ADHD SUBTYPES AND THE CONVERGENT VALIDITY

OF THE BRIEF THREE-FACTOR APPROACH

AND D-KEFS COLOR-WORD INTERFERENCE TEST

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DEDICATION

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Abstract

Deficits in executive functioning (EF) often translate to significant impairment in real-life situations. EF can be assessed by performance-based tests or through the use of behavior ratings; however, most research has found little to no associations between performance-based EF tests and parent ratings. ADHD is a neurodevelopmental disorder characterized by EF deficits, but some studies have found differences on EF measures between subtypes of ADHD. The first aim of this study is to examine the convergent validity between the D-KEFS CWIT, a performance-based EF task, and the recently revised three-factor BRIEF. The second aim of this study is to examine whether there are differences between ADHD-I and ADHD-HI/C subtypes on either of these EF measures. A sample of 49 children with ADHD, aged 6 to 12 years, were administered the D-KEFS CWIT and their parents were given the BRIEF to complete. No significant correlations between Condition 3 of the CWIT and the new Self-Monitor and Inhibit subdomains of the BRIEF were obtained, but the Shift subdomain of the BRIEF significantly correlated with Condition 3. Participants with ADHD-HI/C were rated by parents as having greater executive dysfunction compared to participants with ADHD-I. No significant differences between subtypes were observed on the CWIT after controlling for symptoms of inattention. It would be beneficial to continue developing EF measures with the goal of greater convergent validity between performance-based and informant-report measures. Also, more research should be conducted in identifying differences between ADHD subtypes in their EF profiles as it can potentially aid in improving evaluation and treatment of this disorder. *Keywords: ADHD, BRIEF, D-KEFS, convergent validity, Color-word interference test*

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CHAPTER ONE

Introduction

Executive functioning (EF) is a theoretical construct with various definitions, each of which agrees that it includes the skills that are necessary in order to engage in purposeful and goal oriented activities (Anderson, 1998). These executive functions are governed by the frontal lobes and include, but are not limited to, various abilities such as: set shifting, hypothesis generation, problem solving, concept formation, abstract reasoning, planning, organization, goal setting, fluency, working memory, inhibition, self-monitoring, initiative, self-control, mental/cognitive flexibility, attentional control, anticipation, estimation, behavioral regulation, common sense, and creativity. These frontal regions of the brain are relatively immature throughout the childhood years, explaining why children often exhibit poor organizational skills, attentional capacity, problem solving abilities, and other abilities related to EF (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). Many of these EF subdomains continue to develop through early adulthood; however, the subdomain of inhibition, which involves the ability to self-regulate and resist acting on impulse, is regarded as one of the first executive functions to appear, and one that remains stable at an early age (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Smidts, Jacobs, & Anderson, 2004). Some have even suggested that inhibition is a primary facet of executive functioning, with a number of theoretical models focused on understanding the subdomain of inhibition in order to better understand EF as a whole (Barkley & Grodzinsky, 1994; Fuster, 1989; Roberts & Pennington, 1996).

Executive functions play an integral role in both our ability to function cognitively and emotionally (Gioia & Isquith, 2004). Research has established that EF deficits lead to a globalized dysfunction across numerous settings, further suggesting that EF acts as the control center or “executive” of all thoughts, feelings, and behaviors carried out by an individual (Denckla, 1996; Gioia, Isquith, Retzlaff, & Pratt, 2001; Ylvisaker & DeBonnis, 2000). While the Diagnostic and Statistical Manual of Mental Disorders (4^{th} ed.) does not officially recognize an individual with a disorder of executive functioning (DSM-IV; American Psychiatric Association, 2000), many researchers have found EF deficits to be correlated with the presence of psychiatric disorders such as Obsessive-Compulsive Disorder, Bipolar Disorder, and Attention-Deficit/Hyperactivity Disorder (ADHD) (Moritz et al., 2002). In particular, the diagnosis of ADHD is frequently associated with EF dysfunction, and individuals with ADHD therefore are appropriate participants to use in studies of EF (Nigg, 2006; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

Measurement of EF has traditionally utilized performance-based measures to gauge an individual’s executive functioning abilities, such as the Stroop Test (Golden, 1978) which is purported to assess the EF subdomain of inhibition. However, numerous objections surfaced as to the ability of performance-based tests to truly assess for EF-deficits in real-world settings. These objections contended that the typical testing environment is ecologically invalid and therefore unlikely to accurately appraise an individual’s EF abilities in social, educational, and vocational contexts (Cripe, 1996, Sbordone, 1996, Silver, 2000). As a result, the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) was developed. The BRIEF is a questionnaire that includes a Parent form and Teacher form which is used to assess a child's executive functioning abilities in two ecologically valid environments: at home and in the classroom. Answers provided on each of these forms are then divided among eight subdomains of executive functioning (Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor). These subdomains are further grouped into two composites: Behavioral Regulation Index (Inhibit, Shift, and Emotional Control) and Metacognition Index (Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor). Although the BRIEF was developed to fulfill the need for ecologically valid assessment, most contemporary research studies have found only moderate correlations between the BRIEF and performance-based measures at best (e.g., Parrish et al., 2007; Toplak, Bucciarelli, Jain, & Tannock, 2009). Several explanations for this lack of agreement have been offered, such as a generalized interpretation which proposes that performance-based tests provide a look into an individual's EF capacity in optimal circumstances, where they are free from distractions or interruptions, while informant reports such as the BRIEF afford the opportunity to see the application of EF abilities in natural environments (McAuley, Chen, Goos, Schachar, & Crosbie, 2010; Silver, 2012). However, others have commented that the BRIEF may be assessing for different executive functions than originally theorized, thereby explaining the inconsistencies between BRIEF scores and performance-based testing results and warranting further investigation of the BRIEF's index composites (Alloway, Gathercole, Holmes, Place, Elliot, & Hilton, 2009; Mahone et al., 2002; Toplak, Bucciarelli, Jain, & Tannock, 2009). In addressing the discrepancy between the BRIEF and performance-based measures, the developers of the

BRIEF reviewed the BRIEF items and found that the Monitor scale actually measured two separate dimensions. Consequently, they divided the Monitor scale into two: a Self-Monitor scale which addresses the effect of behavior on others and a Task-Monitor scale that addresses activities related to tasks (Gioia & Isquith, 2002). Following this discovery, Gioia, Isquith, Retzlaff, and Espy (2002) conducted a factor analytic study and found that a three-factor format of the BRIEF was a better fit for the clinical scales than the original two-factor format. The primary aim of this study is to examine the BRIEF three-factor format and its correlations with performance-based testing of EF by comparing performance on the latest version of the Stroop test, the Delis-Kaplan Executive Functioning System's Color-Word Interference Test (D-KEFS; Delis, Kaplan, & Kramer, 2001), with subdomain scores from the new Behavioral Regulation Index (Self-Monitor and Inhibit).

Additionally, with regard to ADHD and EF deficits, many studies have found significant differences on performance-based measures between subtypes of ADHD (Predominantly Inattentive type [ADHD-I]; Predominantly Hyperactive-Impulsive type [ADHD-HI]; Combined type [ADHD-C]), with individuals diagnosed as ADHD-I exhibiting poorer performance on tests of EF compared to individuals with ADHD-HI, as well as ADHD-C when controlling for symptoms of inattention (Chhabildas, Pennington, & Willcutt, 2001; Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; van Mourik, Oosterlaan, & Sergeant, 2005). The implications of these findings suggest that ADHD-I and ADHD-HI may be linked to impairments within separate subdomains of EF, or perhaps that symptoms of ADHD-HI are not associated with significant EF deficits when disassociated from symptoms of inattention. Therefore, the secondary aim of this study is to observe whether there are any differences between ADHD subtypes in their performance on the D-KEFS Color-Word Interference Test and their test profiles on the BRIEF. It is postulated that the three-factor BRIEF format may add to the knowledge base concerning key problem areas of EF in ADHD as a whole, as well as illuminate any differences between ADHD-I and ADHD-HI in terms of executive functioning subdomains.

CHAPTER TWO

Review of the Literature

DEFINITION OF EXECUTIVE FUNCTIONING

Many definitions of EF have been proposed throughout the years, often having overlap in their meaning. Luria (1973) described executive function as holding and maintaining a set of thoughts to achieve a future goal. Baddeley (1986) described executive functioning as mechanisms which allow optimal performance in situations that require simultaneous operations of a number of different cognitive processes. Others have described EF as involving flexibility of thinking, strategizing, inhibition of impulsive behaviors, and organized search (Welsh, Pennington, & Grossier, 1991). Perhaps the most concise and simplest definition of executive functioning comes from Denckla (1996b) in which she describes EF as being attention to both the present and future, and involving intention (preparedness to act). Baron (2004) provided an expansive definition, describing executive functioning as being 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).

Executive function is assuredly a higher order, top-down domain that plays a central role in the mediation of cognition, emotions, and behaviors (Gioia & Isquith, 2004); therefore, any compromise to the EF system is likely to significantly impact adaptive functioning in academic, social, and vocational realms.

THE DEVELOPMENT OF EXECUTIVE FUNCTION

Biological Foundations of Executive Function

Previously, researchers had considered the frontal lobes to be functionally silent until mid to late adolescence (Golden, 1981), explaining why EF received very little attention in pediatric neuropsychology research (Anderson, Anderson, Jacobs, & Smith, 2008). It has since been established that there is a significant degree of activation within the frontal cortex in infancy and early childhood (Chugani & Phelps, 1986; Chugani, Phelps, & Mazziotta, 1987), leading to an emergence of executive functioning early in life. Some have documented evidence of EF functions appearing as early as one year in infants (Diamond, 2002).

Given the association between executive functioning abilities and brain development, some researchers have shown that EF abilities gradually improve over time with age. Cerebral development can be observed as a continuous process of growth during childhood, with the brain weight of an infant at 400 grams increasing to 1500 grams at maturity in early childhood, although the majority of maturation is postulated to happen in the first decade of life (Caesar, 1993). Prefrontal regions of the brain, which have a strong link to EF according to extant research literature, have been found to develop through adolescence and continue to mature until early adulthood. This pattern of brain maturation is likely associated with significant gains in executive functioning capabilities as the brain matures (Klinberg et al., 1999).

Cognitive Foundations of Executive Function

Studies of executive functioning have been found to parallel past cognitive models that historically supported a hierarchical view of development. Piaget’s theory of cognitive development (Piaget, 1963), in which he theorized that cognitive development progressed in a series of stages, now finds substantial support decades later in contemporary research on the development of executive functions. Piaget described four sequential cognitive stages that include: the sensorimotor (birth – 2 years), preoperational (2 – 7 years), concrete operational (7 – 9 years), and formal operational (early adolescence) stages. Although his theory of cognitive development is not entirely congruent with current research, it is nevertheless interesting to note that his cognitive stages do occur on a timeline quite similar to that of growth spurts identified in the central nervous system. A study done by Welsh, Pennington, and Grossier (1991) on a sample of normal children between the ages of 3 and 12 assessed them on a series of executive functioning measures. Their results were consistent with a stage-esque process in the development of executive functioning, describing three distinct developmental stages. The first stage identified at age 6 was characterized by a significant maturation of the ability to resist distraction. The second occurred at about the age of 10, with hypothesis testing, organized search, and impulse control emerging at this stage. Lastly, planning skills, verbal fluency, and motor sequencing were identified as reaching maturity in early adolescence. However, recent studies have found that some executive functions, such as response inhibition, may begin to develop incrementally at an earlier age. Smidt, Jacobs, and Anderson (2004) compared children ranging from age 3 through 7 years on tasks involving task switching, planning, working memory, and response inhibition and found that response inhibition was the first of these subdomains to emerge. Furthermore, Diamond (2002) estimated that response inhibition begins to appear around the age of 7 to 12 months, showing marked improvement between ages 1 and 4, and remaining relatively stable by age 5 with only marginal improvements throughout adulthood. Therefore, one can expect for children at the age of 13 to consistently perform better on a test that requires them to plan ahead than children at the age of 9 who have yet to mature in that particular EF subdomain, while their performance on a test of inhibition (e.g., Trail Making Test, Stroop Color-Word Interference Test) would be similar, despite age differences.

