Reading Difficulties in Children with ADHD and Dyslexia: The Effectiveness of Balance Activities

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ABSTRACT

Comorbid ADHD and dyslexia are prevalent among school age students with attention and reading comprehension impacting academic success. Reading comprehension and attention are skills that many students diagnosed with attention deficit hyperactivity disorder (ADHD) and dyslexia struggle with. While previous studies have investigated physical activity to elicit better attention and reading outcomes, there have not been clear outcomes to improve reading comprehension. The purpose of this study was to determine if doing a balance activity before reading a passage and using a visual checklist during a reading passage could result in an increase in accuracy, comprehension, rate, fluency, overall reading abilities, and a decrease in error type. This was an experimental, single subject design study. The study included three elementary aged students, one third grade and two fifth graders, diagnosed with both ADHD and dyslexia. All participants participated in pretest and posttest measures with Form A and Form B, respectively. All three participants demonstrated significant improvement in the posttest measure for comprehension ($M = 9.0$) from the pretest measure ($M = 5.67$) and overall reading abilities in the posttest measure ($M = 87.33$) from the pretest measure ($M = 77.33$) in a paired samples t-test. While there were no significant improvements were found in paired samples t-test for accuracy, rate, fluency, and error type, results indicated error type did decrease for all participants from the pretest to posttest measure. Implementing a sequenced balance activity before reading and utilizing a visual checklist during reading improves overall comprehension and overall reading abilities demonstrating a potential effective and time efficient intervention for school-aged students.

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Chapter I

Introduction to the Study

The purpose of this single subject design study was to determine if a simple balance activity paired with a visual checklist could increase overall reading abilities to include accuracy, comprehension, fluency, and rate in students with a diagnosis of both attention deficit hyperactivity disorder (ADHD) and dyslexia. As evidenced in the literature review, ADHD and dyslexia have been researched extensively, but little-known research has been implemented to determine if balance activities with a self-monitoring strategy could elicit better reading outcomes.

Statement of the Problem

Reading comprehension is a skill that is not only needed for academic success, but for success in many areas of one's daily life. As young students evolve from learning to read to reading to learn, the skills that help facilitate accurate reading of the text become more automatic and natural which allows for the allocation of more neural resources to comprehending the text instead of trying to decode the words on the page. However, students diagnosed with reading disabilities, such as dyslexia, may need further explicit instruction to help these skills become more automatic and close the gap in reading skills. ADHD can affect the ability of a student to attend to the task and often result in skipping or changing words in the text which can lead to further difficulty with comprehension. While these disorders are prevalent in school settings separately (Peterson & Pennington, 2012; Thomas et al., 2015), students diagnosed with reading disabilities are also often co-diagnosed with attention deficit hyperactivity disorder (ADHD) (Willcutt & Pennington, 2000). Dyslexia is a specific learning disorder characterized by average intelligence and difficulties with accurate or fluent word recognition, poor decoding, and poor spelling abilities (American Psychiatric Association, 2013). ADHD is characterized by behaviors of inattentiveness, hyperactivity, and impulsivity and is often coupled with emotional lability (Skirrow et al., 2009), deficits in cognitive performance (Kofler et al., 2013), and can occur with reading difficulties. Students with dyslexia often have difficulties recognizing print, sounding out words that are not known, and reading at a similar rate when compared to their peers (Caravolas et al., 2012), which can lead to difficulties in comprehending the text. Students diagnosed with ADHD have difficulty attending to the task which can lead to skipping or changing words which can ultimately affect comprehension. Additionally, students diagnosed with ADHD have a harder time understanding the main idea of a text and will often recall details in the text rather than central idea (Miller & Keenan, 2009, 2011, Miller et al., 2012).

Reading disabilities and ADHD frequently have a commonality of reading comprehension difficulties, and studies have demonstrated that these two disorders frequently co-exist (Fawcett & Nicolson, 2001; Fletcher et al., 1999; Willcutt et al., 2000). Studies have concluded that students with comorbid ADHD and reading difficulties demonstrate difficulties in accuracy and rate that are apparent at the basic word reading level (Ghelani et al., 2004). Evidence supports that these difficulties with accuracy and rate can lead to comprehension challenges. The ability to decode words easily is needed so neural resources can be allocated more towards comprehension rather than the task of decoding (LaBerge & Samuels, 1974).

Additionally, dyslexia and ADHD have a common component of involvement with the cerebellum. The cerebellum, located in the back of the brain, is responsible for coordinating movements and balance and is imperative in language, attention, and eye movement tasks (Koziol et al., 2013). Investigations involving the cerebellum have yielded findings showing its involvement in multiple language and semantic tasks that are specific to reading (Addis et al., 2009; Sokolov et al., 2017; Stoodley & Schmahaman, 2009) along with a reduction in activity in people diagnosed with either ADHD or dyslexia within the cerebro-cerebellar network (Durston et al., 2004; Pernet et al., 2009; Stoodley, 2014).

Physical activity in the schools has revealed benefits in executive functioning (Xiong et al., 2017), vocabulary (Bavi, 2018), behavioral (Tantillo et al., 2002), and classroom performance (Jensen, 2008) for students with and without ADHD. Repetitive coordinated bilateral movements for as little as six minutes a day have yielded positive results for boys and girls in the school-based setting in processing speed, focused attention, concentration performance, and attention span (Harris et al., 2018). Further investigation is warranted for reading comprehension outcomes as some studies have not revealed an increase in comprehension but have demonstrated positive effects on both attention and motivation (Goodmon et al., 2014).

Another component that impacts students with both ADHD and dyslexia is mind wandering. Mind wandering is the act of one’s attention not being on the present task at hand and not fully able process the activity or information being received (Feng et al., 2013). If mind wandering occurs while reading, one will not be able to fully comprehend, make inferences, or derive meaning from what is being read (Smallwood et al., 2008; Soemer & Schiefele, 2019). Self-monitoring, the act of being self-aware of one's own attention and independently directing behavior to the task at hand (Bell et al., 2013), is a strategy that helps students monitor their own behavior and can facilitate better reading engagement (Cole & Bambara, 1992; McLaughlin, 1984). A visual checklist is an inexpensive and effective self-monitoring tool (Levendoski & Cartledge, 2000) that can allow students to independently monitor and self-regulate their learning and reading comprehension (Massey, 2003). However, minimal research has investigated the use of a visual checklist to address attention to the text to facilitate accuracy of word reading.

Investigating the use of balance activities and self-monitoring strategies such as a visual checklist is beneficial to help facilitate better comprehension and attention to the text for school-aged students diagnosed with both ADHD and dyslexia by utilizing a cost-effective and time efficient intervention. While there have been many studies investigating ADHD and dyslexia separately, there is little information on investigating an intervention to address reading comprehension struggles in these commonly comorbid diagnoses. This study investigates specifically students diagnosed with both ADHD and dyslexia and how a simple balance activity paired with a visual checklist during reading can positively impact word reading accuracy as well as reading comprehension.

Purpose of the Study

The purpose of this experimental study was to determine if a balance activity paired with a visual checklist would facilitate better attention to a reading task and therefore increase overall reading abilities including accuracy, comprehension, fluency, and rate. The study included three elementary aged students in the third and fifth grades all with diagnoses of both ADHD and dyslexia. This study utilized a single-subject design with a pre and posttest to investigate the benefits that balance activities and visual checklists have on reading outcomes.

Research Questions

The research questions (RQ) for this study focused on the participant outcomes to include:

RQ1: Will performing a sequenced balance activity before a reading passage and utilizing a visual checklist during the reading passage result in an increase in word reading accuracy while reading?

RQ2: Will performing a sequenced balance activity before a reading passage and utilizing a visual checklist during the reading passage result in an increase in reading comprehension?

RQ3: Will performing a sequenced balance activity before a reading passage and utilizing a visual checklist during the reading passage result in an increase in reading rate?

RQ4: Will performing a sequenced balance activity before a reading passage and utilizing a visual checklist during the reading passage result in an increase in reading fluency?

RQ5: Will performing a sequenced balance activity before a reading passage and utilizing a visual checklist during the reading passage result in an increase in overall reading abilities?

RQ6: Will performing a sequenced balance activity before a reading passage and utilizing a visual checklist during the reading passage result in changes in error type?

Investigating these research questions will help expand the research on potential ADHD and dyslexia interventions in the schools that students diagnosed with both disorders can benefit from.

Theoretical Framework of the Study

Dyslexia and ADHD are two prominent, comorbid neurodevelopmental disorders that are prevalent among school-aged students (Fawcett & Nicolson, 2001; Fletcher et al., 1999; Willcutt et al., 2000). Along with simply co-existing, often these two disorders present with similar symptomatology including reading comprehension difficulties which can result from difficulties with accuracy and rate (Ghelani et al., 2004), word decoding deficits (McGrath et al., 2011), difficulty with understanding the main idea of the passage (Miller et al., 2012), and difficulty with inferences from the text (Zentall & Beike, 2012). If students have difficulty with reading comprehension, they may experience academic struggles throughout their school career as prior research has revealed that students with disabilities are more likely to struggle academically and have a greater risk for academic struggles when compared to students without disabilities (Sideridis et al., 2006). Due to the high prevalence of students diagnosed with both ADHD and dyslexia (Karande et al., 2007), it is imperative to investigate an intervention to facilitate better reading outcomes and address symptoms of both disorders.

While previous studies have determined that both ADHD and dyslexia encompass reading difficulties, these two disorders also have a structural commonality of the cerebellum (Pernet et al., 2009; Valera et al., 2005). The cerebellum is responsible for coordinating movement and balance (Koziol et al., 2013) which have been associated with improvements in performance when utilized with individuals with ADHD (Harris et al., 2018). Along with playing a role in language, attention, and eye movement (Koziol et al., 2013), the cerebellum has been linked to reading tasks such as predictive functioning (Sokolov et al., 2017), word retrieval (Addis et al., 2009), and semantic integration (Gatti et al., 2020).

There are many hypotheses postulating the origins of dyslexia, with one of the prominent ones being the cerebellar deficit hypothesis (Nicolson & Fawcett, 1990). This theory argues that children diagnosed with dyslexia have difficulty with processing speech and the automatic skills needed for reading due to abnormal cerebellar functioning which can lead to cognitive processing and reading difficulties (Fawcett et al., 2001). Phonological deficits are often present in dyslexia (Ramus, 2004) along with decreased working memory, processing speed, and difficulty with rapid naming (Fawcett et al., 2001; Gathercole & Baddeley, 1993), all of which are tasks related to the cerebellum (Addis et al., 2009; Stoodley & Schmahmann, 2009; Valera et al., 2005). While studies have demonstrated that individuals with dyslexia and ADHD have atypical cerebellar function (Durston et al., 2004; Pernet et al., 2009; Valera et al., 2007) and have commonalities between the cerebro-cerebellar networks in both (Stoodley, 2014), more investigation into activating the cerebellum for interventional use for students with both disorders is warranted.

Exercise of various forms have been explored in both students with and without disabilities and has demonstrated positive outcomes not only for one’s health, but also positive benefits in learning outcomes for different types of students such as improving educational performance to include coping skills, memory skills, attention, and language skills (Akande et al., 2000; Barkley, 2004; Olsen, 1994; Samaras et al., 1998). Many previous researchers have studied the effects of various amounts of physical activity on children with ADHD (Harris et al., 2018; Mulrine et al., 2008; Tantillo et al., 2002; M.S. Wendt, 2000; M. Wendt, 2001) and have yielded a connection between physical activity, brain function, and increased classroom performance (Jensen, 2008; Labounty, 2007; Pierson, 2002) as well as increased attention span, processing speed, and focused attention (Harris et al., 2018). Additionally, reading comprehension outcomes utilizing different forms of physical activity have been investigated through various studies (Goodmon et al., 2014; Reynolds et al., 2003; Tine, 2014; Wendt, 2000), but more research should be completed to assess specific tasks such as balance activities and the effects they may have on attention during reading to facilitate improved comprehension of a text.

Mind wandering, the act of drifting one’s attention away from the current task and directing it toward an unrelated stimulus, can affect one’s reading comprehension and can be observed in the presence of reading difficulties (Feng et al., 2013). Mind wandering during reading may hinder comprehension as well as the ability to make inferences and derive meaning from the text (Smallwood et al., 2008). Poor readers may have difficulty independently repairing breakdowns in comprehension (Gunning, 2002) and visual checklists have been successful to these students to help self-regulate and monitor comprehension during reading (Massey, 2003). While visual checklists have demonstrated positive outcomes for comprehension breakdowns, utilizing visual checklists to address attention during reading should be investigated more.

In summary, ADHD and dyslexia share a commonality of cerebellar involvement. Many interventions are designed to include various types of physical activity and self-monitoring strategies have been investigated to benefit students with either ADHD or dyslexia regarding reading comprehension. Further research should be implemented to determine if a certain type of physical activity such as balance along with utilizing a visual checklist while reading would help the reader attend the text better to reduce errors and increase reading comprehension accuracy when ADHD and dyslexia are comorbid.

Significance of the Study

Reading comprehension encompasses not only every academic subject, but also one's daily life. Students diagnosed with both ADHD and dyslexia can demonstrate struggles with reading comprehension, which can impact their academic success. While the components of reading are taught throughout school, little research has been completed to investigate cost effective and time efficient interventions to specifically target a population that is prevalent throughout schools. Several stakeholders can benefit from this study to include the students, parents, and teachers. By investigating the effects of balance and visual checklists on reading accuracy, comprehension, fluency, and rate outcomes, students can have increased motivation and self-perceptions due to potential positive outcomes related to their reading abilities. Findings of this study revealed a significant improvement in comprehension and overall reading abilities when analyzed with a paired samples *t*-test. With comorbid ADHD and dyslexia prevalent among school aged children (Karande et al., 2007), results of this study could positively impact academic outcomes for students with both disorders.

Assumptions, Delimitations, and Limitations

Assumptions

An assumption of this study was that the balance activity and visual checklist would facilitate better attention allocation to the text by demonstrating an increase in reading comprehension accuracy and decrease in reading errors. Another assumption of the study is that the participants participated to the best of their abilities and honestly answered questions that were asked of them. While it was confirmed before each study, an assumption was also made that no significant changes to the daily routine happened the day of testing as well as no medication changes if applicable to that participant.

Delimitations

A delimitation of this study was that all participants were volunteers and both parents and students gave consent prior to participation. There was no compensation or effect on academic grades for any of the participants. Another delimitation of this study was that the time of day for implementation was consistent.

Limitations

Limitations of this study included a small sample size of students to include 2 female and 1 male with one female being in the 3rd grade and the other 2 participants being in the 5th grade. All participants previously knew the researcher due to the researcher's position at the elementary school. While the participants were made aware that there was no grade or school affiliation with the current study, a Hawthorne effect could have resulted from the participants simply knowing they were participating in a research study. All sessions were conducted in a one-on-one setting with the clinician.

Further investigation should be done to explore the effects and outcomes of a balance intervention and checklist in the classroom setting.

Definitions

The following terms are defined to help the reader better understand the context of the study:

Accuracy- The ability to pronounce the words in a text correctly.

Additions- The words added in when reading a text.

ADHD- A neurodevelopmental disorder known as attention deficit hyperactivity disorder that can affect an individual's ability to maintain attention and focus, control hyperactivity, and impulses.

Attention- the overall ability of alertness and engagement in a task, activity, or event.

Balance Activity- A set sequence of movements and actions while keeping the body upright and steady.

Cerebellum- A part of the brain located at the back of the head which is responsible for motor movements, balance, and other cognitive skills and processes.

Dyslexia- A learning disorder characterized by an individual with average intelligence having difficulties with reading, writing, and/or spelling.

Fluency- The ability to read with speed, accuracy, and expression

Mind Wandering- when an individual's attention shifts from the task, activity, or event at hand to internal stimuli of other thoughts, plans, or ideas.

Motivation- the reason an individual has for acting or not acting in a particular way.

Neural Resources- The physical and functional components of the brain that support emotional regulation, decision making, and thinking.

Phonemic Awareness- The ability for an individual to take the smallest units of sounds and manipulate, identify, and blend them to make whole words.

Omissions- The words left out when reading a text.

Phonological Awareness- The ability for an individual to recognize and manipulate different sounds in whole words such as rhyming, blending, and segmenting.

Physical Activity- Bodily movements that utilize energy ranging from light activities to vigorous exercise.

Rate- The speed at which an individual can read a text

Reading comprehension- the ability to understand written text through processing, making connections, understanding vocabulary, inferring, and summarizing the main idea.

Repetitions- The same words from the text read again after being already read.

Self-Monitoring- the act of an individual observing, managing, and evaluation their own emotions, thoughts, or actions.

Specific Learning Disability- a neurodevelopmental disorder characterized by an individual having substantial difficulties in one or psychological processes as demonstrated in deficits with listening, speaking, reading, writing, spelling or math.

Visual Checklist- a tool individuals can use to independently complete tasks.

Vocabulary- the words an individual recognizes and understands when reading.

Chapter Summary

This chapter demonstrated how the cerebellum has a significant role in both ADHD and dyslexia and how physical activity and self-monitoring strategies have been investigated to help elicit better reading outcomes. By analyzing data from pretest and posttest measures, this study investigated whether performing a balance activity before reading a text and using a visual checklist during a reading task improve overall reading abilities to include accuracy, comprehension, fluency, and rate. Results indicated significant increases in comprehension and overall reading abilities. These findings address the gaps in literature and establish a connection between balance, self-monitoring strategies such as a checklist, and reading abilities that can help elicit better comprehension outcomes in school-aged children.

Chapter II

Literature Review

Reading comprehension is a skill that is not only needed for academic success, but for success in many areas of one's daily life. As young students evolve from learning to read to reading to learn, the skills that help facilitate accurate reading of the text become more automatic and natural which allows for the allocation of more neural resources to comprehending the text instead of trying to decode the words on the page. However, students diagnosed with reading disabilities, such as dyslexia, may need further explicit instruction to help these skills become more automatic and close the gap in reading skills. Students diagnosed with reading disabilities are also often co-diagnosed with attention deficit hyperactivity disorder (ADHD) (Willcutt & Pennington, 2000). ADHD can affect the ability for a student to attend to the task and often result in skipping or changing words in the text which can lead to further difficulty with comprehension. Many interventions have been investigated to help further comprehension for this group of students in the school-based setting. While interventions such as physical activity and self-monitoring strategies have been implemented separately to yield positive results for reading comprehension, further investigation is needed to distinguish if positive effects can be yielded from using a balance activity combined with a visual checklist during reading to help allocate better attention to text for students with ADHD and dyslexia. Before being able to investigate if an intervention utilizing balance activities and checklists would be successful, one must fully understand the components of reading, dyslexia, ADHD, their commonalities, and the interventions that have been successful with both disorders.

