SYMPTOM PRESENTATION IN ADHD AND ITS ASSOCIATION WITH INHIBITORY CONTROL

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DEDICATION

I would like to thank my committee, for helping me down a path of knowledge and growth. I would like to thank my friends and family, for their continued support and understanding through these past few years.

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Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) has been associated with problems in executive functioning (EF). However, subtype difference in EF may exist between the inattentive type of ADHD and the hyperactive/impulsive and combined types of ADHD. A small number of studies, in fact, have found that inhibitory control is more strongly related to symptoms of inattention than symptoms of hyperactivity/impulsivity, suggesting that children with the inattentive type of ADHD may have more deficits in inhibition. The D-KEFS Color Word Interference Test (CWIT) was administered to 35 children, ages 8-17 years, diagnosed previously with ADHD, to examine possible differences in inhibition between a Predominantly Inattentive group and a Combined group (Predominantly Hyperactive-Impulsive and Combined types). Both ADHD group means on the CWIT were within normal limits. Results from a MANOVA showed no differences between groups on the CWIT, except for the word reading condition (Condition 2). Analysis of the CWIT and symptoms of inattention from the Conners Parent Rating Scale-Revised showed no significant relationship between performance on the CWIT and parent report of inattentive behaviors. Contrary to the hypotheses, this study did not provide evidence that children in the Predominantly Inattentive group display more deficits in inhibition than children in the Combined group, or that deficits in inhibition are related to inattentive behaviors. *Keywords:* executive function; attention-deficit/hyperactivity disorder; inattention; inhibition; cognitive flexibility; Delis-Kaplan Executive Function System

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CHAPTER ONE

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized by impairment caused by symptoms of inattention and/or hyperactivity/impulsivity (American Psychiatric Association [APA], 2000). According to the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV-TR, 2000), the prevalence of ADHD “has been estimated at 3%-7% in school-age children,” (p. 90). However, this may be a significant underestimation of the extent of the disorder, since one study suggests that as many as 17% of children are identified as having ADHD (Williams, Wright, & Partridge, 1999). The diagnosis of ADHD has been linked to problems in executive function (EF) by many researchers (Barkley, 1997; Pennington, Ozonoff, 1996; Seidman, Biederman, Faraone, Weber, Ouellette, 1997). According to Barkley (1997), some of these problems include deficits in cognitive flexibility, working memory, planning, and fluency. Houghton et al. (1999) also found that impairments in executive function are central to children diagnosed with ADHD, specifically in children with no comorbid disorders.

Previous research (Wahlstedt, 2009; Wahlstedt & Bohlin, 2010) has used diverse EF measures to investigate the relationship between EF deficits and ADHD symptoms. Some common tests of EF utilized in previous research include the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1980; Heaton, Chelune, Talley, Kay, & Curtiss, 1993), Trail Making Test (TMT; Reitan &Wolfson, 1985), verbal fluency tasks (e.g., Controlled Oral Word Association Test, Benton & Hamsher, 1989), the Ruff Figural Fluency Test (Ruff, 1996), Tower of London (TOL; Krikorian, Bartok, & Gay, 1994), versions of the Stroop Color and Word Test (Stroop, 1935), and motor sequencing tasks. The Delis-Kaplan Executive Function System (D-

KEFS) was designed to assess EF, and has been used to assess EF in ADHD populations. The D-KEFS utilizes standardized scoring across commonly known tasks of EF, in addition to other scores that allow for comparison between control tasks and more complex tasks. The control tasks are used as a way to ensure participants are able to perform the most basic skills needed to perform the task. For example, if a test requires the ability to count, a control task would ensure the participant is able to count. This becomes useful when trying to determine where deficits exist. The D-KEFS was developed to better assess EF in both children and adults by utilizing these control tasks.

A number of opinions exist regarding differences in subtypes of ADHD (Barkley, 2001; Diamond, 2005). A small number of studies have examined differences in EF for children who meet various criteria for subtypes of ADHD (Nigg, 2006). According to Barkley (2001) children with ADHD, Combined Type (ADHD-C) suffer from more serious impairment, specifically response inhibition, than those diagnosed with ADHD, Inattentive Type (ADHD-I). In contrast, Geurts, Verte, Oosterlaan, Roeyers, & Sergeant (2005) found that there are no reliable differences between the two subtypes. Another studies that investigated EF differences between the ADHD, Hyperactive-Impulsive Type (ADHD-H) subtype and ADHD-I subtype show that children with the ADHD-H subtype do not express EF deficits (Martel et al., 2007). Surprisingly, research has suggested that poor inhibitory control is found in children diagnosed with the inattentive subtype of ADHD, and not in the hyperactive-impulsive subtype (Chhabildas, Pennington, & Willicutt, 2001; Thorell, 2007). When examining the relationship between EF deficits and ADHD symptom domains, Thorell (2007) found that EF deficits were independently related to symptoms of inattention, but not related to symptoms of hyperactivity/impulsivity.

More specifically, EF deficits were present only when symptoms of inattention were present, regardless of the presence of symptoms of hyperactivity/impulsivity. Both Thorell (2007) and Wahlstedt (2009) utilized a Stroop-based task to assess inhibition in children diagnosed with ADHD, in order to explore the relationship between the Inattentive type and EF.

The culmination of the aforementioned research suggests that the current subtypes of ADHD may be different not only in their behavioral symptoms but also in types of EF impairment. Diamond (2005) summarized this research and argued that the ADHD-I subtype is a truly different disorder from the ADHD-H subtype. Although Diamond merely separates ADHD-I and ADHD-H, other researchers include the third subtype of ADHD-C in the separation (Chhabildas et al., 2001; Nigg, 2006; Willicutt, Doyle, Nigg, Faraone, & Penningston, 2005b).. Since researchers (Wahlstedt, 2009; Wahlstedt & Bohlin, 2010) have found significant differences in executive functions between subtypes of ADHD using other Stroop-based tests, the use of the D-KEFS CWIT will allow further investigation into the relationship, by allowing for content-matched control tasks. For example, the CWIT permits investigators to examine the unique roles of lower-level skills such as rapid reading and naming skills on Stroop performance.

CHAPTER TWO

Review of the Literature

Attention-Deficit/Hyperactivity Disorder

Attention disorders have long been characterized not only by inattentive symptoms, but also hyperactive symptoms. The Third Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-III, 1980) was the first manual to differentiate Attention Deficit Disorder (ADD) as being with or without hyperactivity. The creation of two subtypes was controversial at the time, and a departure from both the DSM-II and the World Health Organization's criteria of the disorder revolving around pervasive hyperactivity. According to the World Health Organization (WHO) diagnostic system (WHO, 1993) and the current Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR, 2000), the core symptoms of ADHD include poor attention, impulsive actions, and hyperkinetic behaviors. The required symptoms for diagnosis are the same between the International Statistical Classification of Diseases and Related Health Problems (ICD-10) and the DSM-IV, but the DSM-IV combines the categories for motor and impulsive problems. By only having the two categories of symptoms, the DSM-IV allows four diagnoses, which are ADHD predominantly inattentive type (ADHD-I), ADHD predominantly hyperactive-impulsive type (ADHD-H), ADHD combined type (ADHD-C), and ADHD not otherwise specified (ADHD-NOS). While it is important to mention all four subtypes of the disorder, this review will consider only the predominantly inattentive, predominantly hyperactive/impulsive, and the combined subtypes, as they are the most clearly defined and commonly found types of ADHD.

Attention-deficit/hyperactivity disorder diagnosis

"The essential feature of Attention-Deficit/Hyperactivity Disorder is a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequently displayed and more severe than is typically observed in individuals at a comparable level of development," (DSM-IV-TR, 2000, p. 85). To meet diagnostic criteria, the symptoms must be pervasive, in that they are displayed across two or more settings, such as within the classroom or at home. The symptoms must be persistent for at least six months in order to rule out any transient causes for the behaviors, and must have been present prior to the age of seven. This ensures that the symptoms are caused by the ADHD, and not a reaction to a particular setting, some other learning disorder, or simple disinterest. Symptoms will usually become more obvious in situations where sustained attention is necessary. The symptoms must noticeably interfere with development in both social, academic, and if applicable, occupational functioning. It is also necessary to ensure some other disorders are not the cause of the symptoms, such as bipolar disorder, a psychotic disorder, or even substance abuse. Prior to diagnosis, it is essential that the clinician gather information from multiple sources, including parents and teachers. As mentioned previously, the diagnosis of ADHD can be separated into three subtypes: Predominantly Inattentive Type; Predominantly Hyperactive-Impulsive Type; and Combined Type (DSM-IV, 2000). In the original formulation of the disorder, impulsiveness was thought to be associated with inattention rather than hyperactivity, suggesting a difference in functioning based on the subtypes (American Psychiatric Association, 1980). Research has since shown that impulsive symptoms are in fact on the same behavioral dimension as hyperactive symptoms (DuPaul, Eckert, & McGoey, 1997;

Lahey & Loeber, 1994), causing a reconfiguration of the inattentive type with the DSM-IV release in 1994. Loeber, Green, Lahey, Christ, and Frick (1992) found evidence suggesting hyperactive-impulsive symptoms may emerge earlier than inattentive symptoms, which may suggest a difference in the neuropsychological development of the ADHD subtypes. Murphy, Barkley, and Bush explained that "the hyperactive-impulsive subtype may be a developmental precursor to the combined type," (2002, p. 147), with the inattentive subtype emerging at a later age of onset than the combined subtype (Applegate et al., 1997). This further suggests that developmental differences exist between the inattentive and combined subtypes of ADHD, not just behavioral differences. Some studies (Barkley et al., 1990; Lahey & Carlson, 1992) found sufficient neuropsychological differences between the subtypes to suggest a separate component of attention for each subtype. Barkley (2001) and others (Carlson & Mann, 2000; Milich, Balentine, & Lynam, 2001) indicated that ADHD-I might be better conceptualized as a distinct disorder, rather than thinking of it as a subtype or less serious version of ADHD-C. Differences have been found between ADHD-I and ADHD-C outside of the absence or presence of hyperactive or impulsive symptoms (Bauermeister et al., 2005; Diamond, 2005). Those diagnosed with ADHD-I are characterized as having slower processing speed (Solanto et al., 2007) and different genetic profiles than people diagnosed with ADHD-C (Smoller et al., 2006).

