibition/Switching speed, but he continued to make more mistakes. His RAS performance remained the same between pre- and post-test. See Table 34 for an overview of Student 9.

Student 10. Student 10 was 15 years old when he participated in the study. He was retained in second grade, which prompted an evaluation for special education services. He had an educational classification of SLD in reading comprehension and math problem solving. He was an economically disadvantaged student who also received ELL services on a consultative basis. Student 10 had adequate school attendance, only being absent once during the 2014-2015 school year. He performed consistently within the Below Basic range in reading on with PSSAs. His teachers reported that he completed class work in a timely manner and often asked questions in class. He put forth effort in his classes and remained motivated despite his challenges in reading. Student 10 shared he has a career interest in the automotive industry after completing high school.

Student 10's results indicated a decline in his SRI Lexile Level, but he demonstrated progress on the SPI Sight Word Accuracy and Fluency and Nonsense Word Accuracy from pre-test to post-tests 1 and 2. His post-tests 1 and 2 of the SPI Nonsense Word Fluency remained the same, indicating a regression of 7% from his post-test 1 performance. Student 10's D-KEFS Word Reading Speed and Error scores increased, in

Table 34

Pre- and Post- Intervention Score Profile for Student 9

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	197	253		+56	
SPI Sight Word Accuracy	70%	77%	67%	+7%	-3%
SPI Sight Word Fluency	43%	37%	40%	-6%	-3%
SPI Nonsense Word Accuracy	67%	47%	33%	-20%	-34%
SPI Nonsense Word Fluency	23%	10%	27%	-13%	+4%
D-KEFS Word Reading Speed	9	8		-1	
D-KEFS Word Reading Errors	100%	100%		0%	
D-KEFS Inhibition Speed	11	12		+1	
D-KEFS Inhibition Errors	12	8		-4	
D-KEFS Inhibition/Switching Speed	9	9		0	
D-KEFS Inhibition/Switching Errors	10	7		-3	
PAL-II RAS Speed	10	10		0	
PAL-II RAS Errors	2	2		0	

addition to his ability to inhibit and shift quickly with fewer errors. When presented with a combination of letters and numbers, he struggled to quickly switch between them. See Table 35 for an overview of Student 10.

Student 11. Student 11 was a 13-year-old eighth grade female at the time of the study. She was an ELL student who was identified with an SLD in reading comprehension and oral reading fluency in fifth grade. She was diagnosed with MDD and was not receiving treatment at the time of the study. Her PSSA performance in reading was within the Below Basic range. She struggled with maintaining motivation in the classroom, and was defiant when frustrated with academic tasks. She required extended time for all in-class assignments, quizzes, and tests due to poor academic fluency. Student 11 participated in a supplemental learning support setting for her major classes. She had an interest in pursuing culinary arts post high school.

Student 11's outcomes revealed a drastic increase in her SRI Lexile Level. She continued to make progress on the SPI Sight Word Accuracy and Fluency measures. Her performance on the SPI Nonsense Word Accuracy and Fluency was inconsistent. In the area of Word Accuracy, she regressed initially at post-test 1, and then showed improvements in post-test 2. The opposite occurred on the Word Fluency measure, where she made progress initially on post-test 1, but then regressed on post-test 2. Student 11's ability to attend to orthographic changes improved when she reduced her speed. Her D-KEFS Word Reading Speed Slightly improved, but resulted in more errors by 75%. She made progress in her overall Inhibition and Inhibition/Switching Speed and Errors. Her performance on the RAS indicates her ability to shift between letters and

Table 35

Pre- and Post- Intervention Score Profile for Student 10

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	555	504		-51	
SPI Sight Word Accuracy	60%	83%	83%	+23%	+23%
SPI Sight Word Fluency	20%	47%	33%	+27%	+13%
SPI Nonsense Word Accuracy	40%	47%	63%	+7%	+23%
SPI Nonsense Word Fluency	40%	33%	33%	-7%	-7%
D-KEFS Word Reading Speed	3	6		+3	
D-KEFS Word Reading Errors	1%	100%		99%	
D-KEFS Inhibition Speed	3	7		+4	
D-KEFS Inhibition Errors	2	9		+7	
D-KEFS Inhibition/Switching Speed	6	8		+2	
D-KEFS Inhibition/Switching Errors	7	8		+1	
PAL-II RAS Speed	11	5		-6	
PAL-II RAS Errors	1	1		0	

number quickly improved, but she made more errors when not attending to the changes. See Table 36 for an overview of Student 11.