Reading and Reading Theories

Reading Overview

Reading is a complex skill that requires proficiency in areas such as phonemic awareness, phonics, reading fluency, vocabulary, and comprehension (National Reading Panel, 2000), with the end goal of reading instruction to be comprehension of the text read (Bursuck & Damer, 2011). The complex task of understanding a sentence involves multiple processes such as visually processing the words, identifying the phonological, orthographic, and semantic representations, and connecting the rules of syntax to understand the grammar and the meaning of the sentence (Perfetti & Stafura, 2013). Not only must readers comprehend the meaning of the sentence, but must also use background knowledge, infer, identify text structure, and think about the author's perspective and motive to achieve an understanding of the overall meaning of the text (Graesser, 2015; Kintsch & Van Dijk, 1978).

Simple View of Reading

Many theoretical models have been proposed, with one prominent model focusing on the identification of specific skills to explain the linguistic and cognitive processes involved in reading comprehension. These models state that word decoding, reading fluency, vocabulary knowledge, language comprehension, prior knowledge, comprehension monitoring, and working memory are all vital components that contribute to reading comprehension. Of these theories that encompass these components, the simple view of reading (SVR; Hoover & Gough, 1990) is one of the most influential regarding the process of reading comprehension. SVR postulates that reading comprehension is the product of decoding and language comprehension. SVR identifies these two core components of reading comprehension and the processes included in each. In SVR, decoding encompasses phonological processing, orthographic processing, and word recognition, while language comprehension encompasses vocabulary and inference making for the ability to build coherent mental representations of the text being read (Gough & Tunmer, 1986; Hoover & Gough, 1990). Over the years, evidence has supported the theory of SVR through replications and longitudinal studies following the correlation between the increase of reading comprehension skills as decoding skills increase (Catts et al., 2005; García & Cain, 2014; Lervåg et al., 2018).

Decoding has been investigated using many different studies such as comparing reading true words and nonwords (Adlof et al., 2006) as well as investigating if measuring fluency is a better way to assess decoding accuracy (Cain, 2015). For accurate comprehension, the reader must be able to decode words quickly and precisely (Perfetti, 2007). The SVR states that these two components are of equal importance, and full comprehension cannot be achieved without both. Reading cannot just be word recognition, but additionally the ability to determine the meaning of the words, the sentence, and the message of the text. Furthermore, reading without word recognition results in the lack of ability to derive any meaning from the text (Gough & Tunmer, 1986).

While reading is the product of decoding and comprehension, these skills are two independent components from one another. While both lead to successful reading, decoding is characterized as the ability to recognize words silently, quickly, and accurately while phonics refers to the use of letter-sound correspondence rules These two components are assumed to occur independently and sequentially so the reader can decode the words on the page and then use the same fundamentals to understand the words just as they would if the reader was speaking the words on the page. According to SVR, readers can have intact language comprehension but lack word recognition skills, can lack comprehension but have intact word recognition skills, have difficulties with both skill sets, or have both skills intact. Gough and Tunmer deemed these scenarios as readers who are dyslexic, hyperlexic, and overall reading disabled, respectfully (1986).

In recent years, the terms decoding and listening comprehension have evolved to encompass a broader spectrum by using the words “word recognition” and “language comprehension” in the cognitive foundations framework which is an expansion of the SVR with subcomponents of both word recognition and language comprehension (Hoover & Tunmer, 2020). For readers who struggle with word recognition, such as a person diagnosed with dyslexia, word recognition skills can be increased through explicit instruction in alphabet coding skills which include letter knowledge, alphabetic principle, and phonemic awareness (Chapman & Tunmer, 2020).

The recognition of a word leads to forming a connection between the coding of graphemes and the mental lexicon which allows for the retrieval of semantic information. One construct to explain the process of word recognition is phonological coding which encompasses the letter-sound correspondence rules of language. The basis of phonological coding states that word recognition is achieved by converting the orthographic representation of the word to a phonological representation. This act allows the reader to gain access to the meaning of the word.

Decoding is the ability to identify the words in the text while linguistic comprehension is the ability to understand spoken language. Both are vital for reading comprehension and having one without the other is not sufficient for full comprehension of the text that is being read. Once a child can decode, the words on the page are comprehended in the same way that one would understand words that are spoken. Even if the text has been decoded sufficiently, if the child cannot understand the linguistic components, comprehension will also be lacking. Over time, as decoding mastery is achieved, reading comprehension evolves to be less reliant on decoding and more on how well the reader understands spoken language (Gough & Hillinger, 1980).

When a reader has trouble with understanding the language in the text and/or problems with quickly and accurately identifying the words, it is often due to the lack of explicit instruction and knowledge of the alphabetic principle (Tunmer & Hoover, 2019). All children, no matter the reason of their deficits in reading, should be provided with explicit instruction in the alphabetic principle, letter knowledge, and phonemic awareness to facilitate automatic word reading (Chapman & Tunmer, 2020). The ability to recognize the words in the text facilitates the more complex ability of being able to comprehend the group of words on the page to understand the message being conveyed in the story or text. For individuals to be able to achieve automaticity during this process, individuals must be sufficient in their abilities of lower-level reading skills such as word recognition, decoding, phonics, and phonemic awareness to the higher-level linguistic abilities such as vocabulary, inferencing, and comprehension.

Scarborough's Rope

Skilled readers can efficiently and accurately comprehend the meaning of written text. Skills that help derive meanings of written words are mastered individually; however, these learned skills are used in conjunction with each other when deciphering meaning from text (National Research Council, 1998). While comprehension is the overall goal of reading any written text, skilled reading must encompass both word recognition and text comprehension simultaneously. In doing this, language comprehension and word recognition must work together. However, before they work together, these skills must be developed and honed. Scarborough's Rope (2001) is a visual representation of how the components of word recognition and language comprehension interact to bring about skilled, fluent reading. The rope demonstrates how the two major components of word recognition and language comprehension emerge independently of one another, develop at the same time, and then as the components of each strengthen, combine, and work together to lead to skilled, efficient reading. The bottom of the rope represents the components of word recognition, which includes phonological awareness, decoding, and sight word recognition. These skills work together leading to the reader becoming fluent, accurate, and automatic in recognizing the text.

The top rope represents the components of language comprehension which includes background knowledge, vocabulary, language structure, verbal reasoning, and literacy concepts which become more strategic over time. Background knowledge encompasses the concepts that serve as the foundations to understand written and oral language and obtain new information. Vocabulary, a skill that grows and is accumulated over time, includes the knowledge of the words, how words relate to one another, and the meaning of the words. Language structures relate to the variations of grammar and structure in sentences as well as the meanings of the words in the text. Verbal reasoning combines background knowledge with the ability to make inferences and draw conclusions from the text, and literacy knowledge includes the familiarity of written conventions regarding the mechanics of writing as well as knowledge of various text forms and genres. These skills are intertwined with each other and then work in conjunction with the word recognition skills throughout the reading process.

Word recognition and language comprehension require both repetition and practice for a reader to become efficient. If one thread of the rope demonstrates a weakness, that could lead to a struggling reader. If more than one thread is a weakness, then the struggle to achieve skilled reading becomes greater (Scarborough, 2018).

Building Blocks of Reading

There are five building blocks that lead to successful reading which includes phonological awareness, phonics, fluency, vocabulary, and then comprehension (National Reading Panel, 2000). The first component is phonological awareness which is a broad skill that encompasses identifying and manipulating components of oral language to include syllables, rhyming, alliteration, auditory discrimination, blending and segmenting sounds, and onset and rime. A subset of phonological awareness, phonemic awareness is the ability to isolate and manipulate the smallest units of spoken sounds. The next block for reading comprehension is explicitly teaching phonics which is the ability to understand direct letter and sound correspondence of regular and irregular spelling patterns. Fluency is the ability to read words in the connected text accurately while using appropriate rate, phrasing, and expression. With appropriate fluency comes the ability to decode accurately and seamlessly with appropriate prosody which allows for attention to be allocated to comprehending the text rather than to decoding the text (Wolf & Katzir-Cohen, 2001). The next building block is vocabulary which allows the reader to know the meaning of the words in the text and use them correctly in oral and written language.

Reading comprehension is a multifaceted task that involves subcomponents of comprehension. The direct and inferential mediation model (DIME; Ahmed et al., 2016) states that a multitude of resources such as background knowledge, strategies, word reading, and vocabulary directly support comprehension while also indirectly supporting comprehension by using inferences (Cromley & Azevedo, 2007). Many studies have consistently demonstrated that vocabulary is the strongest predictor of reading comprehension (Lee, 2010; Prior et al., 2014; Qian, 2002). Additionally, other strong predictors of reading comprehension include inference making, background knowledge, and word reading.

All these components cannot come together to help the individual comprehend the text if the student is not able to attend to the task. Students with ADHD can demonstrate difficulties in components of reading such as word reading, reading fluency, and reading comprehension (Tamm et al., 2014). These difficulties may manifest due to the comorbidity of ADHD and reading disabilities (Jacobson et al., 2011) with approximately 24-40% of children diagnosed with a comorbid reading disorder and ADHD (Willcutt & Pennington, 2000). With these difficulties being common for both disorders, it is important to further dive into the components of reading that comprise word reading, reading fluency, and comprehension and the strategies that go along with teaching them.

The Five Components of Reading

Overview of Reading

The National Reading Panel Report (National Reading Panel, 2000) states phonemic awareness, phonics, fluency, vocabulary, and comprehension are the five critical areas for successful reading instruction. These components are successful when students receive systematic and explicit instruction.

For reading instruction to be systematic, skills must first be taught in a progressive sequence that is logically planned and implemented. Additionally, multiple exposures and attempts must be given to help these students retain the new information as well as give them carefully designed opportunities to apply what they have been taught. Assessments are then implemented so students can demonstrate their knowledge and use the skills independently. While these components must be systematically taught, they should also be taught explicitly. To systematically teach a skill, teachers can clearly state what will be taught and model the skills for the students. This specific instruction ensures that the students are given and focus on the important features of the instruction.

Phonemic Awareness

To understand phonemic awareness, one must understand what a phoneme is. A phoneme is the smallest segment of the spoken language which is represented by graphemes, or the written representation of the sound. These graphemes can be single letters or a cluster of the letters. To produce a single word, one must blend the phonemes together to produce the word. There are many tasks that one can implement to teach phonemic awareness. With these increasingly more complex tasks, students can isolate phonemes, blend onset-rimes, blend phonemes, delete phonemes, segment words into phonemes, add phonemes, and substitute phonemes (Schatschneider et al., 1999). Due to the hierarchal nature of these tasks, students should be taught these skills in order where the more difficult tasks, such as substituting phonemes, cannot be accurately done without the precursor skills of being able to isolate or blend phonemes first.

The first essential component of reading instruction is phonemic awareness. This is the understanding that spoken words are comprised of separate units of sound that are blended during the pronunciation of words. Additionally, phonemic awareness encompasses producing separate sounds in words, segmenting sounds in words, blending sounds together to make words, and identifying if words sound the same or if they sound different. While phonemic awareness interventions target the phonemes that comprise the word and is more in line with decoding skills needed for reading, one must not confuse it with phonological awareness interventions that target the increase in awareness of word parts and incorporate skills such as rhyming, segmenting, blending, and manipulating and address the sounds at the syllabic level. For languages that are based on the alphabet, phonemic awareness is imperative when learning to read (Wagner et al., 1994), and research has demonstrated that teaching phonemic awareness to children increases future reading achievement (Cunningham, 1986; Foorman et al., 1998; Lundberg et al., 1988). Phonemic awareness is an essential part of learning to read as well as a strong predictor of reading success (Adams et al., 1998).

Before comprehension can be achieved, the reader must be able to decipher the words of the page. One of the first components of reading instruction is sufficient phonemic awareness which is the ability to analyze, synthesize, manipulate, and separate phonemes within words accurately and explicitly (Ehri et al., 2001). Many hypotheses surrounding phonemic awareness and reading have been constructed suggesting that phonemic awareness skills can predict early reading success (Torgesen, 2004), that speech-sound awareness can reduce reading and spelling difficulties (National Reading Panel, 2000), and that difficulty with phonemic awareness has a high correlation with poor spelling abilities (Cassar et al., 2005).

Phonics

The next major component of reading instruction is phonics. Phonics is the set of rules that detail the relationship between the letter sounds when used in spoken language and the spelling of words. These rules, while not the same for every scenario, are consistent to where young children can use these rules to help decode unfamiliar words (Foorman et al., 1998).

Phonics instruction utilizes the alphabetic principle which states that while sometimes irregular, there is a structured relationship between letter, letter combinations, and individual speech sounds. Additionally, phonics instruction allows students to store the rules to memory and generalize those rules to other sounds and letters. This systematic instruction for phonics at the early stages of reading development can lead to stronger reading achievement when compared to instruction that was provided later and was not considered to be explicit and direct (Adams, 1990).

Systematic instruction for synthetic phonics and larger-unit phonics has demonstrated significant gains in reading ability. Synthetic phonics is phonics instruction where students are taught to sound out words by matching the sounds they say to letters and then blend the sounds together to form words. Larger-unit phonics instruction is comprised of blending parts of words together that are larger than individual phonemes such as using onsets, rimes, and spelling patterns (National Reading Panel, 2000).

Phonics interventions support reading development (Snowling & Hulme, 2012), and early phonic awareness has yielded moderate correlations with literacy later in reading development (Missall et al., 2007; Snowling et al., 2018). Findings have demonstrated that there is a need for phonics checks during a student's schooling to help identify students who need early intervention (Double et al., 2019) due to the critical period of phonics development. This critical point of phonics development coincides with a child's development that happens during the time period a student would typically enter school (Castles et al., 2018). While phonics teaching is imperative for children to improve their phonics skills, and teaching phonics embedded in reading instruction improves reading ability more than solely just reading (Hatcher et al., 1994), it is imperative for students with phonics deficits to receive phonics instruction within that reading instruction rather than in isolation (Double et al., 2019).

Forming strong and fast connections between the visual representation of the word and the ability to read it leads to more proficient reading of new words. To make these connections, there are four developmental phases to learning new words (Ehri, 2013). Children begin to make connections between the visual features of letters in the print and the pronunciation and meaning of the word in the prealphabetic phase. These connections are not based upon letter sound correspondence, but rather the connection between print, such as a logo or design, and what it represents.

In the second phase known as the partial alphabetic phase, students begin to make connections to some letters within the print and begin to store it in their oral vocabulary.

Since the child has some knowledge of the alphabetic principle during this phase, they can increase the rate of the number of new words learned during this phase. In the full alphabetic phase, the third phase of developmental learning, the student makes connections among the full sequence of the letters in the print and matches the speech sounds to phonemes to learn new words. The final phase, the consolidated alphabetic phase, is the phase where students can sequence clusters of letters to make different words that represent the same phoneme series such as -tion, -able, trans-, etc. This allows students to recognize unfamiliar words faster. Using phoneme knowledge to decode and learn new words allows students to store new words in their oral vocabulary to increase their reading skills.

Fluency

The next component of reading instruction is fluency. Fluency encompasses the rapid and accurate recognition of words as well as groupings of words into phrases to make sentences easier to comprehend (Hook & Jones, 2004). By reading the text accurately and quickly as well as using phrasing that resembles the naturalness of speech, readers can read in a way that mimics spoken language. Studies have yielded that students with low fluency skills demonstrate more difficulty with comprehension skills (Pinnell et al., 1995). Fluency and comprehension of text work together to allow the reader to understand the text that is being read. Both decoding and comprehension require cognitive resources and memory can be impacted if too many resources are used for one particular element. If decoding is laborious, then there are not as many cognitive resources to allocate to comprehension thus leading to a slow reading process that may impact understanding the texts adequately enough to comprehend the entire message

(National Reading Panel, 2000). Fluency requires the act of reading to be automatic. To read accurately and fluently, the reader must be able to process the print, meaning, pronunciation, and transfer all the information to working memory with ease and without conscious effort or thought. It is proposed that automatic word recognition is acquired on a continuum that begins as laborious and slow and moves gradually to fast and natural word recognition as the reader becomes skilled and efficient in their reading with the use of consistent instruction and practice (Logan, 1997).

For students to develop adequate reading fluency, the use of repeated reading and guided repeating oral reading have been demonstrated to be useful intervention tools (Samuels & Farstrup, 2011). Repeated reading entails students reading the same passage for a set number of times. This allows for fluency to increase and working memory to be allotted to comprehension rather than word decoding as the reader becomes more fluent in reading the passage. The repeated readings give the reader opportunities to respond and build upon what they read, rather than just reading the same words repeatedly as the emphasis moves from word recognition to comprehension. This also allows for increased motivation for struggling readers due to the increased fluency that comes with the increasing fluency from utilizing repeated readings (Mehigan, 2020). While this intervention can build confidence in reading, some studies have demonstrated that repeated oral reading does not generalize to unread passages (Ardoin et al., 2018; Meindl et al., 2013; Wexler et al., 2007). Guided repeated oral reading gives the same opportunities to move from word recognition to comprehension, but additionally allows for direct support from peers, classroom teachers, or other adults (Rasinski, 1990). Utilizing oral reading allows the reader to hear natural models or phrasing (Taylor et al.,

1985) and the pronunciation of unknown words to allow for focusing on the meaning of the passage (Shany & Biemiller, 1995).

Vocabulary

A robust vocabulary, the words an individual knows and uses to communicate, is imperative in word recognition. As children learn to read, they search their oral vocabulary as they pronounce words to match the words in print. If the word the reader pronounces is not in the reader's oral vocabulary, then the reader would have a difficult time comprehending the word, even with correct pronunciation.

Vocabulary instruction is essential for all students to facilitate better comprehension of text. Studies have demonstrated that oral language skills such as vocabulary as well as word decoding are essential components to reading development (Mancilla-Martinez & Lesaux, 2010; Nakamoto et al., 2008). Children with larger vocabularies demonstrate less difficulty understanding text while children who have weak vocabularies often exhibit poor text recall (Biemiller & Boote, 2006; Ricketts et al., 2007). With vocabulary being a pillar of successful reading comprehension, it is imperative to understand the research that supports vocabulary knowledge.

