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Cognitive Profiles and the Impact of Medication on Children with Attention Deficit Hyperactivity Disorder

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COGNITIVE PROFILES AND THE IMPACT OF MEDICATION ON CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

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Dissertation Approval

This is to certify that the thesis presented to us by Lucy Wimpenny on the 26th day of July, 2011, in partial fulfillment of the requirements for the degree of Doctor of Psychology, has been examined and is acceptable in both scholarship and literary quality.

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"Writing a novel is like driving a car at night. You can see only as far as your headlights, but you can make the whole trip that way." - E.L. Doctorow

Several weeks ago, I came across this E.L. Doctorow quote. I found it to be quite poignant because it related to the long process of writing a dissertation. Initially the project is overwhelming, but with the right support system, it is manageable. The task can be broken down into chapters, sections, paragraphs, and some days, sentences, until it is completed. There are many people who have helped me in my journey to this point.

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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most frequently diagnosed disorders in children and adolescents. Individuals with ADHD often display behavioral symptoms, including inattention and/or impulsivity, which can also lead to struggles in the school setting. Current research has suggested that deficits in processing speed and working memory are common in individuals diagnosed with ADHD and are often seen on measures of cognitive ability. Positive outcomes have been associated with the use of psychostimulant medication to treat the symptoms of ADHD, although little research has supported this form of treatment to improve cognitive functioning in individuals diagnosed with ADHD.

The current study replicated and expanded on Friedman (2006) and McLaughlin's (2009) studies. The purpose of this study was to compare the cognitive profiles of children diagnosed with ADHD and a control sample. The cognitive profiles were analyzed at the Full Scale, Index, and Subtest levels. In addition, the current study sought to determine whether or not the medication status impacted performance on the cognitive measures.

The results of this study indicated that individuals with ADHD did perform lower on measures of Full Scale IQ, Perceptual Reasoning, Working Memory and Processing Speed. It was also noted that the use of medication yielded higher performance, as compared with the non-medicated ADHD group. At the subtest level analysis, ADHD individuals typically performed better on the following task pairs: they worked better on verbal reasoning than on working memory tasks; they were more successful with perceptual reasoning than with processing speed tasks. In addition, ADHD groups also performed roughly the same on the following task pairs:

on nonverbal reasoning and working memory tasks, on verbal reasoning and processing speed, on verbal reasoning and perceptual reasoning, and on working memory and processing speed.

Regarding medication status, positive trends were noted for medication use, but minimal statically significant results were found. Significant results were found in favor of medication use for the VCI > PSI and PRI > VCI comparisons.

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Chapter 1

Introduction

Statement of the Problem

Attention Deficit-Hyperactivity Disorder (ADHD) is one of the most common and most frequently studied behavioral disorders in childhood (Barkley, 1997). The disorder affects three to eight percent of school-aged children in the United States (American Psychiatric Association, 2000). Children diagnosed with ADHD demonstrate difficulties in attention, impulse control and motor activity (APA, 2000). In turn, these symptoms result in academic and behavioral impairments in the home, school and community settings (Salmeron, 2009).

The current version of the DSM (DSM-IV-TR, 2000) identifies three subtypes of ADHD: ADHD, predominantly inattentive type (ADHD-IT); ADHD, predominantly hyperactive-impulsive type (ADHD-HIT); ADHD combined type (ADHD-CT). Research has indicated that learning and behavioral disorders occur in conjunction with ADHD. Jensen and colleagues (1997) found that children diagnosed with ADHD were also likely to have diagnoses of other externalizing behavioral disorders. However, other researchers found that children with inattentive forms of ADHD were also more likely to have learning disabilities or internalizing disorders (Biederman, Faraone & Lapey, 1992; & Jensen et al., 1997). Biederman and colleagues (1992) noted that comorbidity with other disorders makes the diagnosis of ADHD even more complicated. Similarly, the subjectivity of the diagnosis, including rating scales and behavioral observations, is problematic.

Research also indicates that there is a strong connection between cognitive factors and ADHD. Barkley (1997) suggested that ADHD is a deficit in behavioral inhibition and has linked the disorder to neuropsychological abilities. Specifically, Barkley theorized that ADHD was the outcome of specific deficits in the cognitive areas of working memory and processing speed.

Previous research has also indicated that a diagnosis of ADHD affects performance on tests of intellectual ability (Barkley, 2000; Mahone et al., 2003). When comparing the performance of children diagnosed with ADHD and those not diagnosed with ADHD, differences in Full Scale IQ (FSIQ) and Index scores on various editions of the Wechsler Intelligence Scale for Children were found. Similarly, it has been documented that students with ADHD earn lower scores on neuropsychological tests, particularly those with measures of processing speed and working memory (Kail & Salthouse, 1994; Kail, 2000).

In 2006, Friedman studied the difference in FSIQ and Index Scores between medicated and non-medicated individuals with ADHD and matched controls. Friedman's findings indicated that there were no differences in FSIQ between groups. However, the non-medicated ADHD group scored significantly lower than their matched controls on the Working Memory Index of the WISC-IV. Further analysis indicated that the ADHD group scored lower than both the medicated ADHD group and non-ADHD controls on the Digit Span subtest.

