DIAGNOSIS AND ASSESSMENT OF ADULT ATTENTION DEFICIT HYPERACTIVITY DISODER: SYMPTOM SEVERITY AND PERFORMANCE ON CONGITIVE AND ACHIEVEMENT TESTING

A Dissertation

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MORGAN MICHELLE SOWELL

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Chair of Committee,	William Rae
Co-Chair of Committee,	Cynthia Riccio
Committee Members,	Robert Heffer
	James Varni
Head of Department,	Victor Willson

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ABSTRACT

Attention Deficit Hyperactivity Disorder (ADHD) is typically diagnosed in childhood with the individual continuing to exhibit behavioral patterns associated with ADHD throughout their lifespan. Deficits in the ability to inhibit impulse control are a hallmark of ADHD in children and adults. This research study looks at the relationship of a common inhibitory control measure Conners' Continuous Performance Test - II (CCPT-II) and its relationship to self and observer reports of ADHD symptoms, cognitive ability, and achievement scores. This study included 103 adult male and female individuals who were found to meet DSM-IV-TR criteria for ADHD through full individual assessments conducted at a doctoral training clinic located at a major university. Results of this study do not indicate a strong relationship between the CCPT-II and behavior rating scales, cognitive ability, and achievement. This study did find that self-report of ADHD behaviors related to inattention, memory, and self-concept were associated with achievement scores. It was also found that self and observer reports of ADHD behaviors were highly correlated. Within one area related to impulsivity and emotional regulation, observers were more likely to rate the individual as more severe than the individual rated themselves.

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CHAPTER I

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is estimated to affect 5% of children, and 2.5% of adults in the United States (DSM-5; American Psychiatric Association [APA], 2013). ADHD typically emerges in early childhood and is associated with progressive functional impairment, including school dysfunction, problems with peer interactions, family conflict, poor occupational performance, injuries, antisocial behavior, traffic violations, and accidents (Barkley, 2005). ADHD is associated with significant impairment of cognitive and psychosocial functioning with associated lower quality of life in those individuals with ADHD and their families (Barkley, 2002; Biederman & Faraone, 2005). It has been estimated that 6-66% of children diagnosed with ADHD will continue to experience some symptom patterns into adulthood (Barkley, Murphy, & Fischer, 2008; Biederman, Faraone, et al., 2006; Biederman, Monuteaux, et al., 2006; Clarke, Heussler, & Kohn, 2005; Faraone & Biederman, 2005; Kalbag & Levin, 2005; Kessler, Adler, Ames, Barkley, et al., 2005; Mannuzza, Klein, & Moulton, 2003). Further, ADHD is associated with persistent life impairments related to low self-esteem, marital conflict, poor communication and parenting skills, as well as academic and employment underachievement (Advokat, 2010; Baird, Stevenson, & Williams, 2000; Barkley, 2002; Hesslinger et al., 2002; Murphys, Barkley, & Bush, 2002; Pope, 2010; Shaw-Zirt, Popali-Lehane, Chaplin, & Bergman, 2005; Weyandt et al., 2013).

Historically, diagnosing adult ADHD was difficult due to the lack of clear evidence on the validity of specific diagnostic criteria for adults (McGough & Barkley, 2004). This concern has been addressed in the new DSM-5 (APA, 2013) by providing slightly different criteria for diagnosing ADHD in children verses older teens and young adults. Diagnosis of adult ADHD can be problematic due to the reliance on retrospective recall of earlier ADHD symptoms, symptoms that persist into adulthood, frequent presence of comorbid conditions, and cultural expectations of the nature of the symptoms and impairments (Asherson et al., 2012; Faraone et al., 2000; Riccio et al., 2005). The reported history of childhood ADHD diagnosis or symptoms that persist was a prerequisite for the diagnosis of adult ADHD, for which no DSM-IV-TR criteria existed. In the new DSM-5 several inattentive and hyperactive-impulsive symptoms must have been present before age twelve for a diagnosis (APA, 2013). This is an increase in the age of first symptom presentation from seven to twelve (APA, 2000, 2013). Further, fewer current symptoms are required for diagnosis of individuals over the age of seventeen than are required for diagnosis of children.

The functional impairments of adult ADHD are evident and the research into the effect ADHD has on cognitive and achievement performance is still evolving. Further, the understanding of cognitive and achievement effects of ADHD has been plagued by methodological concerns. For example, Barkley (1998, 1997) argued that research that controls for cognitive abilities may be removing variance that is due to ADHD. This research practice could result in concluding that adults with ADHD do not perform differently on given measures, when in fact, true differences exist between those with

ADHD and non-affected adults. At the same time, many studies reveal deficits in processing speed and working memory in children and adults with ADHD (e.g. Castellanos & Tannock, 2002; Hervey, J. N. Epstein, & Curry, 2004; Rapport et al., 2008; Russell et al., 2006). Evidence suggests that students with both ADHD and working memory deficits are at greater risk of academic underachievement than students with ADHD without working memory deficits (Alloway, Gathercole, & Elliott, 2010). Core ADHD symptoms of impulsivity, attention, and behavioral inhibition have been reported to affect performance-based tests that challenge these behavioral facets (J. N. Epstein et al., 2003; Hervey et al., 2004; Quinlan, 2001). Moreover, an association between speed and accuracy in test situations also has been shown such that individuals with ADHD tend to respond quickly but incorrectly (Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010; Young & Gudjonsson, 2005). These findings suggest that adults with ADHD may respond to test items impulsively, possibly without giving each one full consideration, thus performing tasks quickly, but inaccurately. Understanding the relationship between ADHD symptoms and the resulting cognitive and achievement profiles can provide further assistance in treatment planning for the adult with ADHD.

Purpose of Study

The goal of this study is to evaluate the relationship between current ADHD symptoms (self-reported symptoms, observer reported symptoms, and performance on a continuous performance task) and cognitive and achievement abilities in adults with ADHD. This study will contribute to the expanding knowledge base by furthering our

understanding of the relationships between cognitive and achievement profiles ADHD and symptom presentation and severity.

Research Questions and Hypothesis

Research Question 1: What is the frequency of markedly atypical scores (≥70) and moderately atypical scores (60-69) on CCPT-II scales of Omission, Commission, Perseveration, and Detectability among adults with a diagnosis of ADHD?

Hypothesis 1: It is hypothesized that the majority of adults diagnosed with ADHD will fall in the markedly atypical range of ≥70 on Omission and Commission scales, and that fewer individuals will have scores of ≥70 on Perseveration and Detectability.

Research Question 2: What is the relationship between self-report and observer report on the four common scales of the CAARS short and long forms and the ADHD Index on the CAARS short form?

Research Hypothesis 2: It is hypothesized that self report and observer report will correlate to a greater extent for the Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and ADHD Index, compared to the Inattention/Memory Problems and Problems with Self-Concept.

Research Question 3: What is the relationship of the CCPT-II to the CAARS-S and CAARS-O scores in individuals diagnosed with ADHD?

Hypothesis 3: It is hypothesized that Omission scores will be highly correlated with CAARS-S and CAARS-O scales that focus on inattention (Inattention/Memory

Problems, ADHD Index), and that Commission scores will be highly correlated with CAARS-S and CAARS-O scales that focus on hyperactivity/impulsivity (Hyperactivity/Restlessness, Impulsivity/Emotional Lability, ADHD Index).

Research Question 4: Does the CCPT-II, CAARS-S, and CAARS-O scores correlated with performance on the WAIS-IV in adults diagnosed with ADHD?

Hypothesis 4: It is hypothesized that the WAIS-IV (Working Memory and Processing Speed Indexes) will be negatively correlated with the CCPT-II (Omission and Commission), CAARS-S and/or CAARS-O (ADHD Index, Inattention/Memory Problems, Hyperactivity/Restlessness, and Impulsivity/Emotional Lability).

Research Question 5: Do the CPT-II, CAARS- S, and CAARS- S scores correlate with performance on the WJ-III ACH?

Hypothesis 5: It is hypothesized that the WJ-III ACH (Broad Reading, Oral Language, Broad Math, and Broad Written Language) will negatively correlate with the CCPT-II (Omission and Commission) and CAARS-S and CAARS-O (ADHD Index, Inattention/Memory Problems, Hyperactivity/Restlessness, and Impulsivity/Emotional Lability).

Research Question 6: Do scores on the CCPT-II variables of interest predict performance on the Working Memory and Processing Speed Indexes on the WAIS-IV?

Research Hypothesis 6: It is hypothesized that the CCPT-II scores on the Omission and Commission scales will predict performance on the Working Memory and Processing Speed Indices of the WAIS-IV.

CHAPTER II

REVIEW OF LITERATURE

What is ADHD

The *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, text revision (DSM-IV-TR; American Psychiatric Association [APA], 2000) described Attention Deficit Hyperactivity Disorder (ADHD) as a repeated pattern of hyperactivity-impulsivity and inattention, usually present before age seven that is more severe than what is typical for individuals of comparable development (APA, 2000). The DSM-5 (APA, 2013) described ADHD as a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development, with several inattentive or hyperactive-impulsive symptoms present prior to the age of twelve. The vast majority of the research has focused on the diagnosis and treatment of ADHD in childhood. Diagnosis of adult ADHD has been difficult due to the general lack of evidence about the validity of diagnostic criteria for adults (McGough & Barkley, 2004). A large body of research provides evidence that ADHD is a valid clinical diagnosis in adults (Able, Johnston, Adler, & Swindle, 2007; Barkley et al., 2008; Faraone & Biederman, 2004; Faraone & Biederman, 2005; Kessler, Adler, Barkley, et al., 2005).

In a survey study evaluating how clinicians diagnose ADHD in adults, it was found that 38% indicated the use of a screening tool, 19.1% mentioned DSM-IV criteria, 27.9% used patient history alone, or in combination with family input and/or clinical observation, and 4% used history combined with a medication trial (Knutson &

O'Malley, 2010). The diagnostic criteria in the DSM-5 (APA, 2013) specifically address the diagnosis of ADHD in individuals over the age of seventeen. The two significant changes in the diagnostic criteria, with evaluation of adults, is the older age of first symptom presentation and a fewer number of current symptoms reported than are required to diagnose a child.

Males are more frequently diagnosed with ADHD, with ratios ranging from 3:1 to 9:1 (Carlson, Tamm, & Gaub, 1997; DuPaul et al., 2001; Lavigne, Lebailly, Hopkins, Gouze, & Binns, 2009; Lee, Oakland, Jackson, & Glutting, 2008; Pennington, 1997). It has been suggested that girls may be under identified due to the likelihood that boys present with more disruptive hyperactive behavior patterns resulting in greater family or school disturbance than girls. Despite this argument, Lahey et al. (1994) found that boys outnumbered girls across all subtypes of ADHD. Similarly, in a twin study Pearsall-Jones, Piek, Rigoli, Martin, & Levy (2009) found that boys were more likely to be diagnosed with ADHD than girls.

Research into adult ADHD is growing and showing evidence that it can be a lifelong disorder. Typically, hyperactive behaviors dissipate as the child matures and develops coping strategies to alleviate other symptoms that they may have. Epidemiological data estimate that close to 5-7% of adults suffer from ADHD and its presence is associated with a wide range of emotional and functional impairments, impacting all aspects of their lives (Able et al., 2007; Barkley, 2005; Barkley et al., 2008; Biederman & Faraone, 2006; Faraone & Biederman, 2005; Kessler, Adler, Ames, Demler, et al., 2005; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). Adults

who have "undiagnosed" ADHD appear to have a much poorer prognosis (Able et al., 2007; Brook, Brook, Zhang, Seltzer, & Finch, 2013), with higher rates of co-morbid illness, and greater functional impairments than individuals without ADHD.

Etiology of ADHD

Despite the massive amount of research focusing on ADHD, the etiology of the disorder remains unclear. Twin and adoption studies suggest that there is a substantial genetic component to the disorder (Smalley, 1997), with additive genetic affects accounting for as much as 60-80% of the variance in underlying susceptibility (Lehn et al., 2007; Thapar, Holmes, Poulton, & Harrington, 1999). Despite strong indications for a genetic component, it remains unclear which genes cause ADHD (Faraone, 2002). Pearsall-Jones et al. (2009) suggested that, in addition to a genetic susceptibility, trauma during the birthing process may contribute to the expression of ADHD behavior patterns.