Student 12. Student 12 was 14 years old at the time of the study. He was diagnosed with ADHD and was not receiving treatment at the time of the study. He reported an interest in automotive mechanics once he completes high school. He was evaluated previously in first grade and was found to be exceptional with an SLD in reading comprehension and OHI. He performed within the Below Basic range on the PSSA reading tests. He received supplemental learning support services when the study took place. He had difficulty focusing in the classroom, was often distracted, and frequently made careless errors on assignments and tests. Student 12 was very impulsive and disruptive in his classes. His defiant behavior had become increasingly prominent, demonstrated by his refusal to complete work. He struggled with reading comprehension and oral reading accuracy. He frequently made word addition errors when orally reading passages.

Student 12's results indicated no progress on his SRI Lexile Level, with a consistent score of zero. He made progress on the SPI Sight Word Accuracy and Fluency measures, with the most improvement seen in his post-test 1 performance on Sight Word Accuracy. He regressed consistently on the SPI Nonsense Word Accuracy by maintaining a score difference of 10% on post-tests 1 and 2. His Nonsense Word Fluency increased initially on post-test 1; however, it declined during post-test 2 after a prolonged absence from the interventions. His D-KEFS Word Reading Speed remained the same, but he improved his errors by 19%. Student 12's Inhibition Speed score decreased, but he made fewer errors, resulting in a slight improvement in his scores. This was similar to

Table 36

Pre- and Post- Intervention Score Profile for Student 11

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	35	213		+178	
SPI Sight Word Accuracy	43%	47%	53%	+4%	+10%
SPI Sight Word Fluency	7%	10%	13%	+3%	+6%
SPI Nonsense Word Accuracy	57%	40%	70%	-17%	+13%
SPI Nonsense Word Fluency	13%	33%	10%	+20%	-3%
D-KEFS Word Reading Speed	6	7		+1	
D-KEFS Word Reading Errors	100%	25%		-75%	
D-KEFS Inhibition Speed	4	5		+1	
D-KEFS Inhibition Errors	5	9		+4	
D-KEFS Inhibition/Switching Speed	1	7		+6	
D-KEFS Inhibition/Switching Errors	5	11		+6	
PAL-II RAS Speed	5	7		+2	
PAL-II RAS Errors	3	1		-2	

his performance on the RAS. In the area of Inhibition/Switching, his speed increased; however, he made more mistakes. See Table 37 for an overview of Student 12.

Student 13. Student 13 was a 15-year-old, eighth grade ELL female when she participated in the study. She was born in the Dominican Republic, where she resided until she was 11 years old. She and her family relocated to the United States, and she began formal schooling in the district. She was retained in fifth grade, and was referred for special education services in sixth grade. She was evaluated by a district bilingual school psychologist who found her exceptionally low on English and Spanish versions of the cognitive assessments, in addition to having poor adaptive skills. She was identified as a student with an Intellectual Disability (ID). She was opted out of the PSSA reading tests due to limited language proficiency. She demonstrated poor sound to symbol correspondence, decoding, and blending skills. She made significant gains in the area of math calculations. Given her lack of formal education and exposure prior to fifth grade, her reading specialist recommended that she participate in the current study in order to receive additional reading support. Student 13 shared that she has an interest in culinary arts and would like to pursue a career as a chef after high school.