In 2009, McLaughlin replicated and expanded upon Friedman's research. McLaughlin's research indicated that individuals with ADHD performed significantly lower on subtests associated with the Processing Speed and Working Memory Indices of the WISC-IV. McLaughlin did not find differences between medicated and non-medicated individuals with ADHD in terms of FSIQ or Index scores on the WISC-IV. However, individuals in the non-

medicated ADHD group were more likely to show General Ability Index scores exceeding their Working Memory Index scores, suggesting positive outcomes for medication and working memory. Finally, McLaughlin's study did not find support for medication to improve processing speed.

Additional research is needed to examine more closely the cognitive capacities that might be affected by ADHD and how ADHD might affect performance on measures of intellectual functioning.

Purpose of the Study

The purpose of the current study is to determine whether or not significant differences exist between WISC-IV Full Scale, Index and Subtest scores earned by individuals diagnosed with ADHD and non-ADHD controls. In addition, this study will investigate the performances of ADHD and non-ADHD subjects on measures of working memory and processing speed on the WISC-IV, relative to other measures of cognitive ability, including verbal and nonverbal reasoning. Finally, this study will investigate the impact of medication status (medicated versus non-medicated) on subtest score performance in individuals diagnosed with ADHD.

Literature Review

Origins of ADHD. Although many consider attention deficit-hyperactivity disorder (ADHD) to be a common, present day diagnosis, research has indicated that symptoms of the disorder have been documented for hundreds of years. Dating back to Shakespearean times, a character in the play *King Henry IV* was described as having "a malady of attention" (Barkley, 1997, p. 4). European physicians also documented the hyperactive behaviors of children that appeared to be developmentally inappropriate throughout the mid to late 1800's (Barkley, 1997).

However, it was not until the early 1900s that an English physician, George Still, conducted the first study of 20 children who had demonstrated difficulty controlling their own behaviors. Following this study, the results were presented in a series of three lectures and were later published with the Royal Academy of Physicians (Barkley, 1997). The children involved in the study were described as aggressive, passionate, lawless, inattentive, impulsive and overactive. By modern day standards, many, if not all, of these children may be diagnosed as having ADHD and even Oppositional Defiant Disorder (ODD) (Barkley, 1997).

While Still continued his research in Europe, interest in children with similar behaviors began to stir in North America during the time of the encephalitis epidemics of 1917-1918. Records indicated that children who had suffered brain traumas, brain infections and exposures to toxins also demonstrated behaviors similar to children with ADHD (Barkley, 1997). In the 1950s, interest grew in these behaviors in children, specifically in the poor impulse control and in hyperactivity. A biological link was made, indicating that the behaviors in children, referred to as "hyperkinetic impulse disorder" were due to cortical overstimulation which occurred as a result of poor thalamic filtering of external stimuli as it entered the brain (Barkley, 1997).

In 1968, the American Psychiatric Association (APA) published a second edition to *The Diagnostic and Statistical Manual of Mental Disorders* (DSM-II). This publication included a new condition, referred to as Hyperkinetic Reaction of Childhood or Adolescence. The condition was classified as a Behavioral Disorder and was described as a problem "characterized by over activity, restlessness, distractibility and short attention span, especially in young children; the behaviors usually diminishes in adolescence" (p. 50). The description noted that the conditions were "more stable, internalized and resistant to treatment than transient situational disturbances

but less so than psychoses, neuroses and personality disorders" (p. 50). At the time, a diagnosis of the condition was made when these characteristics were described and/or observed by a parent of the child (Barkley, 1997; Goldstein & Naglieri, 2008).

When the third revision of the DSM was published (DSM-III, American Psychiatric Association, 1980), Hyperkinetic Reaction of Childhood was renamed Attention Deficit Disorder (ADD). With this term came a list of specific symptoms, cutoff scores and more specific diagnostic criteria (Barkley, 1997). The new title also indicated that the disorder was not isolated in regard to children, but rather, behaviors could be observed in individuals of all ages. Seven years later, the disorder was renamed again as Attention Deficit-Hyperactivity Disorder (ADHD), to delineate between individuals who exhibit hyperactivity and those who do not (Barkley, 1997).

The most recent revision of the DSM was published in 2000. In this version, ADHD was further described as a condition with extensive diagnostic criteria, including diagnostic symptoms that must be observed prior to age seven in a manner that is more frequent and severe than developmentally appropriate. In addition, a criterion was added that impairment must be observed in two or more settings with evidence of "clinically significant impairment in social, academic or occupational function" (p. 93).

The current version of the DSM (DSM-IV-TR, 200) identifies three subtypes of ADHD: ADHD, predominantly inattentive type (ADHD-IT); ADHD, predominantly hyperactive-impulsive type (ADHD-HIT); ADHD combined type (ADHD-CT). As outlined in the DSM-IV-TR (APA, 2000), an individual must demonstrate six of the nine symptoms in order to meet diagnostic criteria for diagnosis. The nine possible inattentive symptoms are as follows: (a) fails

to give close attention to details or makes careless mistakes in schoolwork, work, or other activities; (b) has difficulty sustaining attention in tasks or play activities; (c) does not seem to listen when spoken to directly; (d) does not follow through on instructions and fails to finish school work, chores, or duties in the work place; (e) has difficulty organizing tasks and activities; (g) loses things necessary for tasks or activities; (h) is easily distracted by extraneous stimuli; and (i) is often forgetful in daily activities. The nine hyperactive-impulsive characteristics are as follows: (a) fidgets with hands or feet or squirms in seat; (b) leaves seat in classroom or in other situation in which remaining seated is expected; (c) runs about or climbs excessively in situations which it is inappropriate; (d) has difficulty playing or engaging in leisure activities quietly; (e) is often "on the go" or acts as if "driven by a motor;" (f) talks excessively; (g) blurts out answers before questions have been completed; (h) has difficulty awaiting turn, and (i) interrupts or intrudes on others.