Genetic findings are confounded by the family environment. It is difficult to quantify the influence environmental factors within the home exert in the development of ADHD from that of an existing genetic susceptibility. It is possible that parents of children with ADHD, particularly those parents who also have ADHD, may experience greater challenges maintaining family structure and cohesiveness (Biederman, Faraone, & Monuteaux, 2002). Evidence is growing that environmental factors within the home affect behavioral relations and metacognitions of children with ADHD. Parents of children with ADHD report higher levels of conflict and lower levels of family organization when compared to parents of children without ADHD (Biederman et al., 1995; Lange et al., 2005; Pressman et al., 2006; Schroeder & Kelley, 2009). While limit

setting strategies for toddlers has been positively associated with greater self-regulation as the child grows (LeCuyer-Maus & Houck, 2002a; 2002b), Schroeder & Kelley (2009) found that parents of children diagnosed with ADHD exhibited significantly less limit setting behaviors in the home than parents of children without ADHD.

Family genetic studies suggest that deficient response inhibition is a marker for a familial form of ADHD. Specifically, children with poor response inhibition are significantly more likely to have a first degree relative with ADHD than are children with ADHD who exhibit good response inhibition (Crosbie & Schachar, 2001). Research findings also support substantive contributions from multiple genes in the etiology of ADHD (Daly, Hawi, Fitzgerald, & Gill, 1999; Hauser et al., 1993; Holmes et al., 2000; Smalley et al., 1998; Waldman et al., 1998). Study findings related to specific genetic components of ADHD have not been consistently implicated across all subtypes. As such, genetic components remain an evolving area of research.

Comorbid Disorders of ADHD

In children and adolescents, many disorders have been found to commonly co-occur with ADHD and sometimes will mask the symptoms of ADHD. These comorbid disorders can be related to other behavioral/psychological disorders, language disorders, learning disabilities (LD), or developmental disorders. It has been reported that almost 80% of adults with an ADHD diagnosis present with at least one lifetime psychiatric comorbidity (Fischer et al., 2007). Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD) are most prevalent, with 40-65% of children diagnosed with ADHD, also displaying ODD or CD (Barkley, 1990; Wilens et al., 2002).

When a diagnosis of ADHD with hyperactive-impulsive features is made, the likelihood of a comorbid diagnosis of ODD or CD has been found to rise (Eiraldi, Power, & Nezu, 1997; Gaub & Carlson, 1997). These same behaviors have been found during adolescence when those without ADHD often demonstrate defiance and non-compliance with rules (Barkley, Anastopoulos, Guevremont, & Fletcher, 1992). In adulthood, individuals with ADHD have been found to have higher rates of antisocial personality disorder and substance abuse disorders (Barkley, Fischer, Smallish, & Fletcher, 2004; Dalsgaard, Mortensen, Frydenberg, & Thomsen, 2002; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993; Mannuzza et al., 1991; Weiss, Hechtman, Milroy, & Perlman, 1985). Studies have also found higher rates of ADHD in adolescent prisoners (Gosden, Kramp, Gabrielsen, & Sestoft, 2003) and among adult prisoners (Ginsberg, Hirvikoski, & Lindefors, 2010; Rasmussen, Almvik, & Levander, 2001; Soderstrom, Sjodin, Carlstedt, & Foresman, 2004; Westmoreland et al., 2010). Reported prevalence rates of ADHD in adults who are incarcerated ranged from 3.6%-26% (Cahill et al., 2012; Coolidge, Segal, Klebe, Cahill, & Whitcomb, 2009; Eme, 2009; Hurley & Eme, 2008). One long-term follow up study reported that, as young adults, children with ADHD were five times more likely to have a criminal conviction and twelve times more likely to have a violent criminal conviction than their typically developing peers (Dalsgaard, Mortensen, Frydenberg, & Thomsen, 2013). In addition to antisocial tendencies, ADHD is frequently comorbid with substance use disorders (e.g., alcohol, tobacco, and other drugs) generally originating in adolescence or childhood and continuing into adulthood (Biederman, Faraone, Monuteaux, Bober, & Cadogen, 2004;

Biederman, Wilens, Spencer, & Adler, 2007; Carroll & Rounsaville, 1993; Caspi et al., 2003; Wilens & Dodson, 2004).

Anxiety and depressive disorders also have been found to co-occur with ADHD with a prevalence of 18-51% in children and adults depending upon the population studied (Biederman et al., 1993; Eiraldi et al., 1997; Fischer et al., 2007; Jense, Martin, & Cantwell, 1997; Kessler et al., 2006; Wilens et al., 2002). Co-occurring major depressive disorder or bipolar disorder has been found to be associated with a higher number of negative life events for adults (Garcia et al., 2012). One study of young adult females found an elevated risk of suicide attempts and self-injury, along with global and specific functional impairments when there was a history of ADHD and other comorbid disorders (Hinshaw et al., 2012). Tourette syndrome also can co-occur with ADHD, with a prevalence of 25-50% (Cirino, Chapieski, & Massman, 2000). Lastly, learning disabilities (LD) have been found to occur in 15-20% of children diagnosed with ADHD (DuPaul, Gormley, & Laracy, 2013; DuPaul & Stoner, 2003; Richters et al., 1995). The research into adult comorbidity of ADHD and LD is limited. Some studies have found minimal to no relationship between ADHD and LD in adults (Biederman et al., 1994; Seidman, Biederman, Weber, Hatch, & Faraone, 1998), while others have found a relationship (McGillivray & Baker, 2009; Samuelsson, Lundberg, & Herkner, 2004). McGillivray and Baker (2009) found that the presence of ADHD and LD led to a higher risk of the development of other psychopathology than ADHD alone in adults.

Self-Report, Observer Report, and Clinical Interview of Adult ADHD Symptoms

Historically, diagnosing adult ADHD is difficult to some extent due to the lack of clear evidence on the validity of specific diagnostic criteria for adults (McGough & Barkley, 2004), and a lack of consistently used diagnostic criteria in the research (Friedman & Zametkin, 2010). The reported history of childhood ADHD diagnosis or symptoms that persists at present is a prerequisite for the diagnosis of adult ADHD, for which no DSM-IV-TR criteria exists. This concern has been addressed in the DSM-5 (APA, 2013), by providing slightly different criteria for diagnosing ADHD in children verses older teens and young adults. In the DSM-5 several inattentive and hyperactive-impulsive symptoms must have been present before age twelve for a diagnosis (APA). This is an increase in the age of first symptom presentation from seven to twelve (APA, 2000; 2013). Previously, the individual was generally required to recall symptoms from as young as 5 years of age, consequently, recall bias may have affected the reliability of retrospective scales, particularly for individuals with ADHD (Mannuzza, Klein, Klein, Bessler, & Shrout, 2002; Ranby et al., 2012; Weiss & Murray, 2003). Although recall bias may still exist with the DSM-5 criteria, by increasing the age of recalled first symptoms onset to 12 years old, this bias may be reduced. Research has found that a review of school records, conduct, and academic and social performance reports from parents or others who knew the client as a child is very useful in establishing childhood presentation of symptoms (Antai-Otong, 2008).

Both the DSM-IV-TR and DSM-5 identify subtypes of ADHD with primarily hyperactive/impulsive or inattentive presentation, or a combined type. The DSM-5 also

provides for a label of partial remission. This is used if full criteria were met in the past, but over the past six months fewer than full criteria have been met, but the symptoms still result in significant impairment. Semi-structured clinical interviews or rating scales can help to distinguish the different subtypes of ADHD. It has been found in epidemiological studies in children that rely primarily on rating scales typically report a higher rate of ADHD-Primarily Inattentive than ADHD-Combined type, whereas clinic-based studies that often rely on information derived solely from parental interview report higher rates of ADHD-Combined type compared to ADHD-Primarily Inattentive (Rowland et al., 2008). In another study of children referred to a pediatric neuropsychiatry clinic, it was found that the method used (rating scale, clinical interview) to measure symptomatology had a significant impact on subtype of ADHD that was diagnosed, consistent with the Rowland et al. findings (Valo & Tannock, 2010).

Research has shown that adults often exhibit limited recall of the time course and nature of symptoms as well as the associated impairments (McGough & Barkley, 2004; Ranby et al., 2012). While it is not uncommon to seek out parents or friends of the client to complete observer reports of ADHD symptoms, studies have shown that these can be discrepant from each other and from self-report of the client (Barkley, Fischer, Smallish, & Fletcher, 2002; Belendiuk, Clarke, Chronis, & Raggi, 2007; DuPaul et al., 2001). The researchers have hypothesized that the discrepant reports may be a result of the individual developing ways to control/hide behaviors at work to maintain a job, or an individual may not be aware of the amount of fidgeting they do within various settings. Sibley et al. (2012) evaluated the diagnosis of ADHD in young adults and found that

parent-report was more diagnostically sensitive than self-report. They found that young adults with ADHD tended to under represent symptoms.

There are formal structured clinical interviews such as the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First, Spitzer, Gibbon, & Williams, 2002) or the Conners' Adult ADHD Diagnostic Interview (J. E. Epstein, Johnson, & Conners, 2001) to evaluate for behaviors associated with ADHD, which clinicians can utilize in determining an ADHD diagnosis. Diagnostic interviews have been found to be a useful tool for identifying a history of ADHD symptoms in adults (J. N. Epstein et al., 2003; Kessler, Adler, Ames, Demler, et al., 2005; Millstein, Wilens, Biederman, & Spencer, 1997; Weiss et al., 1985; Weyandt et al., 2013). There is some reservation among researchers as to the quality of recollection of past symptoms. In the first study addressing symptomatology recollection, Ward, Wender, and Reimherr (1993) demonstrated a moderate correlation between adults with ADHD and their parents' judgment of childhood symptoms.

In looking at self-reported symptoms on a rating a scale of ADHD symptoms of Japanese and United States college students it was found that both populations reported similar levels of ADHD symptoms, with the Japanese population reporting slightly higher inattentive type symptoms (Davis, Takahashi, Shinoda, & Gregg, 2012). Similar findings were found in a Chinese population (Norvilitis, Ingersoll, Jie Zhang, & Shuhua Jia, 2008). An evaluation of draftees in the Taiwanese army found that those whose symptomatology met the criteria for ADHD on a self-report scale had more severe depressive, anxiety symptoms and daytime sleepiness, and had poorer quality of life than

those who did not (Chao et al., 2008). Another study found that college students' performance on reading intensive mock high stakes test, individuals with ADHD performed similarly to controls, but they believed they performed less well and worried more about their performance (Lewandowski, Gathje, Lovett, & Gordon, 2013).

Utilization of self-report measures such as the ADHD Rating Scale (ADHD-RS; DuPaul, Power, Anastopoulos, & Reid, 1998), Adult ADHD Self-Report Scale (AASRS; Kessler, Adler, Ames, Demler, et al., 2005), or the Conners' Adult Attention-Deficit Rating Scale (CAARS; Conners, Erhardt, & Sparrow, 1999) are frequently used to assess current symptoms in clinical and research settings. The CAARS has been used as valid measures of current ADHD symptoms in adults (Adler, Faraone, et al., 2008; Konstenius, Jayaram-Lindstrom, Beck, & Franck, 2010; Kooij et al., 2013; Parker, Majeski, & Collin, 2004). Screeners or checklists have also been developed to measure current symptoms (Manor et al., 2012; Zucker, Morris, Ingram, Morris, & Bakeman, 2002).

Numerous studies mentioned above found that individuals appear to have low self-awareness of their symptoms. In a study of 50 ADHD clients between the ages of 20 and 50 years old, the clients compared their self-report of childhood ADHD symptoms with their parents' report (Murphy & Schachar, 2000). Although clients recalled more symptoms than their parents, there was a positive relationship between self-report and parent report. Zucker, Morris, Ingram, Morris, and Bakeman (2002) demonstrated that adults with ADHD reported less past inattentive symptoms than their parents, but this discrepancy was not observed regarding past hyperactivity symptoms. In a study,

looking specifically at the CAARS self-concept scale, found that college students with ADHD did not report problems with self-concept, but their parents did report problems with self-concept (Nelson, 2013).

In a large-cohort study (Barkley et al., 2002), recollections of childhood ADHD again showed moderate correlations with parent ratings suggesting some validity for such recollections. There was a high agreement rate between self and parent report when individuals did not have an ADHD diagnosis in childhood. ADHD diagnosis was substantially higher using parent reports, suggesting that studies relying on self-report potentially underestimate the persistence of the disorder into adulthood. In this same study, it was found that the ADHD group recalled having significantly more symptoms of ADHD in childhood than did the control group. In a study with 126 adults aged 17 to 77 participating in a genetic investigation research, results indicated that self-report, informant rating scales, and semi-structured interviews have a high convergent validity in at-risk population for ADHD. In contrast, participants reported more inattentive and hyperactive symptomatology during childhood than their informants (Magnusson et al., 2006).