Since the disorder is currently defined by behavioral symptoms, it becomes likely that both the inattentive type and the combined type will be grouped together to some degree (Nigg, 2006). Nigg suggests that we must not assume that all children diagnosed with ADHD will fall into the same biological model of ADHD, and that we must consider other mechanisms of behavior to gain a more accurate picture of a child's disorder. Barkley (1997) suggests that those diagnosed with ADHD-I exhibit different problems of inattention than those diagnosed with ADHD-C. Specifically, Barkley speculates that attention in the ADHD-C subtype is most often associated with distractibility, while the ADHD-I subtype is most associated with passive-inattentive behavior. In reference to Barkley's speculation, Milich et al. (2001) concluded that the evidence suggests that ADHD-C and ADHD-I are quite different and should be categorized as distinct disorders. These findings suggest that differences in the type of inattentive symptoms might lead to a different diagnosis.

Predominantly inattentive subtype. This subtype is characterized by at least six inattentive symptoms that must be persistent and maladaptive with regard to the relative development of the child. According to the DSM-IV-TR (2000), the child may often fail to pay attention to details, and often make careless mistakes in daily activities. He/she may often have difficulty remaining focused in organized tasks or play activities. The child may not seem to listen when spoken to directly, and may have difficulty following instructions in school. He/she may fail to finish schoolwork, chores, or other duties required of him/her, even though the directions were clear and understandable. Organizing daily activities or duties is problematic for children with this subtype. They may avoid any tasks that require sustained mental effort, especially homework, or may be reluctant or show disinterest in such tasks. Losing things necessary to complete assignments or activities can become a recurring problem for them. They are often easily distracted by external stimuli, and demonstrate forgetfulness in daily activities (DSM-IV-TR, 2000). ADHD-I is often characterized by a slower cognitive tempo (Bauermeister et al., 2005), as well as drowsiness, lethargy, and passivity (Carlson & Mann, 2000).

Predominantly hyperactive-impulsive subtype. Similar to the inattentive subtype, children must display at least six hyperactive-impulsive symptoms to the extent that the symptoms are maladaptive and not normal for their developmental level. According to the DSM-IV-TR (2000), children with this diagnosis can be seen fidgeting with their hands or feet, and often squirm when required to sit for extended periods of time. They often will leave their seat in a situation where they are expected to remain seated for long periods of time. Running around or being physically disruptive is common, and they may find it difficult to engage in activities in a non-disruptive manner. They are described as being "on the go," as if they have an overabundance of energy, and often talk excessively (DSM-IV-TR, 2000, p. 86). In class they may blurt out answers before the question has been fully asked, and have difficulty waiting their turn. Interrupting or intruding on conversations or activities is also common (DSM-IV-TR, 2000).

Prevalence. According to the DSM-IV-TR (2000), the prevalence of ADHD "has been estimated at 3%-7% in school-age children," (p. 90). However, several factors make prevalence estimates somewhat complicated. Studies suggest that as much as 17% of children are identified as having ADHD, with boys being five to nine times more likely to have the disorder than girls (Williams, Wright, & Partridge, 1999). According to Pastor and Reuben (2008), boys are diagnosed with ADHD three to four times more often than girls by the time they are of school age. Depending on the subtype of ADHD, the male-to-female ratio ranges from 2:1 to 9:1, with the inattentive subtype being under-diagnosed in girls. There is also speculation that girls are under-identified because they are less likely to show the behavioral problems associated with ADHD (Cohen et al., 1993). It is speculated by Keltner and Taylor (2002) that ADHD is more complicated to diagnose in girls than in boys based on a variety of factors, including a later age of onset, more subtle manifestations of symptoms, and certain limitations with the DSM-IV diagnostic criteria. Research has also found that girls will more commonly present with the inattentive subtype than boys (Hinshaw, Owens, Sami, & Fargeon, 2006; Weiler, Bellinger, Marmor, Rancier, & Waber, 1999). Research by Sciutto, Nolfi, and Bluhm (2004) found that even if all information is equal, teachers are more likely to refer boys than girls for treatment. It is important to remember that although there are differences in boys and girls, research comparing the two has found more similarities than differences, especially in areas of auditory working memory, inhibition, flexibility, and sustained attention (deHaas, 1986; Houghton et al., 1999; Sharp et al., 1999); therefore this study will not examine gender differences in subtypes of ADHD.

Another complication for prevalence estimates is the issue of the source of epidemiological samples. When sampling the non-clinical community, Carlson and Mann (2000) found that ADHD-I was the most prevalent subtype of ADHD, with the number of people diagnosed being almost twice the number diagnosed with ADHD-C. Yet when sampling the clinical population, research has found that the ADHD-C subtype is one and a half times more common, suggesting that those diagnosed with ADHD-C are more likely to be referred to clinics for treatment (Eiraldi, Power, & Nezu, 1997; Lahey et al., 1994; Morgan, Hynd, Riccio, & Hall, 1996). Based on these findings, it is important to recognize the significant differences between the subtypes of ADHD, especially when the differences can alter the success of treatment.

Age represents another complication in prevalence. According to the DSM-IV-TR (2000), it is difficult to make a diagnosis of ADHD for children before they have reached the age of five, particularly because the symptoms necessary for the diagnosis are often present in normal development. When children grow older, especially once they reach school age, developmental problems caused by ADHD can become much easier to identify. Most importantly, children with a diagnosis of ADHD-I often were referred for and diagnosed with ADHD at a later age *(*Faraone & Biederman, 1998; McBurnett et al., 1999*).*

Executive Function

Executive function (EF) is defined by Baron (2004) as "the metacognitive capacities that allow an individual to perceive stimuli from his or her environment, respond adaptively, flexibly change direction, anticipate future goals, consider consequences, and respond in an integrated or common-sense way, utilizing all these capacities to serve a common purposive goal" (p. 135). The various subdomains of executive function include set shifting (cognitive flexibility), problem solving, planning, inhibition, organization, goal setting, working memory, anticipation, common sense, self-monitoring, initiative, and attention control (Baron, 2004). In order to achieve optimal functioning in daily life, a person must be able to utilize multiple executive functions at one time. According to Gioia, Kenworthy, and Isquith (2010), "the construct of executive function is unique among neuropsychological constructs in that it focuses on the overarching execution and regulation of cognitive and behavioral action" (p. 433). They further explain that executive function and dysfunction tend to be context dependent, which causes health professionals many problems in assessment and treatment of these types of disorders.

Research on brain location of executive abilities has found that the prefrontal regions are most directly related (Dennis, 1991; Singer, Cauraugh, Murphey, Chen, & Lidor, 1991; Toga, Thompson, & Sowell, 2006). Yet newer research argues that although the frontal lobes are critical, systems in the whole brain may be essential in order to have efficient EF (Anderson, Anderson, Jacobs, & Smith, 2008). According to Golden (1981), the area of the brain responsible for executive functioning is not something that develops quickly, but rather progresses slowly through the first few decades of life. Anderson, Northam, Hendy, and Wrennall (2001) suggest that the frontal lobe develops more slowly than other parts of the brain during childhood and adolescence, which supports the idea that children have a limited ability to apply EF effectively until their brain matures. Martel, Nikolas, and Nigg (2007) believe the prefrontal cortex develops most during adolescence. Researchers (Smidt, Jacobs, & Anderson, 2004; Zelazo, Craik, & Booth, 2004) have found that different subdomains of EF develop at different times over the lifespan. According to Anderson et al. (2008) cognitive flexibility begins developing around the age of three, and children reach the capacity to successfully shift between more than two dimensions around the age of seven. As mentioned previously, symptoms of ADHD must be present before the age of seven, according to the DSM-IV-TR (2000), which presents the idea that areas of development in the brain for cognitive flexibility and ADHD are similar. The connection between ADHD and EF will be discussed in greater depth later.