According to APA (2000), ADHD is most commonly diagnosed during elementary school when school performance, both behavioral and academic, is compromised. The disorder is typically stable throughout adolescence, with some symptoms, including motor hyperactivity, showing a decrease in later adolescence and adulthood (APA, 2000). Some individuals maintain many symptoms of ADHD throughout their adult lives; yet others continue to exhibit only some of the diagnostic symptoms.

Outcomes associated with ADHD. Children with ADHD present with a number of impairments across various settings. Socially, some children with ADHD may experience difficulty with self-regulation and behavioral inhibition (Hardman, Drew & Egan, 2006). Similarly, some children and adolescents with ADHD may feel a sense of social failure if they

exhibit socially undesirable behaviors, such as restlessness, intrusiveness or verbal outbursts (Salmeron, 2009). Salmeron described a common cycle for some students with ADHD, in which their social isolation leads to further frustration, emotional lability and outbursts, which may continue to push their peers away. As these students enter adolescence, they may demonstrate a greater vulnerability to engage in antisocial behaviors, such as substance abuse and smoking (Culpepper, 2006; DeNisco, Tiago & Kravitz, 2005; Marshal & Molina, 2006).

As previously noted, children and adolescents diagnosed with ADHD often exhibit weaknesses with hyperactivity, inattention, impulsivity and motor activity (APA, 2000). Given these characteristics, students with ADHD are at a higher risk than their non-disabled peers of demonstrating academic struggles (DuPaul & Stoner, 2003). Wolraich and colleagues (2005) also describe a number of academic concerns for students diagnosed with ADHD, including difficulty writing, careless errors on assignments and performance on timed tests that is lower that peers in the classroom. As students move from elementary school to middle school to high school, they are exposed to a greater number of teachers and perhaps have less adult supervision in their education. In addition, the complexity of their homework increases, as do the expectations. For students with ADHD, the academic concerns that were present from a young age may be exacerbated by the increased demands of middle school and high school (Salmeron, 2009).

Barkley (1998) has also noted a number of concerning academic outcomes for students with ADHD. Specifically, he noted that students with ADHD are more likely than their typically developing peers to be retained, suspended and expelled. In longitudinal research, Barkley has followed a large group of subjects, both those with ADHD and those without, finding shocking

outcomes in their education. Throughout the study, approximately three times as many hyperactive students had failed a grade, been suspended or been expelled (Barkley, 1998). At one follow up point, 10 percent of the hyperactive sample had quit school, as compared with none of the normative sample. Barkley also found that the hyperactive sample scored within the lower end of the average range on standardized tests of academic achievement (math, reading and spelling), earning standard scores between 90 and 95 (Barkley, 1998).

Although much research has been conducted on the outcomes of individuals with ADHD, there is also a growing amount of research on the family dynamics and interpersonal conflict associated with ADHD. Salmeron (2009) reported that some siblings reported feeling victimized by their siblings who have diagnoses of ADHD. In addition, other research has noted that parents of children with diagnoses of ADHD have reported feelings of stress, depression and social isolation (Kendall, Leo, Perrin & Hatton, 2005). These parents also reported feelings that they were demonstrating inadequate parenting abilities; they additionally experience a higher rate of divorce (Johnston & Marsh, 2001). Wolraich and colleagues (2005) also discussed the idea that these persistent feelings of inadequacy in addition to the stressors of raising a child with moderate to severe ADHD may result in parent(s) seeking family therapy.

Prevalence of ADHD. An estimated three to seven percent of school-age children are diagnosed with ADHD (APA, 2000). Across the research, prevalence has been reported from two to 18 percent, depending on methodology, population and diagnostic tools utilized. (Rowland, Lesesne & Abramowitz, 2002). Through the 1980s and 1990s, many children and adolescents exhibited characteristics of ADHD, yet remained undiagnosed and untreated. Rates

of referral, diagnosis and treatment have steadily increased in the past two decades, given the influx of research and awareness on the disorder (Goldstein & Naglieri, 2008).

Regarding gender, prevalence of ADHD appears to be higher in males than in females, depending on subtype and setting (APA, 2000). Males are more likely to demonstrate behaviors that are noticeable and more likely to be associated with ADHD, including hyperactivity and aggression. On the other hand, females often demonstrate more inattentive, daydreaming behaviors, which may go unnoticed in the classroom setting (Hardman, Drew & Egan, 2006). In community settings, male to female ratios of ADHD have been estimated at 3:1, and in the clinical setting, the ratios have ranges from 6:1 to 9:1 (Gaub & Carlson, 1997).

ADHD is known in many cultures across the world. Among Western countries, prevalence varies, which APA (2000) attributes more frequently to diagnostic criteria, rather than to the behaviors exhibited by individuals. Worldwide, studies have indicated that prevalence of ADHD is comparable with that in the United States (Anderson, Williams, McGee & Silva, 1987; Brewis, Schmidt & Meyer, 2001).