Adler, Spencer, et al. (2008) used the CAARS to evaluate adult ADHD symptoms through self-report and investigator ratings during a medication treatment study. They found that although both self and investigator baseline ratings on the CAARS were predictive of treatment outcome, that investigator ratings had a greater predictive power than self-report ratings on the CAARS. Another study looked at the relationship between ADHD symptoms (self and observer report CAARS) and life

competencies in adult women (Jiang & Johnston, 2012). They found that observer reported ADHD symptoms on the CAARS were more predictive of life competencies than self-reports.

Course and Prognosis

ADHD is typically diagnosed in childhood with the individual continuing to exhibit behavioral patterns associated with ADHD throughout their lifespan (Faraone, Biederman, & Mick, 2006; Kessler et al., 2006; Ranby et al., 2012). Epidemiological studies have shown that male gender, low socioeconomic status, and young age are associated with a higher prevalence of ADHD (Doyle, 2004; Scahill & Schwab-Stone, 2000). Research has demonstrated that symptoms of inattention, hyperactivity, and impulsivity typically decrease with chronological age, and/or change during adolescence and adulthood (Barkley, Fischer, Edelbrock, & Smallish, 1990; Barkley, Fischer, Smallish, & Fletcher, 2006; Biederman et al., 1996; Biederman, Mick, & Faraone, 2000; Fischer, Barkley, Fletcher, & Smallish, 1993; Hart, Lahey, Loeber, Applegate, & Frick, 1995; Ingram, Hechtman, & Morgenstern, 1999; Langberg et al., 2008; Wolraich et al., 2005). Hyperactivity, for example, although still present, may become much less prominent during this developmental period (Barkley et al., 2006; Milich & Loney, 1979), whereas attentional deficits, distractibility, and disorganization persist and may well become more common or more impairing (Wender, Wolf, & Wasserstein, 2001). Generally, hyperactivity declines more steeply as the individual ages than does inattention and deficits in executive functioning (Barkley et al., 2006). Unaffected by age, ADHD is associated with functional impairments such as school dysfunction, peer

problems, family conflict, poor occupational performance, injuries, antisocial behavior, traffic violations, and traffic accidents (Abikoff et al., 2004; Barkley et al., 2002; Biederman & Faraone, 2006; Biederman, Monuteaux, et al., 2004; Cox, Humphrey, Merkel, Penberthy, & Kovatchev, 2004; DiScala, Lescohier, Barthel, & Li, 1998; Faraone & Biederman, 2004; Greene et al., 2001; Steinhausen, Drechsler, Foldenyi, Imhof, & Brandeis, 2003). These findings support the application of different criteria when diagnosing ADHD in adults as seen with the DSM-5 (APA, 2013).

The course and prognosis of someone diagnosed with ADHD will vary depending on complex interactions of individualistic factors contributing to their behavior patterns. Multiple studies (Barkley et al., 1990; Cantwell & Satterfield, 1978; Faraone & Biederman, 1993; Heiligenstein, Guenther, Levy, Savino, & Fulwiler, 1999; Lambert & Sandoval, 1980; McGee & Share, 1988; Pastura, Mattos, & Araujo, 2009; Rohde et al., 1999; G. Weiss, Hechtman, Perlman, Hopkins, & Wener, 1979) have shown that children and adolescents with ADHD exhibit more difficulties in academic performance than their peers, a higher index of grade repetition, lower grades, and special educational needs. It has been shown that the presence of LD or executive functioning deficits along with ADHD can exacerbate academic difficulties (Biederman, Monuteaux, et al., 2004; Carmeli, Klein, & Sohn, 2007; Fischer & Barkley, 1990; Lambert & Sandoval, 1980). Seidman, Biederman, Weber, Hatch, and Faraone (1998) found that adults with ADHD were significantly impaired on measures of vigilance, semantic encoding for verbal memory, and written arithmetic. Others have found deficits with ability to set shift, focused attention, and response inhibition (Aron,

Fletcher, Bullmore, Sahakian, & Robbins, 2003; Avisar & Shalev, 2011; Gansler et al., 1998; Nigg, 2001; Nigg et al., 2005; Sandson, Bachna, & Morin, 2000). Biederman, Monuteaux, et al. (2004) found that if a child or adolescent has ADHD and an accompanying executive functioning deficit, they were two times more likely to repeat a grade than those with ADHD alone. A follow-up study of adolescents with ADHD hyperactive type found that academic performance for those with ADHD was significantly inferior to controls, with at least three times as many of those with ADHD having failed a grade, been suspended or been expelled (Barkley et al., 1990).

Long-term follow-up studies of children with ADHD as young adults have shown academic and occupational disparities when compared to control groups. These young adults are more likely to have not completed high school or obtained a bachelor's degree, and have lower occupational rankings than controls, usually in skill labor positions (Barkley et al., 2006; Mannuzza, Klein, Bessler, Malloy, & Hynes, 1997; Mannuzza et al., 1993; Weiss et al., 1985). For those who enrolled in post-high school education, young adults with childhood ADHD completed fewer years of college than a comparison group (Barkley et al., 2008; Mannuzza et al., 1997). Of those students with ADHD who do attend college, studies have found them to have significantly lower mean GPA's and to be more likely placed on academic probation than controls (Blase et al., 2009; Heiligenstein et al., 1999). Another study found that college students with ADHD did not differ in the GPA in comparison to the overall student body (Sparks, Javorsky, & Philips, 2004). The exact rates of ADHD in college students are unclear, due to the Family Educational Rights and Privacy Act (FERPA; 1974), which protects educational

records and an individual has the right to choose to identify themselves as a student with a disability to school officials. Research is showing that more and more high school students with ADHD are pursuing college and that 2-4% of college students report clinically significant levels of ADHD symptomatology (DuPaul et al., 2001; Heiligenstein, Conyers, Berns, & Smith, 1998; Janusis & Weyandt, 2010; Weyandt & DuPaul, 2006; Weyandt, Linterman, & Rice, 1995; Wolf, 2001; Wolf, Simkowitz, & Carlson, 2009).

Adults who have "undiagnosed" ADHD appear to have a much poorer prognosis. Able, Johnston, Adler, and Swindle (2007) conducted a study of adults with ADHD as determined through scores on the ASRS, but no previous record of an ADHD diagnosis, a non-ADHD group and diagnosed ADHD group. They reported that the undiagnosed ADHD group demonstrated higher rates of co-morbid illness and greater functional impairments than the non-ADHD group. Specifically, the undiagnosed ADHD group exhibited higher rates of current depression, alcohol abuse, lower educational attainment, greater emotional and interpersonal difficulties, as well as increased rates of traffic, household, or on-the-job accidents. In comparison to the diagnosed ADHD group, the undiagnosed ADHD group had a higher number of minorities and individuals with lower educational attainment. Comparisons between the diagnosed and undiagnosed ADHD groups were variable. The undiagnosed group rated their psychological health and life outlook as poorer than the diagnosed group. Similarly, in a survey study by Biederman, Faraone, et al. (2006) of adults with and without ADHD, those diagnosed with ADHD as a child were more likely to agree ~~"t~~hat their childhood prepared them for adult life" (p.

526) than those diagnosed with ADHD later in life. This finding has possible implications for emphasizing the importance of early diagnosis and intervention.

Studies into prolonged functional impairments have reported evidence supporting the belief that when these impairments linger in adults with ADHD, the result is limited optimism, increased school failure, occupational impairment, strained social and family relationships, substance use, antisocial personality, mood disorders, anxiety disorders disorder and traffic violations (Barkley et al., 2006; 2008; Biederman & Faraone, 2005; Biederman, Faraone, et al., 2006; Biederman et al., 2010; Brod, Perwien, Adler, Spencer, & Johnston, 2005; Kuriyan et al., 2013; Langberg et al., 2011; Mannuzza et al., 1997; Mannuzza et al., 1993; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1998). The long-term mental health of individuals diagnosed with ADHD is concerning. Investigations into the rates and types of comorbid conditions with ADHD in adults are relatively new. Studies are showing significant comorbidity with mood disorders, anxiety disorders, substance use disorders, intermittent explosive disorder, and personality disorders (Barkley et al., 1990; Brown, 1986; Kessler et al., 2006; Kuriyan et al., 2013; Lehn et al., 2007; van Emmerik-van Oortmerssen et al., 2013). Kuriyan et al. (2013) found that adults with a lifetime history of ADHD had a 95% probability of having a lifetime history of at least one psychiatric disorder, compared with 65% in non-ADHD. They found similar results when evaluating for psychiatric disorders present in the past 12-months, 72% in ADHD adults and 33% in non-ADHD adults. In considering these findings, it is important to note that these studies included either all males or very few females. Biederman, et al. (2010) conducted a long-term follow up of females who

had been diagnosed as a child with ADHD. The majority of the 96 females in the ADHD group at follow up had received treatment for ADHD through counseling and/or medication with higher rates of DSM-IV-TR diagnoses in the ADHD group than the control group. Of the subjects, those who were diagnosed with ADHD during childhood, as young adults had a higher life time risk of another DSM-IV-TR diagnosis than the comparison group; hazard ratios were 6.8 for mood disorders, 2.1 for anxiety disorders, 7.2 for antisocial disorders, 3.2 for developmental disorders, 2.7 for substance dependence disorders, and 3.5 for eating disorders (Biederman et al., 2010).

Many individuals with ADHD also experience impairments in social functioning. Such impairment can manifest as rejection by peers and conflicts with others in their lives. Impairment in social functioning may be a component of ADHD or related to the high co-morbidity of ODD and CD (Nijmeijer et al., 2008). Children with ADHD generally want to participate socially, but have difficulty attuning their behavior to social situations. Children and adults have been observed to be more socially intrusive, violate rules, be hostile and controlling, and use physical and verbal aggression (Bagwell, Molina, Pelham Jr, & Hoza, 2001; Buhrmester, Whalen, Henker, Macdonald, & Hinshaw, 1992; Cunningham & Siegel, 1987; Drew Erhardt & Hinshaw, 1994; Grenell, Glass, & Katz, 1987; Hoza et al., 2005; Kuriyan et al., 2013; Mrug, Hoza, Pelham, Gnagy, & Greiner, 2007; Pelham & Bender, 1982; Wymbs et al., 2012). Kuriyan et al. (2013) found that after controlling for co-morbidity in individuals with a lifetime history of ADHD, adults with ADHD had a significantly higher tendency to engage in behaviors reflecting lack of planning and deficient inhibitory control, and to experience high rates

of adverse consequences, including trauma. They also found that a lifetime history of ADHD was associated with significantly lower perceived health, social support and higher stress.

Long-term follow up of young adults who had been diagnosed with ADHD hyperactive type as children reported that these individuals have significantly fewer close friends and report more difficulty maintaining friendships than controls, and overall more social impairments (Barkley et al., 2006; Barkley et al., 2008; Weiss & Hechtman, 1993). Barkley et al. (2008) reported that young adults diagnosed with hyperactivity as children, particularly those with elevated ADHD symptoms as adults, were more impaired in social relationships than non-ADHD adults. In Barkley et al. (2006), the ADHD group reported dating a larger number of individuals, but did not differ on the average duration of steady relationships compared to controls. They also indicated participating in risky sexual behaviors resulting in significantly more sexually transmitted diseases in the ADHD group than in the control group. The inattentive component of ADHD may also contribute to social impairments by not listening, being distracted and off-task, and having trouble switching roles (Landau & Milich, 1988; Whalen, Henker, Collins, McAuliffe, & Vaux, 1979).

Inhibitory Control in ADHD

Deficits in the ability to inhibit impulse control are a hallmark of ADHD in children and adults. The impulsivity construct refers to diverse actions that are performed without sufficient forethought and frequently result in undesirable consequences, including errors on academic assignments and cognitive tasks (Raiker,

Rapport, Kofler, & Sarver, 2012). During childhood, adverse consequences associated with impulsive behavior include an increased risk for mishaps (Palili et al., 2011), excessive errors on schoolwork and homework (Zentall, 1993), peer relational difficulties (Diamantopoulou, Rydell, Thorell, & Bohlin, 2007), and higher rates of ODD (Burns & Walsh, 2002). As adults, difficulties with impulse control continuation results in poor financial planning and lower socioeconomic status (Moffitt et al., 2011), deficient driving behavior (Barkley et al., 2004), earlier/riskier sexual activity, unstable relationships, and impaired occupational functioning (Barkley et al., 2006), as well as increased risk of substance use/abuse (Moffitt et al., 2011; Molina, Smith, & Pelham, 1999; Rodriguez, Tereyak, & Audrain-McGovern, 2008), antisocial behavior (Babinski, Hartsough, & Lambert, 1999), and adult criminal conviction (Moffitt et al., 2011).

