EXECUTIVE FUNCTION SKILL DEFICITS IN CHILDREN WITH DYSLEXIA

by

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ABSTRACT

Parents' perceptions of executive functioning skills among their children identified as having dyslexia were compared to the norm sample mean on the BRIEF. In the current study, the mean for the Global Executive Composite was statistically higher than the mean for the norm sample that served as the control group. The mean for the Behavior Rating Index also was statistically higher than the norm group mean. Both the Inhibition and Shift scales on that index were statistically higher as well. The mean for the Metacognitive Index was more than 1 SD above the control group mean. Statistically significant higher scores were found on all five scales related to Metacognitive Index. Further, the Working Memory scale on that index was found to be in the clinically significant range.

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CHAPTER I

Introduction

Definition of Executive Function

Executive function is a broad term used to classify a set of goal-directed skills used in our every day life (Anderson, 2010). Also known as executive skills, the term for these brain-based abilities originally comes from the neuroscience literature and pertains to skills that are needed for individuals to execute tasks (Dawson & Guare, 2009a). These skills help individuals complete difficult tasks, and can verify what has already been completed, while maintaining task relevance (Cooper-Kahn & Dietzel, 2008). Many children who are intelligent can appear scattered because they do not have skills needed to focus their concentration and/or regulate their behavior (Dawson & Guare, 2009b).

Many people have a variety of executive skill weaknesses in addition to their executive skill strengths (Dawson & Guare, 2009b). When children display an executive function deficit they may lack the ability to sustain their attention or have poor planning skills. Additionally, a lack of executive function skills may contribute to behavioral and/or emotional self-control issues (Raver, 2012).

Executive function skills. Executive functioning is not a singular skill. Instead, executive functioning can be thought of as a cluster of functions that include the following: (a) working memory; (b) response inhibition; (c) executive attention; (d) planning; (e) task initiation; (f) organization; (g) time management; and (h) metacognition (Dawson & Guare, 2009b).

Working memory. A person's working memory can be thought of as their cognitive workspace (Kaufman, 2010). This is where information is held briefly, and put to use in a profitable way (Kaufman, 2010). Working memory holds numbers, words, and sentences in order for them to be processed further and combined with information already known to solve a current problem (Fletcher, Lyon, Fuchs, & Barnes, 2007). If the information is not worked on, it will fade away (Kaufman, 2010). Kaufman (2010) states that using strategy recall and by picturing the information, people are able to keep the information longer in their working memory.

Working memory contains a central executive, which is involved in encoding and retrieving stimuli (Jeffries & Everatt, 2004). It also is where information is manipulated via the visuo-spatial sketchpad and the phonological loop (Jeffries & Everatt, 2004). The phonological loop is involved in sound-based input, and the visuo-spatial sketchpad is for visual and spatial input (Jeffries & Everatt, 2004). A child with working memory deficits may have trouble in school taking notes from lecture because they must concentrate on what is being said by the teacher, what they are writing down, as well as spelling the individual words. Children use their working memory when they learn new words. When learning a new word, a child first has to remember each sound segment (decoding), then blend them together (recoding), and finally remember what it looks like for future use (orthographic processing).

Response inhibition. Response inhibition is often thought of as impulse control, and refers to a person's ability to control their actions by thinking about them first (Kaufman, 2010). Cooper-Kahn and Dietzel (2008) define inhibition as a lack of age-appropriate impulse control. This skill allows us to consider the environment, our behavior, and how the interaction between these factors may impact a situation (Dawson & Guare, 2009b). Kaufman (2010) notes the ability to avert poor responses to stimuli from the environment is an important factor in school and life success. Children who lack response inhibition may interrupt the teacher and/or peers, rarely raise their hand before responding, or say inappropriate comments. Also, they may get into trouble because of their physical responses to others (e.g., losing their temper and hitting a peer). Academically, these students may use ineffective guessing strategies, such as reading a word incorrectly based on the initial one or two letters in the word.

Executive attention. Executive attention, or selective attention, is a person's ability to sustain their attention on material, keep focus, and divide their attention between other aspects of learning; it is often thought of as one of the most essential executive function skills (Kaufman, 2010). Dawson & Guare (2009b) refers to sustained attention as the ability to keep paying attention in a situation, despite distractions, lack of interest, and fatigue. Nigg (2006) states that a child must sift through multiple distractions in order to process what is most important at that point in time. He also suggests that people filter distractions based on different forms including (a) spatial location (e.g., the closer it is the more distracting it becomes), (b) various object features such as atypical shape or size (e.g., bright colors), (c) timing (e.g., an unexpected event), (d) movement, or (e) other characteristics of an object. Additionally, executive attention skills include the ability to shift one's attention quickly and efficiently. Students who struggle with executive attention skill deficits may struggle with reading when they encounter irregular word patterns. Specifically, they may over apply phonetic rules to words that do not follow that pattern.

Planning. Planning is utilized to set goals and develop a strategy or plan of action to accomplish the goal (Kaufman, 2010). Part of planning is focusing on decisions about what to include, and what not to include, as well as creating a roadmap to meet the goal (Dawson & Guare, 2009b). Planning skills include the ability to manage current-and future task demands (Cooper-Kahn & Dietzel, 2008). For these children, a lack of planning skills can greatly affect their academic work (Reid & Lienemann, 2006). Reid and Lienemann (2006) also note that students who struggle with planning skills have trouble completing homework that has multiple steps; their disorganized way of doing things often lacks a purposeful, step-by-step approach.

Task initiation. Task initiation is a person's ability to begin an assignment or project without procrastinating, and to finish it in a punctual manner (Dawson & Guare, 2009b). Students who struggle with these executive skills may have a hard time getting started on a task, organizing their thoughts, as well as deciding where and how to start (Kaufman, 2010). Cooper-Kahn and Dietzel (2008) note that task initiation involves the skills to begin a task, brainstorm, and generate ideas about how to make sure the problem is completed. Children who struggle with task initiation may procrastinate in getting their work done.

Organization. The concept of organization is the capacity to establish order on work, play, and storage spaces. Although functionally related to planning, organization is a different type of executive function skill; it is more of a hands-on skill (Kaufman, 2010). Children who lack organization skills have a hard time keeping up with materials and their planners for each class, as well as maintaining a neat desk; their homework often does not make it home, or back to school to be turned in (Dawson & Guare, 2009b).