INHIBITION

Description of Inhibition

There are a number of subdomains that fall under the umbrella term of executive functioning. Among the many subdomains, inhibition in particular has received much recognition and focus in a few theoretical models of executive function (Fuster, 1989; Roberts & Pennington, 1996). Inhibition, more specifically behavioral inhibition, is the ability to inhibit an automatic or pre-potent response. Inhibition has also been variously termed repression, suppression, or restraining. It is a necessary function that allows individuals to suppress actions they desire to do on impulse so they can consider their actions thoughtfully, and affords the opportunity to resist any interruptions or disturbances from other stimuli to help maintain focus on the task at hand. Inhibition arbitrates the selection of responses when planning or problem-solving (Levin, Song, Ewing-Cobbs, & Robertson, 2001, p. 558).

Attempts to understand the importance of inhibition have become the dominant focus of researchers who aspire to better understand executive functioning as a whole. Behavioral inhibition is a core deficit mentioned within one theoretical model of execution functioning, described as the inhibiting of an initial pre-potent response to an event, halting a recurrent response pattern, and protecting the period of delay directed towards oneself from any disruption by other interfering events and responses (Barkley and Grodzinsky, 1994). Barkley's proposed model claims that behavioral inhibition also plays an important role in several key executive function processes including self-control of mood, arousal, motivation, working memory, reconstitution, and internalization or self-directed speech. He argued that any deficit or impairment in inhibitory functioning would significantly disrupt these processes, elaborating that while inhibition does not control or cause these functions to occur, it facilitates the implementation of these executive functions as they first require a delay in acting or responding to allow "self-directed, executive actions" (Barkley, 1997, p. 68). Altogether, behavioral inhibition is believed to be the first act of self-regulation in response to a stimulus as it allows additional time to think of alternative responses, anticipate the consequences of each response generated, and act accordingly to the behavioral choice decided upon.

Inhibitory Deficits and Social Repercussions

Inhibition plays a key role in moderating behavioral impulses and helps individuals to act in a conventional matter in social contexts; several studies have identified inhibition as playing a vital role in mediating and preventing behaviors that would be deemed inappropriate. Generally, from a biological standpoint, research has found that individuals who often have compromised inhibitory functioning include those who are very young, very old, or have significant brain damage (Beer, Heerey, Keltner, Scabini, & Knight, 2003; Friedman & Leslie, 2004; Kieras, Tobin, Graziano, & Rothbart, 2005; von Hippel & Dunlop, 2005). Social deficits of inhibitory functioning can be expressed in numerous ways, depending on the context and age of the individual. Children younger than five years of age have been known to speak their minds freely and often do not consider the consequences of their actions. Kieras and colleagues (2005) found that children who performed better on measures of inhibition were better at masking any signs of disappointment when receiving a gift they do not like versus receiving a gift they enjoy. Inhibition also plays an important role in suppressing stereotypic beliefs and prejudicial exclamations; for example, individuals who perform poorly on measures of inhibition have significant difficulty behaving in a manner that is socially appropriate and culturally sensitive, even when placed in a situation where it is beneficial to do so (Kunda & Spencer, 2003).

A lack of inhibition also affects the ability to formulate a plan ahead of time and solve a problem effectively and efficiently (Colvin, Dunbar, & Grafman 2001). In the aforementioned study, an experimental group comprised of individuals with left dorsolateral prefrontal lesions performed poorly overall on a measure of planning, especially when they were forced to make a counterintuitive move (one that resulted in temporarily working against the stated goal, requiring the ability to plan ahead of time before acting). Overall, these studies demonstrate the importance of inhibition in helping to maintain positive social interactions and show how a lack of inhibition can cause problems in relationships and daily functioning. Given the number of difficulties that can arise because of a lack of inhibition, researchers have developed a number of tests that aid in identifying individuals who are suspected to have inhibitory deficits.

THE STROOP PROCEDURE

Description

One measure that has received recognition in research for primarily measuring the subdomain of inhibition in isolation, albeit also involving some cognitive flexibility, is the Stroop Procedure (Stroop, 1935). The three components of the original adult version of the Stroop Task include: 1) different colors are named; 2) the names of colors, all printed in black ink, are read; and 3) the colors of the ink are named in printed words when the words themselves are actually names of colors that conflict with the color of the ink (for example, the word "red" is written in blue ink). This third condition, called the interference trial, is the most difficult in the Stroop task. Whereas the participant has been primed to read the word in the previous task, he/she must now inhibit the desire to respond by reading the word and instead name the ink color of the word. In a version of the test devised by Golden, an interference score is calculated by using data from each of the steps listed (Golden, 1976; 1978; 1987). The Golden version is similar to the original but includes three pages with 100 items, each page having 45-second trials. The participant is required to name as many items as possible within a 45 second time limit. When reading down columns on the page, if the last column is completed before the time limit ends, the participant begins the task again until the column is finished within the time limit. Four scores derived from the number of items read correctly are obtained in this version: a color trial score (C), word trial score (W), color-word trial score (CW), and an interference score calculated as INT = CW – (C x W)/(C + W)) (Golden, undated manuscript). The interference score is calculated to account for selective attention as a variable in a participant's completion time.

The Stroop task has been interchangeably described as a task which involves selective attention, interference control, and inhibition, as well as tapping into an individual's ability to "shift cognitive set to conform with changing demands, and suppress a habitual response in favor of a more novel one" (Anderson, 1998, pg. 341). The Stroop task is based on the finding that it takes longer to say color names of colored patches than to read words, and that it takes even longer to name the color of the ink in which a color name is printed when the ink is a color different from the color name (Dyer, 1973; Jensen & Rohwer, 1966). Many interpretations have been postulated to explain why it is significantly more difficult to name the color of the ink when the word is the name of a different color. Some have attributed the difficulty of the task to deficits in selective attention (the ability to purposefully attend to a certain stimulus when presented with multiple stimuli) or response conflict (the need to select between two or more competing responses), while others believe it to be a failure of response inhibition (Dyer, 1973; Zajano & Gorman, 1986). Regardless of the difficulty in knowing the precise conceptual underpinnings of the task, the Stroop test measures the ability to inhibit a pre-potent response in favor of a less habitual response.

Reliability and Validity of the Stroop Test

The Stroop procedure has been described as sufficiently reliable and valid in detecting individuals with neurological impairments by numerous studies and has been shown to be sensitive to stress, gender, and varying measures of personality (Batchelor, Harvey, & Bryant, 1995; Golden, 1974, 1976b, 1978b; Houston & Jones, 1967; Rojas & Bennett, 1995). Spreen, Strauss, and Sherman (2006) found high test-retest reliability effect sizes for the word reading (.90), color naming (.83), and color-word interference (.91) parts of the test after a one month interval between examinations. Studies on the practice effects for the original Stroop procedure have yielded mixed results, with some showing no effect while others finding significant improvements after two or three administrations (McCaffrey, Duff, & Westervelt, 2000). Poorer performance on the Stroop test, as measured by increased interference effect sizes, have been observed in individuals with a diagnosis of Attention-Deficit/Hyperactivity Disorder compared to normal controls (.24) (Lansbergen, Kenemans, & Engeland, 2007). Additionally, significant slowing on the interference trial of the original Stroop test was observed in patients with mild to moderate dementia (Bondi et al., 2002). Lavoie and Charlebois (2006) conducted a study to evaluate the discriminant validity of the Stroop Color-Word Test. Sixteen boys with symptoms of ADHD and who were labeled as disruptive were compared to another group of sixteen disruptive boys without ADHD and to sixteen controls. Findings indicated that the ADHD group had a significantly lower score in comparison to the two other groups in the interference condition, suggesting that performance on the Stroop procedure is poorer when symptoms of an ADHD diagnosis are present.

The Stroop Procedure and the Delis-Kaplan Executive Function System

The Delis-Kaplan Executive Function System (D-KEFS) is a comprehensive battery of tests designed to measure multiple subdomains of executive functioning (Delis, Kaplan, & Kramer, 2001). The D-KEFS is comprised of 9 tests measuring a variety of executive functioning domains, one of which involves a modification of the original Stroop procedure called the Color-Word Interference Test (CWIT; Delis, Kaplan, & Kramer, 2001). Similar to the original Stroop task, the CWIT includes three conditions: naming colored patches, reading color names printed in black ink, and naming the ink color of color words that are printed in a different color than their word's color (e.g., a participant sees the word "blue" that is printed in red ink and must say the color of the ink). Additionally, a fourth condition is added in the CWIT which requires the participant to say the ink color of a printed word (e.g., red, blue, etc.), with the exception of a "box" variable. If a word has a box around it, then the participant must instead read the word rather than say the color of the ink. This fourth condition then introduces the challenge of utilizing cognitive flexibility to shift between saying the colors of the ink and reading the words. For each of the four conditions, performance is measured by the time it takes for the participant to complete each task and the number of errors he/she makes while doing so. The D-KEFS technical manual provides evidence of reliability and validity for each of the tests (Delis, Kaplan, & Kramer, 2001). The D-KEFS CWIT was found to have moderate to high split-half coefficients (.62 - .84), which is a measure of internal consistency, and high test-retest reliability (.77 - .90) (Delis, Kaplan, & Kramer, 2001). Additionally, Mattson, Goodman, Caine, Delis, and Riley (1999) used four tests (California Stroop, Tower of California, California Word Context, and California Trail Making Test) that were later included in the D-KEFS to evaluate executive functioning in children with significant prenatal alcohol exposure. Poorer performance across all tests were observed in the children with significant prenatal alcohol exposure compared to healthy controls, providing some evidence of clinical utility and discriminant validity for the D-KEFS CWIT, as well.

EXECUTIVE FUNCTIONING AND ADHD

Definition of ADHD

Attention-Deficit/Hyperactivity Disorder (ADHD) is a psychiatric disorder characterized by significant and chronic difficulties of inattention, high impulsivity and/or hyperactivity, or both. All symptoms must have been present before the age of seven to qualify for an ADHD diagnosis (American Psychiatric Association, 2000). There are three subtypes of this disorder that include a predominantly inattentive type (ADHD-I), predominantly hyperactive/impulsive type (ADHD-HI), or a subtype that is a combination of both (ADHD-Combined or ADHD-C). While both the predominantly inattentive and predominantly hyperactive/impulsive subtypes are grouped together under the construct of ADHD by the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV; American Psychiatric Association, 2000), the subtypes differ in their symptoms. Symptoms of ADHD-I include problems of sustaining attention, organization, absent-mindedness, distractibility, and forgetfulness in daily activities. In contrast, symptoms of ADHD-HI involve fidgeting, excessive speech, restlessness, excitability, hyperactivity, and a lack of inhibitory control (e.g., a child in school who is impatient, blurts out an answer before the question is finished, often interrupts others in their activities, etc.). Overall, ADHD has been characterized by most researchers as a disorder marked by deficits in executive functioning (Barkley, 1997, 2006; Nigg, 2006; Sergeant, 2005; Sonuga-Barke, 2002, 2005).

Executive Functioning Deficits in ADHD

Research focusing on the relationship between the diagnosis of ADHD and executive functioning deficits suggests that individuals with an ADHD diagnosis often exhibit executive dysfunction (e.g., Pennington & Ozonoff, 1996; Sergeant, Geurts, & Oosterlaan, 2002). However, studies have suggested that there may be differences in performance depending on the subtype of ADHD. In a meta-analysis of seventeen independent studies, each using the standard Color-Word Task developed by Golden (1978), van Mourik, Oosterlaan, and Sergeant (2005) reported deficits in interference control in individuals with ADHD who ranged from age 6 to 27. In order to be included in the meta-analysis, each study had to consist of at least one ADHD group along with a comparison group of normal controls. The study also included only research that used an interference score calculated through subtracting the color-word score from the score on the color condition (C – CW) and the Golden method where correction for word reading and naming colors is also taken into account (Golden, 1978). The results of the meta-analysis found a significant overall effect size, albeit small (.35), for interference scores. The effect size for C – CW was non-significant (.26) and variable; and although the effect size for the Golden method was significant (.40), it varied considerably as well. The authors concluded that individuals with ADHD tend to perform poorer than controls in the third condition of the test as it requires inhibiting pre-potent responses that had been established in the previous two conditions. However, they noted that the distribution of effect sizes was highly variable across each of the studies, with eight of the studies included having an effect size of zero. Van Mourik, Oosterlan, and Sergeant (2005) attributed this inconsistency to faults made by some of these studies that used a procedure that was inconsistent with Golden's original method for calculating interference scores. Nevertheless, van Mourik, Oosterlan, and Sergeant (2005) cautioned that the

Color-Word Task may not be a valid measure of interference or inhibitory control deficits in individuals with ADHD.