In 2009, Miller, Nigg and Miller conducted a mini-meta analysis to review the research on the diagnosis of ADHD in African American children. Articles from the past decade were reviewed and the researchers determined that African American youth demonstrated more characteristics of ADHD than their Caucasian peers, as rated by parents and teachers. The researchers proposed several causes for this disparity. First, the authors noted that there may truly be an elevated level of behavioral problems in African American youth. Second, the authors considered differences in social-economic status (SES), with youth in lower SES demonstrating more behavioral problems. However, this possibility was later ruled out when the researchers

noted that previous studies used in the meta-analysis had controlled for SES. A third and final possible cause noted by the authors was that the African American youth exhibit more symptoms of ADHD due to exposure to etiological agents, including low birth weights, lead exposures and other developmental risk factors (Miller, Nigg & Miller, 2009).

The authors continue their meta-analysis with a second conclusion. They note that although African American youth are rated as having a greater number of ADHD symptoms, they are diagnosed with ADHD at two- thirds the frequency as their Caucasian peers (Miller, Nigg & Miller, 2009). The authors suggest that perhaps African American families do not seek or do not have access to treatment for ADHD, and that Caucasian families may have more resources. Finally, the researchers speculate that there could be less parental understanding of ADHD in African American communities, which could lead to lower compliance with treatment plans for children. However, the authors also note that at the time of their publication, there was not sufficient research to support this school of thought (Miller, Nigg & Miller, 2009).

Etiology of ADHD. At the present time, there is no known cause of ADHD. However, there are factors that appear to be at play, given the fact that these factors have resulted in the increased risk of ADHD in children. Research has suggested many indirect causes for ADHD, some with considerable backing, others with minimal support. Genetic and biological factors appear to have the greatest number of theoretical foundations as possible causes of ADHD (Barkley, 1997; Biederman, 2005). There is limited research to support theories such as environmental, dietary and social factors, to name a few others (Barkley, 1997). Although some researchers consider a chaotic household or poor parenting practices to be social factors that

could results in a child being diagnosed with ADHD, more research actually suggests that there is a stronger link to the parent's own ADHD and a genetic component (Frick & Jackson, 1993).

Barkley (1997) typically does not support environmental theories of ADHD. However, he does suggest that a child's environment can provide additional risk for genetic and biological factors already at play. He suggests that comorbid disorders, including ODD, conduct disorder (CD), anxiety and depression, may be more likely. Therefore Barkley concludes that environment does not play a role in causation of ADHD; however, it does have a role in outcome.

Neurological Factors. As previously noted, there has been a wealth of research suggesting that individuals who suffer brain injuries also exhibit difficulties in attention, inhibition, organization, motivation and regulation of emotion (Grattan & Eslinger, 1991). These characteristics are particularly noticeable in individuals with lesions or injuries to the frontal lobes, specifically the prefrontal cortex (Benton, 1991; Heilman, Voeller & Nadeau, 1991; Mattes, 1980).

There has been consistent research to support a neurological basis for ADHD. Symptoms of ADHD are often observed from an early age and have been linked to pre- and postnatal complications and other developmental disorders. Similarly, symptomatology of ADHD often shows a dramatic improvement when stimulant medication is used as treatment, further supporting a neurological link (Barkley, 1997).

Current research indicates that there is often brain dysfunction associated with ADHD. Specifically, structural imagining studies, including magnetic resonance imaging, has

documented the fact that the individuals with ADHD often have a distinctly smaller frontal cortex, cerebellum and subcortical structures (Biederman, 2005). Similarly, Dopheide (2001) noted that the right prefrontal cortex and globus pallidus are typically smaller in children with ADHD. These regions of the brain are responsible for modulating attention, stimulating processing and regulating processing, which is consistent with ADHD symptomatology Dopheide, 2001). Barkley (1998) has reviewed a great deal of research on the neurological factors of ADHD.

There is consistent research indicating that individuals with ADHD have a smaller caudate nucleus than typically developing peers. Researchers have found the left caudate to be smaller than expected in subjects diagnosed with ADHD (Hynd et al., 1993; Filipek, 1997), yet others found the right caudate to be slightly smaller in their ADHD subjects (Castellanos et al., 1996).

Pregnancy and Birth Complications. Research has indicated that fetal distress, forceps delivery, toxemia or eclampsia have resulted in a slightly higher risk of ADHD (Minde, Webb & Sykes, 1968). Similarly, more recent research has indicated that low birth weight can lead to behaviors commonly associated with ADHD, including hyperactivity, inattention, disruptive behavior, and later, poor school adjustment (Breslau et al., 1996; Schothorst & van Engeland, 1996; Sykes et al., 1997). Although low birth weight may increase the risk of ADHD, it is not a sole predictor. Other factors, including the white matter abnormality from birth injuries, also are contributing factors (Whittaker et al., 1997).

Theoretical Conceptualizations of ADHD

As previously noted, there has been a long history that accompanies the current conceptualization of ADHD. What started out as a "malady of attention" (Barkley, 1997) in *King Henry IV,* has evolved as a disorder spanning hundreds of years. Initially, the disorder was considered to be chiefly a childhood condition primarily concerned with motor disregulation and hyperactivity (Barkley, 1997). Throughout the many years of research, the conceptualization of the disorder has adjusted, with the additions of inattentive symptoms (APA, 1980, 2000; Barkley, 1997). At the current time, it is incorporated into the DSM-IV-TR and is one of the most commonly diagnosed disorders in school age children (APA, 2000).