Some of the first hypotheses regarding the correlation between vocabulary and reading comprehension included three initial hypotheses of Anderson and Freebody (1981). The first hypothesis, also known at the instrumental hypothesis, stated that the more knowledge an individual had regarding the meanings of the words in a passage the better their comprehension of the text would be. A second hypothesis, the knowledge hypothesis, states that vocabulary and reading comprehension are correlated because they are both related to one's conceptual knowledge, while the third, or aptitude hypothesis states that vocabulary and reading comprehension are correlated due to its relation to verbal aptitude. While the second and third hypotheses pose that vocabulary and reading comprehension do not directly affect one another, the instrumental hypothesis suggests that vocabulary and reading comprehension have a causal relationship where one directly effects the other.

Vocabulary, including the knowledge of orthographic, phonological, and semantic relations, has been demonstrated to directly support reading comprehension (Verhoeven & van Leeuwe, 2008). Conversely, a limited vocabulary is correlated with poor reading comprehension (Beck et al., 1982). Studies have demonstrated that vocabulary knowledge is a dependable predictor of reading comprehension (Cain & Oakhill, 2011) and reading comprehension growth depends on vocabulary knowledge (Quinn et al., 2015). Oslund et al. (2016) found that the largest direct effect on reading comprehension came from vocabulary knowledge and inferential comprehension ability.

Focusing on specific, targeted vocabulary words for reading intervention has yielded positive results in comprehension and vocabulary growth outcomes (Gersten et al., 2006; Vaughn et al., 2013). Direct teaching of key concepts using both oral and visual teaching modalities leads to deeper understanding of the text as well as supports the integration of concepts (Kintsch, 2004). Solís et al. (2018) utilized a vocabulary intervention using a 10-minute block time to review essential vocabulary words from the text using student-friendly definitions, synonyms, antonyms, and words in context. Additionally, “turn and talk” activities with partners facilitated comments and questions concerning the vocabulary words. Results indicated that repeated exposure to vocabulary terms through use of discussions, synonyms, antonyms, visuals, and simplified definitions led to better recall and identification of vocabulary word meanings which supported previous vocabulary intervention findings (Wanzek & Vaughn, 2007).

Students start their elementary school careers with varying degrees of vocabulary knowledge. This range of vocabulary skill widens as children progress through grade levels which may put students with low vocabulary lexicons at risk for difficulties for reading comprehension later in their schooling careers (Biemiller, 2005). While the start of vocabulary knowledge begins well before entering school, both direct and indirect vocabulary instructions embedded into school reading programs can increase acquisition of new word meanings as well as improve reading comprehension (Elleman et al., 2009). Vocabulary instruction is needed for children who struggle with reading, but the time spent on direct vocabulary instruction in the classroom is variable. Wanzek (2014) investigated not only the type of direct vocabulary instruction, but the amount of time classroom teachers and supplemental intervention teachers spent on direct vocabulary instruction. After investigating direct vocabulary instruction of second graders in an elementary school, it was concluded that core classroom teachers spent an average of eight minutes utilizing definitions and examples for vocabulary instruction, while students who received supplemental intervention received an average of 25 seconds of direct vocabulary instruction. Throughout the intervention, it was observed that decoding and increased reading fluency were mainly targeted while any vocabulary instruction was incidental. Although prior research has recommended direct vocabulary instruction be addressed in reading interventions utilizing purposefully selected target words, active engagement, and emphasis on word connections and categories (Fisher & Blachowicz, 2005). Wanzek (2014) observed that a systematic intervention approach to vocabulary was not present among second graders in this specific study population. While direct teaching of decoding and other reading specific skills may inadvertently sacrifice direct vocabulary instruction in early grades for children with low vocabulary (Cervetti & Hiebert, 2019), effects due to a lack of direct vocabulary instruction may be mitigated if students are immersed in language rich environments consisting of knowledge building, facilitated vocabulary acquisition through systematic instruction (Black & Wright, 2023).

To understand how students acquire vocabulary through direct instruction, one must understand the theoretical underpinnings behind vocabulary acquisition. Moody et al. (2018) identified educational theories that are connected to vocabulary and the strategies the theories support. These educational theories include social constructivism and sociocultural theories, schema and psycholinguistic theories, dual coding theory, and motivational theory. Social constructivism and sociocultural theories propose that knowledge is gained through interactions with others. Sociocultural theories incorporate Vygotsky's Zone of Proximal Development which encompasses inner speech, psychological tools, and scaffolding (Unrau & Alvermann, 2013). Allowing learners to utilize higher order mental processes and accelerate their learning of the English language, social constructivists suggest students accentuate their knowledge and language skills through structured scaffolded interactions (Vygotsky, 1986). Both social constructivism and sociocultural theories deem active participation of both teachers and students as vital to students being able to learn and retain new meanings of vocabulary words. This sense of classroom community helps both students and teachers work cooperatively to engage in discussions of new vocabulary words and meaning (Wright et al., 2016).

The psycholinguistic theory suggests that students derive meaning from words by making predictions while they read. The theory postulates that processing strategies, background knowledge, and conceptual abilities all work together to facilitate comprehension (Kim et al., 2021). Additionally, the schema theory builds on the psycholinguistic theory to add structure and the representation of knowledge. Vital for reading comprehension, schemas permit the processing, encoding, organizing, and retrieving of information which allows the individual to explain and comprehend the components of the text that is being read. Both theories stress vocabulary instruction where readers analyze morphological structures, identify synonyms and antonyms of the new vocabulary words, and connect new concepts through graphic organizers and concept mapping (Moody et al., 2018). Furthermore, both theories rely on activating background knowledge (Wright et al., 2016). Using schema and psycholinguistic theories as a guide for vocabulary development allows teachers to link prior background knowledge to new concepts being learned (Black & Wright, 2023).

Another theory, the dual coding theory, postulates that verbal codes, significant for representing and processing language, and nonverbal codes, which represent objects and events (Moody et al., 2018), work together so understanding can occur (Thomas & Lenox, 2014). This theory incorporates a multisensory component to embed vocabulary in a student's memory (Black & Wright, 2023). When the text aligns with a student's interests or desires, then they are more engaged in the text they are reading (Kim et al., 2021). This motivational theory theorizes that when students are given autonomy or have an interest in the current topic, they are more likely to be motivated to learn (Moody et al., 2018). Vocabulary strategies and instruction such as word learning games provide autonomy which allows the students to develop word knowledge and enhance their interests in the vocabulary words (Wright et al., 2016). All of these theories help guide effective vocabulary instruction.

Comprehension

Comprehension is the main goal when reading a text, and while strong decoding abilities and fluency are foundational skills for reading (Block & Pressley, 2002), one must be able to understand the meaning of what is being read. Readers who are sufficient in comprehension can use comprehension strategies effectively and be self-aware of the need to use additional strategies for different types of texts. For students who struggle with comprehension of text, it is imperative to implement interventions that provide specific procedures for students to become more aware of how they are comprehending what they are reading (National Reading Panel, 2000). Intervention strategies such as reflection, question generating, using prior knowledge, using picture cues, identifying themes, using inferencing, summarizing, and utilizing story structure (Suggate, 2010) have resulted in positive reading outcomes when implemented with readers struggling with comprehension (Elbaum et al., 2000; National Early Literacy Panel, 2008; Suggate, 2010; Swanson et al., 1999).

Word reading and adequate phonics skills are imperative for reading success, but these skills alone do not automatically lead to comprehension of a text (Oakhill, 2020). While these lower rope skills are imperative for learning to read, comprehension should also be taught simultaneously in early elementary years (Cervetti, 2020). Interventions that explicitly teach higher level oral language strategies, such as reciprocal teaching (Palincsar & Brown, 1984), improve comprehension in students who struggle with this component. This intervention allows students to interact with others to discuss, summarize, ask questions, and make predictions to foster comprehension of the text (Lee & Tsai, 2017).

One's academic content knowledge as well as cultural knowledge from day-to-day activities outside of the school-based setting influence reading comprehension as well (Hwang & Duke, 2020). While building upon known content has been deemed beneficial to comprehension of texts (Cabell & Hwang, 2020; Connor et al., 2017), successful comprehension for struggling readers requires explicit instruction for how to monitor reading and what questions and thoughts to have before, during, and after reading a text (Shanahan et al., 2010).

According to Scarborough's reading rope (2001), the top rope is comprised of higher language comprehension abilities that facilitate comprehension of the text. While research has demonstrated that language comprehension increases over time as students become more efficient decoders as their ability to derive meaning from the text strengthens (Adlof et al., 2010), it is imperative that students simultaneously learn language comprehension skills as they learn to decode so they have the skills necessary to understand the meaning of the text as they decode them (Cunningham & Stanovich, 1997). Students who have difficulty with vocabulary, semantics, and language structures such as syntax and morphology, tend to demonstrate difficulty with reading comprehension throughout their schooling starting in their early elementary school years (Adlof et al., 2010). Both vocabulary interventions (Elleman et al., 2009; Marulis & Neuman, 2010; Stahl & Fairbanks, 1986) and morphology interventions (Bowers et al., 2010; Carlisle, 2010; Goodwin & Ahn, 2013) have individually yielded positive gains in reading comprehension on custom measures. However, focusing on these two components individually does not provide enough for adequate comprehension nor generalize to standardized measures. Readers would benefit more from interventions that target how the components of language comprehension work together for a better understanding of texts (Kieffer et al., 2016; Proctor et al., 2020; Wright & Cervetti, 2017). Interventions and instruction that target multiple components of comprehension specifically in early elementary grades while also targeting decoding is crucial for reading comprehension success (Silverman et al., 2020).

For comprehension interventions to be successful, students must be explicitly taught, given models, and then given guided and independent practice to solidify these skills (Schünemann et al., 2013). Students with poor comprehension benefit from literal comprehension level strategies, such as focusing on information directly from the text, while students with adequate comprehension skills benefit from higher level strategies, which include inferencing, summarizing, and questioning the text. This demonstrates that students with lower comprehension abilities benefit from learning strategies that meet them at their level of current development (McNamara & Kendeou, 2011).

Comprehension strategies such as identifying the main idea and summarizing can be taught together (Elosúa et al., 2013) and is a necessary skill students need to be able to understand and recall events of the text (Duke & Pearson, 2009). Additionally, teaching students how to ask questions about the text can lead to making inferences and associations that support understanding the entirety of the text (McMaster et al., 2015). Asking a variety of deep questions while reading a text allows for deeper cognitive understanding (Graesser et al., 2005). Monitoring, a metacognitive strategy, also has demonstrated enhancement in text comprehension (Stoeger et al., 2014). This strategy allows for improvement in self-regulation skills (Griffith & Ruan, 2006) that allows for students to adjust how they are reading according to level of text difficulty (Graesser et al., 2005).

With the explicit instruction of lower rope and top rope skills (Scarborough, 2001), which all ultimately lead to the end goal of comprehending text, readers can make the transition from learning to read to reading to learn. However, if a reader is struggling in any of the areas that comprise successful reading or is not able to attend to any of the tasks associated with the skill, then the reader may struggle to fully understand the meaning of the content they are reading. A diagnosis of a reading disability or ADHD may lead to these reading and attention difficulties that could impact the ability to decode, comprehend, or both.

Dyslexia

Dyslexia Components

Before considering ADHD and dyslexia as comorbid disorders, one must understand the components of both ADHD and dyslexia separately. Dyslexia is a specific learning impairment that is neurobiological in nature. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These deficits in reading, spelling, writing, or other components such as phonological awareness are not commensurate with the individual's intellectual quotient (IQ), which means "these individuals have within average range of intellectual abilities that do not explain these deficits/difficulties is specific areas" (International Dyslexia Association, 2018).

The DSM-V defines dyslexia as a pattern of learning difficulties characterized by problems with accurate or fluent word recognition, poor decoding, and poor spelling abilities and is a specific learning disorder characterized by difficulties with word recognition and spelling, even though these children have had adequate educational instruction and demonstrate average intelligence (American Psychiatric Association, 2013). Learning to read is one of the prominent goals of early education, and poor reading skills may potentially lead to poor outcomes in adulthood such as lower potential for post-secondary education, poor employment outcomes, and a potential lower quality of life due to lack of reading abilities (Hulme & Snowling, 2016). With approximately 7% of children being diagnosed with dyslexia due to a 1.5 or greater standard deviation below the mean score on standardized assessments (Peterson & Pennington, 2012), these children often have difficulty recognizing print, sounding out words that are not known, and read considerably slower when compared to their peers. For these children, the greatest predictor of reading skills involves their letter knowledge, phoneme awareness, and rapid naming skills (Caravolas et al., 2012).

Studies have demonstrated that dyslexia is more common in males (Hulme & Snowling, 2009) and has been linked in twin studies to have a familial component of heredity (Paracchini et al., 2007). The amount of exposure to literacy in the home as well as the quality of teaching instruction have also been shown to influence reading development (Sénéchal & LeFevre, 2002). Students who are poor readers are more likely to demonstrate a decreased willingness to seek out reading opportunities due to difficulties, which in turn leads to less exposure to print which may then lead to compromised reading development (Snowling & Melby-Lervåg, 2016). Longitudinal studies have followed various groups of children including children with a low risk of dyslexia, children with a family risk of dyslexia, children diagnosed with a specific language impairment, and children diagnosed as language impaired with a family risk of dyslexia (Hulme et al., 2015; Nash et al., 2013; Snowling et al., 2015). These studies revealed that participants in the familial risk for dyslexia category may possess a biological marker that can increase the continuous risk of reading difficulties demonstrated through poor phonological awareness skills, poor literacy skills, and phonological processing deficits.

Cerebellar Deficit Hypothesis

A pertinent question throughout fields of study is the exact cause of dyslexia. Multiple theories have been proposed with one being the cerebellar deficit hypothesis (Nicolson & Fawcett, 1990) which poses that the cerebellum is mildly dysfunctional and that cognitive difficulties are due to that abnormality. The cerebellum plays a role in automatization of overlearned tasks such as driving a car, typing, writing, etc. A weak capacity to automatize would in turn lead to difficulty in forming the grapheme-phoneme correspondence. Support for this comes from poor performance by individuals with dyslexia on motor tasks (Fawcett et al., 1996), dual tasks demonstrating impaired automatization and balance (Nicolson & Fawcett, 1990), and time-estimation of non-cerebellar tasks (Nicolson et al., 1995).

While there is evidence to support the strengths of the cerebellar deficit hypothesis, findings of studies have pointed to weaknesses in the theory as well. In studies testing this hypothesis in a sample of first graders, investigators did not find evidence to a cerebellar deficit hypothesis is more prominent in students with specific reading disabilities and did not associate cerebellar functions with reading disabilities. However, findings supported that phonological awareness, rapid naming, and vocabulary measures were strongly associated with reading difficulties and academic outcomes (Barth et al., 2010).

Even though the cerebellar deficit hypothesis has multiple studies to support it, other theories have since arose and contradicted the claims of this hypothesis. The main charge against the cerebellar deficit hypothesis is that not all children demonstrate impairments in the motor and balance skills that are claimed to exist due to cerebellar abnormalities, whereas most have demonstrated phonological awareness deficits (Ramus et al., 2003). Additionally, some findings have yielded support for more than one theory at the same time such as the cerebellar deficit hypothesis and the phonological deficit theory, which is another theory regarding the origins of dyslexia (Kibby et al., 2008).

Phonological Deficit Theory

Bradley and Bryant (1978) suggested people with dyslexia have a specific impairment in the representation, storage, and or retrieval of speech sounds. They hypothesized this explains the reading impairment of dyslexia by using the fact that learning to read an alphabetic system requires learning grapheme-phoneme correspondence. If these sounds are poorly represented, stored, or retrieved, then the foundation of reading will likely be affected.

The phonological deficit theory suggests that dyslexia is due to a deficit in phonological processing including poor phonological awareness, or in the ability to determine the parts of sounds that comprise words. This deficit leads to difficulty learning grapheme-phoneme correspondence early on which leads to difficulty in learning decoding skills (Wagner et al., 1997). Support for this theory comes from findings demonstrating individuals with dyslexia performing poorly on tasks requiring phonological awareness such as segmentation and manipulation of speech sounds. Individuals with dyslexia also demonstrate poor short-term verbal memory and slow automatic naming (Snowling, 2000). Functional brain imaging studies have also supported the phonological theory with the notion that left perysylvian dysfunction, the region associated with language, is the basis for the phonological deficit (Serniclaes et al., 2001).

The main difference in the phonological deficit theory and other theories is that in the phonological deficit theory, the cognitive deficit is specific to phonology. Other theories do not dispute that phonological impairments contribute to reading difficulties, but they are rooted in impairments with the general sensory, motor, and learning processes, and the phonological deficits are another deficit associated with dyslexia (Ramus et al., 2003). For individuals with dyslexia, it is suggested that the brain codes phonology in a less efficient way than typically developing children even if there is a relative strength in semantic processing. This causes a range of difficulties such as non-word repetition deficits, word retrieval, poor phonological learning of new verbal information, and rapid naming problems (Snowling, 2000).

Ramus et al. (2003) reviewed the phonological deficit and implemented a study using cognitive assessments targeting phonological, auditory, visual, and motor tasks to assess participants with dyslexia and matching controls. His findings demonstrated those with dyslexia all exhibited phonemic deficits but rarely exhibited visual impairments. The most distinctive phonological impairments noted were reduced short-term verbal memory and phonemic awareness. While these findings support a phonological deficit, a purely phonological deficit of dyslexia could not account for the low level, but existent, visual, sensory, and motor coordination deficits reported in many of the participants.

Just as in the cerebellar deficit hypothesis, there are weaknesses in the phonological deficit theory as well. The phonological deficit does not explain the occurrence of motor and sensory disorders in individuals with dyslexia. Supporters of this theory try to dismiss the sensory and motor impairments as not core features of dyslexia, but instead consider the co-occurrence as a potential marker, but not the cause of dyslexia (Snowling, 2000).

Magnocellular Theory

Another prominent theory regarding dyslexia is the magnocellular theory. This hypothesis arose from observations that individuals with dyslexia had impaired visual processing in the magnocellular pathway. The magnocellular pathway is a large, colorblind pathway that carries information about depth perception and the perception of movement such as how fast things go. Patients with dyslexia demonstrated poor thresholds for stimuli in low contrast, low spatial or high temporal frequencies, and poor sensitivity to visual motion (Talcott et al., 2000).