Research findings have been somewhat mixed in regards to performance differences on performance-based measures between ADHD subtypes. Three studies compared children with ADHD-I and ADHD-C and found no significant performance differences between the two groups (Houghton et al., 1999; Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; Scheres et al., 2004). However, Van Mourik, Oosterlan, & Sergeant (2005) found a small but significant and homogeneous effect size which suggested that children with ADHD-I may tend to perform worse on measures of interference than children with ADHD-C. Perhaps the most comprehensive subtype comparison was conducted by Nigg, Blaskey, Huang-Pollock, and Rappley (2002), who examined the executive functions of children with ADHD Combined (ADHD-C) and Inattentive (ADHD-I) subtypes by observing their completion times on a Stop-Signal Paradigm (Logan, Schachar, & Tannock, 1997), and their overall performance on the Tower of London points (Krikorian, Bartok, & Gay, 1994), the Stroop Color-Word Interference Test (Golden, 1978), and the Trail-Making Test. They found that both subtypes did not significantly differ from each other in their overall performance on all tasks; however, the ADHD-C group was noted to have a large deficit on the Tower of London task compared to the control group, whereas the deficit of the ADHD-I group did not significantly differ from the control group. Neither ADHD group experienced a deficit in speed on the interference portion of the Stroop Color-Word Interference Test, although both were significantly slower than the controls on this task. Findings by Chhabildas, Pennington, and Willcutt (2001) compared the neuropsychological profiles of four groups of children (no ADHD, ADHD-I, ADHD-HI, and ADHD-C) and found that symptoms of inattention predicted the poorest performance across all dependent measures, including a Continuous Performance Task (CPT; Beck, Bransome, Mirsky, Rosvold, & Sarason, 1956), a measure of vigilance on the Gordon Diagnostic System (GDS; Gordon & Mettleman, 1988), the Stop Task (Logan, Cowan, & Davis, 1984), Trail-Making Test (Reitan & Wolfson, 1985), and the Coding Subtest from the WISC-R (WISC-R; Wechsler, 1974). In contrast, children with the ADHD Predominantly Hyperactive-Impulsive subtype experienced no impairment across any measures given, including those measures that required inhibitory control, after subclinical symptoms of inattention were controlled. These findings together suggest that the presence of symptoms congruent with a diagnosis of ADHD-I may be more debilitating to an individual's executive functioning in comparison to symptoms of ADHD-HI. This has significant clinical implications in determining whether ADHD-HI and ADHD-I relate to deficiencies within different subdomains of EF. Another question to consider is whether ADHD-I is related to greater impairment on certain tests of executive functioning because the inherent symptoms make focused task orientation more difficult.

INFORMANT REPORTS: THE BEHAVIORAL RATING INVENTORY OF EXECUTIVE FUNCTON

Rationale for Informant Reports

Informant-based rating scales have long been the tools of choice for assessing the emotional and behavioral problems of children in home and school environments. Many rating scales have been developed over the past several decades including the ADHD Rating Scale-IV

(DuPaul, Power, Anastopoulos, & Reid, 1998), the Child Behavior Checklist and Caregiver/Teacher Report Form (CBCL; Achenbach, 1991), the Behavior Assessment System for Children-II (BASC-II; Reynolds and Kamphaus, 2004), and the Conner's Rating Scale-III (CRS-III; Conners, 2008). Each of these scales has different versions depending on the type of informant (i.e., parent's report, teacher's report, a child's self-report) and are tailored to address specific concerns a clinician may have, such as helping to determine whether or not a child has symptoms of ADHD or oppositional defiant disorder, in order to aid practitioners in conceptualizing a child's externalizing behaviors from multiple perspectives (e.g., teachers, parents, etc.). These questionnaires are completed by an informant who observes the child in real-world settings and are therefore an ecologically valid alternative to performance-based measures.

As deficits in EF often manifest in behaviors in the natural environment, EF may be adequately assessed in a clinical or laboratory setting (Cripe, 1996). Although standardized test instruments such as the D-KEFS provide valuable insight into the EF capabilities and limitations of a child, professionals have long been at a disadvantage in understanding a child's EF in a real-world setting (Cripe, 1996; Sbordone, 1996). Performance-based tests, while valuable in the data they provide, are largely unable to capture the qualitative aspects of EF deficits sufficiently well or may be incapable of assessing important aspects of EF altogether (Gioia, Isquith, Guy, & Kenworthy, 2000; Silver, 2000). In response to the growing need for an assessment method to capture the behavioral anomalies caused by EF deficits in a real-life setting such as school or home, the Behavior Rating Inventory of Executive Function (BRIEF) was developed (Gioia et al., 2000). The BRIEF is a questionnaire that was developed in order to provide clinicians the ability to assess EF in children and adolescents from an ecologically valid standpoint (Gioia et al., 2000).

Description of the BRIEF

The BRIEF includes an 86-item Parent form and Teacher form where statements are rated on a three-point scale (Never, Sometimes, Often). According to the manual, a fifth grade education is required to comprehend the instructions on the questionnaire. Each questionnaire is estimated to take about 10 to 15 minutes to complete. In designing the BRIEF, the statements that were selected to be included were considered to be the most likely to inform the clinician of any behavioral deficits due to executive dysfunction, and were chosen based on inter-rater reliability and item-total correlations (Gioia et al., 2000). Also, in contrast with other informant reports of executive functioning, the BRIEF provides a standardized method of assessing real-life executive functions in a manner that is not disease specific and can therefore be utilized to assess children and adolescents who have a variety of difficulties (Gioia et al., 2000).

Eight subdomains of executive function were identified through a principal components analysis: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor. Gioia and colleages (2000) grouped together these subdomains into a Behavioral Regulation Index (BRI) consisting of the Inhibit, Shift, and Emotional Control subdomains, while the Metacognition Index (MCI) incorporates the remaining subdomains. The BRI and MCI are combined to obtain an overall Global Executive Composite (GEC) and are represented by T-scores, with higher scores indicating poorer executive functioning. It is recommended, however, that the BRI index elevations be interpreted first since behavioral regulation significantly influences an individual's metacognitive problem-solving abilities (Gioia et al., 2000).

Reliability and Validity

The reliability of the BRIEF has been described as satisfactory (Gioia et al., 2001). The Cronbach-alpha internal consistency coefficient for the BRIEF ranged from .80-.98 on both the parent form and teacher form, with data being derived from clinical and normative samples. Test-retest reliability analyses found moderately high correlations across all clinical scales for the Parent Form in a normative sub-sample ($r = .81$). The BRI, MCI, and GEC test-retest correlations were found to be .84, .88, and .86, respectively. On the Parent Form in the clinical subsample, the correlation was also moderately high ($r = .79$) with BRI, MCI, and GEC test-retest correlations of .80, .83. and .81, respectively. The Teacher Form normative subsample correlation was the highest ($r = .87$) with BRI, MCI, and GEC retest correlations of .92, .90. and .91, respectively.

Inter-rater agreement between the parent and teacher reports has only been found to be moderate on the BRIEF ($r = .32$; Baron, 2004); however, significant discrepancies between parents and teachers have often been observed on other informant-report measures and have been explained to be due to the different contexts and environments from which they are reporting (Achenbach, McConaughy, & Howell, 1987). In addition, others have emphasized how the variability in informant-child interactions and the differences in informant characteristics (e.g., teachers may be more objective informants compared to parents, while parents may be more sensitive to noticing behavioral changes in their child) can influence how an informant rates a child (Achenbach, 2006; Ferdinand et al., 2003; Konold, Walthall, & Pianta, 2004; Lee, Elliot, & Barbour, 1994; Stanger & Lewis, 1993; Verhulst, Koot, & Van der Ende, 1994; Verhulst & Van der Ende, 1992). The correlation between parent and teacher reports were notably lower in regards to two subdomains, Initiate and Organization of Materials; however, environmental differences between home and school likely influenced the differences between informants (Gioia et al., 2002). Two additional subdomains, Emotional Control and Shift, had lower correlations between parent and teacher reports, though interpretation of this finding was omitted (Gioia et al., 2000).

Convergent and discriminant validity were measured through a comparison of the BRIEF with other partially related and unrelated rating scales of attention or other types of behaviors (Gioia et al., 2000). They found significant scale and summary index correlations between the BRIEF and a multitude of other measures including the ADHD Rating Scale-IV, Child Behavior Checklist and Teacher's Report Form, Behavior Assessment System for Children, and the Conner's Rating Scale. These findings corroborated a later study done by Mahone and colleagues which found highly significant ($P < .0001$) correlations between the CBCL, ADHD Rating Scale-IV, Diagnostic Interview for Children and Adolescents, Fourth Edition (DICA-IV; Reich, Welner, & Herjanic, 1997), and the BRIEF (Mahone et al., 2002).

The Utility of the BRIEF and ADHD

As stated earlier, the BRIEF has been demonstrated to be useful in clinical settings for evaluating children with a variety of disabilities and disorders. The BRIEF is usually utilized to assess executive functions in children with neuropsychological and/or developmental disorders such as pervasive developmental disorders, traumatic brain injury, Tourette syndrome, high functioning autism, learning disabilities, and most often ADHD. Compared to other behavioral rating systems, the BRIEF has been shown to be superior in its ability to evaluate ADHD in children and adolescents, being able to tap into behaviors that are unique to the disorder such as metacognitive abilities and working memory (Jarratt, Riccio, & Siekierski, 2005). McCandless and O'Laughlin (2007) found that the BRIEF's Behavioral Regulation and Metacognition scales are useful as a tool to help determine whether a child or adolescent has ADHD; in particular, the Working Memory subscale of the Behavioral Regulation Scale can help identify the presence of ADHD in an individual while the Inhibit subscale of the Metacognition scale can be used to distinguish between ADHD subtypes. The BRIEF can also aid practitioners in emphasizing differences and determining differential diagnoses between ADHD and other disorders (Mahone et al., 2002; Pratt, 2000).

RELATIONSHIP BETWEEN COGNITIVE MEASURES AND INFORMANT REPORTS

Studies have investigated whether parent or teacher ratings of executive functioning subdomains significantly correlate with performed-based measures that are assumed to measure those same subdomains. Theoretically, if a deficit in a specific subdomain of executive functioning is found on a performance-based test, similar behavioral problems associated with that subdomain should be observable (e.g., a child who has problems on a test of organization should also have some difficulties in sorting his/her toys or board games). A study composed of child participants diagnosed with new onset epilepsy found that poorer performance on three D-KEFS subtests (Sorting Test, Verbal Fluency Test, and Color-Word Interference Test) was significantly correlated with increased report of problems on the BRIEF's Metacognition Index (-0.28, -0.32, -0.33, respectively), although the Behavioral Regulation Index (BRI) was not significantly correlated with any of the D-KEFS measures (Parrish, Geary, Jones, Seth, Hermann, & Seidenberg, 2007). However, most studies of BRIEF parent ratings have found low correlations between performance-based measures of executive functioning and parent reports of EF. For example, Anderson and colleagues (2002) found few significant correlations when comparing performance-based executive function measures with BRIEF profiles of children with early treated phenylketonuria, early treated hydrocephalus, frontal focal lesions, and healthy controls (Anderson, Anderson, Northam, Jacobs, & Mikiwicz, 2002). Similarly, Vriezen and Pigott (2002) found no correlations between the BRIEF and several performance-based tests of executive functions when examining children with moderate to severe brain injury. Bodnar and colleagues (2007) investigated the construct validity of parent ratings specifically on the subdomain of inhibitory control. Their findings show that there was little relationship between parent ratings of inhibitory control and the actual performance on computerized measures of inhibition (Bodnar, Prahme, Cutting, Denckla, & Mahone, 2007). These disparities between scores on measures of executive functioning and informant reports of EF recently sparked McAuley and colleagues (2010) to conduct an analysis that looked at 11 studies which compared performance-based measures of EF with parent and teacher reports on the BRIEF. They found no significant relationship between the Metacognition Index or Behavioral Regulation Index and participants' scores on working memory, performance monitoring, and inhibition measures (McAuley et al., 2010). Several interpretations have been offered to explain this dissociation between parent/teacher reports and performance on EF measures. For example, Silver (2012) and McAuley et al. (2010) argued that performance-based tests may be gauging an individual's EF capacity in optimal circumstances, while informant reports assess an individual's ability to exercise EF abilities in day-to-day life. Others have commented on the multi-factorial nature of performance-based measures, stating that since most tests of EF measure several subdomains at once, it is difficult to correlate an informant report of a singular EF subdomain with a performance-based test that measures multiple domains (Archibald & Kerns, 1999; Baron, 2004; Denckla, 1996). However, to date, no one explanation has been able to adequately explain the discrepancy between performance-based measures and informant reports.