Student 13's outcomes showed no increased performance on the SRI Lexile Levels. During post-test 1 of the SPI Sight Word Accuracy measure, Student 13 showed a decline in her scores, but was able to make improvements on post-test 2 by 20%. She showed consistent progress on the SPI Sight Word and Nonsense Word Fluency scores. Her Nonsense Word Accuracy performance showed regression from her pre-test scores. No changes were seen in her D-KEFS Word Reading Speed or Errors. Her Inhibition Speed remained the same but revealed improvements in reducing errors. During the

Table 37

Pre- and Post- Intervention Score Profile for Student 12

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	0	0		0	
SPI Sight Word Accuracy	53%	63%	57%	+10%	+4%
SPI Sight Word Fluency	23%	27%	27%	+4%	+4%
SPI Nonsense Word Accuracy	60%	50%	50%	-10%	-10%
SPI Nonsense Word Fluency	20%	37%	13%	+17%	-7%
D-KEFS Word Reading Speed	8	8		0	
D-KEFS Word Reading Errors	1%	20%		+19%	
D-KEFS Inhibition Speed	11	9		-2	
D-KEFS Inhibition Errors	6	8		+2	
D-KEFS Inhibition/Switching Speed	9	10		+1	
D-KEFS Inhibition/Switching Errors	8	4		-4	
PAL-II RAS Speed	11	8		-3	
PAL-II RAS Errors	1	2		+1	

Inhibition/Switching subtest, her speed increased, but she produced the same amount of errors from pre-test. Student 13's speed in shifting between letters and numbers remained the same, but she produced more errors during the post-test administration of the RAS. See Table 38 for an overview of Student 13.

Student 14. Student 14 was 13 years old at the time of the study. He was born in New York and attended kindergarten through fourth grade in Tennessee. He moved to Pennsylvania during his fifth-grade year. He previously received special education services in Tennessee starting in grade 3 and later was evaluated by the current district. He was found to have an educational classification of SLD in reading comprehension. He performed within the Below Basic range in reading on the PSSAs. He was diagnosed with MDD and had a history of intermittent schooling due to admissions in psychiatric inpatient and partial hospital programs since fifth grade. He struggled with maintaining attention and regulating emotions in the classroom. He became distracted easily and failed to attend to details when reading, which led to frequent word errors. Student 14 did not indicate a post-secondary career interest or goal at the time of the study.

Student 14's results indicated a regression in his SRI Lexile Levels. He made limited progress on the SPI Sight Word Accuracy and Fluency and Nonsense Word Accuracy measures. His Nonsense Word Fluency performance showed initial progress during post-test 1, but he did not maintain progress during post-test 2. Student 14's post-test 2 score returned to his baseline. A decrease in speed on the D-KEFS Word Reading subtest also showed a 98% drop in his error performance. With the decrease in speed, he made more frequent errors during the post-test. No changes were noted in his Inhibition Speed; however, he made progress in reducing his number of errors during the task.

Table 38

Pre- and Post- Intervention Score Profile for Student 13

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	0	0		0	
SPI Sight Word Accuracy	33%	17%	53%	-16%	+20%
SPI Sight Word Fluency	3%	7%	13%	+4%	+10%
SPI Nonsense Word Accuracy	43%	30%	37%	-13%	-6%
SPI Nonsense Word Fluency	7%	10%	17%	+3%	+10%
D-KEFS Word Reading Speed	1	1		0	
D-KEFS Word Reading Errors	1%	1%		0%	
D-KEFS Inhibition Speed	7	7		0	
D-KEFS Inhibition Errors	1	6		+5	
D-KEFS Inhibition/Switching Speed	1	5		+4	
D-KEFS Inhibition/Switching Errors	6	6		0	
PAL-II RAS Speed	1	1		0	
PAL-II RAS Errors	14	6		-8	

Consistently, his Inhibition/Switching Speed and Errors showed a slight improvement. This was also seen in his RAS Speed performance, but he made the same number of errors on the post-test as on the pre-test. See Table 39 for an overview of Student 14.