Time management. Dawson and Guare (2009b) pointed out that it is critical for students to be able to estimate, plan, and execute an idea within time limits. The ability to manage time is considered important because it is related to goal setting, planning, and anxiety/stress management (Kaufman, 2010). Children who have trouble with time management may get behind in their schoolwork because they do not have the skills to manage time effectively. Also, they may misjudge how long it will take them to complete a task or project such as reading a book and completing the book report.

Metacognition. Metacognition is the ability to monitor your own problem solving progress; it includes skills such as self-monitoring and self-evaluation (Dawson & Guare, 2009b). Metacognition is often referred to as the ability to think about thinking (Reid & Lienemann, 2006). Metacognitive knowledge is the ability to use the knowledge learned accurately and appropriately. Students with a deficit in metacognition often get through a task just to be done with it. Many times students will read a passage but do not check their understanding or knowledge at the end of it; this leads to a poor understanding what the student read.

Development of Executive Functioning Skills

Executive function skills evolve as children grow and they may not fully be developed until children become young adults (Dawson & Guare, 2009b). As an infant, a child may show impulse control as young as 5-12 months old; they may realize that endless crying attracts attention (Kaufman, 2010). In the toddler years, a child's working memory is still largely nonverbal. Once they acquire basic language skills, children are able to use verbal interactions to learn and to use language for comfort as well as control. In preschool, children may use self-regulation skills verbally because working memory has not fully developed yet; concepts like verbal self-talk are often used during this stage in life. Kaufman (2010) notes that around elementary school-age, children acquire language skills that help them internalize the many rules of social behavior. These skills are often practiced and then stored in long-term memory. He further points out that around the elementary school age, children are able to start analyzing the details of their schoolwork; they are able to develop a plan for how to complete the problems, and are able to follow through with the plan with the help of their working memory. Though executive function problems may emerge at any age, they often become apparent during elementary school years (NCLD, 2005). The demand to complete schoolwork by themselves may make a student's executive function deficits hard to miss (NCLD, 2005)

Dyslexia

Definition and prevalence. While there are many definitions of what a learning disability is, dyslexia is almost always included as a subcategory (Smythe, Everatt & Salter, 2004). Dyslexia is often thought of as a poor ability to read, although this definition is not clear and too general to describe a specific reading difficulty (Das, 2009). According to the International Dyslexia Association (2008) dyslexia is

> a specific learning disability that is neurobiological in origin and defined by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction (¶ 1).

Learning to read is an important task for children in their first couple years of schooling; it is different than speaking, which may come naturally; reading must be taught (Das, 2009). Despite appropriate instruction, however, children with dyslexia still have a hard time learning to read (Riddick, 2010).

According to Frost and Emery (1998) as well as Padget (1998), dyslexia occurs in 3-6% of the school-aged population. The U.S. Department of Education states that 51% of the students receiving special education in the schools are diagnosed with a learning disability (Padget, 1998). Furthermore, of those students with a learning disability, 80% have significant deficit in reading.

Academic skill deficits. Dyslexia is a deficit in decoding of single words (Fletcher et al., 2007). Along with affecting the child's ability to decode words, dyslexia also affects a child's spelling skills (e.g., International Dyslexia Association, 2008; Fletcher et al., 2007). Because these children are struggling with decoding unfamiliar words, they lack automaticity, which impairs their reading fluency (e.g., choppy reading, having to sound out unfamiliar words). This lack of reading fluency skills often impairs their ability to comprehend what they are reading (e.g., not fully understanding the main idea of the passage).

Word recognition. Fletcher and colleagues (2007) state the main academic deficit that children with dyslexia have is single word decoding, which is the ability to decode single words rapidly and accurately. Children with dyslexia have difficulty associating sounds (phonemes) with the letters that represent them. This is known as sound-symbol correspondence (Padget, 1998). They may rely on memorization of whole word units (sight words). When trying to read unfamiliar words, they may incorrectly sound out the words often substituting incorrect sounds as they read.

Spelling. Fletcher and colleagues (2007) state that along with struggling to reading words (decoding words), many children have trouble with spelling (encoding words). They note that it is likely due to the same underlying processing difficulties that cause their decoding difficulties. Since they have trouble decoding and encoding, they may lack the ability to isolate each sound in the word and know what letter(s) make up the sound. Children with dyslexia also may struggle with working memory, which may lead to further trouble with spelling (Nicolson & Fawcett, 2008). In order to spell a word, one must hold the word in memory, while figuring out how to break it down to spell it, all while writing the letters down; children with dyslexia may have difficulty with these tasks.

Phonological processing deficits. Fletcher and colleagues (2007) note that dyslexia primarily results from a core phonological deficit. Phonological skills refer to the coding of phonological information in written and oral language (Hosp & MacConnell, 2008). There are three types of phonological processing that are related to reading: (a) phonological awareness; (b) phonological memory; and (c) rapid naming.

Phonological awareness. Phonological awareness encompasses knowledge that individual sounds make up words, and words makeup sentences; in addition, it includes the ability to hear individual phonemes in words, and manipulate them (Hosp & MacConnell, 2008; Nicolson & Fawcett, 2008). Additionally, Joseph (2008) notes that phonemic awareness skills include the ability to isolate, blend, segment, and manipulate the sounds in words.

Phonological memory. Phonological memory involves storing sound-based information that is being read in working memory (e.g., Berninger & Wagner, 2008;

Frost & Emery, 1998). Phonological memory is most important for decoding and temporary storage of phonemes in unfamiliar words. Words that are familiar to the child can often be stored in chunks, and do not seem to place as much of a burden on the phonological memory (Berninger & Wagner, 2008). The impairment of these processes may explain why people with dyslexia have trouble learning phonological decoding.

Rapid automatic naming. Rapid automatic naming is the quick retrieval of known letters, numbers, and objects (e.g., Berninger & Wagner, 2008; Fletcher et al., 2007). Rapid naming is more closely related to the fluent reading of words and phrases than to accurate word reading (Fletcher et al., 2007). Frost and Emery (1998) point out that retrieval of phonological information from long-term memory relates to how the child pronounces a word, word segments, or letters. This quick retrieval generalizes to phonological codes stored in the long-term memory as well. Since a child with dyslexia has a deficit in this area, it causes them to be slow and inaccurate when recalling these phonological codes.