One plausible explanation proposed for this dissociation between parent/teacher reports and performance on EF measures is that some items on the BRIEF may be assessing for different executive functions than originally theorized (Alloway, Gathercole, Holmes, Place, Elliot, & Hilton, 2009; Mahone et al., 2002; Toplak, Bucciarelli, Jain, & Tannock, 2009). As a result, Gioia and Isquith (2002) reviewed the BRIEF and suggested that the Monitor scale actually measures two separate dimensions, prompting them to divide it into two separate scales, a Self-Monitor scale (monitoring one's own behaviors) and a Task-Monitor scale (monitoring of task-related activities). In light of these findings, Gioia, Isquith, Retzlaff, and Espy (2002) conducted a confirmatory factor analysis (CFA) on the BRIEF Parent Form and found that their previously proposed two-factor model consisting of the BRI and MCI was a poor fit to the data. In their

CFA study, Gioia and colleagues (2002) found that the best model for the BRIEF was not a two factor format, but a three factor format that subsequently required a reorganization of the original subdomains into three indices: the Behavioral Regulation factor (Inhibit and Self-Monitor scales), Emotional Regulation factor (Emotional Control and Shift scales), and the Metacognition factor (Initiate, Working Memory, Plan/Organize, Organization of Materials, and Task-Monitor scales. This revamp of the original two factor model to the new three factor model has received support for its use through factor analyses by other independent researchers, with consistent findings that a three-factor model is most appropriate (Peters, Algina, Smith & Daunic, 2012; Slick, Lautzenhiser, Sherman, & Eyrl, 2006). As previously stated, published factor analyses on the BRIEF by Gioia et al. (2002) and Slick et al. (2006) have investigated the use of the parent form of the BRIEF with the three-factor model, with both studies using children from clinical samples. However, only one study by Peters et al. (2012) so far has investigated the use of the three-factor model with the teacher form of the BRIEF; their findings supported the three-factor model as a better fit for the data compared to the two-factor model.

SUMMARY & STUDY AIMS

As it currently stands in the literature, a significant discrepancy exists between scores on numerous performance-based tests of EF and the degree of EF impairment as reported by informants on rating scales (Anderson, Anderson, Northam, Jacobs, & Mikiewicz, 2002; Anderson, Anderson, Northam, & Taylor, 2000; Goulden & Silver, 2009). In order to rectify this disparity, the three-factor format of the BRIEF was developed and has received support in the literature, attesting to its improved internal validity compared to the original two-factor model

(Peters et al., 2012; Slick et al., 2006). Considering the modifications made to the BRIEF's index scales and the separation of the Monitor scale into a Self-Monitor and Task-Monitor scale, the relationship between the BRIEF and performance-based measures of EF may be improved as a result of the aforementioned revisions. To date, no published studies have been conducted to examine whether scores from the new three-factor format of the BRIEF would now better correlate with performance-based measures of executive functioning. Another question to ask is whether the discriminative validity is improved as a result of the three-factor format revision. Past studies have found that the original BRIEF demonstrated good discriminative validity and was useful as a tool for identifying EF profiles (Gioia, Isquith, Kenworthy, & Baron, 2002; Semrud-Clikeman, Walkowiak, Wilkinson, & Butcher, 2010). Therefore, the revised three-factor format may enhance the utility of the BRIEF in identifying characteristics of ADHD subtypes.

Several studies have found that individuals with ADHD-I tend to have inferior performance on performance-based measures compared to those diagnosed with ADHD-HI when symptoms of inattention are controlled for, leading many to speculate that ADHD-I is a more debilitating diagnosis. Some children and adolescents diagnosed with ADHD-HI are known to have high impulsivity, an indicator of poor inhibitory control, and are characterized by problems in school that can involve frequently blurting out answers before a question can be completed, difficulty waiting for their turn, and repeatedly interrupting or intruding on others' activities (American Psychiatric Association, 2000). However, as inhibition has been theorized to play a role in facilitating other executive actions including attentional processes such as working memory (Barkley and Grodzinsky, 1994), individuals with ADHD-I may also struggle with problems related to poor inhibitory control that are not manifested through acting-out behavior.

Two aims will be addressed in this study. The first aim is to examine the relationship between performance-based measures and the new three-factor model of the BRIEF. For the purposes of this study, the D-KEFS Color-Word Interference Test will be utilized as a performance-based measure of inhibition to be compared with the revised Behavioral Regulation Index of the BRIEF three-factor format, which includes an Inhibition and Self-Monitor scale. The second aim is to determine if there are any differences between subtypes of ADHD in regards to CWIT performance and their symptomology as measured by the BRIEF three-factor format. The DSM-IV warrants the use of subtype diagnoses that vary depending on an individual's symptoms (i.e., ADHD-I, ADHD-HI, or ADHD-C); however, it is important to address whether individuals with ADHD differ in their executive functions based on subtype by using the BRIEF and CWIT. The BRIEF three-factor format may help to illuminate specific executive function deficits that could be different between subtypes of ADHD. A comparison of performance scores from individuals with ADHD-I and ADHD-HI/C on Condition 3 of the D-KEFS CWIT also may aid in clarifying whether children with ADHD-I display greater impairment on a test of inhibition.

Hypotheses

- Hypothesis 1: Performance scores on Condition 3 of the D-KEFS Color-Word Interference Test, a test of inhibition, will negatively correlate with the Self-Monitor and Inhibit scores from the BRIEF three-factor format (i.e., poorer performance on the CWIT will be associated with greater dysfunction on the BRIEF).

- Hypothesis 2: Overall, participants with ADHD-I will have significantly higher elevations in their Metacognition Index scores compared to participants with ADHD-HI/C. Participants with ADHD-HI/C will have significantly higher elevations in their Emotional and Behavioral Regulation Index scores compared to participants with ADHD-I.
- Hypothesis 3: Participants with ADHD-I will have lower scores on Condition 3 of the D-KEFS CWIT compared to participants with ADHD-HI/C, after symptoms of inattention are controlled.

CHAPTER THREE

Methodology

Participants

Participants for this study were selected from a larger study examining executive functioning at the University of Texas Southwestern Medical Center. Included in this database were 49 students between the ages of 6 years and 12 years who were recruited from two private schools for children with learning differences located in Dallas, Texas. Students considered for this study had to have been previously diagnosed with ADHD and have no diagnosis of a major neurological or psychiatric condition. Children with comorbid learning disabilities were included. Of the 49 participants included in the database, only 37 participants who were between the ages of 8 and 12 years could be included in this study due to absence of an ADHD diagnosis and/or missing test data. All 37 participants were included in the statistical analyses for hypothesis 1; however, only 35 participants were included in the analyses for hypotheses 2 and 3 due to a missing ADHD subtype diagnosis.

Procedures

The present study was previously approved by the Institutional Review Board (IRB) of the University of Texas Southwestern Medical Center. Participants eligible for this study had been identified by school staff at the two aforementioned private schools for having ADHD. Parents of these children were then contacted by the schools and invited to participate in this research study. Information sessions were provided to parents who were interested in the study and informed consent obtained at these sessions or by school staff at a later time. Packets containing the BRIEF Parent form and Teacher form were distributed by school staff to parents who enrolled in this study and were later collected following their completion. Appointments for testing with the students were scheduled with the assistance of school staff. Testing was conducted by a graduate student in Clinical Psychology, a graduate student in Rehabilitation Counseling, and a faculty associate, all of whom were trained in the administration and scoring of these tests. Data derived from testing and parent reports continue to be maintained within locked files in the principal investigator's office.

Measures

As part of a larger battery of neuropsychological tests, participants in this study were administered the D-KEFS Color-Word Interference Test and parents of the study's participants completed the BRIEF. Only the D-KEFS Color-Word Interference Test and the BRIEF will be used for the purposes of this study.

As mentioned previously, the D-KEFS Color-Word Interference Test includes four conditions: naming colored patches, reading color names printed in black ink, naming the ink color of color words that are printed in a different color than their word's color, and the fourth condition which is identical to the third except that the participant is required to read the word rather than say the color of the ink of the word when there is a box around it. For each of the four conditions, performance is measured by the time it takes for the participant to complete each task and the number of errors he/she makes while doing so.

The BRIEF includes an 86-item Parent form and Teacher form with statements that are rated on a three-point scale (Never, Sometimes, Often). According to the manual, a fifth grade education is required to comprehend the instructions on the questionnaire, with each questionnaire taking about 10 to 15 minutes to complete. The original version of the BRIEF divided item responses into eight subdomains of executive function: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor. These subdomains are grouped into a Behavioral Regulation Index (BRI) consisting of the Inhibit, Shift, and Emotional Control subdomains, and a Metacognition Index (MCI) consisting of the Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor scales. The BRI and MCI are combined to obtain an overall Global Executive Composite (GEC) and are represented by T-scores, with higher scores indicating poorer executive functioning. However, for the purposes of this study, each BRIEF will be re-scored to reflect the three-factor format changes that were proposed by Gioia, Isquith, Retzlaff, and Espy (2002) by first re-distributing the 8 items on the Parent form and 10 items on the Teacher form from the original version of the BRIEF into a Task-Monitor scale and Self-Monitor scale. On the Parent form, items 14, 21, 31, and 60 compose the new Task-Monitor scale and items 34, 42, 52, and 63 compose the new Self-Monitor scale; on the Teacher form, items 15, 22, 36, and 61 compose the Task-Monitor scale and items 33, 44, 46, 54, 55, and 65 compose the Self-Monitor scale (Gioia and Isquith, 2002). The resulting nine subdomains are reorganized into three indices: a Behavioral Regulation Index (Inhibit and Self-Monitor), Emotional Regulation Index (Emotional Control and Shift), and Metacognition Index (Initiate, Plan/Organize, Organization of Materials, Working Memory, and Task-Monitor). Because of the absence of norms for the three-factor BRIEF format, raw scores without age corrections were used in a manner similar to that used by Gioia, Isquith, Retzlaff, and Espy (2002) in their factor analytic study.

Additionally, the Conners Rating Scale – Revised (CRS-R; Conners, 1997) Short form and Long form were utilized to obtain parent ratings of ADHD symptoms. Specifically, the CRS-R was used to account for symptoms of inattention in the sample for the purposes of this study. Symptom severity ratings ranged from 0 to 3, with 0 meaning “not true at all” (never, seldom), 1 meaning “just a little true” (occasionally), 2 meaning “pretty much true” (often, quite a bit), and 3 meaning “very much true” (very often, very frequent). A total of 10 items relating to inattention were calculated on both the short and long form, creating a summed severity rating of 0 to 30 for each participant.

CHAPTER FOUR

Results

Descriptive Statistics

All statistical analyses used in this study were performed using SPSS version 19.0. The following descriptive statistics include demographic variables such as age, gender, and ethnicity, and additional clinical data pertinent to the study's aims including the participant's ADHD subtype diagnosis, comorbid diagnoses, and whether the child had been prescribed ADHD medication. All demographic information is listed in Table 1. The mean age of the sample was 10.49 years (SD = 1.28) with 78.4% of the participants being between the ages of 10 through 12 years. The sample consisted of 56.8% male participants and 43.2% female participants. Most of the sample identified as Caucasian (91.9%). Information regarding ADHD subtype diagnoses, comorbid diagnoses, and medication of the participants was provided by parent report. Subtype diagnoses were: 48.6% with ADHD, Combined Type; 29.7% with ADHD, Predominantly Inattentive Type; 16.2% with ADHD, Predominantly Hyperactive/Impulsive Type; and 5.4% with no reported subtype diagnosis. The majority of the sample was reported having a comorbid diagnosis (89.3%); also, 83.8% of the sample were reported to use ADHD medication.

Scores from the D-KEFS Color-Word Interference Test, BRIEF Parent form, and the CPRS-R are presented in Table 2. Scaled scores are used to represent performance on the CWIT, which have a mean of 10 and a standard deviation of 3. The mean scaled scores on each of the four conditions of the CWIT were 10.19, 10.41, 9.57, and 9.92, respectively, and are indicative of average performance on each condition by the sample. Participant scaled scores ranged from 4 through 15 on Condition 1, 4 through 14 on Condition 2, 2 through 14 on Condition 3, and 4 through 14 on Condition 4.