Table 39

Pre- and Post- Intervention Score Profile for Student 14

Assessment	Pre-test	Post-test 1	Post-test 2	Post-test 1 Difference	Post-test 2 Difference
SRI Lexile Level	261	183		-78	
SPI Sight Word Accuracy	80%	80%	87%	0%	+7%
SPI Sight Word Fluency	30%	30%	40%	0%	+10%
SPI Nonsense Word Accuracy	73%	73%	80%	0%	+7%
SPI Nonsense Word Fluency	27%	43%	27%	+16%	0%
D-KEFS Word Reading Speed	9	8		-1	
D-KEFS Word Reading Errors	100%	2%		-98%	
D-KEFS Inhibition Speed	9	9		0	
D-KEFS Inhibition Errors	1	8		+7	
D-KEFS Inhibition/Switching Speed	9	10		+1	
D-KEFS Inhibition/Switching Errors	1	3		+2	
PAL-II RAS Speed	9	12		+3	
PAL-II RAS Errors	1	1		0	

Chapter 5: Discussion

This study examined the relationship between executive functions and oral reading fluency and accuracy by investigating the impact of an 8-week intervention designed to assist high school struggling readers. The intent of the intervention was to increase the students' capacities to attend to orthography and increase their ability to shift between rapid sight word recognition and decoding of novel words, in order to improve their overall word reading accuracy and word decoding fluency skills. This study used shelf data collected during the 2014-2015 school year in addition to a review of records. It included 14 participants who were receiving special education services in reading at the time of the study. The participants were selected by their reading specialist due to their poor reading performance as measured by their SRI Lexile level scores. The following reviews the findings and the significance of these findings in relation to the individual participants.

Summary of Findings

Regarding this study's first research question, overall, students' word reading fluency improved significantly after exposure to the reading intervention program when comparing the student group's SPI Sight Word Fluency pre-test with their post-test 1 and 2 results. In general, 12 students demonstrated an improvement in their word reading fluency on either post-test 1 or 2. Eight of the students increased their performance from pre-test baseline to post-test 1 and maintained progress at post-test 2. Student 14 did not increase his performance during post-test 1, but demonstrated a 10% increase at post-test 2. Students 4, 7, and 8 showed an initial increase in progress at post-test 1, immediately following the intervention; however, their performance declined at post-test 2, indicating they were unable to maintain progress in the absence of the reading intervention. Student 6 initially showed a decline in sight word fluency scores immediately after the intervention, but returned to baseline at post-test 2. Student 9 did not show progress between his pre-test and either post-test, indicating the intervention was not effective in increasing his sight word fluency.

The students' performance on the SPI Sight Word Accuracy measures shows 13 out of 14 students making progress when comparing their pre- and post-test 1 or 2 scores. Although not statistically significant, nine students showed an immediate increase in their sight word accuracy at post-test 1. Of the nine students, Students 7 and 9 regressed at post-test 2 after an absence from the intervention, meaning the brief intervention showed short-term results, but the gains were not maintained without the continuation of the word fluency drills. Despite the variations in scores, half of the students (Students 2, 4, 5, 6, 10, 11, and 12) showed improved performance at post-test 1 and continued to maintain the skills after the intervention ended, as evidenced by their results on post-test 2.

The SPI Nonsense Word Accuracy and Fluency measures were used to assess the students' skills in decoding accurately and efficiently. No statistical significance was found in the ANOVA-R analyses, meaning the overall group did not show improvements in their decoding accuracy and fluency. Nevertheless, eight students demonstrated an increase in their accuracy performance from pre-test to post-test 1 or 2. Of these eight students, five showed consistent progress at both post-tests. Student 4 made progress at post-test 1 and then returned to baseline at post-test 2. Students 11 and 14 showed an increase in performance at post-test 2 only.

Within the area of decoding fluency, 10 students increased their fluency skills at post-test 1 or 2. However, only 3 of the 10 students demonstrated consistent progress at both post-tests. Students 1, 5, 11, 12, and 14 showed increased performance immediately following the intervention, but were unable to maintain the increases at post-test 2.

Regarding this study's second research question, the students' reading levels as measured by the SRI, which assesses overall reading comprehension, demonstrated no statistically significant results, but there was a wide range of variability among the students' performances. Half of the students demonstrated an increase in their SRI Lexile level scores from their pre-test baseline measure, with Students 5, 6, and 11 showing the best improvements based upon their growth. Student 6 started with a Lexile score of 0 and substantially improved to a Lexile score of 446. Students 5 and 11 increased their Lexile performance to 290 and 213, respectively.