The magnocellular system is important in directing visual attention, eye control, and visual searching, all of which have a role in reading ability (Stein & Walsh, 1997). Findings have suggested a link between reading ability and the visual processes associated with the magnocellular pathway, exhibiting a correlation between motion sensitivity and orthographic performance (Talcott et al., 2000). It has also been suggested that the magnocellular theory can account for other deficiencies such as attention, motor control, or ocular saccades which are rapid movements of the eyes (Biscaldi et al., 2000). The theory states that deficits in the magnocellular pathway are the single biological cause of dyslexia and can explain the manifestation of the deficits reported in dyslexia to include visual, auditory, tactile, motor, and phonological deficits.

Stein and Walsh (1997) attempted to integrate all the findings of the different theories, and suggested the magnocellular dysfunction is not restricted to visual pathways, but is generalized to all modalities such as visual, auditory, and tactile. The cerebellum receives substantial input from the various magnocellular systems and is predicted to be affected by the magnocellular dysfunction. While studies have found magnocellular abnormalities in the brains of people with dyslexia (Livingstone et al., 1991), poor performance in the tactile domain (Stoodley et al., 2010), and a co-occurrence of visual and auditory problems in some individuals with dyslexia (Witton et al., 1998), findings have also demonstrated conclusions that negate the magnocellular theory.

A major criticism of the magnocellular theory is the inability to replicate findings of auditory disorders (Heath et al., 1999) or visual deficits in participants with dyslexia. Studies have ranged from findings in only a subgroup of individuals with dyslexia ranging from just a few participants to 50% of participants in studies (Marshall et al., 2001). When visual impairments have been found, they have been observed across a range of stimuli, not just stimuli specifically tapping into the magnocellular system (Farrag et al., 2002). Another weakness in the magnocellular theory from Share et al. (2002) postulates that auditory deficits do not predict phonological deficits, which is an impairment associated with dyslexia.

Additional Theories

Additional theories include the double-deficit hypothesis, the visual span hypothesis, the rapid auditory processing theory, and the visual theory. While the rapid auditory processing theory states the deficits are a result of a difficulty perceiving short or rapidly varying sounds (Tallal et al., 1993) and the visual theory postulates dyslexia is a visual impairment that leads to difficulty with processing letters and words on a page (Lovegrove et al., 1980). These two theories encompass many components of the magnocellular theory and are now encompassed in the theory as facilitating components.

The double-deficit hypothesis attempts to explain children who have impairments in phonological skills and difficulty with rapid naming. Poor phonological skills lead to reduced reading accuracy, while rapid naming deficits are associated with a slower reading rate. This theory hypothesizes that children with these severe deficits are most likely to develop dyslexia (Wolf & Bowers, 1999).

Findings have suggested that the visual attention span hypothesis contributes to dyslexia independent of a phonological deficit. The visual attention span is the amount of distinct visual elements that can be processed at the same time. Study results have indicated that the visual attention span may account for the unique variance in reading skills just as much as phonological skills due to whether participants demonstrated either phonological or visual attention span disorders. This theory suggests that developmental reading disorders may not originate from phonological disorders, but the visual attention span can be an underlying cognitive deficit of dyslexia (Bosse et al., 2007).

There are many theories that hypothesize the origins of dyslexia. Findings among these theories claim to support or either contradict each other. Three popular theories regarding dyslexia, the cerebellar deficit hypothesis, phonological deficit hypothesis, and magnocellular theory, all present with strengths and weakness supporting the origins of dyslexia. The common theme among the three is the extent sensory and motor impairments are involved in dyslexia and the inability to explain the existence, or lack of these specific impairments. The phonological deficits are not able to explain the motor impairments that are found in many individuals with dyslexia. The magnocellular theory does not explain the absence of the sensory and motor disorders found in a significant portion of individuals with dyslexia. Additionally, the cerebellar deficit theory encompasses both problems that some individuals do have impairments while others do not.

Diagnosing Dyslexia

Although there are multiple hypotheses that try to explain the cause of dyslexia, the way to diagnose the learning disorder is the same despite the etiological theory. To diagnose dyslexia, a professional skilled with the assessment tools will implement a battery of assessments to identify difficulties. Intellectual ability scores are derived from psychologists through the administration of various assessments of processing areas, including, but not limited to, verbal comprehension ability, fluid reasoning ability, processing speed, and working memory (Wechsler, 2014). Reading achievement scores can be acquired also through assessing various areas. The simple view of reading (SVR; Gough & Tunmer, 1986; Hoover & Gough, 1990) states that good reading comprehension is derived from adequate word recognition and language comprehension. To determine if a student has adequate skills, components of word recognition such as phonological awareness, phonemic awareness, automaticity of word recognition, and reading of irregular, nonsense words are assessed. Components of language comprehension that may be assessed can also include assessments in the areas of vocabulary, background knowledge, syntactic comprehension, and pragmatic language to include the understanding of idioms and nonliteral language for comprehension. For the SVR, the ability to recognize words is demonstrated by translating the print into language, and the ability to comprehend language makes sense of the print being read.

Studies have demonstrated that poor language comprehenders often demonstrate deficits in receptive vocabulary and semantic processing (Nation et al., 2004). Typical readers are often able to answer more literal questions regarding the text and make inferences when compared to readers who have difficulty comprehending (Cain et al., 2001). However, readers with language comprehension deficits often demonstrate adequate abilities in phonological processing which supports the phonological deficit hypothesis theory (Stanovich, 2000). Research has supported this specific hypothesis suggesting the link between word reading difficulties, or dyslexia, is phonological awareness and processing difficulties (Catts & Kamhi, 2005; Lyon et al., 2003) while students with difficulty with comprehension perform relatively the same and typical readers (Cain et al., 2000; Nation et al., 1999). If a parent or school-based professional feels a child is struggling and demonstrating weaknesses, multiple areas of cognitive and linguistic abilities are assessed and it is determined whether or not a student meets the profile of characteristics of dyslexia.

Dyslexia Profiles

Various types of profiles can be discovered via assessment. Students can demonstrate adequate language comprehension but poor word recognition and word decoding skills. Students with this profile have reading difficulties specific to word recognition and not comprehension of the text. With these struggles, students often respond to further phonics instruction to bridge the gap and achieve grade level reading. Students can also present with specific comprehension difficulties where students demonstrate adequate word recognition and decoding skills, but poor comprehension abilities. These students require interventions targeting vocabulary, background knowledge, or inferencing that are specific to the comprehension area of weakness. Another profile for students with reading difficulties is poor performance in both word recognition and comprehension. These students with these mixed reading difficulties require both phonics and comprehension interventions to target specific reading needs (Spear-Swerling, 2015).

Interventions

Once the types of difficulties and types of interventions needed are identified, it is imperative to determine a specific intervention strategy to help bridge the gaps in word reading, comprehension, or both sets of skills. Studies have demonstrated that both phonemic and phonological interventions are favorable for younger children. The use of phonics interventions directly incorporate letters and text which build an association between phonemes and orthography (Ehri et al., 2001). Interventions targeting fluency can also demonstrate gains in reading ability (Fuchs & Fuchs, 2005).

When considering the three specific types of reading problems (specific word reading difficulties, specific reading comprehension difficulties, and mixed reading difficulties), there are specific interventions that target each area of weakness. For readers struggling with word recognition, explicit and systematic phonics intervention along with numerous opportunities to decode words with teacher feedback is needed. These types of readers can comprehend texts that are on their decoding level and exhibit a greater ability to learn orally through classroom discussions and teacher read-alouds. Readers with specific comprehension difficulties benefit from interventions that target their specific area of weakness in comprehension as well as incorporate interventions for oral vocabulary. These students often demonstrate good oral comprehension and are good spellers. Readers who have mixed reading difficulties require explicit and systematic interventions targeting both phonics and comprehension. Interventions with a multicomponent approach often benefit these types of readers (Spear-Swerling, 2015).

A multisensory approach to reading interventions incorporates listening, speaking, reading, and writing into the interventions (Baron et al., 2018). This approach implements auditory, visual, tactile, and/or kinesthetic movements which activate different parts of the brain and can benefit all students, but specifically students with dyslexia (Shaywitz et al., 2007). A multisensory approach to instruction is a specific approach that utilizes more than one of the senses at a time. Utilizing a multisensory approach can help emphasize language structure using components of phonology, orthography, syntax, morphology, semantics, and the organization of spoken and written communication (International Dyslexia Association, 2018). Strategies such as tapping out phonemes on one's fingers or hand or moving down one's arm tapping out each different sound when starting at the shoulder have proven beneficial as phonology interventions (Giess et al., 2012). Additionally, using manipulatives to tap out each sound, not each letter, has proven to be an effective multisensory approach for phonological weaknesses as well (Schlesinger & Gray, 2017). While all students can benefit from a multisensory approach, students with dyslexia respond well to utilizing sight, hearing, and touching by using singing, rhyming, music, clapping, audio tones, tapping, and dialogue to learn phonological skills in a progressive order of the easiest components of language to the more complex components. Each new concept must build on the previously learned skills (Ehri, 2002).

Students with dyslexia have difficulty with expressing their words in written form, spelling, and proofreading their written products (Berninger et al., 2008). Multisensory approaches to handwriting and spelling include the use of air writing. This approach has students spell out words in the air or in a substance such as sugar, rice, sand, or shaving cream to incorporate a more tactile approach to spelling the words. Writing letters to fill in words with various missing sequences has also demonstrated an increase in handwriting abilities (Datchuk & Kubina, 2013). Due to its important role in the writing process, handwriting must become more automatic and fluent in students with dyslexia so they can focus their attention and abilities on other parts of the writing process without impeding learning (McMaster et al., 2018). Direct and systematic instruction for letter-sound correspondence, spelling patterns, and spelling of morphemes is also imperative. The use of tactile materials, Elkonin boxes, and manipulatives with diagraphs to help with saying the word, touching the word, and spelling the word are all useful strategies for spelling (Graham et al., 2002).

Graphic organizers help students with dyslexia be aware of how content is related. These organizers have demonstrated to be a useful tool leading to increased comprehension during reading and writing tasks (Kim et al., 2004). Students with dyslexia struggle with grammar and the ability to automatically apply syntactic rules in their reading and writing. While this skill develops in students without reading difficulties through the act of simply engaging and being exposed to more complex material, students with dyslexia tend to not engage or seek out complex material that would give them exposure to grammar rules (Baron et al., 2018). To help facilitate learning grammar rules, exposure to the written word as a new word is given orally has demonstrated positive gains (Berninger et al., 2000). Additionally, writing words on index cards and arranging them into various sentences or correct teacher-given incorrect sentences have proven to be useful strategies to facilitate correct syntactic concepts (Lovett et al., 1990).

Another intervention for students with dyslexia is pre-teaching new vocabulary or concepts while teaching mental strategies to help facilitate listening such as mental note taking, reviewing, and asking questions (Camahalan, 2006). Students with dyslexia benefit from stating the purpose of reading and providing oral responses or circling answers instead of being required to answer fill in the bank questions. Due to these students often having difficulty following directions, restating directions in their own words has proven to be helpful (Klein & Shaywitz, 2005). These strategies help with working memory deficits which are often present in persons diagnosed with dyslexia (Ramus, 2014).

While students with dyslexia are observed to have difficulty with word recall, working with word families as well as prefixes and suffixes has proven successful for building word learning (Law et al., 2018). When working on vocabulary, it is best to start with analyzing words currently in the student's repertoire to find the base of the word and then learning about new words in that same word family. Word meanings should be learned in relation to other word meanings, and vocabulary should be learned with repeated exposures in not only word study, but also in contexts (Cavalli et al., 2016).

Interventions such as the visual arranging of synonyms and antonyms with different colored strips and connecting them allow for students to make connections, or bridges, to antonyms as well as work on explaining and understanding the small differences between synonyms. Students can also be given a root word and be instructed to make as many words from the word as they can. Utilizing strategies such as mind or thinking maps helps to connect the words visually to the concept being learned (Fisher et al., 2015).

Teacher modeling is vital for students with dyslexia due to difficulties with letter knowledge, phoneme awareness, and rapid naming skills (Snowling & Melby-Lervåg, 2016). While automatization of these skills is the ultimate goal, teachers must be cognizant while using the multisensory approach that these skills are truly learned, and not just a learned repeated rote skill. Kinesthetic movements can be added to word reading such as finger tapping or moving their finger or pencil on the page, right to left with each new word (Berninger et al., 2008). Metacognition strategies, such as learning how to organize material, have demonstrated positive effects on reading for students with dyslexia (Camahalan, 2006). Think-aloud strategies such as verbalizing the process of coming to an answer and reciprocal teaching such as having students take turns asking questions, summarizing, clarifying, and predicting what happens next in a text are beneficial for reading achievement. These small group thinking strategies can help facilitate increased metacognition in students with dyslexia (Gersten et al., 2001).

Furthermore, it is imperative that oral presentations be paired with visuals, and large group, small group, and individual instructions should be equally utilized (Foss, 2016). Students with dyslexia may feel overwhelmed at times with the presentation of information. In these instances, using a blank piece of paper to cover up sections and reducing the amount of work given at one time may be beneficial for success. Presenting this information in a small, sequential order may help students that have limited prior knowledge and require explicit and part-to-whole instruction (Ramus, 2014). With these multisensory strategies for the components of language, an environment that fosters engagement and builds upon the strengths of students with dyslexia can be used to help facilitate reading growth in the areas of weaknesses.

Attention Deficit Hyperactivity Disorder (ADHD)

ADHD Characteristics

ADHD, one of the most common neurodevelopmental disorders (Faraone et al., 2021), affects approximately 5-7% of school-aged children worldwide (Thomas et al., 2015), with a parent survey from 2016 estimating approximately 6.1 million children in the United States from ages 2-17 years of age have received a diagnosis (Danielson et al., 2022). Characterized by behaviors of inattentiveness, hyperactivity, and impulsivity, ADHD is also often coupled with emotional lability (Skirrow et al., 2009), deficits in cognitive performance (Kofler et al., 2013), and anxiety, mood, personality, and substance abuse disorders (Fayyad et al., 2007). Additionally, ADHD has been linked to poor outcomes in educational and occupational settings (Kooij et al., 2010), and increased criminal activity (Lichtenstein et al., 2013).

In the school-based setting, teachers perceive ADHD symptoms in boys and girls very differently (Quinn & Wigal, 2004), and there is a clear discrepancy between male versus female diagnosis in both clinical and community settings (Gaub & Carlson, 1997). While boys are considered more hyperactive and are perceived to display more aggression and more school conduct behaviors, girls are perceived as more inattentive and display less disruptive behavior (Biederman et al., 2002). It has been observed that girls often exhibit more emotional problems than boys and these emotional struggles are not seen as disruptive behaviors by the parents and teachers completing the rating scales for a diagnosis (Mowlem et al., 2019). Even though ADHD may differ in presentation in girls and boys, it is imperative to recognize symptoms so children can receive the support needed to be successful. ADHD often goes undiagnosed and untreated due to the comorbidity of ADHD and other mental health disorders (Asherson et al., 2016). Additionally, the diagnosis of ADHD is founded on subjective rating scales that often lead to the under reporting or over reporting of associated symptoms (Du Rietz et al., 2016; Faraone & Biederman, 2016).

The default mode network (DMN) (Raichle et al., 2001) is a group of interconnected regions in the brain that are active when a person is awake, resting, or not actively engaged in a specific task. This network plays an important role in self-awareness, in the ability to monitor one's surroundings for changes, and in the ability to respond to changes in one's environment and stimuli. The DMN is also responsible for daydreaming and thinking about one's own feelings, past events, and future endeavors. Additionally, the executive control network is imperative in one's working memory, problem solving, and decision-making abilities (Raffone et al., 2019). It has been proposed that excessive and spontaneous mind wandering due to irregular regulation in the default mode networks and executive control networks leads to ADHD symptoms and impairments (Bozhilova et al., 2018).

Structural Components of ADHD

The prefrontal cortex (PFC), located in the gray matter of the anterior part of the frontal lobe, regulates complex cognitive, emotional, and behavioral functions in humans. Through the use of a network of neurons, the PFC is able to maintain information in the absence of stimulation from a person's surrounding environment (Fuster, 2008) and inhibits inappropriate responses to environmental stimuli (Gazzaley et al., 2007) while enabling the ability to shift attention as well as alter decision making during tasks (Robbins, 2000). Additionally, the PFC allows for an individual to self-monitor errors and implement a different strategy when an error is apparent (Modirrousta & Fellows, 2008).

The cerebellum, most known as the control center for balance and movement, has been reported as being structurally altered in persons diagnosed with ADHD, specifically the volume has been observed to be reduced in lobes IIIV, IX, and X of the vermis (Castellanos et al., 1996; Hill et al., 2003) as well as lobes VI and VII (Bussing et al., 2002). Reduction in cerebellar volume has also been revealed to have a negative correlation with attention deficits (Castellanos et al., 2002). Lobes VI through IX are a part of the posterior lobe of the cerebellum, with language tasks and spatial tasks associated in the right and left cerebellar regions of lobes VI and VII respectfully and sensorimotor tasks associated with Lobule VIII (Stoodley & Schmahmann, 2009). Verbal and nonverbal working memory tasks have also been linked to the cerebellum (Cardinal et al., 2008; Stoodley et al., 2010). Working memory tasks initiate bilateral cerebellar activation in lobule VI (Stoodley et al., 2012) as well as activity in the posterior lobe (Valera et al., 2005). Findings have revealed that children diagnosed with ADHD demonstrate significantly more working memory deficits than peers who are not diagnosed with ADHD (Kasper et al., 2012) as well as decreased connectivity between the cerebellum and the premotor cortex resulting in poor posture and balance (Kim et al., 2017).

The corpus striatum, made up of the caudate, nucleus accumbens, putamen, and global pallidus, has an imperative role in executive functions and the regulation of attention, action, and action selection (Kesner & Churchwell, 2011). Dopamine is critically involved in attention and the corpus striatum is the biggest source of dopamine in the brain, suggesting that the striatum plays a crucial role in attention (Dougherty et al., 1999). Neuroimaging studies have revealed children with ADHD have a global pallidus that is reduced in size (Overmeyer et al., 2001) and has reduced total volume and caudal head volume (Castellanos et al., 2002) when compared to children without ADHD. While other structures are noted to be reduced in size in people diagnoses with ADHD, studies have demonstrated that the nucleus accumbens is larger in adults with ADHD potentially suggesting the reason for reward dysregulation and impulsivity in adults (Seidman, 2006).