Scores on the BRIEF Parent form were recalculated to reflect the three-factor format changes suggested by Gioia and colleagues (2002). No normative sample for this revision is available at this time; as a result, raw scores were used in this study, with higher scores being indicative of greater executive functioning impairment (see Table 2). The mean scores for each of the subdomains and indices on the BRIEF were: Inhibit 19.16; Self-Monitor 8.03; Emotional Control 19.70; Shift 14.89; Initiate 15.49; Working Memory 22.81; Plan/Organize 24.49; Organization of Materials 15.11; Task-Monitor 9.03; Behavioral Regulation Index 27.19; Emotional Regulation Index 34.32; Metacognition Index 86.92; and Global Executive Composite 148.43. The maximum possible raw scores are shown in Table 2. Although no normative data are available for the three-factor format, the mean raw score for the Global Executive Composite was compared with normative data, in order to provide a general sense of the participants' level of executive functioning as rated by their parents. When compared with boys in the 8-10 year age group and the 11-13 year age group, the sample obtained T scores of 62 and 65, respectively. When compared with girls in the 8-10 year age group and the 11-13 year age group, the sample obtained T scores of 64 and 67, respectively. Thus, overall, this sample was rated as having slightly more executive dysfunction than average.

The Conners Parent Rating Scale-Revised (CPRS-R) Short form and Long form were utilized to assess for symptoms of inattention in the sample. Twenty participants were assessed with the Short form and 17 were assessed with the Long form. To obtain an index of symptom severity, ratings from the 10 items that refer to inattention symptoms as defined by the DSM-IV were summed for each participant. Scores on the CPRS-R ranged between 1 and 28, with higher scores indicating greater severity of attention-related deficits. The mean score of the sample on the CPRS-R was 14.84.

Results of Hypothesis Testing

Hypothesis 1.

Pearson's correlations were calculated between the three-factor BRIEF subdomains and the D-KEFS Color-Word Interference Test. Table 3 shows the results of the Pearson correlations between these measures. Contrary to Hypothesis 1, there were no significant correlations between Condition 3 of the D-KEFS CWIT and the Inhibit (r = .05, p = .77) and Self-Monitor (r = -.014, p = .93) subdomains. Only the Shift subdomain on the three-factor BRIEF was significantly correlated with Condition 3 of the D-KEFS CWIT (r = -.36, p < .05). As a result, Hypothesis 1 was not supported by the data.

Hypothesis 2.

A 2 X 3 repeated-measures ANOVA was used to examine performance between the two ADHD subtypes on the three indices of the three-factor BRIEF. Table 4 provides the means and standard deviations for the three-factor BRIEF indices for the ADHD-I group and the ADHD-HI/C group. The mean BRIEF scores of the ADHD-I group were 21.73 on the BRI, 27.55 on the ERI, and 84.45 on the MCI. The mean BRIEF scores of the ADHD-HI/C group were 30.46 on the BRI, 37.92 on the ERI, and 89.42 on the MCI. A statistically significant difference was found overall between the ADHD-I group and the ADHD-HI/C group in their mean scores on the three-factor BRIEF indices, $F(1,33) = 9.17$, $p = .005$.

Also provided in Table 4 are the F values and p values for the comparison of the ADHD-I and ADHD-HI/C groups on the three-factor BRIEF. Post-hoc analyses for each of the BRIEF indices revealed a significant difference between the ADHD-HI/C group and the ADHD-I group on the BRI and the ERI, with the ADHD-HI/C group being reported by their parents as having significantly greater severity of executive dysfunction on these indices compared to parent ratings of the ADHD-I group. However, there was no significant difference between the two groups on the MCI. Hypothesis 2 was partially supported as participants with ADHD-HI/C had a significantly higher BRI and ERI compared to the ADHD-I participants; however, contrary to Hypothesis 2, participants with ADHD-I did not have significantly higher elevations on the MCI compared to the ADHD-HI/C group.

Hypothesis 3.

An analysis of covariance was used to compare the performance scores on Condition 3 of the D-KEFS CWIT between the ADHD-I group and ADHD-HI/C group. Scores on the CPRS-R was utilized as a covariate to control for symptoms of inattention in both groups. The mean scores of the ADHD-I group for Conditions 1 through 4 of the D-KEFS CWIT were 9.91, 9.91, 9.64, and 9.45, respectively. The mean scores for the ADHD-HI/C group for Conditions 1 through 4 of the D-KEFS CWIT were 10.17, 10.58, 9.38, and 10.04, respectively. After controlling for symptoms of inattention, no statistically significant difference was found between the two groups in terms of their scores on Condition 3 of the D-KEFS CWIT, $F(1,32) = 0.7$, $p = .82$. Therefore, Hypothesis 3 was not supported.

Supplemental Analyses.

In addition to the statistical analyses that were used to investigate the hypotheses, supplemental analyses were also conducted to examine additional relationships on the three-factor BRIEF, the CPRS-R, and the D-KEFS CWIT. Table 3 presents inter-correlational data on the three-factor BRIEF in addition to the findings mentioned for Hypothesis 1. On the three-factor BRIEF, significant inter-correlations were found between the Inhibit and Self-Monitor subdomains ($r = .63$, $p < .01$) and the Emotional Control and Shift subdomains ($r = .68$, $p < .01$). The Initiate and Planning/Organizing subdomains significantly inter-correlated with each of the other MCI subdomains (rs = .45 to .66, $p < .01$). The Working Memory and Organization of Materials subdomains significantly inter-correlated with each other and with the Initiate and Planning/Organization subdomains (rs = .56 to .66, $p < .01$). In addition, Conditions 1 and 4 on the D-KEFS CWIT were significantly inter-correlated with each of the remaining conditions on the CWIT (rs = .47 to .67, $p < .01$). Conditions 2 and 3 of the D-KEFS CWIT were not significantly correlated with each other ($r = .25$, $p = .13$).

Table 5 reveals the relationships between the three-factor BRIEF indices, the CPRS-R, and the D-KEFS CWIT. There were no correlations between the CWIT conditions and the CPRS-R or any of the three-factor BRIEF indices; of particular note, no significant correlations were found between Condition 3 of the D-KEFS CWIT and the BRI ($r = .03$, $p = .84$), ERI ($r = -.29$, $p = .08$), or MCI ($r = -.104$, $p = .54$) of the three-factor BRIEF. Parent reports of inattentive symptoms on the CPRS-R were significantly correlated with the BRI ($r = .49$, $p < .01$) and the MCI ($r = .76$, $p < .01$), but did not correlate with the ERI ($r = .14$, $p = .42$).

CHAPTER FIVE

Discussion

Hypothesis 1

The current study was primarily undertaken to assess whether the three-factor BRIEF format has improved convergent validity with performance-based measurement compared to the original BRIEF format. Although informant-reports and performance-based measures are purported to measure similar EF constructs, past research has found poor associations between these types of measurement (e.g., Anderson, Anderson, Northam, Jacobs, & Mikiwicz, 2002; Bodnar, Prahme, Cutting, Denckla, & Mahone, 2007; McAuley et al., 2010). In addressing this aim, the D-KEFS CWIT was used as a performance-based measure for comparison with relevant domains from the three-factor BRIEF.

It was hypothesized that Condition 3 of the D-KEFS CWIT, a task that requires the ability to inhibit pre-potent responses and to shift between mental sets, would negatively correlate with the Inhibit and Self-Monitor subdomains of the three-factor BRIEF; however, no significant correlations were found between these subdomains and Condition 3 of the D-KEFS CWIT. Supplementary analyses found one significant correlation between Condition 3 of the D-KEFS CWIT and the Shift subdomain in the Emotional Regulation Index. This finding is consistent with past research which suggests that Condition 3 of the D-KEFS CWIT assesses the ability to set-shift between multiple modes of information on a task and provides evidence that this particular skill is associated with the ability to utilize mental flexibility in real-life scenarios (Lezak, Howieson, & Loring, 2004; Spreen, Strauss, & Sherman, 2006). On the other hand, this finding may also suggest that performance on Condition 3 of the D-KEFS CWIT predominantly requires set-shifting abilities rather than response inhibition.

Consistent with the current study, which did not find strong correlations between the Parent BRIEF and the D-KEFS CWIT, a number of previous studies have reported similar null findings (Anderson et al., 2002; Bodnar et al., 2007; Mahone et al., 2002; Toplak, Bucciarelli, Jain, & Tannock, 2009). The discrepancy between informant reports and performance-based measures have caused clinicians significant concern in its practical implications, as it can contribute to inaccurate diagnoses and inappropriate treatment planning (Silver, 2012). Various explanations have been provided to elucidate this dissociation, such as performance-based measures assessing the cognitive components of executive functioning while the BRIEF assesses the behavioral manifestation of these EF constructs (Anderson et al., 2002). Another explanation is that performance-based measures reveal an individual's underlying skills whereas the BRIEF assesses how an individual applies those skills in his/her environment (McAuley et al., 2010). Recently, Toplak, West, and Stanovich (2013) have provided a novel and convincing alternative explanation for the poor convergent validity between performance based and behavior rating measures, stating that these different measures may be assessing separate cognitive levels altogether, which Stanovich (2009, 2011) has termed the "algorithmic mind" and "reflective mind." The algorithmic mind has been conceptualized to be concerned with information processing systems in the brain, such as "input coding mechanisms, perceptual registration mechanisms, working memory, long-term memory, etc.," while the reflective mind focuses on the "goals of the person, beliefs relevant to those goals, and the choice of action that is rational given the goals and beliefs." (Bratman, Israel, & Pollack, 1991; Dennett, 1987; Marr, 1982; Newell 1982, 1990; Pollock, 1995; Stanovich, 2009b, 2011; Toplak, West, & Stanovich, 2013). Toplak and colleagues' (2013) explanation for the dissociation between these two different types of EF measures appears to be reinforced by Biederman and colleagues (2008) who found that EF impairments identified by performance-based measures do not translate into greater EF impairments on rating scales of executive function or vice versa.

The results of this study contradicted expectations that the three-factor BRIEF would be significantly correlated with the D-KEFS CWIT. Given that the three-factor BRIEF was purportedly improved in factorial validity compared to the original BRIEF, it was postulated that the new Task Monitor scale and the revision of the BRIEF indices would lead to improved convergent validity with performance-based EF tasks. Although there was one significant association between the Shift subdomain of the three-factor BRIEF and Condition 3 of the D-KEFS CWIT, no other correlations were identified. Considering the lack of significant correlations between the three-factor BRIEF and the D-KEFS CWIT, it is possible that the three-factor BRIEF may not be improved in convergent validity with performance-based measures of EF. Another possibility is that the D-KEFS CWIT may not be representative of performance-based EF measures, and there may be improved convergent validity between the three-factor BRIEF and other EF tasks. Future research should explore whether the three-factor BRIEF better correlates with other performance-based EF measures in hopes of identifying and addressing the dissociation between informant-reports and performance-based measures of EF in the literature.

Nevertheless, despite the lack of convergent validity between these two types of measurement, both have been shown to be useful tools in assessing different aspects of executive functioning.

Hypotheses 2 and 3

In addition to assessing the convergent validity of the three-factor BRIEF and the D-KEFS CWIT, both measures were used to examine potential differences in executive functioning between participants diagnosed with the ADHD-I subtype and participants diagnosed with the ADHD-HI and ADHD-C subtypes. Previous research has found that a diagnosis of ADHD is associated with EF deficits on performance-based measures, and that symptoms of inattention alone tend to be associated with executive dysfunction rather than symptoms of hyperactivity (Chhabildas, Pennington, & Willcutt, 2001; Schmitz et al., 2002). In consideration of these past findings, two hypotheses were generated. First, participants with ADHD-I were expected to have a higher MCI compared to the MCI of participants with ADHD-HI/C; conversely, participants with ADHD-HI and ADHD-C were postulated to have a higher BRI and ERI compared to participants with ADHD-I. Second, participants with ADHD-I were expected to exhibit poorer performance on Condition 3 of the D-KEFS CWIT compared to participants with ADHD-HI/C after accounting for symptoms of inattention.