Although the whole group did not demonstrate statistically significant improvements on their reading comprehension, a pattern of improvement in word reading is present when reviewing SPI Sight Word and Nonsense Word Accuracy and Fluency results for select individual students. Some students showed an improvement in their SRI Lexile levels, along with increased performances on some of the SPI outcomes. For example, Student 3 achieved an increase in his word reading and decoding accuracy, in addition to his word reading fluency when comparing his pre- and post-test 1 and 2 results. His SRI Lexile level rose 24 points at the end of the intervention. Student 5 increased her SRI performance by 182 points. She made gains in her word reading accuracy and fluency skills following the intervention. Student 6 made the greatest improvements in SRI Lexile level when compared to the rest of the group; he increased his skills in the areas of word reading and decoding accuracy. Student 7 showed a small gain by 4 points on his SRI Lexile level; however, he demonstrated improvements in his decoding accuracy and fluency skills. Student 8's SRI Lexile level rose 45 points. He showed growth in his word decoding accuracy skills at post-test 1 and 2 and made initial progress with his word reading fluency at post-test 1. Student 11's SRI Lexile level progressed by 178 points and she made improvements in her overall word accuracy and fluency skills.

Concerning this study's third research question, the paired measures *t*-test for the D-KEFS Color Word Interference subtest conditions was statistically significant for the Inhibition Time, Inhibition Errors, Inhibition/Switching Time, and Inhibition/Switching Errors Scaled Scores. Overall, the students improved their ability to inhibit impulsive responding and shift cognitive sets with accuracy and speed when performing the Color Word Interference task from pre- to post-test. These findings suggest that exposure to repeated word fluency drills that target attention to orthography and shifting from sight word recognition to decoding may have influenced the students' capacity for attending to and self-monitoring the demands of the D-KEFS Color Word Interference subtest. It appears as though the students increased their inhibitory control during word reading tasks. This is noted in the students' overall sight word fluency levels, which improved greatly following the intervention. The results further support the importance of involving executive functions training with reading programs. By improving students' attention to changes in stimuli and self-regulation through inhibitory control exercises, improvements can be made in both word reading fluency and executive control of the reading process.

In regard to this study's fourth research question, the students' overall performance on the PAL-II RAS Speed score and Total Errors score were not statistically significant. A majority of the students' performance either remained the same between the pre- and post-test, or there was a regression in speed and the ability to shift cognitive set from letters and numbers, resulting in an increase in errors. Although the students performed significantly better on the D-KEFS, the D-KEFS only required students to exert executive function control over word reading. The PAL-II RAS, however, required the students to shift between letters and numbers, a task that was not practiced during the intervention. The word fluency drills used during the intervention focused solely on reading and required the students to attend only to orthographic changes in words. It appears that the students did not perform well on the PAL-II RAS task due to the lack of practice in attention to and shifting from letters to numbers and vice versa. The students were not expected to nor did they perform well on the PAL-II RAS subtest. This supports previous research findings indicating that repetition or lack of exposure impacts performance (McCloskey & Perkins, 2012). In addition, it further supports the presence of separate executive control circuits and cognitive demands involved in the orthographic processing of words and the orthographic processing of numbers (Cippoloti, 1995).

Finally, regarding this study's fifth research question, cultural background should be scrutinized carefully. In this study, all 14 students were identified as economically disadvantaged. They attended an urban public high school and received special education services in a learning support or life skills placement. Twelve of the students are Latino, seven of whom are ELLs. In reviewing the group's SRI Lexile levels, Students 2, 6, 12, and 13 attained a SRI Lexile score of 0 during the pre-test. Three of these students, Students 2, 6, and 13, are ELL students and were the only students in the group that had a history of relocating to the United States from predominantly Spanish speaking countries.

Student 2 was born in Puerto Rico and moved to the district in first grade, where she was retained during her first-grade year. Student 6 was also born in Puerto Rico, but moved to the United States as an infant. Student 13 moved to the district in fifth grade from the Dominican Republic. She did not receive formal education prior to age 11. Students 2 and 13’s SRI Lexile scores remained at 0 on the post-test measure. This suggests that their language proficiency, cultural factors, and exposure to the English language may have impeded their overall performance and growth on the SRI. Student 6’s SRI post-test improved to Lexile 446. His progress on the SRI post-test, compared to Students 2 and 13, may be related to his personal experiences. Student 6 moved to the United States when he was an infant, which may have resulted in a greater degree of acculturation and exposure to the English language during early development compared to Students 2 and 13.