Throughout the evolution of ADHD, many conceptualizations of the disorder have emerged. Currently, two major schools of thought exist on the essentials of the disorder. The first conceptualization is known as the disinhibition model and has been primarily researched by Barkley (1997; 1998). This model focuses on individuals who are diagnosed with ADHD-HIT and ADHD-CT, not those with ADHD-IT (Barkley, 1997). The second model, primarily researched by Rapport and colleagues (2000; 2001), is known as the working memory model.

Disinhibition Model. Barkley developed the disinhibition model under the primary assumption that ADHD is a disorder involving the impairment of inhibition and self-regulation. Because of this assumption, he did not include the individuals diagnosed with ADHD, inattentive type (ADHD-IT). Barkley noted that behavioral inhibition includes three processes: inhibiting the primary response, inhibiting an ongoing response and inhibiting distraction from competing stimuli. Barkley noted that behavioral inhibition can lead to severe impairment of four specific executive functions (nonverbal working memory; internalization of speech; self-regulation of

affect; motivation and arousal, and reconstruction). Impairments in executive functions can be problematic for children and adolescents in home, school, community and social settings (Barkley, 1997). When these primary and secondary problems are combined, they lead to further complications in the motor control area. This manifests in behaviors more commonly associated with ADHD, the hyperactive and impulsive physical outcomes. Barkley (1997) noted that the behavioral inhibitions, self-regulation and associated executive functions are mediated by the prefrontal cortex and interconnected with the striatum. Again, this provides further evidence for neurological link to ADHD.

Working Memory Model. Rapport and colleagues developed a different model for conceptualizing ADHD, which incorporates biological and psychological influences. Specifically, they postulated the following:

> Biological influences (e.g. genetics) give rise to individual differences in the functional properties of neurobiological systems (e.g. dopaminergic-noradrenergic neurotransmission) that are etiologically responsible for the core psychological (cognitive and behavioral) features of ADHD. Peripheral (secondary) features are conceptualized as causal by-products of core features (Rapport et al., 2000).

When Rapport and colleagues refer to the secondary features in the model, they are discussing the outcomes related to ADHD, including academic struggles, poor social skills and strained family relationships. As discussed previously, these outcomes of ADHD can be dramatic and extreme, both on the individual with ADHD and on those around him/her.

Rapport and colleagues discussed the importance of developing interventions that address the psychological (cognitive and behavioral) concerns because they would result in improvements in the peripheral areas (academics, social skills, family relationships). In their research, Rapport and colleagues (2000; 2001) noted that gains in the three main areas (attention, self-control, hyperactivity) accounted for only 20 percent of improvement in one of the peripheral areas (academic achievement). Given this finding, in addition to other research, Rapport and colleagues developed an additional model of ADHD, in which working memory plays an integral role. They suggest that working memory organizes behavior by performing three separate functions, including: (1) generating and holding representations of input stimuli, (2) searching for matches, and (3) accessing and holding onto appropriate behavioral responses to input stimuli (Rapport et al., 2000; 2001). When any of these processes are interrupted, disorganized behavior can result, which is consistent and characteristic of children with ADHD.

In addition, Rapport and colleagues suggest that poor working memory in children with ADHD may also make them more inclined to seek stimulation from other environmental sources. To others, this behavior appears to be hyperactive and impulsive. Based on the model developed by Rapport and colleagues, impulsive behaviors are considered to be disorganized patterns of behaviors stemming from deficits in an individual's working memory. Contrary to Barkley, Rapport and colleagues consider working memory as a core cognitive process of ADHD, with hyperactivity and impulsivity as causal by-products.

These are only two of the many suggested theoretical models of ADHD. Although there has been considerable debate over deficits of the disorder, there does appear to be a general consensus that children with ADHD demonstrate disorganized behavior, difficulty with self-

control and often have weaknesses in cognitive areas (working memory and processing speed). Considerable research has been conducted regarding the links between cognitive functions and ADHD.

Cognitive Functions and ADHD

When considering the diagnostic criteria for ADHD created by the DSM-IV-TR, it is clear that each characteristic is behavioral and can be observed by a neutral party. However, considerable research has emerged linking the disorder with cognitive deficits, including impairments in attention, inhibition and perceptual motor speed (Barkley et al., 1990). In their research, Lahey and colleagues (1998) noted weaknesses in perceptual-motor processing speed in individuals with ADHD. Similarly, other researchers have also noted that ADHD involves neurological deficits in working memory and processing speed (Alloway, Gathercole & Elliot, 2010; Dickerson-Mayes & Calhoun, 2007; Kofler, Rapport, Bolden, Sarver & Raiker, 2010).

Working Memory. As defined by Wechsler test development group (2003), working memory is the capacity to maintain information actively in conscious awareness while performing some operation or manipulation with it, producing a result. Working memory is an integral component of fluid reasoning that is strongly linked to achievement and learning (Baddeley, 2007; Fry & Hale, 1996; Perlow, Jattuso & Moore, 1997).

Various theories and models of working memory have been developed. One of the more widely discussed models of working memory is Baddeley's model, which considers working memory to be a part of short-term memory. In Baddeley's model, working memory is governed by a central executive system which controls two slave systems: the phonological loop and the visuospatial sketchpad (Baddeley, 2003).