Attention as an element of EF. Executive function in children involves attention in both the present and future, including the intention to act (Denckla, 1994). According to Barkley (1994; 1997; 2006), attention is not a single construct that can be easily defined, but is instead a complex and multidimensional executive function. He proposes that, theoretically, attention can be subdivided into the categories of arousal and alertness, selectivity, sustained attention, divided attention, and shifting attention. In addition to Barkley, Mirsky (1991) also felt that attention could be conceptualized as having many components, specifically four separate but interactional components. The first component of attention is the *focus-execute* component, which can be illustrated through the ability to select target information from a group for further processing. The ability to focus and execute becomes essential when immersed in a stimulating environment, where a person must be able to narrow down the abundant external stimuli into relevant and important information that can be used and applied. The second component is *sustained attention*, which can be simply explained as the ability to maintain focus over time. This component can also be referred to as attention span, vigilance, or persistence of effort (Barkley, 2006). *Encoding* is the third component, which overlaps with short-term memory, or at least the ability to create memory. The fourth component of attention is *attentional shift,* which is illustrated by “the ability to change attentive focus in a flexible and adaptive manner” (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991, p. 112). This fourth component will be discussed more in depth in a later section. Mirsky (1987) also notes that another component, divided attention, should be included. Divided attention can be described as the ability to maintain attention to two or more tasks that are being completed at the same time, or to two or more components within a specific task (Cooley & Morris, 1990). He also notes that the inclusion of divided attention does not cause any conflict with the four main components, but rather complements them.

In order to provide data to support the four components of attention, Mirsky et al. (1991) used neuropsychological test batteries to help obtain relevant data. According to Mirsky, Coding and Digit Symbol subtests from the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1991) and Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974) could be combined with letter cancellation and Parts A and B from the Trail Making Test of the Halstead-Reitan Neuropsychological Test Battery (TMT; Reitan &Wolfson, 1985) to provide data supporting the focus-execute dimension. Sustained attention scores could be obtained from correct answers and reaction times from some sort of continuous performance test or vigilance test. Test scores for the encoding portion of attention can be gathered from subtests such as Digit Span and Arithmetic from the WAIS-R or WISC-R. In order to assess the ability to shift attention, Mirsky suggests using scores derived from the Wisconsin Card Sorting Test (WCST, Grant & Berg, 1980; Heaton, Chelune, Talley, Kay, & Curtiss, 1993). Other researchers (Johnson, Maricle, Miller, Allen, & Mayfield, 2010; Reitan & Wolfson, 2004) suggest that Part B of the TMT can also be used to assess the attentional shift as a component of EF.

Barkley (1989) explained that what has normally been described in past research as sustained attention deficits in children may actually be evidence for poor development of rule-governed behavior. According to Barkley (1994), attention problems have yet to be divided into different subtypes like learning disorders, for example, yet some clinical differentiation exists that would allow subtypes to be created. The attention disorders he suggested would revolve around Attention-Deficit/Hyperactivity Disorder being split into a primarily inattentive subtype, and a primarily hyperactive subtype, which is how it is displayed in the DSM-IV currently. Barkley (1990) bases his theory on research that suggests that children without the hyperactive component may instead have a disorder of attention, primarily in their lack of development of the focus-execute portion of attention.

Attentional shift, when considered as a component of attention, is characterized by “the abstract capacity to shift in an adaptive and flexible manner from attending to one aspect or stimulus feature of objects to another aspect” (Mirsky et al., 1991). Mirsky and colleagues postulate that attentional shift is better understood as a component of EF rather than that of attention. They argue this because they include attentional shift as a part of an attention system that controls information processing. This information processing is necessary to create new response sets, and shift attention from one thing to the next, which is part of cognitive flexibility.

Relevant components of attention

Cognitive flexibility. The ability to switch tasks quickly is an important function in responding to changes in the environment (Miller & Cohen, 2001). It is described by Anderson (2008) as including the ability to shift in style or response, to learn from mistakes, to change plans, and the ability to divide attention. Individuals who struggle with cognitive flexibility often require rigid and ritualistic schedules in order to complete work, but also struggle with changes in activities and demands. Cognitive flexibility is synonymous with several terms in the literature, including set shifting. Set shifting can be described as the ability to change attention from one set of stimuli to another, such as shifting focus from letters to numbers as is necessary in Part B of the Trail Making Test (Reitan & Wolfson, 1985), which will be described in a later section. Children learn to regulate their own behaviors by shifting their course of thought or action to meet the requirements of the situation. The ability to switch rapidly between established task sets (Van Holstein et al., 2011) is necessary when performing certain daily functions. In school aged children, for example, cognitive flexibility becomes essential when switching topics in class or in social settings. Defects in cognitive flexibility can be seen when individuals have trouble scanning and shifting their mindset to new stimuli or requirements (Lezak, 1983). Inflexibility can cause a person to make the same mistake or break the same rule continuously.

Inhibitory control. Many researchers speculate that response inhibition plays a major role in identifying EF deficits. Barkley (1997) suggests that inhibition refers to the inhibition of the automatic response to an event and the stopping of an ongoing response that permits a person to delay the decision to respond. These two processes work together to allow interference control, which is the "protection of this period of delay and the self-directed responses that occur within it from disruption by competing events and responses" (Barkley, 1997, p. 67). Barkley argues that behavioral inhibition is a central impairment to ADHD; his viewpoint will be discussed in more detail in a later section. Nigg (2006) describes interference control as the ability to filter out irrelevant information from the task at hand. For example, interference control is necessary to ignore external conversations in a public place in order to focus on reading a book. Nigg adds that the majority of ADHD research on basic cognitive functions has been done on interference control, with the measure of choice being the Stroop procedure (Stroop, 1935). The essence of the Stroop procedure is that the individual taking the test must be able to inhibit an automatic response.

EF measurement.

General issues. According to Anderson et al. (2008), in order for tests of EF to be valid, it is essential that they address attentional control, goal setting, and cognitive flexibility. Measures of executive function must have seven core characteristics according to Denckla (1994). In order of most accepted, the core characteristics to look for are 1) delay between stimulus and response, 2) internal representation of schema, 3) internal representation of action plan, 4) response inhibition, 5) efficiency and consistency of response, 6) active strategies, and 7) flexible strategies. Examiners have used a wide variety of tests to assess for EF, in part because of how difficult EF can be to assess. Cripe (1996) notes that executive functions are "very complex (metacognitive) dynamic processes," (p. 192) which makes them difficult to measure in general assessments.

Some of the most commonly used measures of executive function include the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1980; Heaton, Chelune, Talley, Kay, & Curtiss, 1993), Trail Making Test, verbal fluency tasks (e.g., Controlled Oral Word Association Test, Benton & Hamsher, 1989), the Ruff Figural Fluency Test (Ruff, 1996), Tower of London (TOL; Krikorian, Bartok, & Gay, 1994), versions of the Stroop Color and Word Test (Stroop, 1935), and motor sequencing tasks. The WCST is a standardized test that is used to assess working memory and executive function, such as organization, planning, and cognitive flexibility (Heaton et al., 1993). For the past few decades, performance on the WCST has been linked to ADHD and the development of frontal lobe functioning (Boucugnani & Jones, 1989), and has been used frequently in research regarding executive function in school-aged children. Verbal fluency tasks are timed tasks that consist of retrieval of category-specific words. Figural fluency tasks consist of timed tasks, and involve children drawing nonsense figures in three-minute segments. Disk/Ring transfer tasks, such as the TOL, involve sequentially rearranging a pattern made up of different color or size disks into a target pattern. As stated previously, Stroop procedures are designed to challenge the examinee by requiring him/her to inhibit an automatic response. Specifically, in the standard version of the Stroop test, the examinee is asked to name the color of the words printed in a list, rather than reading the words.

Gioia, Kenworthy, and Isquith (2010) suggest that measurement of these dynamic processes cannot be performed using inflexible test batteries, but may instead require real-world context to accurately diagnose and treat cognitive disorders. Based on these ideas, Gioa, Isquith, Guy, and Kenworthy (2000) developed the Behavior Rating Inventory of Executive Function (BRIEF), as a way to capture information about manifestations of EF impairments as perceived by raters in the daily environment (p. 145). Other researchers have recognized this problem of ecological validity, and instead have retooled commonly used measures and created new measures to detect deficiencies in EF. For example, Anderson et al. (2008) note several test batteries that incorporate measurement of EF, or at least include subtests that address EF. These include A Developmental Neuropsychological Assessment (NEPSY; Korkman, Kirk, & Kemp, 1998), the Test of Everyday Attention for Children (Manly, Anderson, Robertson, & Nimmo-Smith, 1999), the Behavioral Assessment of the Dysexecutive Syndrome for Children (BADS-C; Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003), and the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001).

Most real world executive behaviors have both high and low levels of function involved. However, many EF tests do not acknowledge or separate these skills, yielding only one achievement score. Using a single score from a test of higher-level cognitive function will hide performance of the many cognitive functions required for that task, which was recognized by Kaplan (1988). Delis and colleagues (2001) note that single score tests are most problematic when measuring EF because a single score may produce misinterpretations of EF deficits. For example, good performance on low level functions combined with poor performance on high level functions can potentially mask deficits in EF. Conversely, poor performance on high level functions caused by poor performance on low level functions can lead examiners to report deficits in EF, when instead the low score is related to a problem of basic skills. The utility of the D-KEFS in this regard will be explained in more detail. The development of the D-KEFS was based on the idea that EF needs to be measured multiple ways in order to truly understand a person's functioning. The D-KEFS attempts to ensure ecological validity by including control tasks when applicable, as well as including some new experimental tasks that help clinicians to specify EF deficits, which in turn helps to better predict real world functioning.