Behavioral inhibition is hypothesized to be a cognitive process that sub-serves behavioral regulation and specific components of executive functioning (Barkley, 2005), and underlies the ability to withhold or stop an on-going response (Schachar, Mota, Logan, Tannock, & Klim, 2000). Excessive commission errors are hypothesized to occur by means of two interrelated pathways. The first of these reflects a direct impact of ADHD related deficient inhibitory processes on impulsive errors such that motor responses initiated in response to prepotent stimuli are not overridden or terminated following commands from frontal/pre-frontal cortical areas (Aman, Roberts, & Pennington, 1998; Adam R. Aron & Poldrack, 2005). The second pathway reflects indirect effects of ADHD related deficient inhibitory processes on working memory (WM). More specifically, deficient inhibitory processes fail to prevent extraneous

information from entering WM, resulting in difficulty maintaining task goals and stimulus configurations due to interference (Barkley, 2005; Brocki, Randall, Bohlin, & Kerns, 2008).

Impulsivity can be measured in children and adults with ADHD by measuring omission, commission errors, and reaction time on laboratory based continuous performance tests (CPTs). CPT characteristically requires individuals to respond to infrequently occurring, phonologically encoded stimuli (Dhar, Been, Minderaa, & Althaus, 2010; McGee, Clark, & Symons, 2000; Nichols & Waschbusch, 2004; Purvis & Tannock, 2000). Omission errors are the number of targets missed, and is considered to be related to inattention. Commission errors refer to discrete instances in which the individual responds incorrectly to non-target stimuli, and are related to impulsivity. A meta-analysis of children with ADHD found that boys were more likely to have commission errors on continuous performance tasks than girls (Hasson & Fine, 2012). Reaction time is a measure of the time lapse between exposure to the stimuli and the response. It is considered to reflect lapses in attention and relate to the roles of sustained attention in ADHD. Slower or variable reactions times have been frequently identified in individuals with ADHD (Andreou et al., 2007; Castellanos & Tannock, 2002; J. N. Epstein et al., 2003; Leth-Steensen, King Elbaz, & Douglas, 2000; McLoughlin et al., 2009; Munkvold, Manger, & Lundervold, 2014; Nigg, 2005; Uebel et al., 2010). Alderson, Rapport, Kasper, Sarver, and Kofler (2012) found that children's level of hyperactive behavior was associated more with basic attention than behavioral inhibition

processes, as measured using conventional stop-signal task, two choice-task variants, and the use of an actigraph to measure activity levels.

The research into both children and adults with and without ADHD performance on CPTs is inconsistent due to the existence of multiple CPT paradigms and varying research methodologies (Riccio, Reynolds, & Lowe, 2001). CPTs exhibit moderate strength in detecting the absence of attentional and impulsive difficulties but weakness in identifying and differentiating among disorders associated with such difficulties (Barkley, 2005; J. N. Epstein, Conners, Sitarenios, & Erhardt, 1998; Riccio et al., 2001; Solanto, Estefia, & Marks, 2004). One of the most popular commercial CPTs used in the diagnosis of ADHD in both children and adults is the Conner's CPT-II (CCPT-II; Conners, 2000). Studies of the CCPT-II diagnostic utility with ADHD report weak sensitivity and weak to moderate specificity with children (e.g. J. N. Epstein et al., 2003; Kallitsoglou, 2013; Naglieri, Goldstein, Delauder, & Schwebach, 2005) and adults (e.g. Busse & Whiteside, 2012; Cohen & Shapiro, 2007; J. N. Epstein et al., 1998; Solanto et al., 2004). J. N. Epstein et al.'s (2003) research with children found that hit reaction time (RT) was minimally related to ADHD symptoms as a whole, but did demonstrate some specificity in its link with symptoms of hyperactivity. In a comparison of children with ADHD and reading disabilities, it has been reported that children with ADHD are not significantly different from children with reading disabilities when evaluating inhibitory processes (Marzocchi et al., 2008).

Studies have found that adults and children with ADHD make more commission errors on NoGo trials (Bekker et al., 2005; Casey et al., 1997; Fisher, Aharon-Peretz, &

Pratt, 2011; Murphy, 2002; Slaats-Willemse, Swaab-Barneveld, de Sonneville, van der Meulen, & Buitelaar, 2003; Vaidya et al., 1998), and CPTs (Cohen & Shapiro, 2007; J. N. Epstein et al., 2003; Gu, Gau, Tzang, & Hsu, 2013) compared to controls. It has also been found that children and adults with ADHD make more omission errors in Go tasks (Fallgatter et al., 2004; Fisher et al., 2011; van Leeuwen et al., 1998), and CPTs (J. N. Epstein et al., 2003; Gu et al., 2013; Munkvold et al., 2014) than controls. Some studies have also found that both children and adults with ADHD have a more variable reaction time on CPTs than controls (Cohen & Shapiro, 2007; J. N. Epstein et al., 2003; Gu et al., 2013; Munkvold et al., 2014; Weyandt et al., 2013). Dhar, Been, Minderaa, and Althaus (2010) found that children with ADHD had an overall steeper reaction time decline with time-on-task as well as an overall greater performance variability than controls. This effect has also been found in adults (Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2005; Flint Jr & Turek, 2003).

Impulsive responding on CPTs may reflect distinct or combined underlying executive functioning deficits due to cognitive processing differences associate with how task stimuli are encoded, and the degree of inhibitory control and WM processes required by the tasks (Denney, Rapport, & Chung, 2005; Klein, Wendling, Huettner, Ruder, & Peper, 2006). In trying to explain reaction time variability and poor sustained attention, models of ADHD emphasize alternatively the top-down cortical control of executive attention (Bellgrove, Hawi, Kirley, Gill, & Robertson, 2005; Bellgrove, Hester, & Garavan, 2004; Friedman-Hill et al., 2010) or the role of low arousal and alertness in leading to poor attentional control (O'Connell et al., 2008; van der Meere,

Gunning, & Stemerdink, 1996; Van der Meere, Marzocchi, & De Meo, 2005) or both (Johnson et al., 2007). Loo and Smalley (2008) reported an association between reaction time variability and electroencephalogram indexed under arousal. Similar findings were found by O'Connell et al. (2008) using skin conductance measures. These findings support the relationship between decreased arousal and increased reaction time in individuals with ADHD.

Barkley and Grodzinsky (1994) re-analyzed some of his earlier published data (Barkley et al., 1992) and found that CPTs and letter-word fluency tasks had adequate positive predictive power in discriminating children with ADHD from controls. At the same time, results of research have been mixed on the ability of CPTs to distinguish ADHD individuals from other clinical samples (Alloway et al., 2009; Barkley & Grodzinsky, 1994; Barkley, Grodzinsky, & DuPaul, 1992; J. N. Epstein et al., 2003; Fischer & Barkley, 1990; Horn, Wagner, & Lalongo, 1989; Kallitsoglou, 2013; Loge, Staton, & Beatty, 1990; McGee et al., 2000; Munkvold et al., 2014; O'Dougherty, Neuchterlein, & Drew, 1984; Weyandt, Rice, Linterman, Mitzlaff, & Emert, 1998). McGee et al., (2000) found that children with ADHD did not score worse on the CCPT-II than clinical controls (i.e., children referred for assessment of potential ADHD to an outpatient child mental health clinic but who did not meet criteria). Although they found the test results discerned children with ADHD from typically developing controls, many children with dyslexia performed similarly to children with ADHD. This is of note due to the possibility of false positives in individuals with an LD. Purvis and Tannock (2000), using the CCPT-II, also found inhibitory control to be a problem in children with

dyslexia as well as in children with ADHD. Yet, response variability was greater in children with ADHD only, suggesting that inhibitory control may not be the core deficit in ADHD. Alloway et al. (2009) found that the CCPT-II was unable to distinguish children with ADHD from those with WM deficits, while observer report measures of ADHD symptoms and executive function were able to distinguish the groups.

In adults with ADHD the results also have been limited and mixed (Cohen & Shapiro, 2007; Fisher et al., 2011; Weyandt et al., 1998) with regard to the ability of CPTs to distinguish adults with ADHD from controls. Greenberg (1996) hypothesized that these difficulties may be related to the development of coping mechanisms, and individuals who obtained cognitive ability was two standard deviations above the mean would be expected to perform at a more advanced level on CPTs. Many of the above mentioned studies note that despite inconsistent research findings, CPTs can be a useful component within a full evaluation that gathers information through multiple methods.

Inhibition and Working Memory in ADHD

Behavioral inhibition and WM have emerged as components of executive functioning that help explain a wide array of ADHD symptoms (Holmes et al., 2010; Sergeant, Geurts, & Oosterlaan, 2002; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Executive functioning is believed to be a higher order regulatory and supervisory function that researchers believe is subserved, in part, by the frontal lobes (Zillmer, Spiers, & Culbertson, 2008). Cognitive operations such as planning, mental flexibility, attentional allocation, WM, reasoning, set-shifting, interference control and inhibitory control are considered components of executive functioning (Pennington & Ozonoff,

1996). Behavioral inhibition and WM are processes within executive functioning that are emphasized in models of ADHD (Barkley, 2005; M. Rapport et al., 2008), but the models do diverge. WM has also been found to predict academic achievement (Alloway, Gathercole, Adams, & Willis, 2005; Gathercole, Pickering, Knight, & Stegmann, 2004; Gropper & Tannock, 2009).

The functional WM model of ADHD, proposes that impulsive responsiveness on cognitive tasks is a byproduct of deficient WM processes (Noreika, Falter, & Rubia, 2013; Rapport et al., 2008). A large number of studies have shown that WM is associated with duration discrimination and duration reproduction tasks in ADHD (McInerney & Kerns, 2003; Smith, Taylor, Rogers, Newman, & Rubia, 2002; Toplak, Rucklidge, Hetherington, John, & Tannock, 2003; Toplak & Tannock, 2005; Yang, Hsu, Chiou, & Chao, 2007). Evidence indicates that there are two distinct WM subtypes, phonological (i.e., Numbers Reversed and Letter Number Sequencing) subtest in the Wechsler series of intelligence tests; (Wechsler, 2008), and visuospatial (i.e. CCPT-II), that are overseen by a domain-general attentional controller termed the central executive (Metzler-Baddeley, 2007). Researchers have found that adults with ADHD perform significantly worse on tasks of phonological and visuospatial WM than healthy controls (Alderson, Hudec, Patros, & Kasper, 2013; Gropper & Tannock, 2009). Kempton et al. (1999) also showed that treatment naive children exhibit specific cognitive impairments on spatial short-term memory, spatial working memory, set-shifting ability, spatial recognition memory, delayed matching to sample, and planning ability. Children who were medicated using a stimulant exhibited deficits only in the area of spatial

recognition memory. Phonological and visuospatial WM refer to central executive working in conjunction with the verbal and visuospatial storage/rehearsal mechanisms, respectively, to process internally-held, modality-specific information. Findings suggest that the extent to which the task places demands on WM may be more important than the modality of the tasks (Brocki et al., 2008).

WM deficits in adults with ADHD are well documented. WM is significantly impaired in untreated adults with ADHD (Ross, Harris, Olincy, & Radant, 2000) and significantly improves once treated with methylphenidate (Hermens, Cooper, Kohn, Clarke, & Gordon, 2005; Mehta, Goodyer, & Sahakian, 2004; Turner, Blackwell, Dowson, McLean, & Sahakian, 2005; Verster et al., 2010). In a study evaluating young adults, five domains of executive functioning deficits were found, response inhibition, poor sustained attention, interference control, and verbal and nonverbal WM (Murphys, Barkley, & Bush, 2001). Adults with ADHD are often characterized by their forgetting of appointments, things to do, or even taking their medication on time. These characteristics may be related to the deficits in WM. Studies of the brain have shown a more diffuse pattern of activation and a relative lack of frontal activation in adults with ADHD when performing WM tasks (Castellanos, Giedd, Marsh, & Hamburger, 1996; Schweitzer, Faber, Grafton, Tune, & et al., 2000; Zametkin et al., 1990) indicating fundamental differences in the functioning of the brain.