Student 1 is also identified as an ELL student. She shares a similar performance pattern on the SPI word reading and decoding accuracy and fluency measures to Students 2 and 13. They all demonstrated an increase in their word reading accuracy and fluency skills. Within the area of decoding, they regressed in decoding accuracy, but made improvements in decoding fluency. Student 1 made progress initially on the decoding word fluency at post-test 1; however, her performance declined at post-test 2. This suggests that Students 1, 2, and 13 struggled to attend to orthography on the nonsense word accuracy probe when emphasis was on the speed of reading. They displayed an increase in phonemic errors during decoding tasks. During the word fluency drills, the students were observed making letter sound errors related to patterns in their dominant language of Spanish. This suggests that students with an ELL background, who continue to identify Spanish as their primary language with family members and peer groups, may find it more challenging to self-monitor and produce correct letter sounds in English when they are decoding novel words under a timed condition.

Student 12's lack of SRI progress is not related to language, given his primary language is English. His limited progress may be related to his underlying ADHD diagnosis. He was not receiving services or treatment for his ADHD at the time of the study, and this may have contributed to his difficulty in maintaining his attention and regulating his inhibitory skills. In contrast, Student 6, who also has a diagnosis of ADHD, was receiving psychopharmacological treatment during the study. This may have been another contributing factor to his improvement on his SRI post-test, in addition to the progress seen in his D-KEFS scores. Student 6 increased his ability to shift quickly and accurately on the Inhibition/Switching condition. He improved his ability to self-monitor by reducing the number of Word Reading errors on the D-KEFS. Overall, Student 6 made gains in his word reading and decoding, in addition to improving his ability to shift and inhibit. This suggests that the reading intervention was effective for him in improving his reading and executive function skills.

Student 9 also has a diagnosis of ADHD and was not receiving treatment when the study took place. He was the only participant who was homeless at the time of the study. Due to Student 9's housing problems, he was absent or tardy from school frequently. In general, he did not make much progress with the intervention compared to the other students and showed inconsistent performance in his post-test 1 and 2 results. His SRI Lexile level increased by 56 points; however, his word reading fluency and decoding accuracy regressed. He initially made progress in word reading accuracy, but then declined once the intervention ended. In contrast, his decoding fluency decreased at post-test 1 and then improved slightly, by 4%, at post-test 2. Compared to the group, he did not show improvements in his executive functioning skills. His performance on the D-KEFS either remained the same or declined when he was required to self-monitor in order to shift or inhibit responses. Student 9's results suggest that attendance problems coupled with underlying risk factors, such as homelessness, diagnosis of ADHD, and lack of access to treatment, can impact academic achievement. Additionally, it shows that minimal progress may occur, regardless of implementing an academic intervention, when significant psychosocial stressors are present.

In contrast to Student 9's attendance history, Student 10 had the least amount of absences compared to the group. Student 10 received ELL services and is described by his teachers as being highly motivated and effortful in his work. He has post-secondary goals of attending a trade school to gain future employment in the automotive industry. His SRI Lexile level decreased by 51 points at the end of the intervention; however, he made gains in his word reading accuracy and fluency, in addition to his decoding accuracy skills. Although he did not make progress in his decoding fluency, his performance remained constant between post-test 1 and 2. This may imply he paced his decoding speed in order to increase his attention to orthographic changes during decoding, which is noted in his improvements in accuracy by 23%. Notably, student 10 improved his executive functions on the D-KEFS Color Word Interference subtest. He made advances in his word reading, executive shifting, and regulating self-control with fewer errors and at a fluent rate. Student 10's results suggest self-determination may be a strong contributing factor in school attendance, academic achievement, and skill acquisition.