The first slave system is the phonological loop, which is responsible for storing phonological information through auditory means. This system is considered to be part of the short term memory, and is housed within the working memory system. Stated simply, the phonological memory stores what an individual hears, and keeps the information in the memory system by rehearsing and reinforcing the new knowledge (Baddeley, 2003). The phonological memory stores individual pieces of information, such as words and sounds. Although specific limits of the capacity of the phonological loop may vary from person to person, the average individual can hold three to four pieces of information from the phonological loop in working memory. However, it is the central executive system that combines these individual words or sounds into full thoughts or sentences (Dehn, 2008). The second slave system in working memory is the visuospatial sketchpad, which retains and retrieves information that is stored visually such as location of specific objects (Baddeley, 2003; Gathercole & Alloway, 2008). Three to four objects can be stored in the visuospatial sketchpad at one time, bringing the total amount of information that can be held in the working memory to between six and eight. If stored efficiently, remaining objects can be retrieved from the long-term memory system. Research has shown that the phonological loop may address the remembrance of detailed information, whereas the visuospatial sketchpad may be responsible for recording patterns and overall trends (Baddeley, 2003).

Kofler, Rapport and colleagues conducted a study in 2010 that examined the relationship between ADHD and working memory. The study included 15 children with ADHD and 14 typically developing children and assessed whether or not the children performed differently on tasks involving their central executive, phonological, and visuospatial storage systems. Results of the study indicated that all participants' attention decreased when processing demands increased

via phonological and visuospatial stimuli. However, the children with ADHD demonstrated significantly greater decreases in attention than their typically developing peers. The children with ADHD were also less attentive in the lowest working memory set size conditions, which were noted to be relatively consistent to set sizes often found in general education classrooms (Kofler et al., 2008). The authors note that the working memory demands created in this study are similar to those required in authentic classroom settings, thereby supporting the generalizability of their findings.

In 2005, a meta-analysis of 26 studies published between 1997 and 2003 was published by Martinussen and colleagues to examine the possible connection between working memory deficits in children and adolescents with diagnoses of ADHD. Their review of past research indicated that individuals with ADHD display weaknesses in various areas of working memory, often comorbid with language learning disorders and cognitive ability deficits. The studies indicated that the effect sizes were larger for spatial storage and spatial central executive working memory deficits than for verbal storage and verbal central executive control deficits. The authors cautioned against over-interpretation of these results, however, because the number of studies included in the analysis was small, especially involving the spatial domains. Still, the authors suggested that children and adolescents with ADHD also struggle academically, which is more likely due to their working memory deficits, rather than solely to inattention.

In 2010, Alloway, Gathercole and Elliot also conducted a study to determine any correlation between working memory and academic achievement in individuals with ADHD. Results from the study indicated that students with ADHD demonstrated greater deficits in working memory and also struggled in academic achievement more frequently than typically

developing controls. The authors also expressed the importance of teachers understanding the needs of individual students in the classroom, particularly when it comes to working memory.

There is a strong correlation between working memory and academic success. Working memory is essential for success across all academic areas, including reading decoding, reading comprehension, written language and mathematics. In particular, executive and verbal working memory abilities play an important part in individuals mastering reading decoding and comprehension skills (Dehn, 2008). In many cases, a well-developed working memory system can be the determining factor between proficient and struggling readers. Specifically, it has been determined that efficient memory and processing abilities are a more significant determination of reading success, rather than the capacity of memory alone (Daneman & Carpenter, 1980). Daneman and Carpenter (1980) also found that individuals with efficient working memory systems are often able to perform at higher levels on reading span and reading comprehension activities due primarily to the speed at which they can take in the new information.

In the field of neuropsychology, there is inconsistency and confusion regarding which intellectual process serves as a coordinator in reading. Although Dehn (2008) notes that working memory serves this purpose, other sources lean towards executive functions fulfilling the role of coordinator of mental capacities involving perceiving, feeling, thinking and acting (McCloskey, 2008). The frontal lobe of the brain houses the executive functions, which cue and direct an individual's ability to plan tasks, persist on tasks, inhibit, shift (transition) from task to task, control emotions, initiate activities, and organize thoughts and belongings (Berninger & Richards, 2002). Research has suggested that the executive functions play a critical role in an individual's reading mastery (Berninger & Richards, 2002; McCloskey, 2008). Some research

also suggests that working memory is a component of executive functions, which would combine Dehn's theories with additional research in neuropsychology (Goia et al., 2000).

Processing Speed. Processing speed is widely known as the rate at which one can quickly and efficiently collect, manipulate, store, retrieve and classify information (Wechsler, 2003). Processing speed and working memory are considered to be interrelated constructs. Clinical research has also suggested a strong relationship between processing speed, working memory and reasoning. Given this information, it is not uncommon that individuals with ADHD who demonstrate a weakness in working memory also exhibit weakness in measures of processing speed (Kleinmann et al., 2005; Rucklidge & Tannock, 2001; Weiler et al., 2000; Weiler et al., 2002).