WM deficits are also associated with inattentive behavior in children with ADHD (Rapport et al., 2009). Rapport et al. reported that boys with ADHD exhibited higher levels of inattentive behavior when they completed experimental tasks that placed high

demand on WM, compared with tasks that placed minimal demands on WM. Similar findings have also been found in community samples of children (Alloway et al., 2009; Gathercole et al., 2008). Conversely, research into adult ADHD has found some evidence indicating WM deficits without elevated inattention (Payne & Steege, 2013; Roberts, Milich, & Fillmore, 2012; Stearns, Dunham, McIntosh, & Dean, 2004).

Intellectual Functioning and ADHD

Studies have found differences between individuals with and without ADHD in cortical and subcortical brain regions (Amen & Carmichael, 1997; Filipek et al., 1997; Rubia, Overmeyer, Taylor, Brammer, & et al., 1999; Schweitzer et al., 2000). This may explain difficulties with inattention, executive function, and behavioral disinhibition and may lower scores on assessment measures that rely on these abilities to be functioning in order to obtain accurate measurements. Longitudinal research has found that in adults who continue to exhibit behaviors associated with ADHD that overall cognitive ability remain stable (Biederman et al., 2009). Current research into the relationship between cognitive ability and ADHD has methodological limitations.

Current research practices will utilize ability estimates; short forms utilizing subtest, such as Digit Span and Arithmetic, which are sensitive to inattention and executive dysfunction; and matching ADHD and non-ADHD participants on educational level (Díaz-Orueta et al., 2013; Marx, Pieper, Berger, Häßler, & Herpertz, 2011; Rashid, Morris, & Morris, 2001; Woods, Lovejoy, & Ball, 2002). Woods et al. also observed that researchers frequently matched ADHD and non-ADHD individuals on cognitive ability, thus obscuring any general intellectual test reductions in the adults ADHD

population as a whole. Barkley (1998; 1997) has argued against using cognitive ability as a covariant. More specifically he argued that if a systematic negative relationship between ADHD and cognitive ability exists, then controlling for differences in ability may remove variance that is due to ADHD in the measures under investigation. This research practice could result in concluding that adults with ADHD and non-ADHD adults do not perform differently on given measure when, in fact, true differences exist.

Research suggests that overall cognitive ability scores are reduced modestly by the presence of ADHD (Bridgett & Walker, 2006; Jepsen, Fagerlund, & Mortensen, 2009; Schuck & Crinella, 2005). Research further indicates that differences in cognitive abilities between individuals with ADHD and without ADHD may be evident through relative weaknesses in working memory and processing speed (Arble, Kuentzel, & Barnett, 2014; Dovis, Van der Oord, Wiers, & Prins, 2013; Katz, Brown, Roth, & Beers, 2011). Relatively few studies have specifically evaluated the intellectual test performance differences between adults with ADHD and non-ADHD, nonclinical adults (Goodwin, Gudjonsson, Sigurdsson, & Young, 2011; Hervey et al., 2004; Quinlan, 2001; Wood et al., 2011), although more studies have included measures of cognitive ability as part of the battery of tests (Biederman, Monuteaux, et al., 2004; Biederman, Petty, Clarke, Lomedico, & Faraone, 2011; Biederman et al., 2008; Boonstra et al., 2010; Dalsgaard et al., 2013; Dodrill, 1999; Mahone et al., 2002; McGillivray & Baker, 2009).

Examination of general cognitive ability in adults with ADHD is important. Cognitive ability tests provide a global measure of cognitive functioning and can be used

to establish a foundation from which specific cognitive functions can be compared. Intellectual measures have been shown to discriminate ADHD in adults from normal controls, including subtests of the Wechsler Scales: Digit-Symbol Coding, Arithmetic, Block Design, Letter Number Sequencing and Digit Span (Goodwin et al., 2011; Hervey et al., 2004; Quinlan, 2001; Shelton, Elliott, Hill, Calamia, & Gouvier, 2009). Each of these subtests relies on speed of processing and/or WM and may be affected by the impulsivity and attention deficit characteristic of ADHD and other disorders. Research findings suggest that adults with ADHD may respond to test items impulsively, possibly without giving each one full consideration, thus also performing tasks quickly but inaccurately (J. N. Epstein et al., 2003; Young & Gudjonsson, 2005).

Munkvold, Manger, and Lundervold (2014) found that children with ADHD, and children with ADHD and oppositional defiant disorder, obtained lower cognitive ability than normal controls. They also found that cognitive ability, but not diagnostic group status, was a significant predictor of CCPT-II performance. Goodwin, Gudjonsson, Sigurdsson, and Young (2011) evaluated prisoners with and without ADHD performance on the Raven's Standard Progressive Matrices (RSPM; Raven, Raven, & Court, 2000). They found that the time taken to complete the RSPM and the RSPM score were negatively correlated with adult ADHD symptoms. Longer test-completion times were positively correlated with higher RSPM scores. They found that current ADHD symptoms rather than childhood symptoms had a significant effect on the prisoners test performance.

In a meta-analysis investigating the relationship of cognitive ability, as measure by the WAIS-R or WAIS-III, and adult ADHD a significant difference was found between the Full Scale IQ (FSIQ) of adults with and without ADHD (Bridgett & Walker, 2006). The non-ADHD group had an average of 2.94 points higher FSIQ than the ADHD group. It was found that the method of diagnosing ADHD (i.e. self-report, questionnaire, diagnostic interview, outside documentation) moderated the effect size. Studies that utilized only clinical interviews, studies using both clinical interviews and at least one rating scale, and studies that followed children diagnosed with ADHD into adulthood found adults with ADHD performed lower on FSIQ than non-ADHD adults. In contrast, studies that established the ADHD diagnosis with outside documentation provided by adult found that ADHD participants performed higher than non-ADHD adults on FSIQ measures. The authors determined that due to the moderators found in the study that despite the difference in FSIQ's being statistically significant it is not clinically meaningful.

Achievement and ADHD

Children and young adults with ADHD often demonstrate academic difficulties that result in lower grades and test scores, more grade retention and dropping out of school, more diagnoses of LD's, and less overall academic success than peers (Advokat, Lane, & Luo, 2011; Barkley, 2005; Barkley et al., 2008; Biederman et al., 2009; DuPaul & Volpe, 2009; Gropper & Tannock, 2009; Heiligenstein et al., 1999; Murphys et al., 2002; Pope, 2010; Schwanz, Palm, & Brallier, 2007; Weyandt et al., 2013; Weyandt & DuPaul, 2006; Wolf, 2001; Wolf et al., 2009). Achievement scores have been found to

correlate with cognitive ability in clinical and non-clinical populations of children (e.g., Naglieri, De Lauder, Goldstein, & Schwebech, 2006; Paloyelis, Rijsdijk, Wood, Asherson, & Kuntsi, 2010) and adults (e.g. Biederman et al., 2009; Frazier, Youngstrom, Glutting, & Watkins, 2007). Many children with ADHD are diagnosed with LD's in reading, writing, and/or mathematics (Capano, Minden, Chen, Schacher, & Ickowicz, 2008; Mayes & Calhoun, 2006; Semrud-Clikeman, 2005). Deficits in reading, writing, and/or math abilities have also been found in adults (Biederman et al., 2009; Frazier, Demaree, & Youngstrom, 2004; Frazier et al., 2007).

Research has found correlations between ADHD symptom scores and cognitive ability range from -.20 to -.40 (Fergusson, Lynskey, & Horwood, 1993; Goodman, Simonoff, & Stevenson, 1995; Kuntsi et al., 2004; Rapport, Scanlan, & Denney, 1999; Wood, Asherson, Rijsdijk, & Kuntsi, 2009). Similarly, correlations between reading ability and cognitive ability range from .43 to .50 (Harlaar, Spinath, Dale, & Plomin, 2005; Haworth et al., 2009) and between reading difficulties and cognitive ability from -.37 to -.40 (Cardon, Dilalla, Plomin, DeFries, & Fulker, 1990; Paloyelis et al., 2010). Correlations between reading difficulties and ADHD inattention symptoms range from .28 to .51, and between reading difficulties and hyperactivity-impulsivity symptoms from .19 to .26 (Paloyelis et al., 2010; Trzesniewski, Moffitt, Caspi, Taylor, & Maughan, 2006; Willcutt et al., 2007).

It remains unclear whether these learning problems are due to behavioral interference with learning, such as on-task behavior (DuPaul & Stoner, 2003), comorbidities separate and distinct from the ADHD (Isles & Humby, 2006), and/or core

ADHD neuropsychological deficits (i.e. sustained attention, planning, WM) that may lead to inadequate academic achievement (Goldstein & Naglieri, 2008; Hale, Reddy, Wilcox et al., 2009, Mayes, Calhoun, & Crowell, 1998). Studies have demonstrated that deficits in attention, WM, and processing speed display a relationship to achievement performance in mathematics, reading, and written expression (Biederman, Monuteaux, et al., 2004; Bull, Epspy, & Wiebe, 2008; Bull & Scerif, 2001; Espy et al., 2004; Helland & Asbjornsen, 2000; Latzman, Elkovitch, Young, & Clark, 2010; Mayes & Calhoun, 2006; Swanson, 1999; van der Sluis, de Jong, & van der Leij, 2007). Although WM has been found to have a strong relationship to all areas of academic achievement in ADHD and non ADHD samples, the strongest relationships have been found in relation to achievement in mathematics. Bull, Espy, and Wiebe's (2008) follow up study of preschoolers at age 7 found that visual short-term and WM specifically predicted math achievement at each time point, while executive function skills predicted learning in general rather than learning in one specific domain. In both adults and children some studies find evidence that verbal working memory (Adams & Hitch, 1997; Gathercole et al., 2004; Owens, Stevenson, Norgate, & Hadwin, 2008), visuospatial working memory (Holmes, Adams, & Hamilton, 2008; Kyttälä & Lehto, 2008), or both (Berg, 2008; Holmes & Adams, 2006; Miller & Bichsel, 2004) are related to mathematic performance.

Evidence indicates that children (Biederman, Monuteaux, et al., 2004; DuPaul, 2007) and adults (Biederman et al., 2009; Miller, Nevado-Montenegro, & Hinshaw, 2012) with ADHD perform worse on measures of academic achievement than control

populations. Multiple studies have evaluated the relationship of reading ability to ADHD symptoms and cognitive deficits. In a meta-analysis of 72 studies of children and adults with ADHD, conducted by Frazier, Youngstrom, Glutting, and Watkins (2007), found the largest effect size in relationship to reading abilities (d=0.73). A longitudinal study of young adult females with ADHD found that lower WM scores predicted lower reading scores (Miller et al., 2012). Katz, Brown, Roth, and Beers (2011) found that older adolescents and adults who presented with both ADHD and a reading disorder performed worse on processing speed and WM tasks. Adolescents with ADHD auditory-verbal WM was found to be strongly associated with achievement in reading and mathematics, while visual-spatial WM was found to be associated only with achievement in mathematics (Rogers, Hwang, Toplak, Weiss, & Tannock, 2011).

In one study it was found that technical reading, spelling, and arithmetic posed the most difficulties for adults with ADHD when compared to adults with dyslexia and healthy controls (Laasonen, Lehtinen, Leppamaki, Tani, & Hokkanen, 2010). This study also noted that although the dyslexia group performed the worse on achievement measures, the adults with ADHD displayed difficulties that were scattered across the domains assessed, and reflected less accurate performance rather than specific deficits in any one achievement area. Further, all the differences were removed when cognitive ability was controlled for. While in the area of written expression, researchers have found that deficits in this area are correlated with cognitive performance and less likely to be correlated with ADHD symptoms (DeBono et al., 2012; Del'Homme, Kim, Loo, Yang, & Smalley, 2007; Mayes & Calhoun, 2006; Mayes, Calhoun, & Crowell, 2000;

Re, Pedron, & Cornoldi, 2007; Semrud-Clikeman & Harder, 2011). Research lends support to the idea that inattention and hyperactive characteristics of ADHD can have an impact on academic achievement scores, but that cognitive ability and WM are also key components in understanding academic achievement in ADHD.

CHAPTER III

METHODS

Research Design

This is a retrospective study using extant data. This study drew participants from existing psychological evaluations conducted in the Texas A&M University Counseling and Assessment Clinic (CAC) by doctoral students under the supervision of faculty. Participants consented to have their de-identified data utilized in future research projects when signing consent for full psychological evaluations. Approval by the Institutional Review Board to use this de-identified data was obtained.