According to the statistical analyses, participants with ADHD-HI/C had significantly higher group mean scores on the BRI and ERI of the three-factor BRIEF compared to participants with ADHD-I, meaning parents of children with ADHD-HI/C rated their children as having greater EF impairment compared to the parents of children with ADHD-I in these areas. Notably, BRIEF ratings for both groups on the MCI were not significantly different from each other. This finding suggests that children with ADHD-HI/C have greater impairment in behavioral control and emotional regulation compared to children with ADHD-I, but exhibit similar metacognitive impairments regardless of their ADHD subtype. An alternative explanation to consider is that symptoms of hyperactivity/impulsivity may have led parents of the ADHD-HI/C group to experience a greater degree of stress, explaining why parents of these children would report more behavioral and cognitive issues in their children. A study conducted by Joyner, Silver, and Stavinoha (2009) found that parent ratings of their children's EF are significantly associated with parenting stress, especially when their children exhibit challenging behaviors. It can be surmised that a child with ADHD-HI/C who displays behavioral difficulties related to hyperactivity and impulsive actions would therefore cause greater parenting stress and higher EF ratings on the BRIEF compared to a child with predominant symptoms of inattention.

Additionally, there was no significant difference in scores on the D-KEFS CWIT between the ADHD-I and ADHD-HI/C groups, after accounting for symptoms of inattention as a covariate. This finding contrasts with a few studies that have identified ADHD-I as having a small but significantly greater degree of impairment on performance-based measures (Chhabildas, Pennington, & Willcutt, 2001; Van Mourik, Oosterlan, & Sergeant, 2005). Other studies which utilized performance-based tests (Houghton et al., 1999; Nigg, Blaskey, Huang-Pollock, & Rappley, 2002) have found that individuals with ADHD-I or ADHD-C have identical areas of EF impairment to each other (e.g., deficits in interference control), perhaps explaining why the ADHD-I and ADHD-HI/C groups were not significantly different in their performance on the D-KEFS CWIT. Van Mourik and colleagues (2005) also expressed some reservation about the Color-Word tasks' validity in measuring inhibitory functioning in individuals with ADHD. In their meta-analysis, they found that a majority of studies that report poor performance on the Stroop task did not control for performance on the color-naming condition when reporting performance on the interference condition; furthermore, they identified that when "noninterference aspects of the task are taken into account, children with ADHD do not demonstrate poor interference control on this task" (Van Mourik, Oosterlaan, & Sergeant, 2005). They concluded that the Stroop task as a whole may not be a valid measure for interference control in ADHD. Considering this information, the absence of a significant difference between the ADHD-I and the ADHD-HI/C group on the D-KEFS CWIT suggests that the D-KEFS CWIT alone may not have been sufficient to illuminate any significant differences between the groups.

Limitations

There are several limitations to consider in this study. Given a sample size of 37 participants who met all of the requirements of the study, the power of the statistical analysis is limited, which therefore decreases the likelihood of supporting a hypothesis that may be accurate. Additionally, the children who participated in the study were recruited from a unique population, with each of the participants having a diagnosis of ADHD and being recruited from private schools that specialize in teaching children with various learning difficulties. As a result, findings from this study may not generalize to all children with an ADHD diagnosis. On the other hand, the participants for this study were derived from a highly unique population as they all presented with significant learning and/or behavioral problems; furthermore, parents of these participants are also likely to be unique as they may be forced to contend with more behavioral and school-related issues compared to the parents of a typical child. Therefore, the complexity of this population may have skewed the severity of parent reports on the BRIEF and CPRS-R and may have also led to highly variable performance between participants on the D-KEFS CWIT, depending on the number and severity of learning and/or behavioral disorders. Another limitation of the sample is the high prevalence of participants who were prescribed stimulant medication, which further brings to question whether these results are representative of children with ADHD. In this sample, 82% of the ADHD-I group and 83% of the ADHD-HI/C group were prescribed medications. Specifically, the use of stimulant medications could have benefited some participants in their performance on the D-KEFS CWIT and led to EF ratings of lower severity by the parents of the participants, although subtype differences do not appear to have been affected. Performance on the D-KEFS CWIT may have also been negatively impacted in participants with comorbid learning disabilities or speech motor problems (Golden, Espe-Pfiefer, & Wachlser-Felder, 2000; Mattison & Mayes, 2012), as 82% of the ADHD-I group and 71% of the ADHD-HI/C group had comorbid disorders. Controlling for these variables in future research may yield more associations between the D-KEFS CWIT and the three-factor BRIEF, as well as better illuminate any differences in EF that may exist between subtypes of ADHD.

Another limitation to consider is the sole use of the D-KEFS CWIT as a performance-based measure. The Stroop task, from which the D-KEFS CWIT is derived, has a long history of use in research literature as a measure of an individual's ability to inhibit his/her pre-potent responses and exercise mental flexibility. However, no one performance-based measure of an EF domain can be thought of as representative of other performance-based EF measures. Use of multiple performance-based measures that measure varying EF domains may provide greater insight into whether there is improved convergent validity of these measures with the three-factor BRIEF.

A final limitation is the grouping of the ADHD-HI subtype with the ADHD-C subtype in the statistical analyses. As previously mentioned, very few associations have been found between symptoms of hyperactivity/impulsivity and executive dysfunction on performance-based measures, whereas symptoms of inattention correlate with greater EF deficits according to these measures (Chhabildas, Pennington, & Willcutt, 2001). Chhabildas and colleagues (2001) identified ADHD-I and ADHD-C as having similar EF impairments in their neuropsychological profiles; but as mentioned earlier, children with ADHD-I have been identified as having more severe and pervasive EF deficits, such as poorer performance on a planning task compared to ADHD-C participants (Nigg, Blaskey, Huang-Pollock, & Rappley, 2002). In light of Nigg and colleagues' (2002) findings, it was hypothesized that grouping together the ADHD-HI and ADHD-C participants would still result in significant differences between EF profiles compared to ADHD-I participants. Instead it is likely that by separating the ADHD-C group and ADHD-I into two separate cohorts, two inattentive groups are being compared. Possible future directions for this area of research could be to analyze each of the ADHD subtypes separately and observe whether more detailed neuropsychological profiles of a particular ADHD subtype can be determined.

Implications and Conclusions

In contrast to the vast amount of research that has been conducted to validate performance-based EF tasks and EF rating scales, relatively few studies have sought to address the current divergence between these two types of EF measurements. The current study aimed to examine whether a revision of the BRIEF produced better convergent validity with the D-KEFS CWIT. Most of the findings did not support this hypothesis, although the significant correlation between the Shift domain of the revised three-factor BRIEF and Condition 3 of the D-KEFS CWIT could be encouraging as it suggests a degree of relationship between this component of the CWIT and parent ratings. It would be prudent for all future performance-based cognitive tasks to be evaluated for significant convergent validity with behavioral rating scales and vice versa.

Additionally, with regard to the second aim of the study, no support was found for the hypothesis that children with ADHD-I significantly differ from children with ADHD-HI/C in the area of inhibition. It is possible that performance on EF measures may not be dependent on the ADHD subtype, but rather dependent on the amount and severity of ADHD symptoms. Considering past studies have found some significant differences between ADHD subtypes on EF measures, future research in this area could lead to successful identification of differing EF profiles between ADHD subtypes and help clinicians to develop interventions tailored towards a specific ADHD subtype. Nevertheless, being able to definitively determine differences in EF profiles between ADHD subtypes most likely cannot occur until convergent validity is improved between performance-based EF tasks and EF rating scales. Future research is therefore necessary to understand and ultimately address this disparity between these two types of EF measurement.

REFERENCES

Achenbach, T. M. (1991). *Integrative guide for the 1991 CBCL/4-18, YSR and TRF profiles.* Burlington: Department of Psychiatry, University of Vermont.

Achenbach, T. M. (2006). As others see us: Clinical and research implications of cross-informant correlations for psychopathology. *Current Directions in Psychological Science, 15*, 94-98.

Achenbach, T. M., McConaughy, S. H., & Howell, C. T. (1987). Child/adolescent behavioral and emotional problems: implications of cross-informant correlations for situational specificity. *Psychological Bulletin, 101*(2), 213-232.

Alloway, T. P., Gathercole, S. E., Holmes, J., Place, M., Elliott, J. G., & Hilton, K. (2009). The diagnostic utility of behavioral checklists in identifying children with ADHD and children with working memory deficits. *Child Psychiatry & Human Development, 40*(3), 353-366.

American Psychiatric Association. (2000). *Diagnostic and statistical manuel of mental disorders* (4th ed.). Washington, DC: American Psychiatric Association.

Anderson, P., Anderson, V., Northam, E., & Taylor, H. G. (2000). Standardization of the Contingency Naming Test (CNT) for school-aged children: A measure of reactive flexibility. *Clinical Neuropsychological Assessment, 1*, 247-273.

Anderson, V. (1998). Assessing executive functions in children: Biological, psychological, and developmental considerations. *Neuropsychological Rehabilitation, 8*(3), 319-349.

Anderson, V., Anderson, P. J., Jacobs, R., & Smith, M. S. (2008). Development and assessment of executive function: From preschool to adolescence. In V. Anderson, R. Jacobs, & P. J. Anderson (Eds.), *Executive functions and the frontal lobes: A lifespan perspective* (pp.

123-154). New York: Taylor & Francis.

Anderson, V. A., Anderson, P., Northam, E., Jacobs, R., & Catroppa, C. (2001). Development of executive functions through late childhood and adolescence in an Australian sample. *Developmental Neuropsychology, 20*(1), 385-406.

Anderson, V. A., Anderson, P., Northam, E., Jacobs, R., & Mikiewicz, O. (2002). Relationships between cognitive and behavioral measures of executive function in children with brain disease. *Child Neuropsychology, 8*(4), 231-240.

Archibald, S. J., & Kerns, K. A. (1999). Identification and description of new tests of executive functioning in children. *Child Neuropsychology, 5*(2), 115-129.

Baddeley, A. D. (1986). *Working Memory*. New York: Oxford University Press.

Barkley, R. A., & Grodzinsky, G. M. (1994). Are tests of frontal lobe functions useful in the diagnosis of attention deficit disorders? *The Clinical Neuropsychologist, 8*(2), 121-139.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological Bulletin, 121*(1), 65-94.

Barkley, R. A. (2006). The relevance of the still lectures to attention-deficit/hyperactivity disorder: a commentary. *Journal of Attention Disorders, 10*(2), 137-140.

Baron, I. (2004). *Neuropsychological evaluation of the child.* New York: Oxford University Press.

Batchelor, J., Harvey, A. G., & Bryant, R. (1995). Stroop colour word test as a measure of attentional deficit following mild head injury. *The Clinical Neuropsychologist, 9*, 180-186.

Beck, L. H., Bransome, E. D., Jr., Mirsky, A. F., Rosvold, H. E., & Sarason, I. (1956). A continuous performance test of brain damage. *Journal of Consulting and Clinical Psychology, 20*(5), 343-

350.

Beer, J. S., Heerey, E. A., Keltner, D., Scabini, D., & Knight, R. T. (2003). The regulatory function of self-conscious emotion: insights from patients with orbitofrontal damage. *Journal of Personality and Social Psychology*, *85*(4), 594-604.

Biederman, J., Petty, C. R., Fried, R., Black, S., Faneuil, A., Doyle, A. E., Seidman, L. J., & Faraone, S. V. (2008). Discordance between psychometric testing and questionnaire-based definitions of executive function deficits in individuals with ADHD. *Journal of Attention Disorders, 12*, 92-102.

Bodnar, L. E., Prahme, M. C., Cutting, L. E., Denckla, M. B., & Mahone, E. M. (2007). Construct validity of parent ratings of inhibitory control. *Child Neuropsychology*, *13*(4), 345-362.

Bondi, M. W., Serody, A. B., Chan, A. S., Eberson-Shumate, S. C., Delis, D. C., Hansen, L. A., & Salmon, D. P. (2002). Cognitive and neuropathologic correlates of Stroop Color-Word Test performance in Alzheimer's disease. *Neuropsychology*, *16*(3), 335-343.

Bratman, M. E., Israel, D. J., & Pollack, M. E. (1991). Plans and resource-bounded practical reasoning. In J. Cummins & J. Pollock (Eds.), *Philosophy and AI: Essays at the interface*. Cambridge, MA: MIT Press.

Caesar, P. (1993). Old and new facts about perinatal brain development. *Journal of Child Psychology and Psychiatry*, 101-109.

Chhabildas, N., Pennington, B. F., & Willcutt, E. G. (2001). A comparison of the neuropsychological profiles of the DSM-IV subtypes of ADHD. *Journal of Abnormal Child Psychology*, *29*(6), 529-540.

Chugani, H. T., & Phelps, M. E. (1986). Maturational changes in cerebral function in infants determined by 18FDG positron emission tomography. *Science, 231*(4740), 840-843.