The Delis-Kaplan Executive Function System. As mentioned previously, EFs are very complex processes, and in turn, many measures of EF have tasks that overlap in their assessment of EFs. The D-KEFS utilizes standardized scoring across commonly known tasks of EF, in addition to other scores that allow for comparison between control tasks and more complex tasks. The D-KEFS consists of nine tests that address planning, fluency, inhibition, and flexibility. The D-KEFS is composed of the following instruments: Trail Making Test; Verbal Fluency Test; Design Fluency Test; Color-Word Interference Test; Sorting Test; Twenty Questions Test; Word Context; Tower Test; and Proverb Test (Delis, Kaplan, & Kramer, 2001). The test battery was developed to better assess EF in both children and adults. The measures included in the D-KEFS are modifications of existing tests, rather than newly developed tests. Each subtest is designed to assess specific parts of EF, allowing clinicians to select the subtests they want to use (Baron, 2004).

Color-Word Interference Test.

Background. Denckla (1996) suggests that one major principle must be used to guide all forms of testing for executive function, and that is the "need for content-matched control tasks for every candidate EF task," (p. 273). One of the measures that provides control tasks is the Stroop Color-Word Test (Stroop, 1935). The primary EF measured by the Stroop is the inhibition of an automatic response. According to Lezak (1995), the Stroop first allows examiners to measure the ability to concentrate and resist distraction. Following this control condition, according to Lezak, cognitive flexibility and inhibitory control, core components of EF, affect performance on the test.

The Stroop is based on the Stroop Effect (Stroop, 1935), which was described as the difficulty a person faces when trying to inhibit meaningful but conflicting information from a task, even when the information is not necessary in the task. The Stroop has a long history in psychology, as noted by MacLeod (1991). Both MacLeod (1991) and Nigg (2006) confirm what Comalli, Wapner, & Werner (1962) and Ehri & Wilce (1979) found, which is that the reliability and validity of the Stroop are acceptable in both child and adult populations.

D-KEFS version of the Stroop. Most versions of the Stroop Test are administered with three tasks: naming colors of printed squares, reading words written in black ink, and the interference task. The interference task asks the participant to name the color of the printed ink while inhibiting the automatic response of reading the word. In the D-KEFS version of the Stroop, labeled the Color-Word Interference Test (CWIT), four conditions are used. Conditions 1 and 2 are baseline conditions that evaluate basic skills that are necessary for the higher-level tasks. Condition 1 consists of the basic naming of color patches, while Condition 2 consists of basic reading of words that denote colors, written in black ink. Condition 3 holds to the original Stroop, where the participant must inhibit the reading of the words denoting colors in order to name the color of the ink instead. The D-KEFS CWIT includes a new fourth condition that allows for further examination of the participant's EF. Condition 4 requires the participant to switch back and forth between naming the dissonant ink colors and reading the words. The addition of this Condition allows the examiner to measure both inhibition and cognitive flexibility. The scoring system used in the D-KEFS version provides normative data for the completion times, contrast scores from baseline to higher-level tasks, and uncorrected and self corrected error measures.

Using control tasks, the CWIT can determine more clearly what EF deficiencies are present. Condition 1 of the CWIT is used to gather a baseline measure for basic efficiency when naming colors, while Condition 2 measures baseline efficiency of reading performance. According to Peden (2010), if either of these scores is low, the participant is likely to score lower on the higher-level tasks of Conditions 3 and 4 because of poor word finding or poor reading speed as opposed to poor inhibition or cognitive flexibility. In contrast, examinees who obtain average to above average scores on Conditions 1 and 2 are expected to score average to above-average on Condition 3. If the examinee scores below average on Condition 3 in combination with an average score on Condition 1, it is likely related to an EF deficit in verbal inhibition. Average to above average scores on Conditions 1, 2, and 3 in combination with a low score on Condition 4 would suggest EF deficits in cognitive flexibility. If Conditions 1 and 2 are both average, while Conditions 3 and 4 are below average, scores would suggest problems in both verbal inhibition and cognitive flexibility. Thus, the conditions of the CWIT of the D-KEFS meet Denckla' s (1996) directive that control tasks be included to measure EF accurately.

Executive Function and ADHD

Theories and models. The diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) has been linked to problems in executive function (EF) by many researchers (Barkley, 1997; Pennington, Ozonoff, 1996; Seidman, Biederman, Faraone, Weber, Ouellette, 1997). As mentioned previously, EF has long been associated with frontal lobe function (Anderson et al., 2008). In kind, deficits in attention have also been linked to frontal lobe function (Anderson, 2008). Barkley (1997) suggests that children with ADHD will encounter problems in cognitive flexibility, working memory, planning, and fluency. In support of Barkley's theory, Marzocchi and colleagues (2008) examined possible executive dysfunction in children with ADHD and found that they "showed deficits in planning, working memory, set-shifting, and letter fluency," (p. 549). As explained previously, set-shifting and cognitive flexibility are considered the same in terms of EF. Additionally, the development of cognitive flexibility is most critical between the ages of three and seven (Anderson et al., 2008), which is also a crucial point in determining the presence of ADHD. Willicut, Doyle, Nigg, Faraone, and Pennington (2005) found that children with ADHD show more significant deficits in EF than those not diagnosed with ADHD, supporting the theory that EF plays a large role in ADHD. Houghton et al. (1999) also found that impairments in executive function are central to children diagnosed with ADHD, specifically in children with no comorbid disorders, which illustrates how integral EF is to ADHD. Siedman, Biederman, Faraone, Weber, and Ouellete (1997) found that neuropsychological deficits associated with EF were present in ADHD children regardless of psychiatric comorbidity, also suggesting that these EF impairments are at the core of ADHD.

Children with ADHD often display cognitive and behavioral problems such as inattention, poor planning, a lack of inhibition, and poor set shifting, which are all problems related to impaired executive function. But not all parts of EF affect the functioning of an individual diagnosed with ADHD. By focusing the model of ADHD on deficits in behavioral inhibition, Barkley (1997) links ADHD to four executive functions in charge of internalizing behavioral responses and self-directed actions. Barkley summarizes these four functions as working memory; self-regulation of affect, motivation, and arousal; the internalization of speech; and reconstitution. Working memory serves as a starting point for EF, which can be defined as the "capacity to hold a mental representation in mind to guide behavior," (Barkley, 2000, p. 1065). The function of working memory is to allow an individual to remember something in order to do something. The act of holding on to the mental representation necessary to make a future decision may span over a period of time that continues past the presence of the external event. Therefore, the performance of this EF is associated with the anticipation of a future event or action that requires the information being held in memory (Barkley, 2000). The function of self-regulation of affect is to generate motivation or arousal to support goal-directed actions, as well as the continual persistence to achieve the goal. The process of self-regulation occurs when a person learns to regulate emotions in order to create the necessary motivation to complete a task. Internalization of speech serves as a continuation of self-regulation, as it serves to control an individual's behavior by contributing to self-restraint and guidance (Barkley, 1997). Reconstitution consists of two parts; analysis and synthesis. Analysis occurs when a person breaks down a situation or behavior into separate parts. Then, these parts can be modified to create a new approach or response, which occurs during synthesis. Through analysis and synthesis, reconstitution enables more complex responses to be created (Anderson, 2008).

Barkley (2000) further developed the four functions of EF described above and categorized them as nonverbal working memory; verbal working memory; internalized emotion/motivation; and reconstitution. In his previous definition of the four functions, nonverbal working memory was simply called working memory. Nonverbal working memory functions as two components working together, which are retrospective function and prospective function. As the names suggest, retrospective function acts as a tool to relive and store past information to be utilized by the prospective function, which then prepares the motor function based on the information that is recalled from past experiences (Barkley, 2000). Verbal working memory, which was known in the previous model as the internalization of speech, is comprised of the covert receptive and expressive language that helps a person create his/her own rules and morals that guide behaviors and actions (Barkley, 2000). Barkley redefines the function of self-regulation of affect, motivation, and arousal from his previous model as internalized emotion and motivation, in an effort to consolidate the function as a working concept. Barkley postulates that this function results as a consequence of the first two EF developments, by “representing visual and verbal stimuli to oneself,” (Barkley, 2000, p. 1067) causing emotional or physically motivated reactions to follow, such as a person laughing out loud because of a memory of a previous humorous experience. The final developmental marker of EF is reconstitution, which Barkley carried over from his developing functions of EF. He indicates that it is through play and interaction that goal-directed actions are created during the reconstitution phase (2000). The integration of these four functions permits an individual to control and direct behavior toward achieving a goal. Barkley explains that in this model, ADHD causes deficits in each function/marker of EF. He explains further that these deficits can be called intention deficits, or deficits pertaining to attention toward the future. In this way, Barkley theorizes that the development of EF and the presence of ADHD are linked together.

Nigg (2006) built on Barkley's theory by suggesting that the primary cause of ADHD is impairment in cognitive control, or EF. The major difference in Nigg's theory is that all EFs are equally important, rather than the hierarchy that was theorized by Barkley (1997; 2006). Nigg breaks down the EF domain into two related areas of control and working memory. He further breaks down these two domains into four EFs. Within the domain of control, Nigg describes "control of attention" as a way to choose between competing information, allowing for the proper response to the current situation. The second EF is the control of motor response, which is necessary to suppress the automatic response that occurs when performing such tasks as the Stroop. Nigg suggests that this second area is more behaviorally oriented than cognitively oriented, which is related to Barkley's (1997) definition of behavior inhibition described above. The third EF in Nigg's theory of ADHD is working memory. Within working memory, Nigg includes auditory, spatial, and location working memory, which involve the ability to manipulate information over a short period of time. According to Nigg's description, working memory is closely related to interference control, a necessary EF for completing the Stroop. The final EF in Nigg's theory revolves around activation. In his theory, activation involves the preparedness to respond effectively to a situation. This final EF is most related to Barkley's (1997) self-regulation of affect/motivation/arousal, as described above.