Orthographic processing deficits. Orthographic processing refers to the connections that are formed between the units of spoken and written language, which include letters, words and word families, spelling, as well as pronunciations (Berninger & Wagner, 2008). Some skills that require orthographic processes include coding written words into the short-term memory, while working memory analyzes the letters. These skills also are used when writing words that have been stored in the long-term memory.

Executive Functioning and Dyslexia

Working memory. Research has shown that children with dyslexia display impairments in certain working memory tasks, while certain other tasks have not been found to be impaired (e.g. Brooks, Berninger, & Abbott, 2011; Horowitz-Kraus, 2012; Jeffries & Everatt, 2004; Reiter, Tucha, & Lange, 2004; Schuchardt, Maehler & Hasselhorn, 2008; Vasic, Lohr, Steinbrink, Martin &Wolf, 2008). For example, studies have shown that children with dyslexia performed worse on the backward digit span (a measure of working memory) than their peers in a non-learning disabled control group (e.g., Horowitz-Kraus, 2012; Reiter et al., 2004; Schuchardt et al., 2008). Reiter and colleagues studied a group of 42 children with dyslexia ($M = 10$ years-old) and 42 non-dyslexic children ($M = 10$ years-old); they found that along with the lower scores in backward digit span, the children with dyslexia displayed marked impairments in figural working memory (as measured by the Visual Working Memory Task).

In a more complex study design, Schuchardt and colleagues (2008) studied a group of German children ranging in age from 7-to-10-years-old. The participants included 17 children with arithmetic disorder, 30 children with specific reading disorders (dyslexia), 20 children with comorbid disorders (i.e., arithmetic and dyslexia), and a control group of 30 children. Along with the digit span backward mentioned previously, these children also were given a battery of seven phonological tests (e.g., memory span for digits, non-word repetition), five visual-spatial tasks (e.g., memory span for locations, matrix span simple and complex), and four central executive tasks (e.g., double span, backward spans for one-syllable words and digits). They reported that children with dyslexia were found to have marked impairments in their phonological loop and in tasks assessing the central executive functioning, but unlike Reiter and colleagues (2004) no significant differences in visual tasks were noted between the children in the dyslexia group and the control group.

Jeffries and Everatt (2004) found that dyslexic children had significant impairments in phonological loop tasks when compared to their peers, even ones with other special educational needs. They conducted a study with 21 dyslexic children, 26 children with other special needs (e.g., dyspraxia, attention deficits, and emotional/behavioral difficulties), and 40 children in a control group. These groups of children were then divided based on age: (a) primary (*M* = 9 years-old); and (b) intermediate (*M* = 11 years-old). The participant were given the Working Memory Test Battery for Children (WMTB-C), which measured working memory abilities across the central executive (e.g., backward digit recall, and listening recall), the phonological loop (e.g., forward digit recall, and non-word list recall), and the visuo-spatial sketchpad (e.g., block recall, and maze memory). These authors found that children in each of the dyslexic groups performed no worse than the control group on visuo-spatial tasks. This was similar to the findings from Schuchardt and colleagues (2008). Regarding tasks that measure central executive, they reported that children with dyslexia had more correct name interferences than the control group, and significantly lower backward digit recall than any other special needs group. Also, the difference in backward digit span between the children in the dyslexia group and other special need group was only significant in the primary age group, and not for intermediate age group.

Additionally, research also has found that children with dyslexia perform slower and less accurately when compared to their peers on manipulation tasks of working memory. For example, Vasic and colleagues (2008) administered a cognitive activation task, to a group of German adolescents ranging in age form 16-to-21-years-old; their study included 12 participants with dyslexia, and 13 adolescents for the control group.

During the cognitive activation task, participants were shown three capital letters on a computer screen for 1.5 seconds. One, two or three of the letters became highlighted at the end of the 1.5 seconds, and subjects were instructed to focus the highlighted letter(s) and memorize the letter that follows it in the alphabet (manipulation). These authors reported that the subjects with dyslexia performed worse compared to the control group regarding accuracy and had slower response times on the hardest level (there were 3 levels) only. They also reported that the participants with dyslexia were impaired in phonological working memory tasks when cognitive demands were higher and information had to be manipulated; this was supported by the participants' digit span backward performance, which was significantly lower than the control group.

These research studies have shown that a child with dyslexia may have impairments in a variety of skills associated with working memory. The researchers that utilized manipulation tasks (e.g., Horowitz-Kraus, 2012; Reiter et al., 2004; Vasic et al., 2008) showed that the groups with dyslexia have difficulties not only compared to peers in a control group, but also compared to peers with other learning difficulties (e.g., Jefferies & Everatt, 2004; Schuchardt et al., 2008;), not just in memory span. In addition, Jefferies and Everatt (2004) and Schuchardt and colleagues (2008) found no significant differences between children with dyslexia and their control group peers in visual working memory tasks. These difficulties generalize to the classroom setting; when reading, children with dyslexia have trouble manipulating sounds in words. Berninger and Wagner (2008) note that a core phonological deficit which includes difficulties with phonological working memory may be the primary cause of dyslexia; when this phonological process is diminished, it may have negative effects on phonological decoding abilities.

Inhibition. Many studies have found that children and adults with dyslexia were not able to inhibit distractions from the environment as well as their normal reading (control group) peers (Altemier, Abbot, & Berninger, 2008; Brosnan, Demetre, Hamill, Robson, Shepard, & Cody, 2002; Jeffries & Everatt, 2004; Propapas, Archonti, & Skaloumbakas, 2006; Reiter et al., 2005; van der Schoot, Licht, Horsley, & Sergeant, 2004). As Altemier and colleagues (2008) noted inhibition deficits may lead to representational inflexibility.