Significance of Findings

The findings from this study suggest that the implementation of the word fluency drills improved the students' overall word reading fluency after exposure to an 8-week intervention. Further, it indicates that when the word lists are strategically organized by inserting novel words within groups of sight words and placing the words in order based upon letter changes, it makes the reader more likely to attend to the orthographic changes. With repeated exposure, the intent of this practice is to assist in increasing attention to the whole word and improve shifting by gaining inhibitory control.

Based on the individual students' results, improvements were seen in most of the students' SPI scores. There were four students whose SRI Lexiles regressed at post-test and demonstrated inconsistent performances throughout the pre-test and post-test measures. These students contributed greatly to the wide range of variability among the scores of the group. Nevertheless, seven students made gains on their SRI Lexiles, and a majority of the individuals increased their word reading and decoding accuracy and fluency immediately following the intervention at post-test 1. The regression noted in the post-test 2 measures further indicates the skills declined once the students stopped receiving the interventions. This trend suggests the brief reading intervention was effective when it was implemented; however, the duration of the intervention was too short to sustain the positive effects.

Although significant gains were not observed in the students' SRI Lexiles during the implementation of the study, improvements in word reading fluency occurred. This finding further supports the research that ELLs' oral language proficiency contributes more to their reading comprehension skills than to word reading fluency (Quirk & Beem, 2012). This is consistent with the works of Nakamoto, Lindsey, and Manis (2007), suggesting reading fluency and decoding develops at a quicker rate for ELL students than comprehension skills.

The results also suggest the role of inhibition and shifting is a relative process in the act of reading. The students made improvements in their executive function control of orthography, as noted in the statistically significant findings on the Inhibition and Inhibition/Switching conditions of the D-KEFS. The implementation of the intervention appears to have contributed in some way to an increase in their inhibitory control during word reading and decoding. Additionally, it improved their ability to shift responses in reaction to written language. It is interesting to note that the students did not demonstrate improvements in their ability to shift between letters and numbers on the PAL-II RAS. This suggested that since the students did not practice this skill during the word fluency drills, practice effects were not present. Furthermore, it supports the differences in neurological regions where letters and numbers are processed. Berninger and Richards (2002) indicate that orthography is processed within the left inferior frontal gyrus, whereas number recognition is processed by the right inferior parietal lobes. Given the differences in the cognitive circuits controlling the recognition of letters and numbers, the results suggest that students struggled to shift between the neuronal circuits that control word reading and number naming when administered the RAS.

These findings further support the role of executive functions in the act of reading. The Self-Regulation tier of the Holarchical Model of Executive Functions (HMEF; McCloskey & Perkins, 2012; McCloskey et al., 2009) includes focusing and sustaining attention, inhibition, and shifting. These functions, in addition to the Self-Determination tier, were applied to this study. Students who demonstrated a greater amount of effort and grit in addition to establishing transitional goals and plans performed better on the post-tests than their peers. Their self-determination was evident in classroom behaviors observed by their teachers in addition to their low absenteeism. This suggests that students who regularly attend school and put forth effort have more self-determination than their truant peers. These students are more likely to activate their executive functions under conscious control, which would lead to higher achievement within the academic arena.

Limitations

There are several limitations to this study that are likely to affect the validity of the results and limit the generalizability of the findings. The limitations include the sample size, demographics of the sample, and the study design. These limitations affected the findings and impacted the conclusion of whether the study truly improved the individual students' reading skills and executive functions.

Sample size and demographics. This study consisted of a sample size of only 14 students from a large, economically disadvantaged urban public high school with a predominantly Latino student population. As a result, the sample is not a true representation of the population and cannot be generalized to students from suburban or rural school districts that may vary in racially, ethnically, culturally, linguistically, and socioeconomically. Additionally, the sample size was small and was provided through a sample of convenience, which further restricts the generalizability of the findings. The availability of the 14 students who were identified as poor readers was limited to the accessibility within the specific school building where the study took place.

The participants were secondary level students in grades 8^{t} and 9 at the time of the study. All of the students have extensive educational histories with learning challenges, reading difficulties, and received special education services. The students were not proficient readers at their age, and each had been presenting with reading problems for a long period of time. The histories of each of the students included one or more high risk factors, including lack of responsiveness to remediation efforts, lack access to appropriate interventions, possible absence of fidelity in the use of previous interventions, limited exposure to educational role models in their home environments, coming from families with various cultural views and values on education, being ELLs, having parental models with limited education or history of learning disabilities, and being diagnosed with disabling comorbid conditions such as ADHD, autism, intellectual disability, depression, learning disabilities, or histories of trauma.