Baddeley (1986) described adults who suffer from deficits in central executive function (planning, abstract thinking, and cognitive flexibility) as having dysexecutive syndrome. Although Baddeley utilized this diagnosis with adults, Diamond (2005) suggested that the same symptoms of dysexecutive syndrome can be seen in children diagnosed with the ADHD-I subtype. As mentioned previously, the individuals with deficits in EF will have difficulty shifting their focus from one thing to another. Diamond suggested that assessing an individual's ability to hold information and repeat it back will not show evidence of deficits in EF. She instead proposes that assessing performance during the act of holding information in focus while combining it with another task, such as manipulation or inhibition, will show evidence of EF deficits (Diamond, 2005).

ADHD rating scales. Several rating scales quantify the symptoms described above. One of the most well-known rating scales is the revised Conners' Rating Scale (CRS-R, 1997). The Conners' scales were developed to assess common behavior problems in children, including problems with attention, sleep, eating, and peer relationships (Conners, 1970). The revised version includes a number of changes that allow a more in depth measure of ADHD and related behavior problems in children and adolescents. The CRS-R also allows examiners to combine report ratings from teachers, parents, and adolescents, which allows for a more reliable rating scale. The CRS-R has a direct link to the DSM-IV criteria for ADHD, and provides T-scores for determining the severity of the symptoms within the ADHD subtypes.

According to Conners (1997), the CRS-R is suitable for use on children aged 3 to 17. The self-report measure can be completed by children 12 to 17 years old. More specific to this research is the Conners' Parent Rating Scale-Revised (CPRS-R). The CPRS-R has a long and short version, with both forms being used for this research. The CPRS-R:S has four scales: Oppositional, Cognitive Problems, Hyperactivity, and an ADHD Index. The CPRS-R:S was normed using 2426 children, with 1220 being male, and 1206 being female. It has a reliability coefficient of 0.938 for males, and 0.921 for females. The CPRS-R:S has a test-retest reliability coefficient of .72 after a period of six to eight weeks. Conners, Sitarenios, Parker, and Epstein

(1998) conducted a criterion validity analysis for the CPRS-R using 91 children, with 68 being male and 23 being female, with a mean age of 10.16. The purpose of their analysis was to determine the predictive power of the CPRS-R for differentiating ADHD from other disorders. They found that the CPRS-R had a positive predictive power of 94.4%, a negative predictive power of 92.5%, a sensitivity rate of 92.3%, and a specificity rate of 94.5%. The overall correct classification rate was 93.4%. These CPRS-R:L validity ratings are the same as those of the CPRS-R:S, as the specific questions used on the CPRS-R:S are also on the CPRS-R:L. In a study of EF in ADHD, Fischer, Barkley, Smallish, and Fletcher (2005) used the CPRS-R in combination with other diagnostic tools to help confirm a diagnosis of ADHD, but did not attempt to use scores on the CPRS-R to predict EF deficits. Additionally, the CPRS-R has been successfully used by many researchers as a way to help confirm a diagnosis of ADHD in their sample, although it was not used to determine subtypes of ADHD (Aebi et al., 2010; Fischer, Barkley, Smallish, & Fletcher, 2005; Mahmoudi-Gharei, Dodangi, Tehrani-Doost, & Faghihi, 2011; Troost et al., 2006).

Relevant research in EF and ADHD. The following section will discuss research on relevant tests of EF and how they relate to ADHD as a whole, followed by research on EF in subtypes of ADHD. Prior to the D-KEFS, measures such as the Wisconsin Card Sorting Test, the Trail Making Test, and other switching tasks, have all been used to assess EF in children with ADHD (Altmann, 2004a, 2004b; Martel et al., 2007; Mirsky, Pascualvaca, Duncan, & French, 1999; Oades & Christiansen, 2008; Pennington & Ozonoff, 1996). Mirsky et al., (1999) examined in depth how EF relates to ADHD in comparison to control groups. They utilized data from all three of the previously mentioned measures to confirm a connection between executive dysfunction and ADHD. Altmann (2004a, 2004b) related EF problems to ADHD by attempting to determine ways to correct EF related errors by preparing each participant for the task prior to beginning the test. Martel et al. (2007) also found that when comparing scores on the Stroop, children with ADHD performed worse than control groups. Oades & Christiansen (2008) compared symptom severity in ADHD, and found that not only did ADHD groups performed significantly worse on the Trail Making Test and a Stroop like task than children in control groups, but also that the more severe the symptoms of ADHD, the worse the children performed. However, according to Nigg (2006), previous findings from EF measures, such as those mentioned above, were often limited by sample size, psychometrics, or lack of control tasks.

As mentioned previously, the D-KEFS has been successfully used in the past decade to measure EF. In one study, researchers utilized six subtests of the D-KEFS in order to determine the EF of children diagnosed with ADHD, including the CWIT (O'Brien, Dowell, Mostofsky, Denckla, & Mahone, 2010). Their objective was to examine EF categories of response inhibition, response preparation, working memory, and planning/shifting. O'Brien and colleagues found that children with ADHD showed deficits in planning/shifting on Condition 4 of the CWIT, regardless of age or gender. Koschack, Kunert, Derichs, Weniger, and Irle (2003) had previously found that children diagnosed with ADHD performed more slowly on measures of response preparation than control groups, which led O'Brien and colleagues (2010) to measure response preparation using the D-KEFS CWIT.

EF and subtypes of ADHD. A number of opinions exist regarding differences in subtypes of ADHD (Barkley, 2001; Diamond, 2005) A small number of studies have examined differences in EF for children who meet various criteria for subtypes of ADHD (Nigg, 2006).

According to Barkley (2001), children with ADHD-C suffer from more serious impairment than those diagnosed with ADHD-I. In contrast, Geurts, Verte, Oosterlaan, Roeyers, & Sergeant (2005) found that there are no reliable differences between the two subtypes. However, those studies did not include measurements of cognitive flexibility, which has been found to differ between subtypes. Houghton et al. (1999) used both parts of the original Trail Making Test to assess for EF differences between the DSM-IV-TR subtypes of ADHD, and found that children with ADHD-I made more errors than children with ADHD-C, and also took longer to complete each part of the TMT. The results from Martel et al. (2007) also suggest that deficits in cognitive flexibility as measured by the TMT Part B, are more severe in the ADHD-I subtype. Based on their findings, Martel et al. (2007) also concluded that "EF impairment was related to the inattention-disorganization ADHD symptom domain but not the hyperactive-impulsive ADHD symptom domain" (p. 1442). According to Goth-Owens, Martinez, Martel, and Nigg (2010), the criteria in the DSM-IV-TR may not be the most useful for determining ADHD subtype. Results from their research found that when altering the criteria for ADHD-I by lowering the number of hyperactive/impulsive symptoms allowed, those in the ADHD-I group showed weaker performance on tasks of motor sequencing and set-shifting (Goth-Owens, Martinez-Torteya, Martel, & Nigg, 2010). The altered ADHD-I group was defined by no more than two hyperactive/impulsive symptoms, while still having the normal six inattentive symptoms, as suggested by Milich et al. (2001) and Volk, Todorov, Hay, and Todd (2009). Derefinko et al., (2008) utilized cued reaction time tasks, and go/no-go tasks to determine differences in EF between subtypes of ADHD. They found that although the ADHD-I group had slower reaction times and larger variability on a component of the go/no-go task, they did not find differences in inhibition between the subtypes of ADHD.

Other studies that investigated EF differences between the ADHD-H subtype and ADHD-I subtype show that children with the ADHD-H subtype do not express EF deficits. Surprisingly, research has suggested that poor inhibitory control is found in children diagnosed with the inattentive subtype of ADHD, and not in the hyperactive-impulsive subtype (Chhabildas, Pennington, & Willicutt, 2001; Thorell, 2007). This gives credibility to the idea that EF impairment, when measured in a laboratory setting, is most prominent in ADHD subtypes where inattention is significant (Schmitz, Cadore, Paczko, Kipper, Chaves, Rohde et al., 2002). Thorell (2007) used a Stroop like interference task to assess the relationship between EF deficits, such as inhibition, and ADHD symptom domains. Thorell found that inhibition deficits were independently related to symptoms of inattention, but not related to symptoms of hyperactivity/impulsivity. More specifically, deficits were present only when symptoms of inattention were present, regardless of the presence of symptoms of hyperactivity/impulsivity.

Thorell also analyzed the relationship of EF deficits to individual symptoms of ADHD when a diagnosis was absent, as well as the relationship when an ADHD diagnosis was present. Both Thorell (2007) and Wahlstedt (2009) utilized a Stroop based task to assess inhibition in children diagnosed with ADHD, in order to explore the relationship between the Inattentive type and EF. Although the Stroop task used by Wahlstedt was not the CWIT found in the D-KEFS, their Stroop-like test, developed by Berlin and Bohlin (2002), was shown to have adequate test-retest reliability (r=.82, p<.0001; Berlin, Bohlin, Nyberg, & Janols, 2004; Brocki, Nyber, Thorell, & Bohlin, 2007). Wahlstedt found that inhibitory control had a significant relationship

(r=.33, p<.001) with symptoms of inattention, and not hyperactivity/impulsivity. In another study, Wahlstedt and Bohlin (2010) again used a Stroop-like task that was geared toward younger children in order to assess the relationship of EF impairment (inhibition, working memory, etc.) and the DSM-IV defined inattentive symptoms. Their findings suggest a connection between DSM-IV defined symptoms of inattention and EF impairments, including inhibition. This study, mentioned previously, was only conducted in children who were too young to utilize the comparison analyses available in the D-KEFS CWIT.