Studies have revealed that the inferior parietal cortex, associated with attention and language (Caplan, 1992), is also increased in size in children diagnosed with ADHD (Makris et al., 2006). Additionally, the dorsal anterior cingulate cortex has also been confirmed as having abnormalities in persons with ADHD (Tamm et al., 2004). Widely associated with cognition, motor control, and arousal/drive state (Paus, 2001), the dorsal anterior cingulate cortex is also reported to be involved in error detection, action monitoring, target detection, response selection, and reward-based decision making, all of which are tasks that are impaired in persons with ADHD (Bush et al., 2000).

Strategies for ADHD

Children with ADHD benefit from evidence-based strategies to be successful in the school setting. Strategies including repeating instructions and pairing the directions with visual instructions, such as writing instructions on the board, can facilitate success for students when they are receiving auditory instructions. Reminders in the form of accessible checklists have demonstrated success in providing students independence to check each task on their own without the need for verbal reminders from the instructor (Murphy, 2014). Children diagnosed with ADHD often have strong interests and those interests may make it difficult to shift their attention to other tasks; therefore, it is imperative to incorporate highly engaging items that interest students to help them demonstrate their knowledge. Students with executive functioning deficits, such as in ADHD, have demonstrated less intrinsic motivation than typical students (Barkley, 2013) and benefit greatly from immediate and positive feedback (Murphy, 2014).

These students often have difficulties with reading comprehension due to missing words and key details as a result of inattention. Additionally, students may also have difficulty remembering the story due to working memory deficits (Sesma et al., 2009). For strategies to support reading comprehension, students with ADHD often benefit from reading text aloud although those with severe decoding deficits may struggle with this activity. For those who are helped, it is hypothesized that the auditory input from hearing their own voices helps readers pay attention to the text. Creating graphic representations also may be beneficial to students with ADHD when paired with the metacognitive strategies of visualizing, thinking aloud, highlighting, and writing words or pictures to go along with what is read (Murphy, 2014).

ADHD and Reading Difficulties

Students with ADHD, when displaying reading difficulties, often demonstrate poor performance in either word reading, fluency, or comprehension (Tamm et al., 2014). Studies have demonstrated that 15%-50% of students diagnosed with ADHD also meet criteria for a diagnosis of a reading disorder (Gayan et al., 2005; Langberg et al., 2010; Willcutt et al., 2013), and students often present with difficulties in reaction times, working memory, and processing speed, all of which can impact successful reading (Jacobson et al., 2011; Tamm et al., 2014). Additionally, children diagnosed with ADHD often have executive functioning difficulties as well which can be characterized as having difficulties with recognizing errors that are made and being able to make self-corrections (Marcovitch & Zelazo, 2008).

One consistent error observed more in children with ADHD than children without ADHD are omissions on tasks that require continuous performance (Frazier et al., 2004; Willcutt et al., 2005). This could potentially be applied to children with ADHD who often make errors in reading by omitting words, which can lead to the inability to get the full meaning of the text being read. These students often miss words, leading to the inability to grasp key details due to the inattention while reading. Furthermore, students may also have difficulty remembering the story due to working memory deficits (Sesma et al., 2009).

Students who demonstrate these errors benefit from strategies such as reading the text aloud. This allows the auditory input from hearing their own voices help readers pay attention to the text. Creating graphic representations also are beneficial to students with

ADHD when paired with metacognitive strategies of visualizing, thinking out loud, highlighting, and writing words or pictures to go along with what is read (Murphy, 2014).

Comorbidity of ADHD and Reading Disorders

Etiology Theories

Although reading disorders and ADHD often occur comorbidly (Gayan et al., 2005), these two disorders are completely different in their diagnostic criteria. Reading disabilities are diagnosed from an array of cognitive assessments and reading batteries including assessment in subareas such as phonological awareness and rapid automatized naming (Snowling, 2005), while an ADHD diagnosis requires multiple reports and information from various sources in the student's life including caregivers, teachers, parents, and other school personnel that may interact with the student through rating scales and standardized cognitive assessments (Faraone et al., 2015). While students with ADHD can have comorbid reading disorders, they often demonstrate more inattention, hyperactivity, and impulsivity than students diagnosed solely with a reading disorder (Faraone et al., 2021).

Many researchers have theorized the reasoning behind ADHD and reading disorder comorbidity (Germano et al., 2010; Willcutt, 2018; Willcutt et al., 2005). One hypothesis, the phenocopy hypothesis, theorizes that children diagnosed with both ADHD and reading disorders only suffer from one of the diagnoses, but demonstrate symptoms of the secondary condition because of the primary disorder. For example, children who have a primary disorder of reading disability, have difficulty with reading but demonstrate these difficulties through inattention and behavioral difficulties associated with ADHD which impede their learning to read (Hinshaw, 1992; Pennington et al., 1993). While early studies demonstrated support for this hypothesis (Pennington et al., 1993), many studies have since revealed insufficient evidence (Kibby & Cohen, 2008; Martinussen & Tannock, 2006; Willcutt et al., 2010).

Opposing these former hypotheses, the common etiology model suggests that both environmental and genetic influences may increase the likelihood of comorbidity while each disorder is distinctly etiologically different from one another (Willcutt, 2018). The three independent models or cognitive subtype model theory, which has been the topic of debate through multiple studies (Bental & Tirosh, 2007; Shanahan et al., 2006; Van De Voorde et al., 2010), suggests that the comorbidity of the two disorders results in neurocognitive deficits that are different from either of the disorders have individually (Katz et al., 2011).

Reading Disorders, ADHD, and Comprehension

Reading disabilities and ADHD frequently have a commonality of reading comprehension difficulties, and studies have demonstrated that these two disorders frequently co-exist (Fawcett & Nicolson, 2001; Fletcher et al., 1999; Willcutt et al., 2000). While some studies have revealed that reading comprehension difficulties do not always coincide with a reading disability diagnosis (Cain et al., 2000; Ransby & Swanson, 2003; Simmons & Singleton, 2000; Snowling, 2001), when reading comprehension difficulties are present, difficulties often arise at the word level which may decrease the ability to allocate attention to the text (LaBerge & Samuels, 1974; Perfetti, 1985). Children diagnosed with ADHD in the absence of reading disorders have demonstrated decreased performance on reading passages as the passage length increased (Cherkes-Julkowski et al., 1995). In the absence of word reading accuracy and rate difficulties, children diagnosed with ADHD had more difficulty with comprehension of the main idea of a passage (Brock & Knapp, 1996).

Studies have concluded that students with comorbid ADHD and reading difficulties demonstrate difficulties in accuracy and rate that are apparent at the basic word reading level (Ghelani et al., 2004). These difficulties in turn lead to comprehension difficulties which is supported through evidence that the ability to decode easily is needed to allocate neural resources for comprehension (LaBerge & Samuels, 1974).

Children diagnosed with ADHD often have academic struggles (Barkley, 2002) and often demonstrate deficits with word decoding which may hinder reading comprehension (McGrath et al., 2011). When word decoding is not automatic, children with ADHD have difficulty connecting the text and forming coherent ideas and instead, use their cognitive resources for word decoding. This in turn leads to less coherent mental representation of the text that is read and the children with ADHD have a harder time understanding the central, or main idea of the text and in turn recall more peripheral points of the text (Miller & Keenan, 2009, 2011). Recalling the central idea of a text is an important task when reading. However, children with ADHD have demonstrated decreased central idea recall on passages when compared to students without ADHD (Miller et al., 2012).

The underlying similarity between reading difficulties and ADHD in relation to reading comprehension is the misallocation of cognitive resources toward word reading, which should be an automatic task, rather than for comprehending the text. For these students to be able to focus their attention on comprehending the text, interventions such as exercise or balance may lead to allocating neural resources to focus on the text.

Comorbidity and Cerebellum

Findings have demonstrated that the percentage of children diagnosed with at least one disability has significantly increased over the years, with two of them being dyslexia and ADHD (Zablotsky et al., 2019). ADHD and comorbid learning disabilities frequently co-occur (Wilcutt et al., 2013), with dyslexia often being diagnosed comorbidly with ADHD (Willcutt & Pennington, 2000). Children diagnosed with learning disabilities often exhibit more hyperactivity, distractibility (Kavale & Forness, 1996), and impulsivity in the classroom (Al-Dababneh & Al-Zboon, 2018). Children with dyslexia demonstrate similar symptoms to children with ADHD including slower processing speeds (Willcutt et al. 2010).

Students diagnosed with both comorbid ADHD and reading disabilities often exhibit more executive functioning difficulties, negative social and occupational outcomes (Purvis & Tannock, 2000; Willcutt et al., 2010), lower grades (McNamara et al., 2005), and greater attention difficulties (Mayes & Calhoun, 2007) than students who are diagnosed with only ADHD or a reading disability. Treatments such as medication (Sibley et al., 2014), behavioral interventions (Evans et al., 2014), and specific reading interventions (Fletcher et al., 2007) have yielded positive gains for children diagnosed with ADHD or reading disabilities such as dyslexia. However, there has not been extensive research for interventions with children diagnosed comorbidly with ADHD and reading disabilities.

Influence of the Cerebellum

One commonality between ADHD and dyslexia is the involvement of the cerebellum. The cerebellum, located in the back of the brain, is responsible for coordinating movement and balance. Additionally, this “little brain” is vital in language, attention, and eye movement (Koziol et al., 2013). In persons diagnosed with ADHD, cerebellar differences have been observed in structural, functional, and spectroscopic imaging (Valera et al., 2007). Reduced right cerebellar volume has also been observed in children with ADHD when compared to siblings without a diagnosis of ADHD (Durston et al., 2004). Additionally, reduced cerebellar activation has been observed in the left lobule VI during working memory tasks in persons diagnosed with ADHD (Valera et al., 2005). Conversely, a region in the right lobule VI of the cerebellum has previously been reported to be a significant biomarker for adults diagnosed with dyslexia (Pernet et al., 2009). Although meta-analysis findings report different cerebellar regions are affected in ADHD and dyslexia, there are some commonalities evident between the cerebro-cerebellar networks in both disorders (Stoodley, 2014). In children diagnosed with ADHD, structural MRI studies have revealed smaller posterior-inferior vermis than children without an ADHD diagnosis (Berqiun et al., 1998) as well as correlations between ADHD severity ratings and the morphology of the posterior-inferior vermis (Castellanos et al., 2001), which is a structure that is associated with regulating posture and movement.

The cerebellum not only integrates motor and non-motor inputs (Ito, 2008), but it is also imperative for language production (Ackermann & Hertrich, 2000) and has a specific involvement in reading tasks (Fulbright et al., 1999). The cerebellum is involved in phonological and semantic processing (Stoodley & Schmahmann, 2009). Findings have indicated that cerebro-cerebellar connections are segregated (Kelly & Strick, 2003), which suggests that parts of the cerebellum have specific cognitive functions

(Schmahmann, 2019) such as integrating proprioceptive, visual, vestibular, and motor tasks to create multimodal representations of events (Baumann et al., 2014). Previous findings have suggested that the right cerebellum is involved in multiple language and semantic processes (Stoodley & Schmahmann, 2009), and the right posterior cerebellum is activated during the semantic processing and understanding of two complex nouns to form a new meaning (Graves et al., 2010).

Reading requires the understanding of the sequences of words to comprehend the text that is read. Evidence has demonstrated that the cerebellum is involved in reading, semantic memory, language production, object naming, and lexical processing (Stoodley & Schmahmann, 2009). Additionally, the cerebellum has been linked to reading tasks such as predictive functioning (Sokolov et al., 2017) and word retrieval (Addis et al., 2009). Findings of Gatti et al. (2020) revealed transcranial magnetic stimulation (TMS) on the right cerebellum affected accuracy of related word-pairs and unrelated word-pairs, suggesting semantic integration, the combining and consolidating of input from various sources, was hindered, thereby supporting the cerebellum's involvement in semantic integration.

The cerebellar deficit hypothesis argues that children with dyslexia have abnormal cerebellar functioning that leads to difficulty with automaticity of skills and reduced processing speed (Nicolson & Fawcett, 1990), as well as motor and oral-motor deficits due to a dysfunction of the cerebellum when compared to typically developing children (Nicolson et al., 2001). Difficulty with these skills can lead to cognitive processing and reading problems (Fawcett et al., 2001). Phonological deficits, such as deficits in phonological awareness, are commonly associated with children diagnosed with dyslexia

(Ramus, 2004). Functional and structural abnormalities in the cerebellum are also associated with dyslexia (Pernet et al., 2009). The cerebellar deficit hypothesis proposes that the cerebellar dysfunction initiates mild motor problems. This may lead to articulation difficulties as a child gets older, which results in impaired phonemic structures and reduced phonological awareness (Nicolson et al., 2001). These deficits can lead to decreased working memory functioning which could potentially lead to struggles with language acquisition (Gathercole & Baddeley, 1993). Additionally, the difficulties with processing speed caused by cerebellar dysfunction could lead to difficulties with rapid naming (Fawcett et al., 2001).

During reading tasks, people with dyslexia have abnormal activity in lobule VI of the cerebellum; however, meta-analyses have indicated lobule VI is not activated during reading tasks in children with isolated ADHD (Stoodley, 2014). Instead, the left region of lobule VI is activated during working memory tasks (Valera et al., 2005), which is required for comprehending text. Orthographic, phonological, and semantic information processing has also been observed in lobule VI during reading tasks in persons diagnosed with dyslexia (Price, 2012; Stoodley, 2012; Turkeltaub et al., 2002). Furthermore, evidence suggests persons with reading disabilities, such as dyslexia, have cerebellar gray and white matter abnormalities (Stoodley & Stein, 2012). Studies using fMRI imaging have revealed abnormal lateralization in gray matter volume in people diagnosed with dyslexia (Rae et al., 2002), as well as lateralized activity in the right cerebellum during reading (Price, 2012). In a study aimed to determine if cerebellar peduncle structural properties differ between full-term and pre-term children, findings indicated there were not significant differences in the cerebellar activity. However, results did reveal specific associations for decoding and comprehension with the left inferior cerebral peduncle and right superior cerebral peduncle, respectively. These results suggest the cerebellar white matter connecting the cerebellum to other structures potentially work together to compensate for reading difficulties by allocating other resources, leading to a faster transfer of information due to increased myelinization (Fernandez et al., 2016). This suggests the increased transfer speed of information potentially leads to better reading abilities.

Previous studies have yielded findings that readers with dyslexia demonstrate different cerebro-cerebellar functional connectivity during phonological tasks. This cerebro-cerebellar function is suggested to predict the formation of motor control, learning, and cognitive functions (Stanberry et al., 2006). The cerebellum potentially plays a role in spatial and visual processing (Deluca et al., 2014; Fink et al., 2000; Gogos et al., 2010). These findings suggest that activating the cerebellum could potentially activate a compensatory function in the cerebellum that utilizes other neural resources during the process of reading (Fernandez et al., 2016).

Cerebellum and Motoric Movements

Children with dyslexia have also demonstrated less motoric stability than children without dyslexia, and do not compensate as well as children without dyslexia when included in sensory-loaded conditions (Viana et al., 2013). The poor posture observed in children with dyslexia is potentially due to decreased sensory input functioning as well as decreased cerebellar integration (Goulème et al., 2015). Previous results have revealed postural training improved posture in both healthy adults and adults diagnosed with Parkinson’s disease, suggesting gray matter changes in the right cerebellum demonstrates the capability of brain plasticity (Sehm et al., 2014). Utilizing short postural training for children with dyslexia has yielded increased postural control, suggesting that brain plasticity allowed for better task performance due to stimulating the use of sensory inputs and cerebellar integration (Goulème et al., 2015).

Postural stability encompasses balance control, which has been a component of Quadrato Motor Training (QMT). QMT, a whole-body, sensorimotor, training program involving following oral directions while stepping on the structured corner of a given square, has demonstrated cognitive benefits in spatial cognition and creativity (Ben-Soussan et al., 2013). QMT utilizes coordination of smooth movements, balance and posture maintenance, motor learning, and visually guided movements which all incorporate cerebellar activity (Manto et al., 2011). A four-week daily training QMT regimen resulted in increased cerebellar alpha activity in adults with dyslexia, leading to better reading performance and indicating that the sensorimotor training elicited increased cerebellar activity. This potentially led to increased cerebellar plasticity, resulting in better performance on reading related tasks (Ben-Soussan et al., 2014).

Other interventions for children with dyslexia have involved neurofeedback (Breteler et al., 2009), but results did not yield any positive reading results. Home-exercise treatment programs (Reynolds et al., 2003) have also been implemented for children with dyslexia to increase cognitive processes and literacy skills. However, these studies were met with criticism citing fundamental flaws in the study as well as in the interpretation of the results (Snowling & Hulme, 2003). Furthermore, interventions such as Fast ForWord that used slowed down synthesized speech to target the auditory magnocellular system (Tallal et al., 1998) were deemed initially successful but have since been linked to controversy due to the minimal number of children with dyslexia who present with magnocellular deficits (Hook et al., 2001).

Motivation and Disabilities

Motivation is a behavior driven by internal or intrinsic motivation (Deci & Ryan, 1985) guided by the want to achieve (Maehr & Zusho, 2009). As academic failures and pressure from adults to achieve become more prevalent, the once intrinsic motivation of a child develops into an extrinsic motivation to succeed by the desire to please people such as parents and teachers (Vansteenkiste et al., 2006). Children with ADHD have demonstrated decreased motivation throughout academic areas when the content is considered challenging. However, the use of novel reading material involving unusual characters, surprise endings, and dramatic action have yielded more reading comprehension gains than material that is not interesting to the student (Beike & Zentall, 2012). Zentall and Lee (2012) discovered students with both ADHD and reading disabilities benefited from the use of specific labeling, individual feedback regarding mastery of goals, and stating performance goals during reading tasks. Using these strategies while involving motivating components can lead to students being more motivated during an intervention, which can lead to better academic outcomes. For interventions to be successful, tasks that are motivating to students should be explored to help elicit maximum participation and motivation for them to complete the tasks such as physical activities that are deemed as fun or exciting by the student.