As with the finding regarding working memory deficits, outcomes have been found to vary based the specific measures as well as techniques used to assess inhibition. For example, while Reiter and colleagues (2004) used a Go/No-Go task, van der Schoot and colleagues (2000) used a Stop Signal task. Both of these tasks required the participant to inhibit certain responses to stimuli on a computer screen. Reiter and colleagues (2004) found that there were no significant differences in performance on the inhibition task for the children with dyslexia and their control group peers. They noted that the Go/No Go task was developed originally for the assessment of inhibition on brain lesion patients, and that it may only pick up severe inhibition impairments. Using the Stop Signal task, van der Schoot and colleagues (2000) found that mean reaction times were significantly slower for the group with dyslexia compare to their peers in the control group, and they also made more errors. They pointed out that inhibition functions were significantly slower for guessers (fast reading speed but inaccurate reading style) than for decoders (slow reading speed but accurate reading style), when they dyslexia group was broken down. Also, guessers were found to have a slower inhibitory processing speed and lower inhibitory function, as measured by the same assessment.

Several researchers (e.g., Jeffries & Everatt, 2004; Protopapas et al., 2006; Reiter et al., 2005; van der Schoot et al., 2000) used the Stroop Color-Word assessment to measure interference in word reading. During this task the child is given a paper and told to name the colors on the paper. Next, the child is to name the color the word is printed in instead of reading the word (e.g., the word *blue* is written in yellow ink, so they say *yellow*). An interference score was calculated by subtracting the time from the words not matching up with their colors from the color-only time. All studies reported that the children with dyslexia exhibited more interference reading the words that were not congruent with their colors compared to children in the control group, and that the children with dyslexia had a significant increased processing time while reading the colors of the words compared to their peers in the control group. For example, van der Schoot et al., (2000) reported that guessers (fast reading speed but inaccurate reading ability) needed on average an additional 74 seconds to complete the task compared to the controls, while decoders (slow reading speed but accurate reading ability) required on average an extra 66 seconds compared to the control group.

Several studies (e.g., Reiter et al. 2004; van der Schoot et al., 2000) have used the Tower of London (TOL) task, which involves planning and thinking before one reacts. Specifically, this task required the children to move a pattern of beads from a start location to a goal location as quickly as possible in a minimum number of moves. Reiter and colleagues (2004) noted that while the subjects with and without dyslexia did not differ in the TOL task concerning the number of problems solved in the minimum number of moves, the children with dyslexia required more time to plan their moves compared to the children in the control group. Similar results were found by van der Schoot and colleagues (2000); they point out that the mean TOL score of guessers (fast reading but inaccurate reading ability) was significantly lower than that of decoders (slow reading, but accurate reading ability), the readers who read quickly, but were inaccurate made significantly more incorrect moves. They further suggested the type of planning needed to solve these types of problems may not be fully developed in guessers, or they are disrupted by impulsive responses.

Researchers (e.g., Bronsnan et al., 2002; Jefferies & Everatt, 2004; Protopapas et al., 2006; Reiter et al., 2004; van der Schoot et al., 2000) have found that children with dyslexia have impairments in their ability to inhibit responses on a variety of tasks. Those that used a Go/No Go or similar Stop Signal task found that children with dyslexia made more errors and were significantly slower on the tasks (Reiter, et al., 2004; Van der Schoot, et al., 2000). Researchers (Jefferies & Everatt, 2004; Protopapas, et al., 2006; Reiter, et al., 2004; Van der Schoot, et al., 2000) that used the Stroop Color-Word task found that children with dyslexia experienced more interference while reading the words not congruent with their color, and had an increased processing time compared to their peers. Studies that used the Tower of London task (e.g., Reiter et al., 2004; van der Schoot et al., 2000) found that children with dyslexia did not differ in the problems solved in the minimum number of moves; however, they did require more time to plan their moves. As Alteneier and colleagues (2008) note, inhibition is thought to affect both encoding new information as well as retrieval skills. They further note that efficient retrieval of letter sound correspondences (e.g., alphabetic principle) as well as retrieval of sounds associated with larger phonics patterns (e.g., orthographic processing) may therefore be negatively impacted by a child's ability to suppress irrelevant codes and quickly retrieve relevant responses. This may be evident in the oral reading and spelling errors that dyslexics often make.

Executive attention/shift. Some research has found impairments in executive attention among students with dyslexia (e.g., Helland & Asbjornsen, 2000; Horowitz-Kraus, 2012). For example, Horowitz-Kraus (2012) studied event-related potentials (ERPs) in the brain with an electroencephalography (EEG). His study included 27 participants with dyslexia (*M* = 12 years old), and 30 age-matched skilled readers from Israel. While wearing the EEG, participants were given a variety of tasks including cognitive ability tasks (e.g., coding, digit span forward, digit span backward, letter naming, etc.), as well as, the Madrid Card Sorting Task, which was a computerized program that measures event-related potentials in the brain. Horowitz-Kraus noted that N100 in the brain is referred to as a marker of attention abilities; this marker was significantly decreased, as measured by the EEG, in children with dyslexia in the study when compared to the skilled readers. Horowitz-Kraus pointed out that the difficulty that people with dyslexia have performing the card sorting tasks was primarily due to working memory and attention, rather than shifting. Further, he noted that any deficits in basic functions, such as attention, may affect many other cognitive areas.

Helland and Asbjornsen (2000) also hypothesized that children with dyslexia when compared to their typical reading peers would exhibit differences in executive attention and that these differences would vary depending on receptive language skills. Their study included 43 participants with dyslexia (*M* = 12-years-old), and 20 age matched peers in a control group. When the authors conducted their study, they divided their dyslexic groups into how well they performed on the Receptive Language Task. One group, *the dyslexic norm*, scored greater than or equal to 22 points on this task, and *the dyslexic under norm*, who scored less than 22 points on this task. The participants were given: (a) The Dichotic Listening Test; (b) The Stroop Color Word Test; as well as, (c) The Wisconsin Card Sorting Task. All these measures assess sustaining/shifting attention. The authors divided attention into three functions: (a) sustaining; (b) focus/execute; and (c) the ability to shift. On the sustaining tasks, children in both dyslexic groups scored significantly lower than their peers in the control group. Children in both dyslexic groups also performed slower on the focus/execute tasks when compared to the children in the control group. Interestingly the children in the *dyslexics under norm* group showed significant impairment in speed of naming, while children in the *dyslexic norm* group showed impairments in analyzing correct responses. Regarding shifting attention tasks, children in both dyslexic groups performed significantly lower than did the children in the control group. Specifically, they needed more trials, made more errors, and completed fewer categories in the task compared to those in the control group.