Participants

Participants for this study were selected from all of the possible evaluations conducted between 2009-2013 based on the presence of Wechsler Adult Intelligence Scale-IV (WAIS-IV), Woodcock Johnson-III Test of Achievement (WJ-III ACH), Conners' Continuous Performance Test-II (CCPT-II), and Conners' Adult ADHD Rating Scale - Self Report Short Form (CAARS-S:S) or Long Form (CAARS-S:L) and the Observer Report Short Form (CAARS-O:S) or Long Form (CAARS-O:L) as part of the assessment. Participants also must have received a diagnosis of ADHD from the evaluation. The participants did not participate in any randomization or experimental conditions, and therefore no adverse events occurred.

Participants are 103 English-speaking males and females ages 18-31 with a mean age of 20. Individuals over 32 and individuals with a FSIQ of 79 or below, were

excluded from this study due to low numbers of individuals in those ranges (n=4), and to control for age and FSIQ as cofounding variables. Individuals were referred by the Texas A&M Athletic Department, Student Counseling Service, Blinn College, or self-referred for psychological evaluations, to the Counseling and Assessment Clinic at Texas A&M University, due to concerns related to inattention, hyperactivity, poor grades, and mood related concerns. All clinical interviews and all measures were administered in the Counseling and Assessment Clinic at Texas A&M University. .

The sample of 103 was comprised of 62 (60%) males and 41 (40%) females. Individuals identified themselves as Caucasian n=72 (71%), African American n=16 (15%), Hispanic n=10 (10%), and other n=4 (4%). All individuals were found to meet DSM-IV-TR criteria for ADHD, and 69 (67%) also had a comorbid diagnosis. Individuals were also found to meet DSM-IV-TR criteria for an anxiety disorder n=16 (15%), learning disabilities n=14 (14%), depression n=11 (11%), other mood disorders n=6 (6%), and other diagnosis (medical condition or psychosocial/environmental) n=60 (58%). Sample characteristics are summarized in Table 1.

Table 1

Demographic Characteristics of Sample

		N (%)	
Gender	Male	62 (60%)	
	Female	41 (40%)	
Ethnicity	African American	16 (15%)	
	Hispanic	10 (10%)	
	Caucasian	73 (71%)	
	Other	4 (4%)	
Comorbid Diagnosis	Comorbid Disorder w/ADHD	69 (67%)	
	Learning Disability	14 (14%)	
	Anxiety	16 (15%)	
	Depression	11 (11%)	
	Other Mood Disorder	6 (6%)	
	V-Code Diagnosis	60 (58%)	
	Range	N	M (SD)
Age	18-31	103	20 (2.64)

Note. ADHD = Attention Deficit Hyperactivity Disorder, SD = Standard Deviation.

Diagnostic Procedure. All tests were administered by trained examiners in accordance with standardized instructions and were selected to address the presenting concerns of the client. The Diagnostic and Statistical Manual-IV-Text Revision (DSM-IV-TR) diagnostic criteria were utilized by clinicians to determine if individuals met criteria for ADHD or other diagnoses. Clinical interviews were utilized to obtain background histories. The CCPT-II, CAARS-S, and CAARS-O were utilized by clinicians to evaluate for current symptoms and behavior associated with ADHD, in

addition to anecdotal history to assist in determining if individuals met qualifications for ADHD. All diagnoses were confirmed by a licensed psychologist.

Measures

Intake Questionnaire. Individuals completed the Intake Questionnaire-Adult Personal History form for the CAC, as part of the intake process for psychological evaluations. General demographic information (e.g., age, ethnicity, education), and referral source were obtained from the form.

Conners' Continuous Performance Test Computer Program for Windows (CCPT-II): The CCPT-II (Conners, 2000) is an assessment tool used to measure attention problems in individuals six years of age and older, and was administered according to instruction manual. The individual is given instructions to press the space bar when any letter except the letter "X" appears. Letters appear on a black screen at varying Inter-Stimulus Intervals of one, two, and four seconds with a display time of 250 milliseconds. There are six blocks, with three sub blocks, each containing twenty-letter presentations. The CCPT-II takes fourteen minutes to complete.

The computer program captures response times and records them to the nearest millisecond. Speed and consistency of reactions are measured. The program classifies reaction times less than 100 milliseconds as perseverations. In addition to analyzing the response speed, the CCPT-II also provides measures of the accuracy of responses. Errors fall into two main categories: omission errors (no response after a non-X letter) and commission errors (a response to an X). Scores are calculated by block results (changes in reaction time speed and consistency as the test progresses). Scores are

calculated by change in reaction time speed and consistency at differing presentation rates. Scores are presented as T-Scores and percentiles and a narrative is produced by the scoring software to assist in interpretation.

The CCPT-II manual (Conners, 2000) recommends that the omission score can indicate the validity of the profile, as an extremely high T-score (i.e., T>100) indicates a high percentage of omissions and a strong likelihood that the individual may have stopped responding during the administration or misunderstood the directions of the test. Perseverations can be interpreted similarly to omissions, as an extremely high number of perseverations (i.e., T>100) suggests the possibility of random responding or a misunderstanding of the rules of the protocol, leading to a high likelihood of an inaccurate profile. It is important to consider that although high omission or perseveration scores could suggest an invalid profile, they could also imply serious inattention and or neurological problems. The validity of the CCPT-II was determined by the examiner at the time of assessment. Inattentiveness is associated with performance measured by the following index scores: Omission, Commission, Hit Reaction Time (slow), Detectability *d'*, and Perseveration Indices. Impulsivity is often associated with Commission, Hit Reaction Time (fast), and Perseveration Indices.

The CCPT-II has adequate reliability, with split-half coefficients on all measures ranging from .73-.95 (Conners, 2000). Standard error measurement values show that scores derived from the instrument are a reasonable match to the true performance of individuals. Comparisons of CCPT-II results between persons with ADHD and cognitively healthy controls of comparable age and education exhibit excellent

discriminant validity, with ADHD participants performing more poorly than controls (Schweiger, Abramovitch, Doniger, & Simon, 2007). Research has shown that omission and commission errors (e.g., Cohen & Shapiro, 2007; J. N. Epstein et al., 2003; Gu et al., 2013) are most likely to have a relationship to ADHD, but the hit RT, perseveration, and detectability indices (e.g., Cohen & Shapiro, 2007; J. N. Epstein et al., 2003; Weyandt et al., 2013) have shown more inconsisent relationships with ADHD. For the purposes of this study, the principal investigator will examine the performance of the participants on the following indices: omission, commission, hit RT, perseveration, and detectability.

The Conners' Adult ADHD Rating Scale-Self Report (CAARS-S) and Conners' Adult ADHD rating Scale-Observer Report (CAARS-O): The CAARS-S and CAARS-O (Conners et al., 1999) are multi-dimensional self or observer report instrument used to measure the presence and severity of current ADHD symptoms in adults 18 years old and above. Both are 26-item paper and pencil questionnaire that takes approximately 10–15 minutes to complete. The participant or a friend/family member rates the individual's behavior on a 4-point Likert-type scale, ranging from not at all, never, very much, very frequently. The CAARS-S yields an ADHD Index and four-factor derived subscales: Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and Problems with Self-Concept. The ADHD Index aims to identify adults who are likely to be diagnosed with ADHD.

The normative sample of the CAARS consisted of 1,026 normal adults between the ages of 18 and 80 years of age (mean age of 38.99 for males and 38.84 for females) from various parts of the U.S. and Canada (Conners et al., 1999). Research has found

the CAARS to have sound psychometric properties (Adler, Faraone et al., 2008; Erhardt, Epstein, Conners, Parker, & Sitarenios, 1999; Kooij, Boonstra, Swinkels, Bekker, de Noord, & Buitelaar, 2008). Erhard et al. (1999) found the CAARS to have high internal reliability with coefficient alphas for the subscales ranging from .86 to .92 for both males and females. These same authors also found strong test-retest correlations ranging from .80 to .91 for the subscales. The manual (Conners et al., 1999) reports significant correlations between self-report subscales ranging from .32 to .98.

Due to this study using archival data, the CAARS-Self-Report Long and Short forms were utilized by clinicians. There are 16 cases where the CAARS-Self-Report Long form was used, 87 cases the CAARS-Self-Report Short form was used, 35 cases where the CAARS-Observer Report Long form, and 68 cases where the CAARS-Observer-Report Short form was used. The CAARS-Self-Report Long and Short forms have a .92-.98 correlation with the Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and Problems with Self-Concept scales, and a .75 correlation with the ADHD Index. The CAARS-Self-Report Long and Short forms share the same questions that make up the scales scores on the short form, but have additional questions that make up the ADHD Index. This study will utilize the four scales that are generated on both forms that are associated with ADHD (Inattention/Memory Problems, Hyperactivity/Restlessness, and Impulsivity/Emotional Lability) and the ADHD Index from the CAARS Short Form in the data analysis.

Wechsler Adult Intelligence Scale -IV (WAIS-IV): The WAIS-IV (Wechsler, 2008) was utilized as a measure of intellectual abilities and administered according to

instruction manual. The WAIS-IV is a widely utilized battery of tests designed to measure adult intellectual abilities. The WAIS-IV was standardized using 2,200 healthy people between the ages of 16 and 90 years. The sample was based on and is consistent with the 2005 U.S. Census results. The WAIS-IV is composed of 10 primary subtests (Similarities, Vocabulary, Information, Block Design, Matrix Reasoning, Visual Puzzles, Digit Span, Arithmetic, Symbol Search, and Coding) and yields four Index scores (Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed), as well as an overall Full Scale IQ score (FSIQ).

The WAIS-IV has been found to have internal consistency of .78 - ≥ .90. All four composite scores have reliability coefficients within the excellent range (≥ .90), with the FSIQ found to have a reliability coefficient of .98. Inter-rater reliability was found to be .91-.99. Test retest reliability was found to range from .74-.90 for subtests, .87-.96 for composites, and .96 for FSIQ. The WAIS-IV has been found to be a valid measure of intellectual functioning in both the technical manual (Wechsler, 2008) and in multiple independent studies (Benson, Hulac, & Kranzler, 2010; Bowden, Saklofske, & Weiss, 2011; Canivez & Watkins, 2010). The WAIS-IV FSIQ, Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed scores will be utilized in analysis.

Woodcock-Johnson-III Test of Achievement (WJ-III-ACH): The WJ-III-ACH (McGrew, Schrank, & Woodcock, 2007) was utilized to evaluate current academic knowledge and skills, and was administered according to instruction manual. The WJ-III-ACH is a widely used measure of academic achievement in reading, math, written

language, and oral language. The test includes 22 achievement subtests organized into clusters. Each achievement subtest and cluster yields a standard score with a mean of 100 and a standard deviation of 15 (McGrew, Schrank, & Woodcock, 2007). Additionally, combinations of the subtests from the battery are grouped together to form composite scores: Broad Reading, Oral Language, Broad Math and Broad Written Language.

There is strong evidence of construct validity with the WJ-III-ACH. The WJ-III-ACH was co-normed with the WJ-III Cognitive on 8,818 participants. The manual lists two concurrent validity studies that compared the WJ-III-ACH and the Kaufman Test of Educational Achievement (Kaufman & Kaufman, 2004) and Wechsler Individual Achievement Test (Wechsler, 1991). Composite scores showed strong validity with correlations ranging from .67-.82 with corresponding scales on the KTEA and WIAT. The reliability characteristics of the WJ-III-ACH meet or exceed basic standards for both individual placement and programming decisions. The WJ-III-ACH technical manual (McGrew et al., 2007) reported reliability coefficients of .87-.94 for the composite scores. The WJ-III-ACH scores of Broad Reading, Oral Language, Broad Math and Broad Written Language will be utilized in data analysis to evaluate the effect of ADHD on achievement scores.

Procedures

Texas A&M University Institutional Review Board approval for the study was obtained prior to the start of data identification and analysis. All adult cases who received a diagnosis of ADHD were initially retained from the data set (n=116). It was

then determined which had all four of the measures of interest (CCPT-II, CAARS:S, CAARSO:S, WAIS-IV, WJ-III-ACH), and met inclusion and exclusion criteria for age and FSIQ. After those steps, 103 remained in the sample for data analysis.