Physical Activity Interventions

Effects of Movement on ADHD and Reading Disabilities

With the high prevalence of comorbid ADHD and reading disabilities (Karande et al., 2007), it is only natural to investigate an intervention that improves symptoms of both disorders. Students with disabilities are potentially at greater risk of academic difficulties and failures when compared to typically developing peers (Sideridis et al., 2006). Children diagnosed with ADHD often demonstrate comprehension difficulties with making causal connections from text that is read (Cherkes-Julkowski & Stolzenburg, 1991), while children with reading disabilities demonstrate different difficulties with reading comprehension such as those regarding inferential and causality comprehension (Zentall & Beike, 2012). Furthermore, inattention can impact word reading outcomes (Jacobson et al., 2013).

Exercise activities from rigorous aerobic exercise to easy movement activities have been investigated to determine the benefits on not only one's health and well-being, but also the implications for learning in students both with and without disabilities. Research has revealed that the human body learns during movement (Samaras et al., 1998). Studies have demonstrated exercise activities can improve educational performance (Barkley, 2004; Majorek et al., 2004), and lead to effective coping skills, positive self-image, and improvements in memory in the student's learning environment (Akande et al., 2000). Exercise can increase motivation in students (Jensen, 2005), as well as increase brain activity associated with emotion, memory, attention, language, and spatial perception (Olsen, 1994). Elementary school students have showed significant retention of learned vocabulary when using movement and fun games to learn the vocabulary words when compared to traditional vocabulary teacher methods (Bavi, 2018), demonstrating that the level of interest during movement interventions can positively impact vocabulary growth (Herlina, 2016). Findings have revealed that withholding exercise from students with ADHD can lead to behaviors that could not only disrupt classroom settings but also the capability of learning for those students with ADHD (Holtkamp et al., 2004). Additionally, a lack of physical activity in preschool and primary grades has been associated with poorer working memory (López-Vicente et al., 2017) while structured physical activity during school for these students can lead to increased executive functioning skills (Xiong et al., 2017).

The benefits of physical movement have been investigated from vigorous physical activity to increase positive behavioral outcomes in children with ADHD (Tantillo et al., 2002), to 40 minutes of physical activity for 5 days a week for 6 weeks improving behaviors in students diagnosed with ADHD (Wendt, 2000). Additionally, studies have investigated jogging to increase positive behavioral outcomes in the classroom (Wendt, 2001). The connection between physical activity, brain function, and improved classroom performance (Jensen, 2008; Labounty, 2007; Pierson, 2002) has led to further investigation of the links between behavioral characteristics and academic performance in children diagnosed with ADHD (Hall, 2007; Van Puymbroeck, 2006). Incorporating some form of movement in the classroom can be beneficial for transitions as well as academic learning (Mulrine et al., 2008); however, it is imperative to determine how much and how vigorous of an activity is needed for a student to be able to focus and comprehend what they are reading.

Investigators have experimented with the effects of various levels of exercise on reading comprehension such as implementing regimented home programs (Reynolds et al., 2003), consistent daily aerobic exercise differing in duration (Tine, 2014; Wendt, 2000), and using engaging balancing activities while students sit on therapy balls in a classroom setting (Goodmon et al., 2014). Repetitive coordinated bilateral movements for as little as 6 minutes a day have yielded positive results for boys and girls in the school-based setting in processing speed, focused attention, concentration performance, and attention span (Harris et al., 2018).

Physical activity has demonstrated calming effects on children diagnosed with ADHD (Jenson & Kenny, 2004). Therapy balls have yielded positive behavioral outcomes for children with attention difficulties (Schilling et al., 2003). When the positive effects of therapy balls were investigated for both children diagnosed with ADHD and dyslexia, Goodmon et al. (2014) found positive behavioral outcomes for attention and motivation but did not reveal increases for reading comprehension tasks. This could have been attributed to a high initial baseline, but future studies should investigate interventions to elicit better reading comprehension in students with both ADHD and dyslexia. Although sitting on therapy balls does require some core balance, the extent of balance activities should be investigated to determine if an increased physical activity before reading could allocate more neural resources for better attention to the reading material.

Mind Wandering

What is Mind Wandering?

Mind wandering refers to one's attention drifting away from the current task and being diverted towards an unrelated task or stimulus. When someone's mind wanders, they are not able to fully process the activity (Feng et al., 2013). Regarding reading, when the mind wanders, the person reading is not fully able to comprehend the text being read (Soemer & Schiefele, 2019). During mind wandering, thoughts shift from the immediate task to internal thoughts and feelings regarding tasks or events not current or pertinent to the ongoing, immediate task (Smallwood & Schooler, 2015). Mind wandering during reading may interfere with the reading, making inferences and deriving meaning from the content of the text difficult (Smallwood et al., 2008).

The act of mind wandering is vastly different for individuals in experiences, content, intentionality, and the relationship to the current task and the stimuli involved (Seli et al., 2018). Additionally, it is suggested that the act of mind wandering may be influenced by low working memory capacity (McVay & Kane, 2012), decreased executive functioning (Keulers & Jonkman, 2019), lack of interest or motivation in the text topic (Unsworth & McMillan, 2013), or a negative attitude regarding reading (Seli et al., 2019). Furthermore, reading difficulties (Feng et al., 2013) and overly lengthy texts (Forrin et al., 2019) may also influence the occurrence of mind wandering.

Studies have suggested that mind wandering is not solely detrimental but can have positive cognitive effects (Mooneyham & Schooler, 2013) such as leading to future planning and thinking (Stawarczyk et al., 2011) and creative problem solving (Baird et al., 2012). However, the detrimental effects of mind wandering are just as apparent, specifically the potential effects on reading comprehension (Feng et al., 2013; Smallwood, 2011; Unsworth & McMillan, 2013). In a study to determine whether reading silently, reading aloud, or listening to a story resulted in less mind wandering, results indicated students without reading difficulties demonstrated less mind wandering when reading out loud and the most mind wandering when solely listening to the text (Varao Sousa et al., 2013). However, contradicting studies have demonstrated that reading aloud produced more mind wandering instances than reading silently (Franklin et al., 2014).

Mind wandering can be measured either objectively or subjectively. To measure objectively, mind wandering is assessed indirectly through tracking reaction times (Cheyne et al., 2006) or through tracking eye movements (Reichle et al., 2010). To measure subjectively, participants are directly assessed through self-reporting on their current internal state either through self- catching mind wandering instances (Giambra, 1989) or through probing (Klinger, 1984). Currently, probing is the most universally used method of measuring mind wandering by utilizing probes where participants are stopped mid task and asked where their attention is directed and that specific point in time (Weinstein, 2017).

Mind Wandering and ADHD

Increased levels of spontaneous mind wandering have been exhibited in children diagnosed with ADHD (Biederman et al., 2017) which can potentially lead to deficits in cognitive, emotional, and education domains such as working memory deficits (Mrazek et al., 2012), poor reading comprehension (Mrazek et al., 2013), and lower academic achievement (Seli et al., 2016). Children with a diagnosis of ADHD who are medicated have demonstrated a higher occurrence of mind wandering during a task while children diagnosed with ADHD who are not medicated have demonstrated higher occurrences of mind blanking (Van den Driessche et al., 2017). While mind wandering involves the shifting of attention to an idea that is not current with the present task, mind blanking refers to the loss of voluntary control of the mind due to relaxation or intense fatigue or distraction where one does not have or want to control the mind in the current state (Taylor, 1978). During these times of blanking, the mind is not focused on any internal or external stimuli (Ward & Wegner, 2013).

During mind wandering, the individual continues to appear to be engaged in the task, as their eyes may continue to move across a page when reading. When the mind wandering episode is finished, the individual likely redirects their attention to the current spot on the page, and not necessarily the spot in which they stopped actively attending. This results in potentially missing large portions of a text read thus leading to deficits in the comprehension of the text. Mind blanking, however, results in an individual physically pausing during the task and then returning to where they left off. The act of mind blanking may result in an individual not missing as much vital information needed to comprehend a text. Furthermore, individuals engaging in mind blanking are less likely to demonstrate deficits when tested on the information read when compared to individuals engaging in mind wandering during the same task (Ward & Wegner, 2013).

Mind wandering is measured through self-reporting, which is subjective in nature. Individuals with ADHD have consistently described mind-wandering experiences as numerous internal thoughts at one time that are distracting, and the thoughts often jump from one topic to the next and are continuous (Mowlem et al., 2019). Studies have demonstrated that children with ADHD demonstrate more spontaneous mind wandering than children without an ADHD diagnosis. Spontaneous mind wandering in children can predict lower working memory, emotion regulation, and academic achievement when elevated. When treating children with ADHD, mind wandering should be assessed to develop target outcomes (Frick et al., 2019).

Mind Wandering and Dyslexia

The inability to read accurately and quickly is a common deficit among students with reading difficulties (Shaywitz & Shaywitz, 2005). These deficits with fluency are suggested to impact readers longer than difficulty with decoding words accurately (Kim et al., 2010). While disfluent reading is a common marker of dyslexia, other determinants such as phonology, speed of processing, attentional processing, and visuo-perceptual processing may also comprise the underlying profile (Pennington, 2006). It is hypothesized that children with dyslexia may mind wander more than children who are typical readers due to the strenuous and fragmented characteristics of disfluent reading that allow the mind to wander, or due to the working memory (Giofrè et al., 2017) and attention deficits (Helland & Asbjornsen, 2000) that are often associated with dyslexia profiles (Keulers & Jonkman, 2019; McVay & Kane, 2012). Additionally, children with dyslexia may associate levels of text as more compared with typical readers. With levels of text seeming more difficult than a typical reader would think, it is plausible that a higher difficulty text level may lead to a higher level of mind wandering (Feng et al., 2013), leading readers with dyslexia to experience more mind wandering moments. This is of great concern given that a reader must sustain attention throughout the text to fully understand the words and meaning (Arrington, 2012).

Effects of Reading Modalities on Mind Wandering

Reading out loud has been investigated over the years regarding the benefits it may have on reading comprehension with or without the presence of ADHD and/or reading disabilities in participants (Collins, 1961; Hale et al., 2007; Rowell, 1976). Elementary school provides multiple forms of reading opportunities such as reading aloud and silent reading. With various forms of input, the level of attention students relay to the task may vary. Students must be able to attend to the material and remember it. It has been suggested that the more systems involved in a task the more likely the person is fully engaged in the task rather than engaging in mind wandering (Smallwood et al., 2013). When comparing different modes of reading, findings have suggested that children ages ten to 12 have reported less mind wandering when reading aloud and the most instances of mind wandering when solely listening to reading material, which resulted in the poorest results of the memory test. While children reported reading aloud led to less mind wandering than silent reading (Varao Sousa et al., 2013), contradictory findings have yielded reports of silent reading resulting in less mind wandering than reading out loud (Franklin et al., 2013). Although variable, findings in studies are consistent that either silent reading (Franklin et al., 2011; Schooler et al., 2004; Smallwood et al., 2008) or reading aloud (Varao Sousa et al., 2013) may yield less instances of mind wandering than solely listening to material. It is theorized that the more difficult and cognitively demanding and effortful the task, the less instances of mind wandering occur (Forster & Lavie, 2009; Smallwood et al., 2007; Thomson et al., 2013). If these hypotheses hold true, then reading aloud, which uses oculomotor activity (reading silently also requires oculomotor activity as well as ongoing verbalizations), would be a more cognitively demanding task which could lead to less mind wandering and more attention to the material for comprehension.

Investigators have demonstrated that reading aloud has yielded better comprehension scores on multiple choice tests following reading in children in primary and secondary grades (Hale et al., 2007). Varao Sousa et al. (2013) investigated various modalities involving text such as reading out loud, reading silently, and listening to text while engaging in periodic probe questions regarding mind wandering. Results concluded that reading out loud resulted in less mind wandering while listening to reading resulted in more. Investigators deduced this was attributed to reading out loud potentially involved more systems being engaged during reading while listening to reading engaged the least number of systems. Researchers stated the decreased amount of mind wandering in reading out loud was due to more systems being used, thus less likelihood for off-task behavior. In contrast to these findings, Franklin et al. (2014) discovered reading out loud resulted in more instances of mind wandering when probed with a similar method to the one Varao Sousa et al. (2013) used. In this study, researchers suggested that rather than reading out loud using more systems to lessen off-task behavior and mind wandering, reading out loud promoted self-conscious awareness that increases the tendency to direct attention to the self, leading to a greater propensity for internal off-task behavior of thoughts about themselves.

Studies investigating the effects of mind wandering on comprehension have suggested more motivating and interesting content will have a positive effect on comprehension (Kopp & D'Mello, 2016). Findings have also demonstrated that the type of reading modality or the reading condition, such as the type of story, may impact the amount of mind wandering exhibited (Franklin et al., 2014; Kopp & D'Mello, 2016).

Mind Wandering Strategies

Mind wandering can be measured using rating scale and trait measures. Even though one can sample instances of mind wandering experiences in daily life and during mind wandering experience scenarios (Bozhilova et al., 2018), it is difficult to recognize and control the experience of mind wandering (Smallwood et al., 2011). It is imperative to figure out strategies to combat detrimental mind wandering, especially during reading. Intermittent thought probes during tasks and questionnaires are strategies that have been the interventions used most consistently for mind wandering instances (Smallwood et al., 2004). Self-monitoring strategies for students with attention difficulties allow students to learn regulation strategies that can generalize across circumstances (Brooks et al., 2003; Levendoski & Cartledge, 2000). Implementation of self-monitoring strategies have demonstrated increased on-task behavior, decreased instances of talking out (Smith & Sugai, 2000), and increased work completion (Brooks et al., 2003) in students with ADHD (Stewart & McLaughlin, 1993). Self-management plans allow students to demonstrate completion of the task independently with the use of prompts to assist in the desired task (Craft et al., 1998). By self-monitoring academic performance using strategies, students diagnosed with ADHD and learning disabilities have both demonstrated increased academic productivity due to on-task behavior (Carr & Punzo, 1993; Harris, 1986; Lloyd et al., 1982; Maag et al., 1993; Reid, 1996; Reid & Harris, 1993).

Self-Monitoring Strategies

Benefits of Self-Monitoring

Self-monitoring, a crucial component of self-regulation, is the direct attention to one's behavior and is essential in learning (Lan, 1996). Self-monitoring is a strategy that trains students to observe their own behavior and independently determine if they are on-task in the academic, social, or behavior task that they are working on (Bell et al., 2013). Self-monitoring strategies have resulted in successful gains in reading performance (Joseph & Eveleigh, 2009), academic productivity (McDougall et al., 2012), and on-task behavior for students with diagnosed disabilities (Boswell et al., 2013). This two-step intervention of observing behavior and then recording the behavior in some component (Mace et al., 1989) is one of the most common self-management interventions used to manage one's own behavior (Mooney et al., 2005). When students are able to monitor their own behavior, they are more likely to complete reading assignments and engage in reading tasks (Cole & Bambara, 1992; McLaughlin, 1984).

Checklists

A checklist is a visual representation of the task that helps students with self-monitoring. Using a checklist for self-monitoring during tasks has demonstrated a decrease in disruptive behavior in students (Bruhn & Watt, 2012), an increase in on-task behavior (Graham-Day et al., 2010; Gureasko-Moore et al., 2006), and even an increase in spelling accuracy (Harris et al., 2005) in students diagnosed with ADHD. Self-monitoring strategies such as checklists are an inexpensive, effective, and easy to implement intervention for students with ADHD (Levendoski & Cartledge, 2000) that can be implemented in various educational settings for various grades and ages throughout a school environment (Webber et al., 1993). It is important that the individual students who use the self-monitoring tools be explicitly trained on how to utilize the checklists (Bell et al., 2013).

While students who are adequate readers can independently use strategies to help with their comprehension of the text (Pressley, 2002), students with poor reading ability lack the strategies to repair any comprehension breakdowns that may occur while reading (Gunning, 2002). Checklists can offer a concrete way to become aware of strategies and utilize them before, during, and after reading (Massey, 2003). Checklists can allow for readers to independently monitor where the breakdown is in comprehension by helping them self-regulate their learning (Pressley, 2000). Checklists have been implemented successfully for repairing comprehension breakdowns during reading (Massey, 2003), but minimal research has been implemented utilizing checklists for attention to the text to facilitate accuracy of word reading and reduction of skipping words and lines in the text to facilitate comprehension.

Chapter III

Methodology

This chapter discusses the participants, procedures, and data analyses of the study. This study follows an experimental, pre- and posttest design utilizing a pretest and posttest measure. This study was approved by both the Institutional Review Board (IRB) as well as the elementary school county review board (see Appendices A & B).

Research Design

This quantitative, experimental study utilized a pre- and posttest design. Three participants in an elementary school were selected by the clinician based upon meeting participation criteria of a diagnosis of both ADHD and dyslexia. Data was collected solely by the clinician for pre-experimental, pretest, and posttest measure to determine if reading accuracy, comprehension, fluency, reading rate, or overall reading abilities increased and if error types decreased by using a paired samples *t*-test for data analysis.

Population and Sample

Participants for the study included three students from a diverse population in an affluent suburban elementary school in Georgia. Participant A is a Caucasian female in the third grade (8 years, 3 months) with a medical diagnosis of specific learning disability in reading- dyslexia and ADHD. Participant B is a Caucasian female in the fifth grade (10 years, 5 months) with a medical diagnosis of specific learning disability in reading- dyslexia and ADHD primarily inattentive type. Participant C is a Caucasian male in the fifth grade (11 years, 2 months) with a medical diagnosis of dyslexia and ADHD-combined type. All participants received intellectual quotient testing within three years of the study with results for all participants within the average range. It was reported that Participant B does not take any medication for their ADHD diagnosis. It was reported that Participant A and C were on consistent medication for ADHD at the time of the study. All participants passed a hearing and vision screening prior the study. All participants did not present with any motor impairments that would hinder participation in the study. All participants of the study solely spoke English. All parents of participants were contacted via phone and consent was signed for participation in the study. It was shared with participants that participation was completely voluntary and would have no bearing on their grades or services at school.

Both Participants A and B receive all components of their school day in a general education setting and have an Individual Accommodation Plan (504) in place at school due to their diagnoses of ADHD and dyslexia. Participant C receives special education services through the eligibility impairment criteria of Specific Learning Disability and Other Health Impairment and receives special education services in the areas of reading and math. All participants were in different classrooms and did not have opportunities to talk about the experiment after the sessions were completed.

Participants were administered pre-experimental testing measures to assess their baseline functioning of sight word and phonemic decoding efficiency, phonological and rapid naming skills, and listening comprehension skills prior to starting the study. Administration consisted of the Test of Word Reading Efficiency - 2nd Edition (TOWRE-2; Torgeson et al., 2012), Comprehensive Test of Phonological Processing - 2nd Edition

(CTOPP-2; Wagner et al., 2013) and Listening Comprehension Test-2nd Edition (LCT-2; Bowers et al., 2006). Data are found in Table 1.