Researchers (e.g., Altemeier et al., 2008; Helland & Asbjornsen, 2000; Horowitz-Kraus, 2012) found that children with dyslexia were impaired when compared to their peers in the area of executive attention/shifting and automatic switching. Horowitz-Kraus (2012) found that a marker in the brain was significantly decreased in children with dyslexia when performing a card-sorting task as measured by an EEG. Helland and Asbjornsen (2000) found that children with dyslexia scored significantly slower in the sustaining task, focus/execute task, and shifting task. These finding may generalize to common reading errors made by children with dyslexia such as pronouncing a psuedoword as a real word. Reading real words may represent a more automatic process and therefor, students with dyslexia may have difficulty shifting to the less common task of decoding nonsense words.

Planning. Researchers (e.g., Brosnan et al., 2002; Reiter et al., 2004; Sesma, Mahone, Levine, Eason, & Cutting, 2009) have found that children with dyslexia performed more poorly than children in the control group on tasks that involve planning. Interestingly, Leather, Hogh, Seiss, and Everatt (2011) found planning ability was correlated with self-efficacy and job satisfaction when looking at job satisfaction in adults with dyslexia. They note that adults who had better planning skills had higher levels of self-efficacy and were more satisfied with their job; their study also showed that planning was correlated with personal success. They state that setting goals and planning that is deliberate lead to higher achievement and greater focus. Brosnan and colleagues (2002) also conducted a study with adults (undergraduate students) with and without dyslexia. Their study showed no significant differences between the two groups for planning, and the authors note that this is not consistent with previous research.

Sesma and colleagues (2009) studied 60 children ages 9-to-15-years-old with word recognition deficits (i.e., dyslexia) and reading comprehension deficits. They found that planning along with other skills were significant contributors to reading comprehension, but were not significant contributors to single word reading. They note that their results are not surprising since reading comprehension is a more complex process than basic word reading, and it requires higher order cognitive processing to decipher the passage's meaning through sentences and paragraphs.

Researchers have found that children with dyslexia exhibit significant impairments in their planning ability. For example, Reiter and colleagues (2004) conducted a study with 84 children, half who had dyslexia and half who did not. Their study showed that the children who had dyslexia had an increase in planning time compared to the non-dyslexic children, even though the number of problems solved in the minimal number of moves was not significantly different between the two groups. They concluded that children with dyslexia required more time planning compared to their peers without dyslexia. In a further extension of their study on undergraduate students listed above, Brosnan and colleagues (2002) also found similar results when they looked at 16 children with dyslexia, and 16 gender matched controls to look at specific aspects of planning with verbal fluency; the children with dyslexia produced significantly less words than their peers without dyslexia.

Research has shown that children with dyslexia had an increased need for planning time compared to their peers (e.g., Brosnan et al., 2002; Reiter et al., 2004; Sesma et al., 2009). However, when studying undergraduate university students, Brosnan and colleagues (2002) found that there was no significant difference between the group with dyslexia and the group without in tasks that involved planning. Leather and colleagues (2011) found that in adults with dyslexia planning was correlated with self-efficacy and job satisfaction. This generalizes to the classroom for children with dyslexia; they may have difficulty creating a plan before working on a project, and they may struggle with directions that may have multiple steps. When they are completing writing assignments, they lack the ability to sequence what they want to write for the assignment.

Additional research. Less dyslexia research has been investigated on the executive function skills such as organization and time management. Moreover, most studies have used adults with dyslexia, not children. Regarding time management skills, Kirby, Silvestri, Allingham, Parrila, and La Fave (2008) conducted a study with college age students. The sample included 36 participants with dyslexia, and 66 typically achieving students. Participants filled out the Learning and Study Strategies Inventory (LASSI), which is a questionnaire that measures a person's motivation, attitude, anxiety management, use of self-testing and test taking strategies, concentration, use of study aids, information processing, and time management. The authors found that significantly more students with dyslexia reported greater use of time management strategies compared to the typically achieving group; they believe this may be due to the dyslexia-support programs that the students may have previously completed which could have promoted these strategies. They also point out that typically achieving students may use time management strategies as well as, but the processes may be automated for these students and therefore, they may be unaware of using the strategies.

Mortimore and Crozier (2006) also conducted a study with university students; however, their study focused on organization skills. The participants (62 men with dyslexia, and 74 men without dyslexia) were given a questionnaire that asked about their experiences with different aspects of learning, their level of education (primary, secondary, or university) when difficulties in learning affected them, and needs for support. These authors found that significantly more students with dyslexia (67%) reported having trouble with organization skills compared to the control group (36%). They also reported that throughout primary, secondary, and higher-level education the percentage of students reporting difficulties with organization went up (e.g., 43% in primary, 53% in secondary, and 67% in higher-level education). Further, 82% of students with dyslexia reported needing a resource to help organize coursework compared to 47% of the control group.

Summary

Overall, the research has shown that children with dyslexia have impairments in many areas of executive functioning such as working memory, inhibition, executive attention/shift, and planning skills. Additionally, among studies using surveys, adults with dyslexia have reported weaknesses in time management, and organization skills.