According to MacLeod (1991), the color naming and word naming conditions of the Stroop test do not require the same sort of inhibition necessary to complete the interference task on the Stroop. Schmitz et al. (2002) explored the relationship between ADHD subtypes and scores on each condition of the original Stroop test. They found that when comparing error scores and completion time on the naming condition of the Stroop, the ADHD-I group performed similarly to both the ADHD-H, ADHD-C groups. However, children in the ADHD-I group took longer to complete the interference condition of the Stroop when compared to those same groups. These results suggest that the subtypes of ADHD may perform similarly on Condition 1 and 2 of the D-KEFS CWIT, while the ADHD-I subtype may perform slightly worse on Conditions 3 and 4.

The culmination of the aforementioned research suggests that the current subtypes of ADHD are different in both their presentation and classification. Diamond (2005) summarized this research and argued that the ADHD-I subtype is a truly different disorder from the ADHD-H subtype; therefore, she classified the ADHD-I subtype as ADD, and the ADHD-H and ADHD-C subtypes as ADHD. Diamond believes that the presence of hyperactive symptoms should always be followed by a diagnosis of ADHD, rather than ADD, even if inattentive symptoms are present. To further clarify, Diamond believes that only the diagnosis of ADD and the diagnosis of ADHD should exist. Furthermore, Diamond indicates that "ADD and ADHD are characterized by dissociable cognitive and behavioral profiles, different patterns of comorbidities, different responses to medication, and different underlying neurobiological problems" (2005, p. 807). Although Diamond merely separates ADHD-I and ADHD-C, other researchers include the third subtype of ADHD-H in the separation. Nigg (2006) reported that researchers often include the hyperactive/impulsive subtype within the combined subtype (e.g., Chhabildas et al, 2001; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005b) because ADHD-H is less grounded with regard to symptom validity than ADHD-C and ADHD-I. Even though inattentive symptoms are present in ADHD-C, researchers (Barkley, 2001; Cantwell, 1983; Carlson, 1986; Carlson & Mann, 2000; Goodyear & Hynd, 1992; Milich, Balentine, & Lynman, 2001) have all argued that the Inattentive subtype of ADHD is a truly different disorder from ADHD when hyperactivity is present. Because of this similarity between ADHD-H and ADHD-C, the current study will focus on the comparison between the predominantly inattentive subtype and the combined subtype.

Summary

Executive function is defined as "the metacognitive capacities that allow an individual to perceive stimuli from his or her environment, respond adaptively, flexibly change direction, anticipate future goals, consider consequences, and respond in an integrated or common-sense way, utilizing all these capacities to serve a common purposive goal" (Baron, 2004, p.135). A growing number of psychologists suggest that ADHD is associated with EF deficits across the developmental spectrum, starting in childhood and continuing through adulthood (Shuai, Chan, & Wang, 2011). Distinct symptom differences exist between the predominantly inattentive subtype of ADHD, and the combined subtype of ADHD. These differences are laid out in the criteria for diagnosis in the DSM-IV-TR (2000). Furthermore, other differences between the subtypes may be significant enough to warrant further distinction in the ADHD diagnostic category (Diamond, 2005; Milich, Balentine, & Lynam, 2001). Some of these differences are observable when comparing the executive functioning of individuals diagnosed with each subtype (Bedard, Ickowicz, Logan, Hogg-Johnson, Schachar, & Tannock, 2003; Chhabildas et al., 2001). These differences may not be properly accounted for in the current DSM-IV-TR, according to Goth-Owens and colleagues (2010).

Researchers have attempted to assess the relationship between EF and ADHD subtypes, with varying outcomes. Some researchers (Thorell, 2007; Wahlstedt, 2009; Wahlstedt & Bohlin, 2010) have utilized a Stroop-based task to assess for inhibition in young children diagnosed with ADHD, and found that inhibitory control was correlated with symptoms of ADHD. Thorell (2007) utilized a Stroop-like task to assess the relationship of ADHD symptoms to EF deficits. Thorell found that that EF deficits, including inhibitory control, were independently related to symptoms of inattention, and that these deficits were present only when symptoms of inattention were present, regardless of the presence of symptoms of hyperactivity/impulsivity. When using a Stroop-like task comparing neuropsychological factors in the two ADHD symptom domains, inattention and hyperactivity/impulsivity, Wahlstedt (2009) also found that inhibitory control was related to symptoms of inattention rather than hyperactivity/impulsivity. Wahlstedt and Bohlin (2010) utilized a similar Stroop-like task, and found that symptoms of inattention were significantly correlated with inhibitory control, even when controlling for other factors, including hyperactive/impulsive symptoms. Mentioned previously, Schmitz et al. (2002) utilized the original Stroop test to assess the relationship between ADHD subtypes and scores on the Stroop test. When comparing the ADHD groups to a control group, Schmitz et al. found that overall, the control group performed better on Stroop tasks, suggesting that the Stroop is an effective measure of deficits in EF, such as inhibitory control. When comparing the ADHD groups to each other, Schmitz et al. found that the three subtypes of ADHD performed comparatively on the naming condition of the original Stroop when measuring for both the number of errors committed and completion time. When comparing completion time on the interference condition, the overall completion time for the inattentive group was significantly longer than the other two ADHD groups. These findings suggest that the first two conditions of the Stroop Test, and subsequently the D-KEFS CWIT, do not require the complex executive functions that are measured in the interference portion(s) of the Stroop and D-KEFS CWIT.

As mentioned previously, Denckla (1996) suggested that one major principle must be used to guide all forms of testing for executive function, and that is the "need for content-matched control tasks for every candidate EF task," (p. 273). The D-KEFS is one of the only test batteries that offers content-matched control tasks for a large number of EF tasks, which allows for proper testing of EF. Since researchers (Schmitz et al., 2002; Thorell, 2007; Wahlstedt, 2009; Wahlstedt & Bohlin, 2010) have already found significant differences in executive functions, including inhibitory control, between subtypes of ADHD using other tests, the use of the D-KEFS CWIT will allow further investigation into the relationship, by allowing for multiple content-matched control tasks and experimental tasks. Additionally, the D-KEFS is currently being used in clinical settings, including the assessment of children, making it an ideal test battery for this research.

Hypotheses

1a: *No significant differences in scores on Conditions 1 and 2 of the D-KEFS Color Word Interference Test will be found between children diagnosed with ADHD and average scores as defined by normative data from the D-KEFS Color Word Interference Test.*

1b*: Scores on Condition 3 of the D-KEFS Color Word Interference Test will be significantly lower (more impaired) in children diagnosed with ADHD than the average scores as defined by normative data from the D-KEFS Color Word Interference Test.*

1c*: Scores on Condition 4 of the D-KEFS Color Word Interference Test will be significantly lower (more impaired) in children diagnosed with ADHD than the average scores as defined by normative data from the D-KEFS Color Word Interference Test.*

2a*: No significant differences in scores on Conditions 1 and 2 of the D-KEFS Color Word Interference Test will be found between children with the Predominantly Inattentive type of ADHD and Combined type of ADHD.*

2b*: Scores on Condition 3 of the D-KEFS Color Word Interference Test will be significantly lower (more impaired) in children with the Predominantly Inattentive type of ADHD than in children with the Combined type of ADHD.*

2c*: Scores on Condition 4 of the D-KEFS Color Word Interference Test will be significantly lower (more impaired) in children with the Predominantly Inattentive type of ADHD than in children with the Combined type of ADHD.*

3a*: In children with ADHD-I, no significant correlation will be found between scores on Conditions 1 and 2 of the D-KEFS Color Word Interference Test and the severity of inattentive symptoms on the Conners Parent Rating Scale: Revised.*

***3b**: In children with ADHD-I, Scores on Condition 3 of the D-KEFS Color Word Interference Test will be significantly correlated with severity of inattentive symptoms on the Conners Parent Rating Scale: Revised.*

***3c**: In children with ADHD-I, Scores on Condition 4 of the D-KEFS Color Word Interference Test will be significantly correlated with severity of inattentive symptoms on the Conners Parent Rating Scale: Revised*

CHAPTER THREE

Method

Participants

Data for the study were selected from an archival database collected at a child neuropsychology evaluation service at the University of Texas Southwestern Medical Center. All files contained an IRB-approved consent form signed by the child's parent to allow use of the data for research purposes. The participants ranged in age from 8 to 17, with a mean age of 10.99. The sample consisted of children diagnosed previously with ADHD. The sample included children who have comorbid diagnoses of Learning Disabilities, and excluded children with ADHD, Not Otherwise Specified, other neurological conditions, and brain injuries. The sample was divided into two groups: (Group 1: Inattentive) Predominantly Inattentive type, and (Group 2: Combined) Predominantly Hyperactive-Impulsive and Combined types.