Kail and colleagues (Kail & Salthouse, 1994; Kail, 1991; Kail, 2000) have summarized research on processing speed and its pertinence to mental capacity. Kail and Salthouse (1994) noted that throughout the lifespan, processing speed plays an integral part in how an individual's cognitive skills develop. In particular, they noted that processing speed is critical in the ability to think, reason, and remember. In 1991, Kail noted that when children and adolescents have been required to respond quickly to motor, perceptual or cognitive tasks, eight to ten year olds responded at a speed that is five to six standard deviations below the average speed for young adults. In addition, 12 and 13 year olds responded at a speed slightly more than one standard deviation below the average speed for young adults. This research suggests that there may be an overall limit to the speed at which children and adolescents can process information. This limit is not thought to be linked to particular tasks or domains, but rather to an individual's processing system as it develops though the lifespan (Kail, 2000).

Since there has been consistent research supporting the relationship between processing speed and neurological development, as well as the research examining the relationship between working memory, processing speed and reasoning, it is critical to assess processing speed in children and adolescents (Kail & Salthouse, 1994), especially those suspected of having ADHD. As noted in the literature, the ability to process information quickly and efficiently may reduce demands on working memory, which further facilitates reasoning. Because of this, processing speed is considered to be a central component of cognition, and is therefore often incorporated into standardized assessments of intelligence.

Stimulant Medication

In 2007, The Child and Adolescent Health Measurement Initiative conducted the National Survey of Children's Health (NSCH) to collect data from parents and caregivers on various aspects of health and day to day medical information. The data were analyzed and posted on a website where the general public can access survey items of particular interest. One question on the survey examined the prevalence of ADD/ADHD and the use of medication. The question asked parents/caregivers to identify if their child fits one of the following descriptions: has ADD/ADHD and is taking medication; has ADD/ADHD but is not taking medication; had ADD/ADHD but not currently; never had ADD/ADHD. Results of the survey indicated that an estimated 4.2 percent of children (approximately 2.75 million individuals) ages two to 17 years who are diagnosed with ADD or ADHD are also taking medication to treat their symptoms. In addition, the survey data indicated that 2.2 percent of children (approximately 1.41 million individuals) ages two to 17 years are diagnosed with ADD or ADHD but do not take medication to manage their symptoms. The NSCH noted that the data should be interpreted with caution, given the fact that unknown values, including responses coded as "refused" or "don't know"

were not included in calculations for prevalence estimates or weighted population counts (HSCH, 2007).

Stimulant Medication and Cognitive Performance

Although a great deal of evidence is present connecting the effect of stimulant medication on behavior, less research exists on the relationship between stimulant medication and cognitive performance. The research that does exist varies, based on the measures and methods utilized in the study. Barkley (1998) found that the effect of stimulant medication on concentration and behavior was significant, but performance on assessments of intelligence was not impacted as significantly. Another study indicated slightly different results; individuals taking stimulants medications performed better on rote tasks, but their performance on tasks that required higher order processing was not impacted (Brown & Borden, 1989).

Livingston and colleagues (1996) found that there were no significant differences in cognitive functioning between medicated and non-medicated children and adolescents who had taken the WISC-R and WISC-III. In that study, both groups had struggled with subtests associated with the Freedom from Distractibility Index. The researchers suggested that some research indicates that stimulant medication improves upon behavioral symptoms of ADHD and cognitive performance in laboratory settings, but that there is minimal long term improvement in neuropsychological or achievement measures. Livingston et al. (1996) suggest several hypotheses for this conclusion. First, they suggest that methodological limitations may have played a part in the results. Second, biological factors may also be involved. Goldstein and Goldstein (1990) have noted that stimulant medications improve the functioning of the subcortical attention centers, but do not as effectively enhance the information processing

components of the cortical areas. Finally, Livingston et al. (1996) suggested that their findings were due to the homeostatic down-regulation of receptors in different sites of the brain. Down-regulation occurs when there is a sudden decrease in the number of excitatory receptors in the brain, often a result of certain medications or exposure to high levels of stress (Preston et al., 2005).

Given the prevalence of ADHD in children and adolescents and the rates of medication use among these individuals, it is important to determine the extent to which the medication impacts test results (Doyle et al., 2000). A medication commonly prescribed to children and adolescents for the treatment of symptoms associated with ADHD is methylphenidate. Again, the research varies on the effect of methylphenidate on IQ scores. Saklofske and Schwean (1993) noted that the drug did not result in any effects on subtest, factor or index scores on the WISC-III. However, Faraone (2003) later found that in the treatment of ADHD, there was a greater effect size for stimulants than for non-stimulants. Specifically, he found that long-acting stimulants having a slightly larger effect size on the Wechsler scales.

As previously discussed, ADHD has significant impacts on cognitive areas, including ADHD. There has been research examining the effects of methylphenidate on working memory, although the results of the research conflict. Several studies have yielded results indicating that methylphenidate improves auditory-verbal working memory and visual-spatial memory (Bedard et al., 2004; Mehta, Goodyer & Shahakian, 2004). However, other studies have suggested the opposite (Rhodes, Coghill & Matthews, 2004). These latter studies, though, measured just one aspect of working memory rather than the four dimensions, thereby limiting the findings.

IQ Tests and Effect of Content on ADHD Subjects

As noted, there is consistent evidence noting cognitive deficits in individuals with ADHD. Sattler (1992) has also suggested that it is appropriate to utilize the Wechsler scales for diagnostic purposes, because they can measure cognitive abilities, including attention, memory, processing speed and visual organization.