A wide variety of neuopsychological measures have been used to assess specific executive function skills among children and adolescents with. For example, using manipulation tasks, researchers (e.g., Horowitz-Kraus, 2012; Reiter et al., 2004; Vasic et al., 2008) found that children with dyslexia have impairments in working memory when compared to their control group peers as well as their peers with other learning disabilities. Research has shown that children with dyslexia have deficits in phonological memory (e.g., Berninger & Wagner, 2008; Fletcher et al., 2007) which involves working memory for sound based information and that it is important for decoding and temporary storage of phonemes in unfamiliar words (e.g., Berninger & Wagner, 2008). Researchers also found that children with dyslexia have significant impairments in their ability to inhibit responses on a variety of tasks (e.g., Bronsnan et al., 2002; Jefferies & Everatt, 2004; Protopapas et al., 2006; Reiter et al., 2004; van der Schoot et al., 2000). For example, when using the Stroop Color-Word task researchers (e.g., Jefferies & Everatt, 2004; Protopapas et al., 2006; Reiter et al., 2004; van der Schoot et al., 2000) found that children with dyslexia experienced more interference and had an increased processing time compared to their peers. Difficulties in cognitive inhibition may be related to the ineffective guessing strategies used by some children with dyslexia in both the oral reading and spelling errors they make. Additionally, researchers (e.g., Helland & Asbjornsen, 2000; Horowitz-Kraus, 2012) have found that children with dyslexia were impaired in the area of executive attention/shift when compared to their peers in the control group. Difficulties in executive attention/shift may be related to the difficulties children with dyslexia sometimes exhibit over apply a more automatic phonics rule to less familiar words that have an irregular pattern. Finally, several studies (e.g., Brosnan et al., 2002; Reiter et al., 2004; Sesma et al., 2009) also found that children with dyslexia have impairments in the area of planning. For example, researchers (e.g., Reiter et al., 2004; van der Schoot et al., 2000) using the Tower of London task children with dyslexia required more time to plan their moves compared to their control group peers.

While much of the available research has focused on the direct assessment of executive functioning skills, less is known about parent's perceptions of their child's executive functioning skills among children with dyslexia. A review of the literature revealed only one published peer-reviewed research study (Gioia, Isquith, Kenworthy, & Barton, 2002). Gioia and colleagues (2002) conducted a study to determine executive function profiles among different groups of children including ones with dyslexia using the Behavior Rating Inventory of Executive Function (BRIEF). They found that the children with dyslexia had significantly higher score on the scales of Working Memory, Plan/Organize, and Monitor compared to the control group; the group with dyslexia also had higher reported scores on the Inhibit, Shift, and Emotional Control scales, but the difference was not significant compared to the control group.

Purpose. The purpose of this current study was to replicate the research of Gioia and colleagues (2002) among a sample of parents whose children had been diagnosed as having dyslexia. Much of the published research that directly assessed executive functioning skills among children with dyslexia noted in this literature review occurred after the publication of Gioia and colleagues study.

Hypothesis 1. Parents would report observing more difficulties among their children with dyslexia in areas similar to those identified through direct assessment. Specifically, scores would be significantly different from the norm sample in the following areas: (a) working memory; (b) inhibition; and (c) shift.

Hypothesis 2. Parents would report observing more difficulties among their children with dyslexia in areas similar to those reported by adults with dyslexia on surveys. Specifically, scores would be significantly different from the norm sample in the following areas: (a) plan/organize; and (b) organization of materials.

CHAPTER II

Methods

Participants

The parents of 25 children (18 boys and 7 girls) diagnosed as having dyslexia through the Tennessee Center for the Study and Treatment of Dyslexia at Middle Tennessee State University completed an assessment of their child's executive functioning skills. The children ranged in age between 7 and 16 year- old (*M* = 10; *SD* = 2). As can be seen in Table 1, all of the children had an the average (within 1 *SD* of the *M*) full scale IQ score as well as listening comprehension scaled scores. They all had deficits (more than 1 *SD* below the *M*) in basic word reading (i.e., WIAT II Basic Word Reading Composite), reading fluency (i.e., Test of Word Reading Efficiency II Index Composite and WIAT II Oral Reading Fluency), and phonological processing (i.e., CTOPP Phonological Awareness, Phonological Memory and Rapid Automatic Naming).

Measures

The BRIEF is a questionnaire administered to parents and teachers to evaluate a child's executive function various environments (e.g., home, academic) (Gioia, Guy, & Kenworth, 2000). Children (5-18 years old) with a variety of disabilities including learning disabilities, attentional disorders, traumatic brain injuries, and pervasive developmental disorder, just to name a few, can be assessed with the BRIEF. The Parent form had 86 questions regarding eight clinical scales, that were theoretically and empirically based, which measured executive functioning. These individual scales formed two Indexes that were more expansive, Behavior Regulation and Metacognition; the BRIEF also included the Global Executive Composite, an overall score. The eight

Table 1.

Descriptive Statistics for Children Identified as Dyslexic

	N	*Mean*	*Standard Deviation*
Full Scale Intelligence Quotient	21	100.10	9.17
WIAT III Listening Comprehension	25	101.36	10.59
WIAT III Basic Word Reading Composite	25	76.04	7.39
WIAT III Word Reading Subtest	25	75.12	8.33
WIAT III Pseudo Decoding Subtest	25	76.92	8.88
WIAT III Spelling	25	77.48	9.95
TOWER II Word Reading Efficiency	22	71.09	10.35
WIAT III Reading Fluency	24	73.50	11.19
CTOPPII Phonological Awareness	25	83.84	13.58
CTOPPII Phonological Memory	25	79.60	11.38
CTOPP II Rapid Automatic Naming	25	83.76	11.88

Note: All measures listed above have a normative M of 100 and SD of 15.

individual scales that assessed executive functioning include: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor.

Inhibit. Items on the Inhibit scale evaluated a person's control of inhibition, and the ability to appropriately control their behavior in certain situations (Gioia et al., 2000). The test authors further noted that children who lack inhibitory control disregard personal safety, have elevated levels of physical activity, and inappropriate physical and verbal responses to other people. Test-retest reliability for the Parent Form clinical sample for the Inhibit scale was 0.76.

Shift. Items on the Shift scale evaluated a person's ability to flow as the circumstances demand from one situation, activity, or problem to another (Gioia et al., 2000). The test authors note that children who are unable to shift effectively have a difficult time with transitions and require a strict routine; they struggle focusing when moving from one topic to another, and may repeatedly attempt the same wrong approach when solving a problem. Test-retest reliability for the Parent Form clinical sample for the Shift scale was 0.72.

Emotional control. The items on the Emotional Control scale assessed the ability to regulate emotional responses, and involve the emotional domain of executive functions (Gioia et al., 2000). Gioia and colleagues point out that children who lack emotional control may be uncontrollable in their emotional reactions; they may have frequent temper tantrums, or have intense laughing fits for small causes. In the manual the test authors reported that test-retest reliability for the Parent Form clinical sample for the Emotional Control scale was 0.79.