Table 1

Individual Participant Pre-Experimental Testing Results

Participant	TOWRE SW	TOWRE PD	TWRE	CTOPP EL	CTOPP BW	CTOPP PI	CTOPP RANL	CTOPP RAND	CTOPP PA	CTOPP RAN	LCT
A	77	73	74	9	11	9	5	6	98	73	99
B	96	98	97	7	6	12	11	10	90	104	117
C	87	81	83	6	8	6	11	7	80	95	94

Variables and Instrumentation

The current study investigated the effect of a balance activity and visual checklist, the independent variables, on reading accuracy, comprehension, fluency, rate, overall reading abilities, and error type, the dependent variables.

Pre-experimental measures were administered to all participants to include the Test of Word Reading Efficiency - 2nd Edition (TOWRE-2) to assess accuracy and fluency of sight word and phonemic decoding efficiency. This test has alternate forms which can address alternate form reliability. It is normed for ages 6 to 24 years, 11 months with Sight Word Efficiency alternate form reliability being .91 and Phonemic Decoding Efficiency alternate form reliability being .95. Additionally, test-retest reliability for both subtests used had average coefficients between .89 to .93 (Torgesen et al., 2012). Participants also received the Comprehensive Test of Phonological Processing - 2nd Edition (CTOPP-2), normed for ages 4 through 24 years, 11months, for the Phonological Awareness Composite Score and Rapid Symbolic Naming Composite Score. This assessment was selected due to including assessment of common skill difficulties that are associated with dyslexia. Internal consistency coefficients for all composites were .85 or higher (Dickens et al., 2014; Wagner et al., 2013). Additionally, participants were administered the Listening Comprehension Test-2nd Edition (Bowers et al., 2006) normed for ages 6 years through 11 years, 11 months. The LCT-2 has a reliability coefficient of .91 and a Standard Error of Measure of 3.65. This assessment examined strengths and weaknesses through subtests of Main Idea, Details, Reasoning, Vocabulary, and Understanding Messages through natural classroom situations. The LCT-2 is approximately a 35-minute assessment that assesses skills of receptive language, language cohesion, detail recall, inferencing, semantics, attending, and processing. This assessment has a high reliability coefficient of .91 and a low Standard Error of Measurement (SEM) of 3.65 (Bowers & LoGiudice, 2006).

For both the pretest and posttest, participants were administered reading comprehension passages from the Gray Oral Reading Test - 5th Edition (GORT-5; Wiederholt & Bryant, 2012). The test has two parallel forms: Form A and Form B. Form A was used for the pre-test and Form B was used for the post-test and was chosen due to its high test-retest reliability (average coefficient alphas > .90) due to alternate forms available to measure improvements. Additionally, the GORT-5 yielded a high concurrent validity (.70 - .89) when compared to scores from the Woodcock Johnson-4th edition (Jennings et al., 2024). Furthermore, the GORT-5 manual provides substantial evidence for content, construct, and criterion related validity (Wiederholt & Bryant, 2012). The reading passages for the learning session of the experiment were passages from the Qualitative Reading Inventory-6th Edition (QRI-6; Leslie & Caldwell, 2017). The passages used were quasi-equivalent passages and were appropriate for each participant's grade level. The QRI-6 was used due to its high validity when compared to other reading tests with validity coefficient of .90 for word reading and .75 for comprehension.

Procedure

All sessions were administered individually to each participant. The clinician was trained and familiar with the testing protocols for each assessment given. A script of acceptable prompts to elicit the balance sequence (Appendix C) was available to the clinician to ensure the same verbiage was used with each participant. The clinician also had a script for the “Brain Check” visual checklist (Appendix D). For the baseline measure, all participants completed Form A of the GORT-5. The visual checklist and balance activity were not discussed during the baseline testing. For the practice session, all participants were brought into the room with the balance activity set up and the visual checklist displayed on the table. The clinician first demonstrated the balance activity saying out loud what each of the steps for the activity were. The balance activity was completed as follows:

1. The participant stepped up onto the first balance bucket. The participant then raised on to their toes and counted out loud to five. After counting to five, the participant lowered their heels and stepped to the next balance bucket.
2. The participant stood on one leg with the other leg beside them, not on the bucket, and counted out loud to five. After counting to five, the participant stepped to the next bucket.
3. The participant stood on the opposite leg from the previous bucket and had the other leg beside them, not on the bucket, and counted out loud to five. After counting to five, the participant stepped to the next bucket.

4. The participant stood on the opposite leg from the previous bucket, held the other leg straight out in front, and counted out loud to five. After counting to five, the participant stepped to the next bucket.
5. The participant stood on the opposite leg from the previous bucket, held the other leg straight out in front, and counted to five out loud. After counting to five, the participant stepped to the next bucket.
6. The participant stood on the bucket with both feet. The participant then did 5 toe raises by raising their heels off the bucket counting each toe raise out loud to five. When finished, the participant jumped down and went to the table where they began reading the passage.

After demonstrating the balance activity, the clinician directed the participants to look at the "Brain Check" visual checklist on the table. The clinician then read the script for the "Brain Check" for the visual checklist and the participants were explicitly taught how to use the "Brain Check" visual checklist. Next, the clinician directed the participants to complete the balance activity on their own while the clinician read the script. Once completed, the participants were directed to sit at the table and read a passage appropriate for their grade level and answer 5 comprehension questions from the QRI-6. The visual checklist was on the table next to the participant for the entirety of the practice session. Once the participant finished answering the questions, the participant was directed to answer the questions on the Brain Check visual to self-assess attention.

For the post-test measure, each participant entered the room and was directed to the balance buckets. The clinician read from the script to direct the participants to complete the balance sequence.

Once completed, participants were directed to sit at the table. The “Brain Check” visual was displayed on the table. The GORT-5 Form B was administered to all participants. At the end of administration, the clinician had the participants self-assess attention by answering the questions on the “Brain Check” visual check list. All sessions were administered on separate days at the same time for validity purposes. If a participant was on medication, the clinician verbally confirmed with the parent that there were no changes in medication and that the medication had been administered that morning with no changes.

Data Analysis

To address the research questions which asked if accuracy, comprehension, fluency, rate, overall reading abilities, and error type were positively impacted by the intervention, pretest and posttest measures were analyzed using a paired samples *t*-test to determine if there were significant differences in Form A and Form B of the GORT-5. This is appropriate due to the participants being measured before and after the intervention was implemented. Prior to the analysis, variance assumptions were assessed, and alpha (*a)* was set at a significance level of a = .05). Data was analyzed utilizing SPSS software to determine if there was a significant difference resulting in a main effect between pretest and posttest measures for participants due to the implementation of the balance activity and “Brain Check” visual checklist. The null hypothesis was that there was no significant difference between pretest and posttest scores after implementing the intervention. For the alternate hypothesis, an increase in accuracy, comprehension, fluency, rate, and overall reading abilities, and a decrease in error type on the posttest assessment would indicate that the balance activity and the visual checklist may have contributed to better allocation of attention resources while reading after the intervention evidenced by positive gains in the posttest measure.

Chapter Summary

In summary, three participants, meeting all diagnostic criteria, participated in the current study. All participants completed each session individually and at a consistent time for validity purposes. Paired samples *t*-tests were used to determine if there was a significant difference in pretest and posttest GORT-5 measures. The next chapter provides detailed results to the research questions of whether accuracy, comprehension, fluency, rate, overall reading abilities, and error type were significantly impacted due to the implementation of the balance activity and "Brain Check" visual checklist.

Chapter IV

Findings

Analyses of Research Questions

The experimental measures in the current study were obtained from the pre- and posttreatment administrations of the GORT-V. From the GORT, measures of Rate, Accuracy, Fluency, and Comprehension were all obtained as scaled scores with a mean of 10 and a standard deviation of three whereas the Overall score was a standard score with a mean of 100 and a standard deviation of 15.

In order to investigate the experimental question which asked if performing sequenced balance activities would impact reading rate, a paired samples *t*-test was conducted on the pre- and posttreatment GORT-Rate scores. No significant improvement was found.

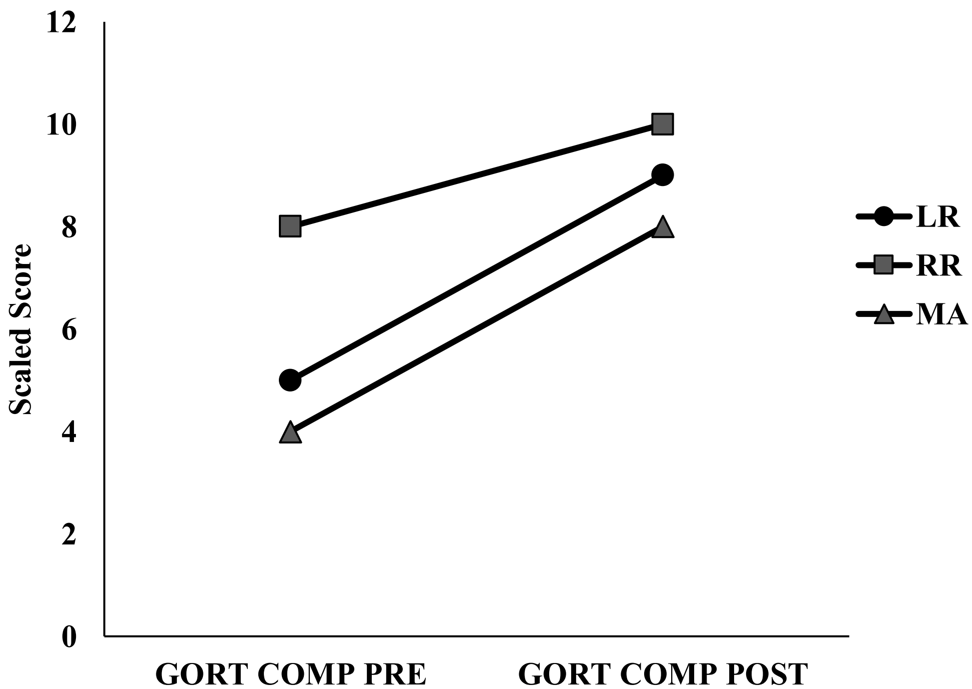
In order to investigate the experimental question which asked if performing sequenced balance activities would impact word reading accuracy, a paired samples *t*-test was conducted on the pre- and posttreatment GORT-Accuracy scores. No significant improvement was found.

In order to investigate the experimental question which asked if performing sequenced balance activities would impact reading fluency, a paired samples *t*-test was conducted on the pre- and posttreatment GORT-Fluency scores. No significant improvement was found.

In order to investigate the experimental question which asked if performing sequenced balance activities would impact reading comprehension, a paired samples *t*-test was conducted on the pre- and posttreatment scores from the GORT-Comprehension. Results indicated significant improvement for the posttreatment GORT-Comprehension measure (*M* = 9.0, *SD* = 1.0) compared to the pretreatment administration of the GORT-Comprehension measure (*M* = 5.67, *SD* = 2.08), *t*(2) = -5.0), *p* = .038 (see Figure 1).

Figure 1

Main Effect of GORT Comprehension Pretreatment vs. Posttreatment

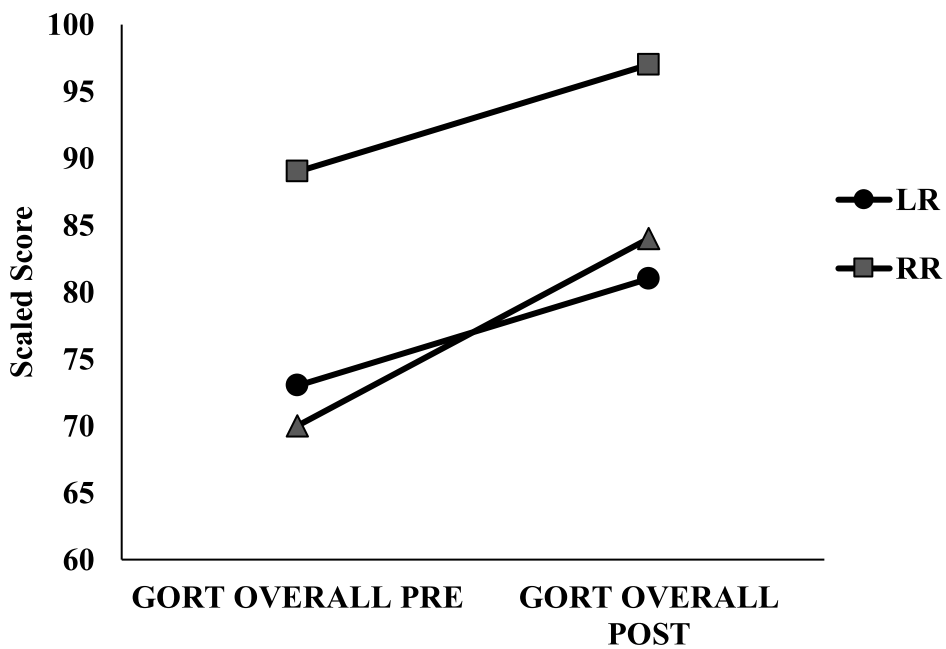


In order to investigate the experimental question which asked if performing sequenced balance activities would impact overall reading performance, a paired samples *t*-test was conducted on the pre- and posttreatment GORT-Overall scores. The analysis found significant improvement for the posttreatment GORT-Overall measure (*M* = 87.33, *SD* =

8.51) compared to the pretreatment calculation of the GORT-Overall measure (M = 77.33, SD = 10.21), $t(2) = -5.0$), p = .038 (see Figure 2).

Figure 2

Main Effect of GORT Overall Pretreatment vs. Posttreatment



In order to investigate the experimental question which asked if performing sequenced balance activities would impact reading error types, each error was categorized as an omission, substitution, addition, or repetition. A paired samples t-test was conducted on the pre- and posttreatment error type analyses. No significant differences were found between any of the error types although decreases in the amount of omissions, additions, and repetitions were noted during the experimental condition (see Table 2).

Table 2

Means and Standard Deviations of Error Types per Number of Passages Read

	Omissions	Substitutions	Additions	Repetitions	Total Additions (Adds + Reps)	Total Errors
Control	.53 (.32)	1.43 (1.54)	.98 (.90)	4.5 (2.63)	4.89 (2.86)	10.61 (3.12)
Experimental	.31 (.241)	3.57 (4.16)	.52 (.43)	1.71 (1.42)	2.27 (1.83)	7.58 (2.32)

Chapter Summary

Results of the current study indicated a significant improvement for comprehension and overall reading abilities when measured by a paired samples *t*-test. No main effects were found for accuracy, fluency, rate, and error type. While there was not a significant improvement on error type, analysis did demonstrate a reduction in error type omissions, additions, and repetitions. Analysis of substitutions did not reveal a reduction in errors. The next chapter discusses in depth the findings, implications of the results, and recommendations for future studies.

Chapter V

Discussion and Implications

Summary of the Study

In summary, the current study investigated if a balance activity before reading paired with a visual checklist while reading would potentially allocate attention more efficiently leading to subsequent increases in reading accuracy, comprehension, fluency, rate, and overall reading abilities as well as decrease error types in elementary-aged students diagnosed with both ADHD and dyslexia. Three participants participated in this study which utilized pretest and posttest measures. Significant improvements were revealed for comprehension and overall reading abilities. Additionally, while no significant improvements resulted from analysis for error type, the number of errors for omissions, additions, repetitions, and overall total errors did decrease from pretest to posttest measures.

Discussion

The aim of this study was to determine if a balance activity and visual checklist could facilitate better attention to a reading task to improve accuracy, comprehension, fluency, rate, overall reading abilities, and decrease error types in students diagnosed with both ADHD and dyslexia. With ADHD and dyslexia sharing a commonality of cerebellar involvement (Pernet et al., 2009; Valera et al., 2005), the current study focused on activating the cerebellum through known modalities such as movement and balance (Floyer-Lea & Matthews, 2005; Lehéricy et al., 2005). It was hypothesized that the sequenced balance activity would activate the cerebellum to help allocate attention to the reading task presented. While physical activity has been studied for children with ADHD and children with dyslexia separately (Goodmon et al., 2014; Reynolds et al., 2003; Tantillo et al., 2002; Tine, 2014; Wendt, 2000; Xiong et al., 2017) little research has explored reading comprehension and attention for students specifically with a comorbid diagnosis. The use of visual checklists as a self-monitoring tool has yielded positive results when used for repairing reading breakdowns and reading comprehension (Massey, 2003), but little research has been implemented to investigate the pairing of these two interventions together to elicit better reading gains in students. This current study investigated the gaps in the literature to use both balance activities and visual checklists to stimulate better reading outcomes for this population of students.

Results indicated that there was no significant improvement to accuracy, fluency, and rate from pretest to posttest measures. This study utilized one pretest and posttest measure to determine if the intervention elicited positive gains. Previous research has revealed that repetitive readings, such as being exposed to the same text multiple times (Samuels, 1979), is an effective intervention for children diagnosed with dyslexia (Chen, 2023). When utilizing this intervention for academic success in a classroom setting, accuracy, rate, and fluency could potentially increase if repeated readings are used in conjuncture with the balance activity and visual checklist.

Results indicated a significant improvement in reading comprehension from the pretest (M = 5.74, SD = 2.08) and posttest measures (M = 9.0, SD = 1) and for overall reading abilities from pretest (M = 77.33, SD = 10.2) to posttest measures (M = 87.33, SD = 8.51). These analyses supported the hypothesis that the balance activity and visual checklist would elicit positive gains after reading a text. While previous studies have demonstrated better attentional outcomes utilizing therapy balls (Goodmon et al., 2014), this study was able to demonstrate a connection between physical activity, such as balance, and increased reading comprehension outcomes, unlike previous literature reports that have had mixed results in regards to either attention or reading outcomes (Goodmon et al., 2014, Reynolds et al., 2003; Tine, 2014; Wendt, 2000). This could be due to the fact that previous literature has investigated interventions such as therapy balls for sitting (Goodmon et al., 2014), intense physical activity (Reynolds et al., 2003), and consistent aerobic exercise of varying amounts (Tine, 2014; Wendt, 2000) and not specific balance related activity to initiate cerebellum activity. While therapy balls require some balance (Goodmon et al., 2014), this current study utilized a more regimented balance sequence that could have activated the cerebellum to allocate neural resources to the task at hand (Fernandez et al., 2016). Other intensive training programs spanning over weeks using postural stability and whole body, sensorimotor movements have yielded better reading outcomes in adults with dyslexia (Ben-Soussan et al., 2013); however, this study yielded positive outcomes in a single-session, time efficient balance sequence activity in students.