Study design. There are several limitations that stem from the design of this study. This study lacked a control group; therefore, direct comparisons between participants receiving and not receiving the interventions could not be made. A control group would be useful to determine whether the students benefited from the interventions by showing an improvement in reading skills and executive functions when compared to another similar group of students.

Another limitation in this study is the brief length of time the intervention was in place and the limited frequency of the delivery of the intervention. The length of the intervention was only in place for 8 weeks at a rate of two intervention sessions per week per participant. Given the severity of the participants' reading needs, the length of time and frequency of delivery may have been insufficient to address their significant reading deficiencies adequately.

Lastly, the word fluency drills used in the intervention were not designed to meet the individual needs of each student. The word fluency drills were developed by using the System 44 curriculum that was currently in place in the students' reading class. The drill procedure was intended to create a challenging level that would be appropriate for all participants; however, the students were performing at such a wide range of skill levels that the universal use of the established drill lists may not have adequately targeted the specific skill deficiencies of each student. During the implementation of the intervention, some of the participants were exceeding the expectations of the drill lists, whereas others were struggling with the current lists. Given the variability in their reading performance, the word fluency drills used did not address all of the students' presenting needs as effectively as might have been the case if lists were tailored individually to each student's specific reading skill profile.

Future Directions

Future research is recommended to further explore this intervention framework and to apply it to students in elementary school. This would potentially target the delivery of the intervention during the early stages for beginning readers who may be struggling and demonstrating a need for tier two level of support. Increasing the frequency of the word fluency drills to daily practice could increase the rate of student progress. It would also be beneficial to increase the length of the intervention to the full school year, with frequent progress monitoring to include weekly probes on the word fluency drills. Additionally, future researchers could implement oral reading passages during the weekly sessions to review and analyze students' individual error patterns in order to show areas of weakness. With frequent progress monitoring, the development of the word lists could be structured and tailored to meet the individual needs of the students.

Further investigation should be extended to other student population groups in rural and suburban school districts with varying demographics, and with students who are not receiving special education services, identified with a learning disability or disabling conditions, or receiving ELL supports. This would allow future researchers to develop a baseline for a prototypical intervention, to then assist in developing ways to adapt it to different groups of elementary and secondary readers with unique demographic backgrounds. Lastly, future research would assist in increasing the literature on the need for early reading interventions to include strengthening the use of executive functions in the coordination of reading as an essential component in remedial instruction. This would support educators in conceptualizing executive functions as necessary skills for academic achievement and assist with the development of interventions targeted at improving executive function coordination of the reading process.

Conclusion

In sum, the current study investigated the impact of a brief intervention targeting executive functions and oral reading fluency and accuracy within a group of eighth and ninth grade struggling readers. The results indicate that students made statistically significant progress in their word reading fluency and improvements were made in their executive functioning skills, primarily in the areas of shifting and inhibitory control. As a whole, the intervention did not improve the students' overall reading levels as measured by the SRI. Nevertheless, individual differences in performance were indicated, proving the intervention may have had a short-term effect on their word reading and decoding skills. Due to the wide range of variability in the performance of the students in the group, fewer significant outcomes were obtained. Each of the students brought forth a unique educational and cultural background that further affected the individual and group findings.

Interestingly, the intervention greatly improved the students' executive functions involved in inhibitory control and cognitive shifting as measured by the D-KEFS Color Word Interference subtest. By increasing the students' attention to orthographic changes and rapidly shifting between known and novel words, the skills were transferred to an alternative word reading task that required the use of these skills to suppress the reading of words and instead name the color of the ink in which the words were printed. This finding lends support to the notion that using an intervention targeting the improvement of executive functions may have a generalized effect when engaging tasks that involve executive control of orthographic processing and supports the notion that executive functions are involved when performing academic tasks such as reading.

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