Chugani, H. T., Phelps, M. E., & Mazziotta, J. C. (1987). Positron emission tomography study of human brain functional development. *Annals of Neurology, 22*(4), 487-497.

Colvin, M. K., Dunbar, K., & Grafman, J. (2001). The effects of frontal lobe lesions on goal achievement in the water jug task. *Journal of Cognitive Neuroscience, 13*(8), 1129-1147.

Conners, C. K. (1997). *The Conners Rating Scales – Revised*. North Towanda, NY: Multi-health Systems.

Conners, C. K. (2008). *Conners' Rating Scales* (3rd ed.). Toronto, Ontario, Canada: Multi-Health Systems.

Cripe, L. I. (1996). The ecological validity of executive function testing. In R.J. Sbordone & C.J. Long (Eds.), *Ecological validity of neuropsychological testing.* Delray Beach, FL: St. Lucie Press

Damasio, H., Grabowski, T., Frank, R., Galaburda, A. M., & Damasio, A. R. (1994). The return of Phineas Gage: clues about the brain from the skull of a famous patient. *Science, 264*(5162), 1102-1105.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System (D-KEFS).* . San Antonio, TX: The Psychological Corporation.

Denckla, M. B. (1996). *A theory and model of executive function: A neuropsychological perspective*. Baltimore: Paul H. Brookes.

Dennett, D. C. (1987) *The intentional stance.* Cambridge, MA: The MIT Press.

Diamond, A. (2002). *Normal development of prefrontal cortex from birth to young adulthood: Cognitive* *functions, anatomy, and biochemistry*. New York: Oxford University Press.

DuPaul, G. J., Power T. J., Anastopoulos, A. D., & Reid, R. (1998). *Manual for the ADHD Rating Scale-IV*. New York: Guilford Press.

Dyer, F. N. (1973). Interference and facilitation for color naming with separate bilateral presentations of the word and color. *Journal of Experimental Psychology, 99*(3), 314-317.

Ferdinand, R. F., Hoogerheide, K. N., van der Ende, J., Visser, J. H., Koot, H. M., Kasius, M. C., & Verhulst, F. C. (2003). The role of the clinician: three-year predictive value of parents', teachers' and clinicians' judgment of childhood psychopathology. *Journal of Child Psychology and Psychiatry, 44*(6), 867-876.

Friedman, O., & Leslie, A. M. (2004). Mechanisms of belief-desire reasoning. Inhibition and bias. *Psychological Science, 15*(8), 547-552.

Fuster, J. M. (1989). *The prefrontal cortex: Anatomy, physiology, and neuropsychology of the frontal lobe.* (2nd ed.). New York: Raven Press.

Gilotty, L., Kenworthy, L., Sirian, L., Black, D. O., & Wagner, A. E. (2002). Adaptive skills and executive function in autism spectrum disorders. *Child Neuropsychology, 8*(4), 241-248.

Gioia, G. A., Isquith, P. K., Retzlaff, P. D., & Pratt, B. M. (2001). Modeling executive functions with everyday behaviors: A unitary or fractionated system? *Brain and Cognition, 47*, 203-207.

Gioia, G. A., & Isquith, P. K. (2004). Ecological assessment of executive function in traumatic brain injury. *Developmental Neuropsychology, 25*(1-2), 135-158.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Behavior rating inventory of executive function. *Child Neuropsychology, 6*(3), 235-238.

Gioia, G. A., Isquith, P. K., Kenworthy, L., & Baron, R. M. (2002). Profiles of everyday executive function in acquired and developmental disorders. *Child Neuropsychology, 8*(2), 121-137.

Gioia, G. A., Isquith, P. K., Retzlaff, P. D., & Espy, K. A. (2002). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Function (BRIEF) in a clinical sample. *Child Neuropsychology*, *8*(4), 249-257.

Golden, C. J. . (1974). Sex differences in performance on the Stroop color and word test. *Perceptual and Motor Skills, 39*, 1067-1070.

Golden, C. J. (1976). Identification of brain disorders by the Stroop color and word test. *Journal of Clinical Psychology, 32*, 654-658.

Golden, C. J. (1978). *Stroop Color and Word Test: A Manual for Clinical and Experimental Uses*. Chicago, Illinois: Skoelting.

Golden, C. J. (1981). *The Luria-Nebraska children's battery: Theory and formulation.* . New York: Grune & Stratton.

Golden, C. J., Espe-Pfeifer, P., & Wachsler-Felder, J. (2000). *Neuropsychological interpretations of objective psychological tests.* New York: Kluwer Academic/Plenum.

Gordon, M., & Mettleman, B. B. (1988). The assessment of attention: Standardization and reliability of a behavior-based measure. *Journal of Clinical Psychology, 44*, 682-690.

Goulden, L. G., & Silver, C. H. (2009). Concordance of the children's executive functions scale with established tests and parent rating scales. *Journal of Psychoeducational Assessment, 27*, 439-451.

Houghton, S., Douglas, G., West, J., Whiting, K., Wall, M., Langsford, S., Powell, L., & Carroll, A.

(1999). Differential patterns of executive function in children with attention-deficit hyperactivity disorder according to gender and subtype. *Journal of Child Neurology*, *14*(12), 801-805.

Houston, B. K., & Jones, T. M. (1967). Distraction and Stroop Color-Word performance. *Journal of Experimental Psychology, 74*(1), 54-56.

Jarratt, K. P., Riccio, C. A., & Siekierski, B. M. (2005). Assessment of attention deficit hyperactivity disorder (ADHD) using the BASC and BRIEF. *Applied Neuropsychology*, *12*(2), 83-93.

Jensen, A. R., & Rohwer, W. D., Jr. (1966). The Stroop color-word test: a review. *ACTA Psychologica (Amsterdam), 25*(1), 36-93.

Joyner, K. B., Silver, C. H., & Stavinoha, P. L. (2009). Relationship between parenting stress and ratings of executive functioning in children with ADHD. *Journal of Psychoeducational Assessment, 27*(6), 452-464.

Kieras, J. E., Tobin, R. M., Graziano, W. G., & Rothbart, M. K. (2005). You can't always get what you want: effortful control and children's responses to undesirable gifts. *Psychological Science*, *16*(5), 391-396.

Klinberg, T., Vaidya, C. J., Gabrieli, J. D., Moseley, M. E., & Hedehus, M. (1999). Myelination and organization of the frontal white matter in children: A diffusion tensor MRI study. *NeuroReport*, *10*(13), 2817-2821.

Konold, T. R., Walthall, J. C., & Pianta, R. C. (2004). The behavior of child behavior ratings: Measurement structure of the Child Behavior Checklist across time, informants, and child gender. *Journal of Behavioral Disorders*, *29*, 372-383.

Kunda, Z., & Spencer, S. J. (2003). When do stereotypes come to mind and when do they color judgment? A goal-based theoretical framework for stereotype activation and application. *Psychological Bulletin, 129*(4), 522-544.

Krikorian, R., Bartok, J., & Gay, N. (1994). Tower of London procedure: a standard method and developmental data. *Journal of Clinical and Experimental Neuropsychology, 16*, 840-850.

Lansbergen, M. M., Kenemans, J. L., & van Engeland, H. (2007). Stroop interference and attention-deficit/hyperactivity disorder: a review and meta-analysis. *Neuropsychology, 21*(2), 251-262.

Lavoie, M. E., & Charlebois, P. (2006). The discriminant validity of the Stroop color and word test: Toward a cost-effective strategy to distinguish subgroups of disruptive preadolescents. *Psychology in the Schools, 31*(2), 98-107.

Lee, S. W., Elliott, J., & Barbour, J. D. (1994). A comparison of cross informant behavior ratings in a school based diagnosis. *Behavioral Disorders, 19*, 87-97.

Levin, H. S., Song, J., Ewing-Cobb, L., & Roberson, G. (2001). Porteus Maze performance following traumatic brain injury in children. *Neuropsychology, 15*(4), 557-567.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004) *Neuropsychological assessment* (4th ed.). New York: Oxford University Press.

Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological Science, 8*, 60-64.

Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple and choice reaction time responses: a model and a method. *Journal of Experimental Psychology: Human Perception and Performance, 10*(2), 276-291.

Luria, A. R. (1973). *The working brain*. New York: Basic Books.

Mahone, E. M., Cirino, P. T., Cutting, L. E., Cerrone, P. M., Hagelthorn, K. M., Hiemenz, J. R., Singer, H. S., & Denckla, M. B. (2002). Validity of the behavior rating inventory of executive function in children with ADHD and/or Tourette syndrome. *Archives of Clinical Neuropsychology, 17*(7), 643-662.

Mangeot, S., Armstrong, K., Colvin, A. N., Yeates, K. O., & Taylor, H. G. (2002). Long-term executive function deficits in children with traumatic brain injuries: assessment using the Behavior Rating Inventory of Executive Function (BRIEF). *Child Neuropsychology, 8*(4), 271-284.

Marr, D. (1982). *Vision.* San Francisco: W. H. Freeman.

Mattison, R., E., & Mayes, S. D. (2012). Relationships between learning disability, executive function, and psychopathology in children with ADHD. *Journal of Attention Disorders, 16*(2), 138-146.

Mattson, S. N., Goodman, A. M., Caine, C., Delis, D. C., & Riley, E. P. (1999). Executive functioning in children with heavy prenatal alcohol exposure. *Alcohol: Clinical and Experimental Research, 23*(11), 1808-1815.

McAuley, T., Chen, S., Goos, L., Schachar, R., & Crosbie, J. (2010). Is the behavior rating inventory of executive function more strongly associated with measures of impairment or executive function? *Journal of the International Neuropsychological Society, 16*(3), 495-505.

McCaffrey, R. J., Duff, K., & Westervelt, H. J. (2000). *Practitioner's guide to evaluating change with neuropsychological assessment instruments*. New York: Kluwer Academic/Pleum Publishers.

McCandless, S., & O' Laughlin, L. (2007). The Clinical Utility of the Behavior Rating Inventory of Executive Function (BRIEF) in the diagnosis of ADHD. *Journal of Attention Disorders, 10*(4), 381-389.

Moritz, S., Birkner, C., Kloss, M., Jahn, H., Hand, I., Haasen, C., & Krausz, M. (2002). Executive functioning in obsessive-compulsive disorder, unipolar depression, and schizophrenia. *Archives of Clinical Neuropsychology, 17*(5), 477-483.

Newell, A. (1982). The knowledge level. *Artificial Intelligence*, *18,* 87-127.

Newell, A. (1990). *Unified theories of cognition.* Cambridge, MA: Harvard University Press.

Nigg, J. T. (2006). *What causes ADHD? Understanding what goes wrong and why*. New York: Guilford Press.

Nigg, J. T., Blaskey, L. G., Huang-Pollock, C. L., & Rappley, M. D. (2002). Neuropsychological executive functions and DSM-IV ADHD subtypes. *Journal of the American Academy of Child and Adolescent Psychiatry, 41*(1), 59-66.

Parrish, J., Geary, E., Jones, J., Seth, R., Hermann, B., & Seidenberg, M. (2007). Executive functioning in childhood epilepsy: parent-report and cognitive assessment. *Developmental Medicine & Child Neurology, 49*(6), 412-416.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37*(1), 51-87.

Peters, C., Algina, J., Smith, S. W., & Daunic, A. P. (2012). Factorial validity of the Behavior Rating Inventory of Executive Function (BRIEF)-Teacher form. *Child Neuropsychology, 18*(2), 168-181.

Piaget, J. (1963). *The origins of intelligence in children*. New York: W. W. Norton.

Pollock, J. L. (1995) *Cognitive carpentry: A blueprint for how to build a person.* Cambridge, MA: MIT Press.

Pratt, H. (2000). Improving the clinical utility of event-related potentials. *Clinical Neurophysiology, 111*(8), 1425-1426.

Reich, W., Welner, Z., & Herjanic, B. (1997). *The Diagnostic Interview for Children and Adolescents* (4th ed.). North Tonawanda: Multi-Health Systems.

Reitan, R. M., & Wolfson, D. (1985). *The Halstead-Reitan Neuropsychological test battery: Theory and clinical interpretation*. Tucson, AZ: Neuropsychology Press.

Reynolds, C. R., & Kamphaus, R. W. (2004). *Behavior assessment system for children* (2nd ed.). Circles Pines, MN: American Guidance Service.