Furthermore, visual checklists have been utilized as an independent tool for students to self-regulate their learning and repair the breakdown in comprehension (Pressley, 2000). This study demonstrated not only an informal way of attending to task, but also one that potentially helped lead to gains in overall reading abilities even though accuracy, fluency, and rate outcomes did not specifically yield significant improvements. The visual checklist was presented to each participant in the trial session of the study and students were explicitly taught how to use the checklist (Bell et al., 2013). During the post-test implementation, the visual checklist was on the table next to the participant in eyesight. At the end of the post-test session, each participant was directed to read the three questions out loud and answer them for the clinician. Participant A read the questions each checklist question out loud and answered, "The stories," to Question 1, "The stories," to Question 2, and "Yes," to Question 3 on the "Brain Check" questions. Participant B answered, "The reading passages," to Question 1, "The reading passages," to Question 2, and "Yes," to Question 3 on "Brain Check" questions. When Participant C was directed to answer the "Brain Check" questions after completing the post-test reading task, Participant C answered, "What I am reading," to Question 1, "I thought about my homework I didn't do for a minute and then back to what I was reading," for Question 2, and "Mostly yes," for Question 3. All three participants demonstrated the ability to use the checklist independently (Pressley, 2000), and Participant C demonstrated regained attention after mind wandering during post-test administration. These findings uphold previous literature of utilizing strategies during before, during, and after tasks (Massey, 2003) and further demonstrates that the use of a visual checklist potentially increases attention to task therefore helping elicit better reading comprehension outcomes. It should be noted that Participant C acknowledged the act of mind wandering through the answer to questions 1 and 2 of the "Brain Check" visual checklist. This demonstrates that while it is difficult to recognize and control when an individual experiences mind wandering (Smallwood et al., 2011), the visual checklist was able to help Participant C recognize the instance of mind wandering and turn his attention back to the reading task.

While there were no statistically significant improvements found for decreases in error type after the analysis, upon further review, the number of omissions, additions, repetitions, total additions (additions plus repetitions), and overall errors when reading the text decreased from the control to the experimental session after the intervention was implemented. Prior studies have revealed that children with ADHD exhibit reduced reading fluency and automatic and smooth recognition of words when compared to children without ADHD leading to reading errors such as omissions (Jacobson et al., 2011). Additionally working memory and processing deficits may lead to more repetitions when reading a text (Jacobson et al., 2013). Omissions, additions, and substitutions are also consistent errors demonstrated in children with dyslexia (De Rom & Van Reybroeck, 2024). This current study specifically investigated the effect the balance sequence and visual checklist would have on these types of reading errors. Omissions decreased from .53 (.32) to .31 (.241), additions decreased from .98 (.90) to .52 (.43), repetitions decreased from 4.5 (2.63) to 1.71 (1.42), total additions decreased from 4.89 (2.86) to 2.27 (1.83), and total errors decreased from 10.61 (3.12) to 7.58 (2.32). It can be postulated that the decrease in errors could be due to better neural resource allocation (Fernandez et al., 2016) to the text from the balance activity stimulating the cerebellum, and decreased impulsivity which can help reduce the number of words skipped (Gray & Climie, 2016). Additionally, the self-monitoring of reading errors was able to be implemented independently and increased on-task behavior due to the use of a visual checklist (Graham-Day et al., 2010). It should be noted that substitutions increased from 1.43 (1.54) to 3.57 (4.16), but overall errors exhibited while reading still decreased even with a noted increase in substitutions.

Limitations to the Study

Limitations of this study included a small sample size of students to include two female and one male with one female being in the third grade and the other two participants being in the fifth grade. All participants previously knew the researcher due to the researcher's position at the elementary school. While the participants were made aware that there was no grade or school affiliation with the current study, a Hawthorne effect could have resulted from the participants simply knowing they were participating in a research study. All sessions were done in a one-on-one setting with the clinician. Further investigation should be completed to explore the effects and outcomes of a balance intervention and checklist in the classroom setting.

Recommendations for Future Research

Children with ADHD and reading disabilities demonstrate academic difficulties in reading comprehension which is vital for academic success. While this current study investigates implications of a balance activity paired with a visual checklist in a one-on-one setting, future research should investigate results within a classroom or small group setting. Additionally, a small sample size was used, and future research should investigate outcomes with a larger sample size.

Summary and Conclusion

Reading comprehension is a vital part of not only a student's academic career but also in most future endeavors that occur throughout their life. With ADHD and dyslexia being prominent comorbid disorders in the school-based setting, it is natural to investigate a cost effective, time efficient intervention that can benefit reading outcomes. This study aimed to determine if a balance activity before reading a text out loud paired with a visual checklist during the reading of the text would elicit positive reading outcomes in this group of students. Analysis of the intervention revealed that reading comprehension and overall reading abilities demonstrated a significant improvement from pretest and posttest measures in all participants. Additionally, while not demonstrating a statistically significant impact, data revealed error types of omissions, additions, repetitions, total additions, and overall errors decreased as a result of the intervention. Future research should investigate this intervention with larger sample sizes as well as implementation in a small group or classroom setting.

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Appendix A:

Valdosta State University IRB Submission

Institutional Review Board (IRB)
for the Protection of Human Research Participants
Expedited Protocol Approval Report

Protocol Number: 04591-2025 **Responsible Researcher:** Allison (Daniels) Donovan

Supervising Faculty: Dr. Matthew Carter

Project Title: *Reading Difficulties in Children with ADHD and Dyslexia: The Effectiveness of Balance Activities.*

Level of Risk:	☒ Minimal ☐ More than Minimal
Type of Review:	☒ Expedited ☐ Convened (Full Board)
Approval Category:	6 & 7
Approval Date:	08.22.2025
Expiration Date:	08.22.2028

Consent Requirements:

- ☐ Adult Participants – Written informed consent with documentation (signature)
- ☐ Adult Participants – Written informed consent with waiver of documentation (signature)
- ☐ Adult Participants – Verbal informed consent (research statement) – interview
- ☐ Adult Participants – Research consent statement – online survey
- ☐ Adult Participants – Waiver of Informed Consent
- ☒ **Minor Participants – Written parent/guardian permission with documentation (signature)**
- ☐ Minor Participants – Written parent/guardian permission with waiver of documentation (signature)
- ☐ Minor Participants – Verbal parent/guardian permission
- ☐ Minor Participants – Waiver of parent/guardian permission
- ☐ Minor Participants – Written assent with documentation (signature)
- ☒ **Minor Participants – Written assent with waiver of documentation (signature)**
- ☐ Minor Participants – Verbal assent
- ☐ Minor Participants – Waiver of assent
- ☐ Waiver of some elements of consent/permission/assent

Comments: *IRB approval must be received before altering the scope of the project, research protocol, or consent process/forms.*

Approval: *This research protocol is approved as presented.*

Elizabeth Ann Ophie *08.22.2025*
Elizabeth Ann Ophie, IRB Administrator Date

Form Revised: 07.09.2024 - tw

Appendix B:

Gwinnett County IRB Submission

GWINNETT COUNTY PUBLIC SCHOOLS

437 Old Peachtree Road, NW
Suwanee, GA 30024-2978
678-301-6000
www.gcpsk12.org

[illegible]

The Mission of Gwinnett County Public Schools
is to pursue excellence in academic knowledge, skills, and behavior for each student, resulting in measured improvement against local, national, and world-class standards.

August 22, 2025

Ms. Allison Donovan
Simpson Elementary School

Re: File ID 2026-04L

Dear Ms. Donovan,

This is to advise you that your research application, "Reading Difficulties in Children with ADHD and Dyslexia: The Effectiveness of Balance Activities" (ID Number 2026-04L), has satisfactorily met GCPS Research Standards and was approved by the Institutional Review Board. The approved research period is 09/08/2025 to 10/27/2025. Should you need more time to complete your project, you will need to contact us for the approval of an extension. Please note the following comments regarding your study and the requirements of you as a researcher in GCPS:

Strengths

- Research Standard 1. The study addresses reading comprehension in students with ADHD and dyslexia, aligned with the district's focus on academic achievement and equity in support services.
- Research Standard 2.5: The study design includes a clear pre/post-test structure using established standardized assessments.
- Research Standard 3.1 - The study requires minimal instructional disruption for students, as it is incorporated into regular class time.

Limitations

Appendix C:

Balance Activity Script

1. Step up on the bucket. Raise up on your toes and count out loud to 5
2. Step to the next bucket. Stand on one leg with your other leg straight down and count out loud to 5
3. Step to the next bucket. Stand on your other leg with your other leg straight down and count out loud to 5
4. Step to the next bucket. Stand on one leg and hold your other leg out in front of you and count out loud to 5
5. Step to the next bucket. Stand on your other leg and hold your other leg out in front of you and count to 5
6. Step to the next bucket. Stand on both feet and do 5 toe raises while counting out loud.
7. When you are done, jump down and sit at the table to complete some reading passages.

Appendix D:

"Brain Check" Visual Checklist and Script

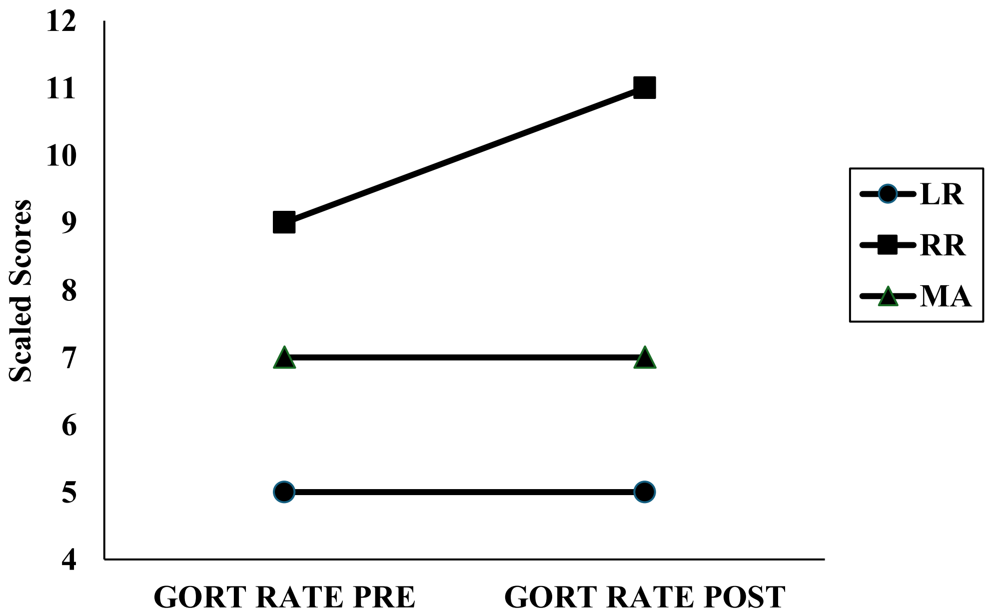
Brain Check

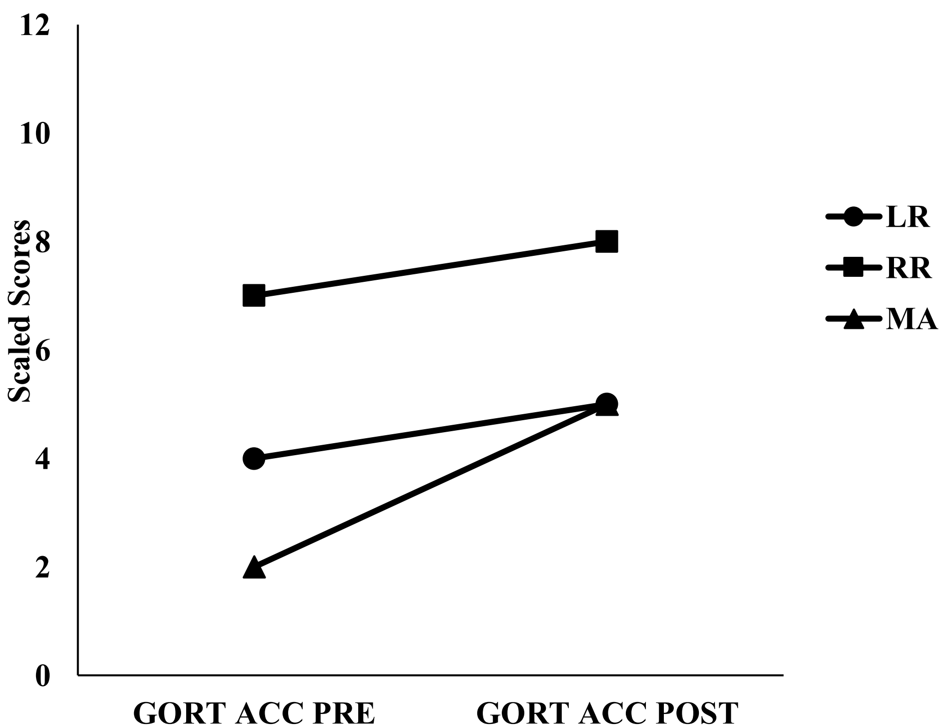
1. What should I be thinking about?
2. What am I thinking about?
3. Do my answers to 1 and 2 match?

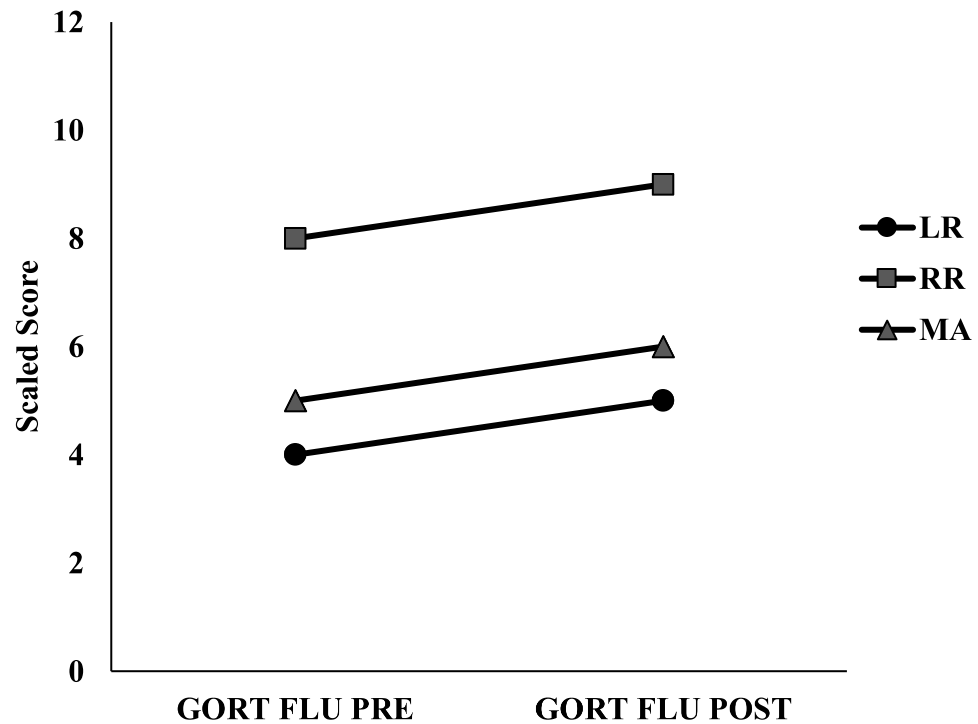
"Here is a checklist to help you stay focused on the reading tasks. It will be beside you while you are completing the reading passages. I will read the questions first. Number 1- What should I be thinking about? Number 2- What am I thinking about? Number 3- Do my answers to 1 and 2 match? Now you read them out loud and answer the questions."

Appendix E:

Figures for Pretest and Posttest GORT-5 Results






12
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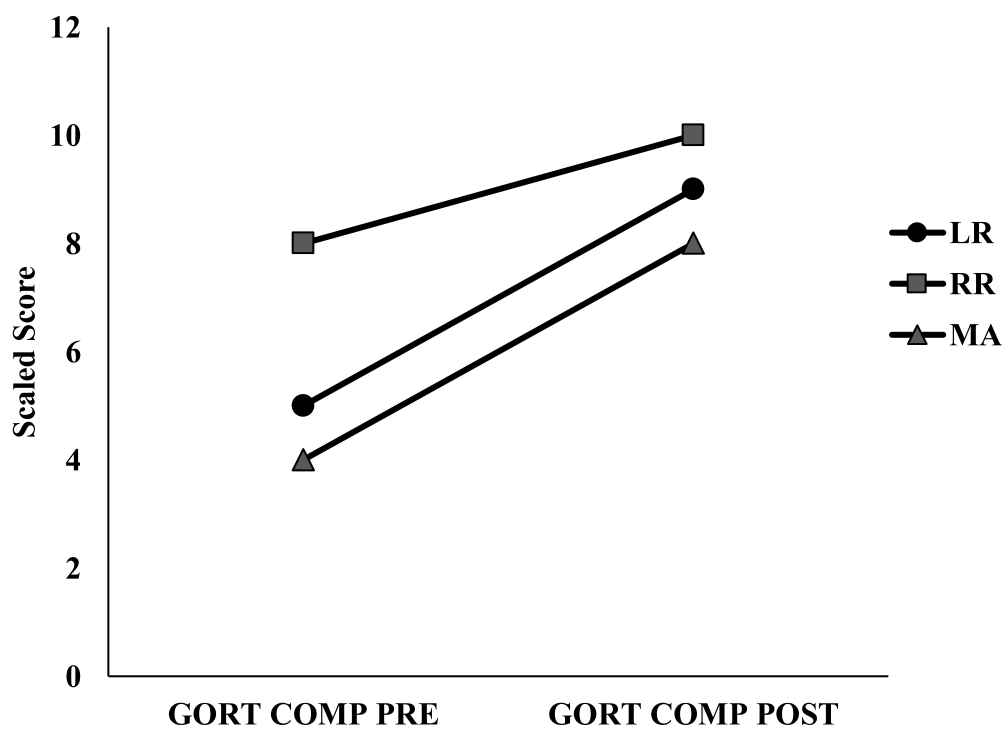
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