Materials

The data were extracted from a larger test battery consisting of a more comprehensive assessment of EF. Scores from the D-KEFS Color-Word Interference Test, and the Conners Parent Rating Scale, Revised Edition (CPRS-R; Conners, C.K., 2001) were used. It should be noted that critics of the D-KEFS suggest that the norms for the subtests are based on insufficient validity data (Schmidt, 2003). Delis, Kramer, Kaplan, and Holdenack (2004) disagree with Schmidt's view, and explain that the D-KEFS manual contains only small amounts of new validity data, in part because they utilized earlier validity studies on previous versions of the tests contained in the D-KEFS. Delis et al. (2004) further explain that the test makers decided to publish the preliminary validity data for the D-KEFS in peer reviewed scientific journals, thus allowing outside researchers to replicate their results without holding back the release of the test. Finally, Delis et al. (2004) reported that they chose to use peer-reviewed journals to reduce any biases towards validity that are generally seen when validity is reported by the test authors in the test manual. Delis et al. (2004) include a list of validity studies (Baldo, Delis, & Kaplan, 2003; Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Beatty, Jocic, Monson, & Katzung, 1994; Beatty & Monson, 1990; Crouch, Greve, & Brooks, 1996; Delis, Squire, Bihrle, & Massman, 1992; Dimitrov, Grafman, Soares, & Clark, 1999; Kramer, Reed, Mungas, Weiner, & Chui, 2002) on the tests used in the D-KEFS, including Donnelly, Carte, Kramer, Zupan, and Hinshaw (2001), who measured validity of the D-KEFS in an ADHD population.

As reported in Chapter Two, the CPRS-R was normed using 2426 children, with 1220 being male, and 1206 being female. It has a reliability coefficient of 0.94 for males, and 0.92 for females. The CPRS-R has a test-retest reliability coefficient of .72 after a period of six to eight weeks. Conners, Sitarenios, Parker, and Epstein (1998) conducted a criterion validity analysis for the CPRS-R using 91 children, with 68 being male and 23 being female, with a mean age of 10.16. When comparing results of the CPRS-R to an existing ADHD diagnosis, they found that the CPRS-R had a positive predictive power of 94.4%, a negative predictive power of 92.5%, a sensitivity rate of 92.3%, and a specificity rate of 94.5%. The overall correct classification rate was 93.4%. These CPRS-R validity ratings are the same as those of the CPRS-R:S (short form), as the scales in the short version include all the inattentive items from the long form. Additionally, the CPRS-R has been used by many researchers as a way to help confirm a diagnosis of ADHD in their sample (Aebi et al., 2010; Fischer, Barkley, Smallish, & Fletcher, 2005; Mahmoudi-Gharei, Dodangi, Tehrani-Doost, & Faghihi, 2011; Troost et al., 2006). For the purpose of this study, severity of inattentive symptoms will be represented by raw scores from questions on the CPRS-R related to DSM-IV inattentive symptoms.

Procedure

Data were gathered from archival files at the child neuropsychological evaluation service. The data from each file included age, gender, D-KEFS CWIT scores on Conditions 1, 2, 3, and 4, and scores from the CPRS-R long form or CPRS-R short form. Raw scores from ten CPRS-R questions relating to DSM-IV inattentive symptoms were summed to create a variable with scores from 0-30, (each question on the CPRS-R may be rated 0-3, with 0 meaning not true at all, and 3 meaning almost always true). A listing of these questions can be found in Appendix A. D-KEFS CWIT scaled scores based on completion time were used.

Statistics

Descriptive statistics (e.g., frequency, mean, SD) were calculated for demographic variables and test scores. Single sample t-tests were used for Hypothesis 1a-c to determine how participants' scores on the D-KEFS CWIT compared to the normative data. For Hypothesis 2a-c, a MANOVA was performed to determine the differences between the ADHD-I and ADHD-C types using scaled scores on each Condition of the D-KEFS CWIT as the dependent variables. For Hypothesis 3a-c, Pearson correlations were used to determine the strength of the relationships between scaled scores on all Conditions of the D-KEFS CWIT and the severity of inattentive symptoms reported on the CPRS-R.

CHAPTER FOUR

Results

Descriptive Statistics

The sample consisted of 38 participants ranging in age from 8 to 17 years, with a mean age of 10.99 years (SD = 1.54). There were 23 males (60.5%) and 15 females (39.5%). The sample was divided into two groups: ADHD-I (*n*=13) and ADHD-C (*n*=25). Comorbid disorders were found in 18 participants (i.e., dyslexia, dysgraphia, and other learning disorders). Of the children with learning disorders, 13 were identified as having dyslexia or a reading disorder. Of these, 6 were in the ADHD-I group, and 7 were in the ADHD-C group. Medications had been previously prescribed to 10 (76%) children in the ADHD-I group, and to 18 (72%) children in the ADHD-C group. No information was available about whether or not the children were taking their medication on the day of testing.

Means and standard deviations for scores on the CWIT are shown in Table 1. For the entire sample, the means and standard deviations for each condition of the CWIT are: Condition 1=10.05 (3.16), Condition 2=10.50 (2.59), Condition 3=9.34 (3.16), and Condition 4=9.82 (2.75). These scores all represent an average level of functioning. The mean CPRS-R raw score for the entire sample was 15.25 (7.21) with a range of 1 to 28. The mean CPRS-R raw score for the ADHD-I group was 12.17 (6.69), with a range of 1 to 25.

Results of Hypothesis-Testing

Significance level was set at .05. Single sample t-tests were performed to determine if there were significant differences between the normative data for each condition of the D-KEFS CWIT and this sample of children diagnosed with ADHD. As seen in Table 1, no significant difference was found on any condition of the CWIT. Hypothesis 1a was supported, while Hypotheses 1 b-c were not supported.

A MANOVA was performed to determine the differences between the ADHD-I and ADHD-C groups using scaled scores on each condition of the D-KEFS CWIT as the dependent variables. Table 2 shows the mean, standard deviation, and level of significance for each condition of the CWIT. Box's M was used to test for homogeneity of variance. Box's M (9.91) was not significant (p=.581), indicating equivalent variances. Wilks' Λ = .844, F (4, 33) = 1.524, α = .218, multivariate $\eta 2$ = .156, indicating that there is no overall significant difference between groups when comparing all scores on the CWIT. Table 2 also shows that when comparing each between-group difference, only Condition 2 was significant. For Condition 1, F (1,36) = 2.27, p =.14, $\eta 2$ = .06. For Condition 2, F (1, 36) = 5.31, p = .03, $\eta 2$ = .13. For Condition 3, F (1, 36)= .02, p = .88, $\eta 2$ = .001. For Condition 4, F (1, 36) = 1.15, p = .29, $\eta 2$ = .031. With regard to Hypothesis 2a, partial support was found, as the difference between groups was not significant for Condition 1, but the difference between groups was significant for Condition 2. Hypotheses 2b and 2c were not supported.

Pearson correlations were calculated to determine the strength of the relationship between each condition of the CWIT, and the severity of inattentive symptoms measured by the raw scores from the ten inattentive items of the CPRS-R. Two participants, one from each group, were excluded from CPRS-R analyses because of missing data. To address Hypothesis 3, the ADHD-I group was used, and results are shown in Table 3. No significant correlation was found between scores on Condition 1 of the CWIT and severity of inattentive symptoms, r = -.32, p = .32. No significant correlation was found between scores on Condition 2 of the CWIT and severity of inattentive symptoms, $r = -.10$, $p = .76$. No significant correlation was found between scores on Condition 3 of the CWIT and severity of inattentive symptoms, $r = -.26$, $p = .42$. No significant correlation was found between scores on Condition 4 of the CWIT and severity of inattentive symptoms, $r = .19$, $p = .56$. Therefore, Hypothesis 3a was supported, while Hypotheses 3b-c were not supported.

To obtain a better picture of the relationship, correlations also were calculated for the entire sample. These results also are found in Table 3. When examining all participants with ADHD, no significant correlation was found between scores on Condition 1 of the CWIT and severity of inattentive symptoms, $r = .07$, $p = .68$. No significant correlation was found between scores on Condition 2 and severity of inattentive symptoms, $r = .04$, $p = .81$. No significant correlation was found between scores on Condition 3 and severity of inattentive symptoms, $r = .002$, $p = .99$. No significant correlation was found between scores on Condition 4 and severity of inattentive symptoms, $r = .08$, $p = .65$.

CHAPTER FIVE

Discussion

The primary purpose of this study was to determine if differences existed between subtypes of ADHD when comparing scores on a test of EF that uses control tasks. This study hypothesized that there would be no significant differences in scores on Conditions 1 and 2 of the D-KEFS CWIT between children diagnosed with ADHD and average scores as defined by normative data for the CWIT, as Conditions 1 and 2 are control conditions for word and color naming. This study also hypothesized that scores on Condition 3 and Condition 4 would be significantly lower in children diagnosed with ADHD than the average scores as defined by normative data for the CWIT. The results show that the overall sample was not impaired relative to the standardization sample on all conditions of the CWIT. Thus, for this ADHD sample, impairment was not observed in the control tasks of the CWIT, nor did the CWIT reveal EF deficits on the tasks involving inhibitory control and cognitive flexibility.