Roberts, R. J., & Pennington, B. F. (1996). An interactive framework for examining prefrontal cognitive processes. *Developmental Neuropsychology, 12*(1), 105-126.

Rojas, D. C., & Bennett, T. L. (1995). Single versus composite score discriminative validity with the Halstead-Reitan Battery and the Stroop Test in mild brain injury. *Archives of Clinical Neuropsychology, 10*(2), 101-110.

Sbordone, R.J. (1996). Ecological Validity: Some Critical Issues for the Neuropsychologist. In Sbordone, R.J. & Long, C.J. (Eds.) *Ecological Validity of Neuropsychological Testing*. Delray Beach, FL: St. Lucie Press

Scheres, A., Oosterlaan, J., Geurts, H., Morein-Zamir, S., Meiran, N., Schut, H., Vlasveld, L., & Sergeant, J. A. (2004). Executive functioning in boys with ADHD: primarily an inhibition deficit? *Archives of Clinical Neuropsychology, 19*(4), 569-594.

Schmitz, S., Cadore, L., Paczko, M., Kipper, L., Chaves, M., Rohde, L. A., Moura, C., & Knijnik, M. (2002). Neuropsychological performance in DSM-IV ADHD subtypes: An exploratory study with untreated adolescents. *The Canadian Journal of Psychiatry, 47,* 863-869.

Semrud-Clikeman, M., Walkowiak, J., Wilkinson, A., & Butcher, B. (2010). Executive functioning in children with Asperger syndrome, ADHD-combined type, ADHD-predominately inattentive type, and controls. *Journal of Autism and Developmental Disorders, 40*(8), 1017-1027.

Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: a critical appraisal of the cognitive-energetic model. *Biological Psychiatry, 57*(11), 1248-1255.

Sergeant, J. A., Geurts, H., & Oosterlaan, J. (2002). How specific is a deficit of executive functioning for attention-deficit/hyperactivity disorder? *Behavioural Brain Research, 130*(1-2), 3-28.

Silver, C. H. (2000). Ecological validity of neuropsychological assessment in childhood traumatic brain injury. *The Journal of Head Trauma Rehabilitation, 15*(4), 973-988.

Silver, C. H. (2012). Sources of data about children’s executive functioning: review and commentary. *Child Neuropsychology*. http://dx.doi.org/doi:10.1080/09297049.2012.727793

Slick, D. J., Lautzenhiser, A., Sherman, E. M., & Eyrl, K. (2006). Frequency of scale elevations and factor structure of the Behavior Rating Inventory of Executive Function (BRIEF) in children and adolescents with intractable epilepsy. *Child Neuropsychology, 12*(3), 181-189.

Smidts, D. P., Jacobs, R., & Anderson, V. (2004). The Object Classification Task for Children (OCTC): a measure of concept generation and mental flexibility in early childhood. *Developmental Neuropsychology, 26*(1), 385-401.

Sonuga-Barke, E. J. (2002). Psychological heterogeneity in AD/HD--a dual pathway model of behaviour and cognition. *Behavioural Brain Research, 130*(1-2), 29-36.

Sonuga-Barke, E. J. (2005). Causal models of attention-deficit/hyperactivity disorder: from common simple deficits to multiple developmental pathways. *Biological Psychiatry, 57*(11), 1231-1238.

Spreen, O., Strauss, E., & Sherman, E. M. S. (2006). *A Compendium of neuropsychological tests: Administration, norms, and commentary* (3rd ed.). New York: Oxford University Press.

Stanger, C., & Lewis, M. (1993). Agreement among parents, teachers, and children on internalizing and externalizing behavior problems. *Journal of Clinical Child & Adolescent Psychology, 22,* 107-115.

Stanovich, K. E. (2009). Distinguishing the reflective, algorithmic, and autonomous minds: is it time for a tri-process theory? In J.St.B.T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond*. New York: Oxford University Press.

Stanovich, K. E. (2011). *Rationality and the reflective mind*. New York: Oxford University Press.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 28,* 643-662.

Toplak, M. E., Bucciarelli, S. M., Jain, U., & Tannock, R. (2009). Executive functions: performance-based measures and the behavior rating inventory of executive function (BRIEF) in adolescents with attention deficit/hyperactivity disorder (ADHD). *Child Neuropsychology, 15*(1), 53-72.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54*(2), 131-143.

van Mourik, R., Oosterlaan, J., & Sergeant, J. A. (2005). The Stroop revisited: a meta-analysis of interference control in AD/HD. *Journal of Child Psychology and Psychiatry, 46*(2), 150-165.

Verhulst, F. C., Koot, H. M., & Van der Ende, J. (1994). Differential predictive value of parents' and teachers' reports of children's problem behaviors: a longitudinal study. *Journal of Abnormal Child Psychology, 22*(5), 531-546.

Verhulst, F. C., & van der Ende, J. (1992). Agreement between parents' reports and adolescents' self-reports of problem behavior. *Journal of Child Psychology and Psychiatry*, *33*(6), 1011-1023.

von Hippel, W., & Dunlop, S. M. (2005). Aging, inhibition, and social inappropriateness. *Psychology and Aging, 20*(3), 519-523.

Vriezen, E. R., & Pigott, S. E. (2002). The relationship between parental report on the BRIEF and performance-based measures of executive function in children with moderate to severe traumatic brain injury. *Child Neuropsychology, 8*(4), 296-303.

Wechsler, D. (1974). *Manual for the Wechsler Intelligence Scale for Children - Revised*. New York: Psychological Corporation.

Welsh, M. C., Pennington B. F., & Groisser, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology, 7*, 131-149.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biological Psychiatry*, *57*(11), 1336-1346.

Ylvisaker, M., & DeBonis D. (2000). Executive function impairment in adolescence: TBI and ADHD. *Topics in Language Disorders, 20*(2), 29-57.

Zajano, M., & Gorman, A. (1986). Stroop interference as a percentage of congruent items. *Perceptual and Motor Skills, 63*, 1087-1096.

Table 1. Demographic Information

Variables	N	Percentage
Age (in years)		
8	3	8.1
9	5	13.5
10	11	29.7
11	7	18.9
12	11	29.7
Gender		
Male	21	56.8
Female	16	43.2
Race		
Caucasian/White	34	91.9
African American	2	5.4
Did Not Identify	1	2.7
ADHD Subtype Dx		
Hyperactive/Impulsive	6	16.2
Inattentive	11	29.7
Combined	18	48.6
Unknown Subtype	2	5.4
Comorbid Disorders		
Learning Disorders	33	89.2
Other developmental disorders	12	32.4
Depression/Anxiety	16	43.2
ADHD medication		
Yes	31	83.8
No	6	16.2

Table 2. Descriptive Statistics for Measures

Variables	Range	Mean (SD)
D-KEFS Color-Word Interference Test (Scaled Scores)		
Condition 1	4 – 15	10.19 (2.85)
Condition 2	4 – 14	10.41 (2.26)
Condition 3	2 – 14	9.57 (3.15)
Condition 4	4 – 14	9.92 (2.61)
BRIEF Three-Factor Format: Scales and Indices (Raw Scores)		
Inhibit	11 – 29 (max = 30)	19.16 (5.59)
Self-Monitor	4 – 12 (max = 16)	8.03 (2.19)
Emotional Control	11 – 29 (max = 30)	19.70 (4.88)
Shift	8 – 21 (max = 24)	14.89 (3.22)
Initiate	9 – 23 (max = 24)	15.49 (3.64)
Working Memory	14 – 30 (max = 30)	22.81 (4.59)
Plan/Organize	13 – 35 (max = 36)	24.49 (5.32)
Organization of Materials	8 – 18 (max = 18)	15.11 (3.03)
Task-Monitor	5 – 12 (max = 16)	9.03 (2.17)
Behavioral Regulation Index	15 – 40 (max = 46)	27.19 (7.18)
Emotional Regulation Index	18 – 47 (max = 54)	34.32 (7.88)
Metacognition Index	55 – 117 (max = 124)	86.92 (15.23)
Global Executive Composite	89 – 187 (max = 224)	148.43 (24.44)
CPRS – Total Scores (Raw Scores)	1 – 28	14.84 (7.13)

Table 3. Correlations of BRIEF subdomains and CWIT Conditions

	CWIT #1	CWIT #2	CWIT #3	CWIT #4	Inhibit	Self Monitor	Emotional Control	Shift	Initiate	Working Memory	Plan/Org.	Org. of Materials	Task Monitor
CWIT #1	____												
CWIT #2	.582**	____											
CWIT #3	.527**	.251	____										
CWIT #4	.470**	.518**	.669**	____									
Inhibit	.026	.102	.050	.045	____								
Self Monitor	.106	.132	-.014	-.004	.634**	____							
Emotional Control	-.134	-.185	-.166	-.024	.592**	.637**	____						
Shift	-.043	-.112	-.361*	-.084	.371*	.362*	.683**	____					
Initiate	-.100	.161	-.124	.230	.359*	.426**	.405*	.317	____				
Working Memory	-.010	.226	-.194	.040	.383*	.348*	.052	.113	.635**	____			
Plan/Org.	.069	.013	-.053	.103	.386*	.535**	.377*	.281	.630**	.658**	____		
Org. of Materials	-.093	-.156	-.001	.040	.410*	.444**	.282	.147	.560**	.605**	.660**	____	
Task Monitor	.112	.032	.018	.271	.084	.345*	.329*	.303	.449**	.305	.491**	.224	____

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4. Means, SDs, F-values, and p-values for BRIEF Indices by AD/HD Group

	ADHD-I	ADHD-HI/C	*F*	*p*
BRI	21.73 (5.26)	30.46 (6.00)	17.19	0.000
ERI	27.55 (7.80)	37.92 (5.59)	20.18	0.000
MCI	84.45 (17.60)	89.42 (13.99)	0.807	0.376

Table 5. Correlations of BRIEF Indices, Color-Word Conditions, and CPRS-R Inattentive Symptoms

	CPRS-R	CWIT #1	CWIT #2	CWIT #3	CWIT #4
BRI	.485**	.053	.120	.034	.033
ERI	.136	-.135	-.200	-.289	-.077
MCI	.760**	-.005	.085	-.104	.149

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Appendix A

Conners Parent Rating Scale – Revised: Long form and Short form Inattention Items

- Inattentive, easily distracted
- Difficulty doing or completing homework
- Short attention span
- Fails to complete assignments
- Messy or disorganized at home or school
- Only attends if it is something he/she is very interested in
- Avoids, expresses reluctance about, or has difficulties engaging in tasks that require sustained mental effort (such as schoolwork or homework)
- Gets distracted when given instructions to do something
- Has trouble concentrating in class
- 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)

BIOGRAPHICAL SKETCH

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EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	YEAR(s)	FIELD OF STUDY
University of Hawai'i at Manoa	B.A.	2011	Psychology
The University of Texas Southwestern Medical Center	M.R.C.	2014	Rehabilitation Counseling

<u>Positions and Employment</u>

2013-Present Research Assistant, NeuroPsychometric Research Laboratory
2011-2013 Student Research Associate, Department of Rehabilitation Counseling
2009-2011 Research Assistant, Blanchard Laboratory

<u>Clinical Experience</u>

2013 Research Assistant, Zale-Lipshy Inpatient Psychiatry Unit
2013 Intern, Eugene McDermott Center for Pain Management
2012-2013 Intern, Zale-Lipshy Inpatient Psychiatry Unit
2012-2013 Practicum student/Intern, UT Southwestern- University Rehabilitation Services
2011 Research Assistant, Child and Adolescent Mental Health Division – Research, Evaluation, and Training

<u>Presentations and Publications</u>

2011 Oasay, L., Pobbe, R. L., Pearson, B. L., Defensor, E. B., Blanchard, D. C., & Blanchard, R. J. (2010). "Expression of repetitive and stereotyped behaviors of C57BL/6J versus BTBR inbred mouse strains", *UC Berkeley Psychology Undergraduate Research Conference*, Berkeley, CA, University of California, Berkeley.

2010 Pearson, B.L., Pobbe, R. L., Defensor, E. B., Oasay, L., Bolivar, V. J., Blanchard, D. C., & Blanchard, R. J. (2010). Motor and cognitive stereotypies in the BTBR T+tf/J mouse model of autism. *Genes, Brain, and Behavior, 10*(8), 228-235.

<u>Professional Memberships</u>

2013 American Psychological Association (Student Associate)
2013 Dallas Psychological Association
2012-Present Texas RehabACTion Network