Initiate. The items on the Initiate scale addressed getting started on a activity or task, as well as autonomously coming up with ideas and strategies to solve problems (Gioia et al., 2000). In general, children who have problems with initiation want to do well on tasks, but have trouble getting started on them; these children may need many prompts to begin homework or chores at home. Further, they point out that children who experience other types of executive dysfunction problems may have trouble with initiation as a secondary consequence (e.g., a child with poor organization skills may become overwhelmed with a complex assignment, and thus may have trouble beginning the task). Test-retest reliability for the Parent Form clinical sample for the Initiation scale was reported to be 0.77.

Working memory. The Working Memory scale contains items that measure the ability to hold information in mind in order to complete an activity or task (Gioia et al., 2000). Working memory is critical in performing a variety of tasks including completing mathematics problems, following directions, and remembering important information. The test authors explain that children with working memory problems often have trouble completing a difficult activity for an age-appropriate amount of time, and often move from task to task or even fail to complete tasks. Test-retest reliability for the Parent Form clinical sample for the Working Memory scale was 0.82.

Plan/organize. The items from this scale measure the child's ability to manage demands for the current task they are working on and plan for future tasks (Gioia et al., 2000). According to the manual the component of planning pertains to the anticipation of events in the future, setting goals, and thinking of the steps to complete the task. Children with planning problems often do not have the materials needed to complete a project in the timeframe needed, or starting a project in timely manner. The organization component pertains to the ability to impose order to information, and to recognize key ideas and main information when learning or communicating. Children with organizational problems have trouble processing large amounts of information, and not being able to accurately express their ideas on assignments. Test-retest reliability for the Parent Form clinical sample for the Plan/Organize scale was reported to be 0.80.

Organization of materials. The items of the Organization of Materials scale assess the imposed order of a child's work, play, and storage spaces (e.g., their room, desk, locker, folders) (Gioia et al., 2000). The children who have problems with organization have trouble performing well at school because they often cannot find their materials, or assignments when they are needed. According to the test authors, test-retest reliability for the Parent Form clinical sample for the Organization of Materials scale was 0.84.

Monitor. This scale measures the child's ability to habitually check their work, and their ability to monitor their behavior (e.g., what kind of impact their behavior is having on others) (Gioia et al., 2000). Children who have trouble with monitoring often make careless mistakes, and are in a rush to get their work done. Test-retest reliability for the Parent Form clinical sample for the Monitor scale is 0.80.

Procedure

Written permission was first obtained from the director of the Tennessee Center for the Study and Treatment of Dyslexia. After approval was obtained from the center, approval was obtained from the Institutional Review Board (IRB) committee (Appendix A). Once approved, the center staff mailed the BRIEF to parents of students who met criteria for dyslexia. Parents were provided postage paid return envelopes. To ensure anonymity, no names were collected on the consent forms.

CHAPTER III

Results

A series of *t-tests* were used to determine if parents' scores were significantly higher than the scores reported by the norm group (M =50, SD =10). as provided in the BRIEF manual (Gioia et al., 2000). According to the manual t scores at or above 65 are considered clinically significant (Gioia et al., 2000).

As can be seen in Table 2, on the Global Executive Composite, which takes into consideration all the scales, children with dyslexia were rated by their parents statistically higher than their peers in the norm group. Parental perceptions related to the Behavior Regulation Index, which is comprised of the Inhibit, Shift, and Emotional Control Scales also was statistically higher among the current sample when compared to the norm sample. The Metacognitive Index score, which is made up of Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor Scales was found to be statistically higher in the current sample when compared to the norm sample.

Hypothesis 1

It was predicted that parents of children with dyslexia would report their children having statistically higher scores on the following scales: (a) working memory; (b) inhibition; and (c) shift, compared to the norm sample. As can be seen in Table 2, this hypothesis was supported. In particular, the Working Memory Scale was in the clinically significant range when compared to the norm sample. On this scale parents rated their children 1.5 standard deviations higher than the norm sample.

Table 2.

Descriptive Statistics and t-tests for BRIEF Composites, Indexes and Scales

Composite/Index/ Scale	*M*	*SD*	*t-test*	*M* diff
Global Executive Composite	59.76	10.03	4.87**	9.76
Behavior Rating Index	55.24	11.18	2.34*	5.24
Inhibit	54.40	10.09	2.18*	4.40
Shift	56.72	13.24	2.54*	6.72
Emotional Control	53.96	12.34	1.60	3.96
Metacognitive Index	61.20	9.94	5.63**	11.20
Initiate	58.52	10.10	4.22**	8.52
Working Memory	65.00	10.38	7.23**	15.00
Plan/Organize	60.48	10.26	5.11**	10.48
Organization of Materials	54.68	10.31	2.27*	4.68
Monitor	59.24	9.10	5.08**	9.24

$N = 25$; $df = 24$; * $p \leq .05$; ** $p \leq .000$.

Note: Scores on the Brief of 65 or higher could be considered clinically significant.

Hypothesis 2

It was predicted that parents of children with dyslexia would report their children having significantly high scores on the following scales: (a) plan/organize; and (b) organization of materials when compared to the norm sample. As can be seen in Table 2 this hypothesis also was confirmed. It should be noted that the average score reported by parents of children with dyslexia on the Plan/Organize scale was 1 standard deviation higher than the norm sample.

Additional Findings

Parents also completed scales that measured Monitoring, Initiation, and Self-Control. On the Monitor scale, parents of children with dyslexia rating their child approaching 1 standard deviation higher than the norm sample. On the Initiate scale parents rated their children with dyslexia significantly higher than the norm sample. The Emotional Control scale did not indicate any significant difference between the current sample and the norm sample.

CHAPTER IV

Discussion

The purpose of the current study was to replicate the research of Gioia and colleagues (2002) among a sample of parents whose children had been diagnosed as having dyslexia. While much of the published literature exploring the relation between executive functioning and dyslexia has focused on direct assessment of skills on discrete tasks (e.g., Protopapas et al., 2006; Reiter et al., 2004; van der Schoot et al., 2000), the current study focused on the parent's perceptions of their child's executive function strengths and weaknesses. The content of the BRIEF examines real world situations and behaviors that parents encounter on a daily basis while interacting with their children. For example, 'Trouble concentrating on schoolwork' and 'Needs help from an adult to stay on task' are working memory items from the BRIEF that are much more easily understood by parents than direct assessment measures such as digits backwards. In addition, the current study focused only on children with dyslexia, while previous research (Jeffries & Everatt, 2004; Sesma et al., 2009; Schuchardt et al., 2008) had included groups with various other diagnoses (ADHD, dyspraxia, reading comprehension deficits).