Data Analysis

Data was entered by graduate students from the archival assessment files into Excel. All data was converted from Excel to SPSS 22 for analysis by the primary researcher. Prior to actual analysis, the frequency and type of missing data was determined. It was found that on both the WAIS-IV and WJ-III-ACH that scores were not available due to insufficient subscales being administered to obtain the scores. This was found to be present with the WAIS-IV Processing Speed (n=2), and the WJ-III-ACH Broad Written Language (n=1) and Oral Language (n=8) scales. Due to the use of both the long and short forms of the CAARS the ADHD Index from the short form is being used in analysis due to different questions making up this scale on the short and long forms. This resulted in n=16 missing ADHD Index scores on the CAARS-Self. Due to not all individuals having the CAARS-Observer report resulted in a total of n=25 not having observer scores, and n=35 individuals without an ADHD Index scores due to only using the short form score. This missing data was treated as missing and only cases with the appropriate data were utilized in analysis. Descriptive statistics were generated for demographic information, as well as means and standard deviations of the scales on the WAIS-IV, WJ-III ACH, CCPT-II, CAARS-S, and CAARS-O. Data was checked to ensure that all assumptions of normality were met (skewness, kurtosis), the need for any transformations determined. Using a Bonferroni correction, alpha was set at .01 to

control for Type I and Type II errors. Descriptive data were generated for the sample. Additional data analyses by research question included correlation, frequency, and regression analyses.

CHAPTER IV

RESULTS

Test of skewness and kurtosis were within normal limits for most variables. It was found that the CCPT-II Omissions and Perseveration scores did not meet the assumptions of normality. In further analysis it was found that these variables have an abnormally large range and standard deviation with a large number of individuals clustered around the mean. Due to this measure measuring behaviors associated with ADHD, and this sample being comprised exclusively of individuals with ADHD, it was determined that these scores are appropriate for this sample, therefore no transformation of the data was performed. Overall, the sample displayed average cognitive ability despite displaying a wide range of scores from below average to well above average, and the participants did not display evidence of lower Working Memory and Processing Speed scores as would have been expected with an exclusively ADHD sample. The participants also exhibited average achievement despite displaying a wide range of scores from below average to well above average. Significant variability was found on the ADHD measures with some individuals having atypically high scores on some variables. The mean scores on the CAARS Self and Observer ratings were found to be elevated, but not as elevated as would be expected given an exclusively ADHD sample. Descriptive statistics for the measures used are summarized in Table 2.

Table 2

Assessment Measures Descriptive Data

	N	Range	Mean	SD
Wechsler Adult Intelligence Scale-IV				
Full Scale IQ	103	80-144	102.1	10.47
Verbal Comprehension	103	66-147	103.05	12.55
Perceptual Reasoning	103	79-133	103.01	10.97
Working Memory	103	77-150	101.52	12.23
Processing Speed	101	68-135	98.66	12.54
Woodcock-Johnson-III Test of Achievement				
Broad Reading	103	79-121	99.61	8.96
Broad Math	103	71-131	101	12.63
Broad Written Language	102	60-128	101.87	10.91
Oral Language	95	63-124	97.71	10.73
Conner's Continuous Performance Test-II				
Omissions	103	40.86-152.32	55.1168	17.84
Commissions	103	35.46-86.08	58.1043	9.91
Hit Rt	103	27.99-110.21	57.9021	14.19
Detectability	103	24.98-71.85	55.1297	7.88
Perseveration	103	32.79-133.77	54.5686	17.48
Conners' Adult ADHD Rating Scale - Self				
Inattention/Memory Problems	103	39-83	65.55	9.37
Hyperactivity/Restlessness	103	34-81	62.66	9.47
Impulsivity/Emotional Lability	103	36-83	50.89	10.12
Problems with Self-Concept	103	34-76	51.6	11.34
ADHD Index	87	32-84	60.2	9.32
Conners' Adult ADHD Rating Scale-Observer				
Inattention/Memory Problems	78	37-82	64.09	10.56
Hyperactivity/Restlessness	78	37-81	61.22	10.75
Impulsivity/Emotional Lability	78	37-79	54.22	10.27
Problems with Self-Concept	78	37-75	54.28	11.04
ADHD Index	68	38-85	61.94	9.65

Note. SD = Standard Deviation, Hit RT = Hit Reaction Time.

Research Question 1

What is the frequency of markedly atypical scores (≥70) and moderately atypical scores (60-69) on CCPT-II scales of Omission, Commission, Perseveration, and Detectability among adults with a diagnosis of ADHD? It was hypothesized that the majority of adults diagnosed with ADHD would fall in the markedly atypical range (≥70) on Omission and Commission scales, and that fewer individuals would have scores in the markedly atypical range on Perseveration and Detectability. Frequency analysis revealed that the majority of participant's scores fell in the ≤ 59 range across all CCPT-II scales. A total of 13% (n=13) fell in the markedly atypical range and 7% (n=7) fell in the moderately atypical range (≥60) for Omissions, and 10% (n=10) fell in the markedly atypical range and 34% (n=35) fell in the moderately atypical range for Commissions. A total of 2% (n=2) fell in the markedly atypical range and 24% (n=24) fell in the moderately atypical range for Detectability, and 12% (n=12) fell in the markedly atypical range and 4% (n=4) fell in the moderately atypical range for Perseveration. The largest number of individuals in the markedly atypical range was found with Hit RT 14% (n=14). A total of 34% (n=34) of individuals fell in the moderately atypical range for Hit RT. The highest number of individuals that had moderately atypical scores or higher were in Commission's (44%, n=45), and Hit RT (48%, n=49); see Table 3.

Table 3

CCPT-II Impairment Level (N=103)

	Omissions N(%)	Commission N(%)	Hit Rt N(%)	Perseveration N(%)	Detectability N(%)
Markedly Atypical (≥70)	13(13%)	10 (10%)	14 (14%)	12 (12%)	2 (2%)
Moderately Atypical (60-69)	7 (7%)	35 (34%)	35 (34%)	4 (4%)	24 (23%)
Typical (≤59)	83 (80%)	58 (56%)	54 (52%)	57 (84%)	77 (75%)

Note. CCPT-II = Conners' Continuous Performance Test-II, Hit Rt = Hit Reaction Time.

Research Question 2

What is the relationship between self-report and observer report on the four common scales of the CAARS short and long forms and the ADHD Index on the CAARS short form? It was hypothesized that self report and observer report would be at greater agreement across the Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and ADHD Index, compared to the Inattention/Memory Problems and Problems with Self-Concept relationships. To analyze this, Pearson correlations were run between the CAARS Self-Report and Observer-Report for the 78 participants who had both raters. Correlations between the self and observer reports were positive and significant across all scales: Inattention/Memory Problems (p=.46, p <.01), Hyperactivity/Restlessness (p=.42, p <.01), Impulsivity/Emotional Lability (p=.58, p <.01), Problems with Self-Concept (p=.50, p <.01), and ADHD Index (p=.51, p <.01). See Table 4 for correlations. To further evaluate the relationship between the self and observer reports dependent t-

test's were run. It was found that the participants were more likely to rate themselves as less severe on the Impulsivity/Emotional Lability scale than the observers rated the participants $t(77)=-2.88$, $p<.01$.

Table 4

CAARS Self and Observer Correlation (n=78)

	Inattention/ Memory Problems	Hyperactivity/ Restlessness	Impulsivity/ Emotional Lability	Problems with Self-Concept	ADHD Index [a]
Self-Report	Observer Report				
Inattention/ Memory Problems	.46**	.19	.22	.32**	.42**
Hyperactivity/ Restlessness	.22	.42**	.28	.08	.30
Impulsivity/ Emotional Lability	.24	.30**	.58**	.18	.49**
Problems with Self-Concept	.18	.04	.24	.50**	.31**
ADHD Index [a]	.31	.26	.49**	.36**	.51**

Note. CAARS = Conners' Adult ADHD Rating Scale.
[a]$n=68$
**$p<.01$

Research Question 3

What is the relationship of the CCPT-II to the CAARS-S and CAARS-O scores in individuals diagnosed with ADHD? It was hypothesized that Omission scores would be

highly correlated with CAARS-S and CAARS-O scales that focus on inattention (Inattention/Memory Problems and ADHD Index), and that Commission scores would be highly correlated with CAARS-S and CAARS-O scales that focus on hyperactivity/impulsivity (Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and ADHD Index). Pearson correlations were not significant between the CCPT-II Omissions and Commission scores and any CAARS self or observer scales (Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, *n*=78, or the ADHD Index *n*=68). Similarly Hit RT, Detectability and Perseveration scores for the CCPT-II were not significantly correlated. See Table 5 for correlations.

Table 5

CCPT-II Correlation with CAARS Self and Observer Report (n=78)

	CCPT-II Omissions	CCPT-II Commissions	CCPT-II Hit Rt	CCPT-II Detectability	CCPT-II Perseveration
CAARS-Self Report Inattention/ Memory Problems	-.06	.11	-.08	.02	.08
CAARS-Self Report Hyperactivity/ Restlessness	-.10	.13	.01	.07	.04
CAARS-Self Report Impulsivity/ Emotional Lability	.02	.04	-.11	.04	.01

Table 5 Continued

	CCPT-II Omissions	CCPT-II Commissions	CCPT-II Hit Rt	CCPT-II Detectability	CCPT-II Perseveration
CAARS-Self Report Problems with Self-Concept	-.17	.12	-.24	.11	.03
CAARS-Self Report ADHD Index [a]	-.00	.18	-0.09	.13	.11
CAARS-Observer Report Inattention/ Memory Problems	-.04	.04	-.21	.04	-.01
CAARS-Observer Report Hyperactivity/ Restlessness	-.10	.03	-.10	-.10	-.11
CAARS-Observer Report Impulsivity/ Emotional Lability	-.20	-.12	-.15	-.15	-.07
CAARS-Observer Report Problems with Self-Concept	-.12	.08	-.10	.04	-.10
CAARS-Observer Report ADHD Index [a]	-.10	-.08	-.22	-.14	-.06

Note. CCPT-II = Conners' Continuous Performance Test, CAARS = Conners' Adult ADHD Rating Scale, Hit Rt = Hit Reaction Time.
[a] n=68
** p<.01

Research Question 4

Do the CCPT-II, CAARS-S, and CAARS-O scores correlate with performance on the WAIS-IV in adults diagnosed with ADHD? It was hypothesized that the WAIS-IV (Working Memory and Processing Speed Indexes) would have a negative correlation with the CCPT-II (Omission and Commission), CAARS-S and/or CAARS-O (ADHD Index, Inattention/Memory Problems, Hyperactivity/Restlessness, and Impulsivity/Emotional Lability). One-tailed Pearson's correlations were run due to the directionality hypothesized. No significant correlations were found between the WAIS-IV Working Memory and Processing Speed Indices and the CAARS-S and CAARS-O (ADHD Index, Inattention/Memory Problems, Hyperactivity/Restlessness, and Impulsivity/Emotional Lability) or the CCPT-II (Omission and Commission). See Table 6 for correlations. Further analysis was run to evaluate the relationship of the WAIS-IV FSIQ and Verbal Comprehension Index with the CAARS and CCPT-II. It was found that the CAARS-S Inattention/Memory Problems subscale had positive significant correlations with FSIQ (p=.23, $p < .01$) and Verbal Comprehension (p=.31, $p < .01$).

Table 6

WAIS-IV Correlation with the CCPT-II and CAARS Self and Observer (n=78)

	WAIS-IV	
	Working Memory	Processing Speed [b]
CAARS-Self Report Inattention/Memory Problems	.07	.04
CAARS-Self Report Hyperactivity/ Restlessness	-.06	.12
CAARS-Self Report Impulsivity/Emotional Lability	.07	.01
CAARS-Self Report Problems with Self-Concept	-.10	.10
CAARS-Self Report ADHD Index [a]	-.05	-.00
CAARS-Observer Report Inattention/ Memory Problems	.09	-.10
CAARS-Observer Report Hyperactivity/ Restlessness	.09	-.02
CAARS-Observer Report Impulsivity/ Emotional Lability	.26	-.08
CAARS-Observer Report Problems with Self-Concept	-.04	-.26
CAARS-Observer Report ADHD Index [a]	.14	-.15
CCPT-II Omissions	-.08	-.17
CCPT-II Commissions	-.23	-.15

Note. WAIS-IV = Wechsler Adult Intelligence Scales-IV, CAARS = Conners' Adult ADHD Rating Scale, CCPT-II = Conners' Continuous Performance Test-II, Hit Rt = Hit Reaction Time.
[a]n=68, [b]n=101
** p<.01

Research Question 5

Do the CPT-II, CAARS- S, and CAARS- S scores correlate with performance on the WJ-III ACH? It was hypothesized that the WJ-III ACH (Broad Reading, Oral Language, Broad Math, and Broad Written Language) would have a negative correlation with the CCPT-II (Omission and Commission) and CAARS-S and CAARS-O (ADHD Index, Inattention/Memory Problems, Hyperactivity/Restlessness, and Impulsivity/Emotional Lability). One-tailed Pearson's correlations were run due to the directionality hypothesized. The CAARS-S Problems with Self-Concept scale was found to negatively significantly correlate with WJ-III-ACH Broad Math scores ($r=-.27$, $p<.01$). This was the only negative correlation that was found. The CAARS-S Inattention/Memory Problems positively significantly correlated with Broad Reading ($r=.29$, $p<.01$) and Broad Written Language ($r=.25$, $p<.01$) scores on the WJ-III-ACH. See Table 7 for correlations.