This study hypothesized that there would be no significant differences between ADHD groups on Conditions 1 and 2 of the D-KEFS CWIT, based upon the assumption that naming of color patches (Condition 1) and quick reading of color words (Condition 2) do not require the complex executive functions that are measured in the interference portion(s) of the D-KEFS CWIT (Schmitz et al., 2002). The results indicated that there was no significant difference between groups when naming color patches (Condition 1), but there was a significant difference on when quickly reading color words (Condition 2), with the ADHD-I group earning lower scores. The significance difference for Condition 2 may be related to comorbid diagnoses, such as dyslexia. As reported previously, the number of participants with dyslexia in the ADHD-I group was 6, while the ADHD-C group had 7. As reported in the results section, a portion of the participants was comorbidly diagnosed with learning disorders, including dyslexia, which may have caused participants to struggle on the reading condition of the CWIT. Since the ADHD-I group had a higher proportion of participants diagnosed with comorbid disorders (46%) than the ADHD-C group (28%), the overall scores for the ADHD-I group may have been more affected. This study hypothesized that there would be significant differences between the ADHD-I and ADHD-C groups when comparing scores on the Stroop-like tasks (Conditions 3 and 4) of the D-KEFS CWIT, based on the research that showed inhibitory control was related to symptoms of inattention rather than hyperactivity/impulsivity (Wahlstedt, 2009; Wahlstedt & Bohlin, 2010). The results indicated that there was no difference between the groups in this sample. The lack of significant differences in this sample may be related to the specific characteristics of the sample and the small number of participants, as subtype differences have been found in previous research (Thorell, 2007; Wahlstedt, 2009; Wahlstedt & Bohlin, 2010). One such factor is the general absence of impairment on the CWIT for the entire sample, as stated previously. Another factor is the presence of medication effects for some of the participants, as medication had previously been prescribed to roughly 76% (ADHD-I) and 72% (ADHD-C) of participants. As mentioned previously, if a child was taking medication used to treat ADHD, he or she may have performed at a higher level due to the therapeutic effects of the treatment, which may include improved concentration and focus. Unfortunately, it was not known if participants had taken their medication on the day of testing.

This study hypothesized that no significant correlation between the severity of inattentive symptoms and scores on Conditions 1 and 2 of the D-KEFS CWIT would be present because previous research (Schmitz et al., 2002) found that children diagnosed with the different subtypes of ADHD performed within the average range in comparison to the standardized sample on the naming condition of the original Stroop when measuring for both the number of errors and completion time. The results indicated that there was no relationship between the severity of inattentive symptoms measured by the CPRS-R and Conditions 1 and 2 of the D-KEFS, which supported the hypothesis. This study hypothesized that a significant correlation would be present between the severity of inattentive symptoms and scores on Conditions 3 and 4 of the D-KEFS CWIT, based on research (Thorell, 2007) that found that inhibition deficits were present only when inattention symptoms were present, regardless of the presence of symptoms of hyperactivity/impulsivity. Wahlstedt (2009) and Wahlstedt and Bohlin (2010) also found that inhibitory control had a significant relationship with symptoms of inattention, and not hyperactivity/impulsivity. However, in this sample, no relationship was found between the severity of inattentive symptoms and scores on the CWIT. In other words, the severity of inattentive symptoms reported by the parent was not associated with more impairment on the conditions of the CWIT that measure inhibitory control and cognitive flexibility. One possible explanation is that the CPRS-R assesses lapses in attention in daily life in the natural environment, while the CWIT requires the child to focus attention just for a few minutes, which may allow him/her to perform at a higher level. Another possible explanation is that the CWIT may not be sufficiently sensitive as a measure of EF. A small sample size may also explain the lack of significant results, as more participants would have created a more diverse and global sample, which may better reflect previous research. Additionally, the sample may not be representative of the general population as most participants were research volunteers. Finally, a larger sample would have increased the power to find differences that might exist.

Limitations

As stated above, this research was limited by multiple factors, but primarily by the sample size. The low number of participants decreased the size of each group, which in turn decreased the strength of the analyses. Additionally, certain comorbid disorders that were not analyzed in this study may have affected scores on the CPRS-R and the D-KEFS CWIT, which may account for differences between participants. For example, 6 of the 13 children in the ADHD-I group and 7 of the 25 children with the ADHD-C group were diagnosed with dyslexia or a reading disorder that may have caused them to perform poorly on Condition 2 of the CWIT. Qualitative examination of the mean scores on Condition 2 of the CWIT for children diagnosed with dyslexia or a reading disorder indicated that they performed at a lower level than children who had not been diagnosed with dyslexia or a reading disorder. Means for the ADHD-I participants with and without dyslexia were 8.17 and 10.14 , respectively. Means for the ADHD-C participants with and without dyslexia were 9.57 and 11.78, respectively. However, excluding participants diagnosed with comorbid learning disorders would have been impractical, which may have added to the limitations. As mentioned previously, the presence of psychiatric medications may have added to the limitations, as roughly 76% of children in ADHD-I group and 72% of children in the ADHD-C group had previously been prescribed medication.

Future Direction

Given the small sample in the current study, a good future direction would be to increase the sample size with ongoing recruitment efforts. Additionally, newer versions of the Conners are becoming more widely used, and include several additional scales that may allow more precise analysis of EF differences between the subtypes through new scales that include questions more specific to each subtype of ADHD. By providing greater clarity between each subtype, clinicians will be able to better compare symptoms to deficits in ADHD, which may provide additional support for ADHD-I and ADHD-C being completely different disorders as suggested by Diamond (2005). Given the presence of research showing EF differences between subtypes of ADHD, future research using the D-KEFS would be beneficial, particularly the tasks that have control conditions. For example, additional subtests from the D-KEFS, such as the Trail Making Test or Card Sorting Test, can be used in combination with the CWIT to help determine specific EF deficits that are present in each subtype of ADHD.

Although this study was unable to provide evidence for differences in EF between subtypes of ADHD, the presence of previous research showing EF differences gives enough support to the need for variations in treatment. If children diagnosed with ADHD-I do in fact suffer from more severe deficits in EF, additional treatments may be needed beyond what is done for children diagnosed with ADHD-H or ADHD-C to ensure they are able to cope with EF deficiencies that may not be present in the other subtypes.

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Table 1

CWIT score means (sd)

	m	*sd*	*t-value*	*p*
CW_1	10.05	3.16	.103	.92
CW_2	10.50	2.59	1.19	.24
CW_3	9.34	3.16	-1.29	.21
CW_4	9.82	2.75	-.41	.68

Table 2

Results of MANOVA

MANOVA							
Effect	*Value*	*F*	*df*	*Error df*	*p*	η^2_P	*power*
Wilks' Λ	.844	1.524[b]	4	33	.218	.16	.42

b. Exact statistic

Scale score means (sd)

	ADHD-I	*ADHD-C*	*F*	*P*	*power*
CW_1	9.00 (3.46)	10.60 (2.92)	2.27	.14	.31
CW_2	9.23 (3.14)	11.16 (2.01)	5.31	.03	.61
CW_3	9.23 (3.44)	9.40 (3.07)	.02	.88	.05
CW_4	9.15 (2.67)	10.16 (2.78)	1.15	.29	.18

Table 3

Relationship of CPRS-R to CWIT Scores

	All Participants (n=36)		*ADHD-I Group (n=12)*	
	Pearson Correlation	*p*	*Pearson Correlation*	*p*
CW_1	.070	.684	-.315	.319
CW_2	.043	.805	-.100	.758
CW_3	.002	.993	-.257	.420
CW_4	.078	.651	.187	.560

Appendix A

Questions used from the CPRS-R:L and CPRS-R:S

CPRS-R:L	*Question*	*CPRS-R:S*
2	Difficulty doing or completing homework	1
9	Avoids, expresses reluctance about, or has difficulties engaging in tasks that require sustained mental effort (such as schoolwork or homework	3
12	Fails to complete assignments	5
19	Has trouble concentrating in class	8
29	Does not follow through on instructions and fails to finish schoolwork, chores or duties in the workplace (not due to oppositional behavior or failure to understand instructions)	10
38	Inattentive, easily distracted	13
48	Gets distracted when given instructions to do something	17
56	Short attention span	19
63	Messy or disorganized at home or school	21
69	Only attends if it is something he/she is very interested in	25

Questions taken from the Conners Parent Rating Scales found in:

Conners, C. K. (2001). *Conners' rating scales—revised: Technical manual*. North Tonawa N.Y.: Multi-Health Systems.

BIOGRAPHICAL SKETCH

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EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	YEAR(s)	FIELD OF STUDY
Texas Christian University, Fort Worth, TX	B. S.	2006-2010	Major: Psychology Minor: Child development
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Positions and Employment

2012-Current	Disability Claims Manager	*Cigna Group Operations*-Plano, TX
2006-2011	Media Production Assistant	*Texas Christian University, Center for Instructional Services*- Fort Worth, TX
2008-2010	Research Assistant	*Texas Christian University Psychology Department*- Fort Worth, TX

Presentations

"The Role of Social Learning in the Development of Context-Dependent Changes in Song"
Loris, C., Secora, K. R., Twynham, L. Whetstone, A., Peterson, J. R. & Cooper, B. G. (2009). Poster presented at the Student Research Symposium at Texas Christian University on April 17, 2009.

"Ultrasonic Vocalizations: An Index of Social Interest and Frustration in Aged Rats?"
Peterson, J. R., Loris, C., Russo, N., Cooper, B.G. (2010). Submitted to 2010 Southwestern Psychological Association.