Unlike what was found by Gioia and colleagues (2002), parents of children with dyslexia in the current sample were significantly different from their control group peers on the Global Executive Composite, Behavior Regulation Index, and the Metacognitive Index. While scores on these measures were statistically significant none were in the clinically significant range. The Metacognitive Index, however, was 1 standard deviation above the mean and the Global Executive Composite approached 1 standard deviation above the mean. One possible explanation for this could be the difference in the degree of reading difficulty among those in the current study and in the sample used by Gioia and colleagues (2002). In their study Gioia and colleagues (2002) do not report the mean scores for the reading measures that were used. They do state that their participants had a marked deficit in decoding and fluency compared to their IQ. In the current sample, decoding and fluency scores were all 1.5 standard deviations below the mean or greater. Similar to Gioia and colleagues (2002), the Emotional Control scale, was not significantly higher for the participants in the current study when compared to the norm sample which served as the control group.

Hypothesis 1

It was predicted that parents would rate their children with dyslexia significantly higher than the norm sample on the Working Memory, Inhibition, and Shift scales. The data showed that students with dyslexia have significant trouble with these tasks as reported by their parents. Specifically, the mean for the Working Memory scale was 1.5 standard deviations higher than the norm sample. These data were consistent with what Gioia and colleagues (2002) reported; children with dyslexia struggle significantly with Working Memory, Inhibition, and Shift. Researchers utilizing direct assessment of these skills have noted weaknesses in these areas as well (e.g. Berninger & Wagner, 2008; Helland & Asbjornsen, 2000; Horowitz-Kraus, 2012; Jefferies & Everatt, 2004; Reiter et al., 2004)

Hypothesis 2

It was predicted that parents of children with dyslexia would rate their children significantly higher on the Plan/Organize, and Organization of Materials scales compared to their same-aged peers in the norm sample. The data indicated that parents rated their children with dyslexia as having significantly more trouble with these tasks than their peers in the norm group. This was similar to previous research indicating deficits in these areas among children with dyslexia (e.g. Brosnan et al., 2002; Reiter et al., 2004)

Limitations of the Study

This study had several limitations. First, the interpretation of the BRIEF is limited; the child might act differently in the home environment than the classroom. The parent was the only informant to fill out the BRIEF for the current study, and important school information may have been left out. A child's ability to shift their attention may be harder at school with all the various distractions in the classroom. In the current study important academic information from the teacher was not examined.

In addition, survey scales like the BRIEF can have a variety of problems. First, the survey measured a skill that has not been directly assessed. The parent filled out the BRIEF based on their perception or indirect assessment. Second, the parent may have been biased in their reporting either rating their child poorly, or to compensate for their abilities, by rating them higher.

Future Research

Much of the research exploring the relation between dyslexia and executive functioning deficits has focused only on a certain executive function skill rather than taking a more broad perspective. For example, the Stroop Color-Word task was used to measure word reading interference (or inhibition) by several researchers (Jefferies & Everatt, 2004; Protopapas et al., 2006; Reiter et al., 2004; van der Schoot et al., 2000). Also, researchers (e.g. Horowitz-Kraus, 2012; Reiter et al., 2004; Schuchardt et al., 2008) have used backward digit span to study children's working memory performance. Even when studies were looking at more than one executive function skill, researchers pulled measures from many different batteries. For example, Reiter and colleagues (2004) used a flexibility task, Go/No Go test, and the Stroop task to measure a child's inhibition, while Jefferies and Everatt (2004) used the Stroop task, forward/backward digit span, and the Tower of London (TOL) to measure the same executive function skill. Using multiple individual tests can be problematic because they are not usually co-normed (meaning scores cannot be directly compared to each other because the norm samples are different). In addition, using different tests can affect the interpretation of test results because of differences in reliabilities. Future research should be conducted using a broad, direct assessment battery of the executive function skill. For example, the NEPSY directly measures several executive function skills while using the same norm sample (as opposed to using several assessment measures with different norm groups).

Additionally, assessment batteries used by researchers are conducted in environments that are not familiar to the child. In addition to the novel environment, the assessments used (Stroop task and Tower of London for example) are not usually related to the classroom or the home environment. This information may show the parent what specific tasks their child struggles with, but does not offer real world information that the parent can use. This lack of generalizability may leave parents confused and unsure of how to help their child. Future research should compare the results of broad, direct assessment measures with perceptions of parents and teachers. Furthermore, comprehensive evaluations along with BRIEF rating scales should be looked at across children with different conditions (e.g. ADHD, TBI) to see if there are specific profiles for other disabilities.

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APPENDICES

Appendix A

IRB Approval

Investigator(s): Aimee Holt
Department: Psychology
Investigator(s) Email: aimee.holt@mtsu.edu
Protocol Title: "Parent Perceptions of Executive Function Skills among Children/Adolescents Identified as Having Dyslexia "
Protocol Number: 15-112

Dear Investigator(s),
The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110, and you have satisfactorily addressed all of the points brought up during the review.
Approval is granted for one (1) year from the date of this letter for 100 participants.
Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918. Any change to the protocol must be submitted to the IRB before implementing this change.
You will need to submit an end-of-project form to the Office of Compliance upon completion of your research located on the IRB website. Complete research means that you have finished collecting and analyzing data. **Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date.** Please allow time for review and requested revisions. Failure to submit a Progress Report and request for continuation will automatically result in cancellation of your research study. Therefore, you will not be able to use any data and/or collect any data. Your study expires **12/17/2015**.
According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to complete the required training. **If you add researchers to an approved project, please forward an updated list of researchers to the Office of Compliance before they begin to work on the project.**
All research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion and then destroyed in a manner that maintains confidentiality and anonymity.

Sincerely,
Kellie Hilker, Institutional Review Board
Middle Tennessee State University