Table 7

WJ-III-ACH Correlations with CCPT-II and CAARS Self and Observer (n=78) Reports

	WJ-III-ACH			
	Broad Reading	Broad Math	Broad Written Language [b]	Oral Language [c]
CAARS-Self Report Inattention/Memory Problems	.29**	.13	.25**	.12
CAARS-Self Report Hyperactivity/Restlessness	.14	.08	.20	.06
CAARS-Self Report Impulsivity/Emotional Lability	-.01	-.11	.12	-.04
CAARS-Self Report Problems with Self-Concept	-.13	-.27**	-.18	-.12
CAARS-Self Report ADHD Index [a]	.05	-.09	.07	-.06
CAARS-Observer Report Inattention/Memory Problems	-.09	.01	-.07	-.10
CAARS-Observer Report Hyperactivity/Restlessness	-.05	.02	.05	-.16
CAARS-Observer Report Impulsivity/Emotional Lability	-.07	.09	.06	-.14
CAARS-Observer Report Problems with Self-Concept	-.14	-.20	-.14	-.16
CAARS-Observer Report ADHD Index [a]	-.18	-.12	-.08	-.16
CCPT-II Omissions	-.08	-.04	-.01	.11
CCPT-II Commissions	-.11	-.19	-.08	-.07
CCPT-II Hit Rt	.09	.07	.03	.09
CCPT-II Detectability	-.09	-.21	-.09	-.04
CCPT-II Perseveration	.02	-.06	-.03	.02

Note. WJ-III-ACH = Woodcock-Johnson III Test of Achievement, CAARS = Conners' Adult ADHD Rating Scale, CCPT-II = Conners' Continuous Performance Test-II, Hit Rt = Hit Reaction Time.
[a]*n*=68, [b]*n*=102, [c]*n*=95
** $p<.01$

Research Question 6

Do scores on the CCPT-II variables of interest predict performance on the Working Memory and Processing Speed Indexes on the WAIS-IV? It was hypothesized that the CCPT-II scores on the Omission and Commission scales would predict performance on the Working Memory and Processing Speed Indices of the WAIS-IV. Linear regression with WAIS-IV Processing Speed as the dependent variable and CCPT-II Omission and Commissions scales as independent variables was not significant [$F(2,98)=2.23$, $p=.11$]. Linear regression with WAIS-IV Working Memory as the dependent variable and CCPT-II Omission and Commissions scales as independent variables also were not significant [$F(2,100)=2.84$, $p=.06$]. These results indicate that the CCPT-II Omission and Commission scales do not predict performance on WAIS-IV scales of Processing Speed or Working Memory, which are typically impacted by ADHD symptoms (Arble et al., 2014; Davis et al., 2012; Katz et al., 2011). See Table 8 for regression table.

Table 8

Linear Regression WAIS-IV Processing Speed and Working Memory (N=103)

Variable	*B*	95% CI
WAIS-IV Processing Speed		
Constant	113.49	[97.89, 129.08]
CCPT-II Omission	-0.11	[-0.24, 0.03]
CCPT-II Commission	-0.15	[-0.41, 0.10]
R^2	0.04	
F	2.23	
WAIS-IV Working Memory		
Constant	119.09	[104.11, 134.07]
CCPT-II Omission	-0.03	[-0.17, .10]
CCPT-II Commissions	-0.27	[-0.51, -0.03]
R^2	0.05	
F	2.84	

Note. CI = Confidence Interval, WAIS-IV = Wechsler Adult Intelligence Scale-IV, CCPT-II = Conners' Continuous Performance Test-II.

CHAPTER V

CONCLUSIONS

Discussion

The present study sought to examine the relationship of the CCPT-II and CAARS self and observer reports to cognitive and achievement scores. To understand the findings of this research it is important to first note the surprisingly average to above average cognitive and achievement scores for a sample of individuals diagnosed with ADHD. Previous studies have found that cognitive (Bridgett & Walker, 2006; Jepsen et al., 2009; Schuck & Crinella, 2005) and achievement (e.g. Advokate et al., 2011; Weyandt et al., 2013) scores can be lower in individuals with ADHD. Each individual in this study was assessed at a training clinic located on a major university campus. When characterizing referral sources for subjects and the location of the assessment clinic, it is highly probable that a large number of individuals assessed were college students (although this information was not tracked). It is also highly probable that these individuals had medication or therapy treatments in the past, and/or developed compensatory strategies that previously helped them achieve their goals (although treatment history was not tracked in this sample). The scoring pattern in this study may be explained by the large number of individuals included in the sample who may have been college students actively engaged in efforts to understand their struggles with their coursework.

Results from this study do not support the CCPT-II as having a relationship with the CAARS, WAIS-IV, or the WJ-III-ACH scores. This sample set had CCPT-II score that although elevated, were relatively low for an ADHD sample, and had a very large range of scores. The majority of individuals had typical scores on the CCPT-II scales. When clinicians or researches utilize the CCPT-II, the majority focus on Omission and Commission errors. Surprisingly, this sample had the largest number of individuals with moderately atypical scores for Commission and Hit Rt. Further analysis for cofounding variables (i.e., past or present medications, past or present therapies, previous diagnosis) to attempt to understand these findings was not able to be run, due to the archival nature of the data, and this information not being available. This sample set also had a very large percentage of individuals with a comorbid diagnosis (67%) along with ADHD. Due to the research establishing low sensitively and specificity for ADHD with the CCPT-II (e.g. Barkley, 2005; Busse & Whiteside, 2012; Kallitsoglou, 2013; Munkvold et al., 2014; Riccio et al, 2001), the unusual CCPT-II scores could very well be effected by the comorbid conditions, and not just by behaviors of ADHD. These findings suggest that although the CCPT-II can be a component of a full psychological evaluation, clinicians may want to be cautious about the importance they place on the scores when making clinical determinations.

The CAARS was found to have strong relationships between the self and observer reports. The strong relationship between self and observer reports in this study was surprising as research has shown a trend of observer reports being more severe and having a relationship to outcome measures (e.g., Nelson, 2013; Zucker et al., 2002). The

lack of variance between the scores of self and observer reports may have originated from the relationship between the subject and the observer (i.e., friend or parent). Typically, parental reporting was used in past research. Only one scale (Impulsivity/Emotional Lability) showed significant differences between the subjects and the observers ratings in this study. On this scale observers were more likely to rate the individual's behavior as more severe than the individual. A possible explanation of this finding may be individual subject's denial of their behaviors and emotions. As with CCPT-II, cofounding variables were not able to be evaluated (i.e., past or present medications, past or present therapies, previous diagnoses, relationship of observer, length of time the observer knew the individual) due to that information not being available.

The WAIS-IV Working Memory and Processing Speed Indices have previously been shown to be impacted by ADHD in research (e.g. Arble et al., 2014; Davis et al., 2012; Katz et al., 2011). The CAARS self and observer reports did not show any relationship with Working Memory and Processing Speed. The lack of a relationship in this sample may have been due to the Working Memory and Processing Speed scores having average mean scores (i.e., scores were not depressed compared to the other WAIS-IV indices). With further analysis, the CAARS-S Inattention/Memory Problems scale was found to have a significant positive relationship with the WAIS-IV FSIQ and Verbal Comprehension. This possibly may indicate that the individuals felt they had more attention and memory problems, but performed relatively well on the overall cognitive ability and understanding of verbal language. This suggests that an individual

subject's self perception of their ability to maintain focus and retain information may not be indicative of their actual performance on tasks in a laboratory setting. This may also be a product of the short duration of the tasks, and the lack of distractions to promote optimum performance during assessment.

The CAARS self report was found to have some relationship with achievement scores. The more Problems with Self-Concept subjects reported, the lower their performance was on Broad Math. This finding may indicate that poor self-concept may impact an individual's academic achievement and confidence in their ability to perform at academic tasks and learn new academic skills. As with the WAIS-IV FSIQ and Verbal Comprehension index, the CAARS self report scale of Inattention/Memory Problems was found to positively correlate with Broad Written Language and Broad Reading. This finding is interesting in that the individuals did not believe that they could sustain attention to tasks, but were able to perform well on the short writing and reading tasks of the WJ-III ACH. This is similar to findings by Lewandowski et al. (2013) where individuals with ADHD performed comparable to healthy controls, but they did not have confidence in their performance. It is important to consider that the WJ-III ACH writing and reading tasks are brief; on other achievement tests or school assignments that require longer written and reading responses and require longer sustained attention, this positive correlation may not be found. Tasks that require longer periods of sustained attention may be more likely to trigger the inattentive/impulsive behaviors associated with ADHD, and may overwhelm an individual's coping skills in maintaining focus/retaining information.

Given the common use of the CCPT-II by clinicians when assessing for ADHD, the importance a clinican places on CCPT-II scores may be an area for future study as the sample showed no meaningful relationship between the CCPT-II and other measures. This study did not have access to information obtained through the clinical interview from the evaluation, and the importance the evaluators placed on the clinical interview in relationship to assessment measures could not be determined. Additonally, this study did not have access to data that indicated if ADHD was considered an active impairing condition, or if the other comorbid conditions were considered to be more impairing than ADHD. Previous research noted that the importance placed on clinical interviews or rating scales has an impact on the type of ADHD diagnosis indivduals receive (Rowland et al., 2008; Valo & Tannock, 2010). In considering previous research, the findings of this study may suggest that the diagnosis of ADHD is an art form using clinical judgment in combination with the data from assessment measures. Related to this, the diagnosis of ADHD is based on behavioral symptoms and history, not solely on test scores.

Limitations

There are several limitations of the current study. This study was limited by the use of archival data of individuals who were self-referred for evaluation for ADHD and other disorders. The results of this study may have been impacted by the importance placed on the various components within the evaluation by the graduate student performing the evaluation and their supervisor. This may have influenced clinician's diagnostic decisions related to ADHD presence or absence in individual subjects. Due

to the archival nature of the database, several variables that would have been useful in understanding the data were not tracked (e.g., prior diagnosis, past or present medication, past or present therapies, relationship of observer reporter on the CAARS, length of time the observer knew the individual), all of which may have contributed to the diagnostic decision-making . Due to using archival data, a relatively small number of individuals who had a diagnosis of ADHD and who consistently were given the same measures during the evaluation process qualified for the study. This has previously been noted as a concern in relation to analysis with the CAARS-O, as even fewer individuals' assessments included this measure. This study was also limited in that there was no healthy control sample to evaluate if these findings are specific to individuals with ADHD. There is also the cofounding variable of a large number (67%) of individuals having comorbid disorders in addition to ADHD. This also makes it difficult to understand if these findings are specific to ADHD or ADHD with comorbid disorders. This study was also limited in geographic region.

Future Research

The present study was an attempt to further the understanding of the relationship between CPTs, symptom questionnaires, and cognitive and achievement scores. Further research into whether the DSM-5 ADHD criteria impact the relationship between these measures would be of value. From the findings in this study, it may be of interest to further investigate the relationship that behavior rating scales have with cognitive and achievement scores in a larger sample, and with more in-depth writing and reading assessments. The use of a healthy control group compared with an exclusively ADHD

group and/or ADHD with specific comorbid conditions would help to further understand how rating scales relate to cognitive and achievement scores. The inclusion of information related to performance on or off medication would also help to further understand the nature of ADHD.

Conclusion

This research study adds further support to the idea that the CCPT-II has a general lack of sensitivity and specificity (e.g. Barkley, 2005; Busse & Whiteside, 2012; Munkvold, et al., 2014) for ADHD, and does not have a strong relationship with ADHD symptom checklists, cognitive, or achievement scores. One finding of interest was that the CAARS self report was found to have some correlation with cognitive and achievement scores, specifically related to ratings of self-concept, inattention, and memory. This finding adds support to previous research related to how individuals perceive their abilities and what their abilities actually are (Lewandowski et al., 2013), and that within ADHD adults their perceptions may be inaccurate. Future research may be able to understand the role of inhibitory controls in adult ADHD with the addition of measures of executive functioning (Klein et al., 2006; Friedman-Hill et al., 2010) and more specific tasks of working memory (Alderson et al., 2013; Ross et al., 2000; Yang et al., 2007). It may also be useful in future research to further evaluate how self perceptions of skills related to an individual's ability to perform on tasks when they have ADHD.

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