Many intelligence tests used today report a general Intelligence Quotient (IQ) score which is intended to indicate an individual's overall level of cognitive functioning. The IQ score is calculated from the various tasks that the individual completes throughout the entire intelligence test. The tasks on IQ tests require sustained attention and attention to details, which are often difficult for individuals with ADHD. As a result, the effects of ADHD may be evident in performance of the cognitive activities used to calculate a general IQ.

WISC-IV and ADHD

The Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) is an individually administered intelligence test for children ages six to 16 years of age. The scale yields a Full Scale IQ Score (FSIQ), based on four indices, including the Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI). Subtests contributing to each index of the WISC-IV measure retrieving and reasoning with verbal information (VCI), reasoning with nonverbal visual information (PRI), speed of processing of visual information (PSI) and working memory applied with auditorily presented verbal information (WMI).

Each index of the WISC-IV consists of two to three core subtests, with additional supplemental subtests for the administrators to use at their discretion. The VCI consists of the

Similarities (SI), Comprehension (CO) and Vocabulary (CO), subtests, which measure crystallized knowledge, verbal reasoning, comprehension and conceptualization of verbal information. The Information (IN) and Word Reasoning (WR) subtests are supplemental subtests to the VCI. The PRI consists of the Block Design (BD), Picture Concepts and Matrix Reasoning (MR) subtests which measure organization and perceptual reasoning applied to nonverbal visual material. Picture Completion (PCM) is a supplemental subtest for the PRI. The WMI is composed of the Digit Span (DS) and Letter Number Sequencing (LNS) subtests, which measure working memory, attention and concentration applied to auditorily presented verbal information. Arithmetic (AR) is a supplemental subtest to the WMI. Finally, the PSI consists of two core subtests, Coding (CD) and Symbol Search (SS), which measure mental and graphomotor processing speed applied with visual information. Cancellation (CS) is included on the WISC-IV as a supplemental subtest for the PSI.

The WISC-IV is thought to incorporate current theories on intelligence, recognizing that intelligence is composed both of overall abilities and of discrete skills (Friedman, 2006). In addition, the WISC-IV includes an increased emphasis on working memory and processing speed as components of general intelligence, when compared with previous editions of the Wechsler scale. For example, processing speed and working memory subtests on the WISC-III accounted for two of the 10 subtests used to calculate the FISQ. However, the WISC-IV processing speed and working memory subtests now account for four of the 10 subtests used to calculate the FSIQ. Because of this increase in emphasis on working memory and processing speed as part of general intelligence on the WISC-IV, in conjunction with the research indicating that individuals with ADHD struggle with tasks requiring working memory, it is very possible that the IQ scores of students with ADHD could be negatively impacted.

During the standardization of the WISC-IV, the test was administered to 89 children who met DSM-IV-TR criteria for ADHD. The children, ages eight to 13, included all ADHD subgroups (ADHD-IT, ADHD-HIT and ADHD-CT). At the time of testing, 64 percent were receiving pharmacological treatment for maintenance of their ADHD symptoms but separate results for medicated and non-medicated groups were not reported. Results for the combined ADHD group indicated a moderate effect size for group mean differences compared with matched controls for the PSI and small effect sizes for the VCI, WMI and FSIQ. At the subtest level, however, larger effect sizes for group mean differences were found for the Coding and Arithmetic Subtests. Modest differences were reported for the other subtests associated with the PSI and WMI. Finally, small effect sizes for group mean score differences were found on Digit Span, Symbol Search, Letter-Number Sequencing and Cancellation.

In addition to these findings, the WISC-IV standardization clinical sample comparisons also indicated that children with ADHD had slightly lower mean FSIQ scores, as compared with their non-ADHD matched controls (97.6 versus 102.7). Although this finding is statistically significant, the effect size (.38) is not large. The WISC-IV standardization sample analyses also showed that the children with ADHD earned their lowest mean index score on the PSI, with the lowest mean subtest score on Coding. Similarly, children with ADHD performed lower as a group than their non-ADHD matched controls on the WMI, with their lowest WMI mean subtest score occurring on Arithmetic.

The WISC-IV Technical and Interpretive Manual (Wechsler, 2003) indicates that further research is necessary to explore children's performance on the WISC-IV, based on their specific subtype of ADHD. Additional research also should be conducted on children who are medicated

for symptoms of ADHD versus non-medicated children with ADHD. It should be noted that data existed regarding medication status of the ADHD sample included in the standardized sample; however, no analyses were reported comparing these two groups.

In 2006, Friedman studied the WISC-IV score profiles of 109 children diagnosed with ADHD. The ADHD subjects were matched with non-ADHD controls. Results indicated that there were no significant group mean differences among FSIQ scores between the ADHD sample and non-ADHD controls. However, Friedman did find that the non-medicated ADHD group performed slightly lower on the WMI than their non-ADHD controls. Within the WMI, the ADHD group earned the lowest mean score on the Digit Span Subtest. Friedman did not find significant group mean differences on measures of processing speed which differed from the previous findings from the WISC-IV standardization clinical sample study. Based on her findings, Friedman recommended further analysis to examine the differences between VCI and WMI in children with ADHD, because her data suggested that statistically significant differences may be present.

In 2009, McLaughlin continued Friedman's research and further examined the effects of ADHD and medication on the cognitive processing of children. Consistent with Friedman, McLaughlin used two ADHD groups and matched controls in her study. The sample consisted of the WISC-IV scores of the children diagnosed with ADHD from the Friedman study and the WISC-IV scores of an additional 100 children diagnosed with ADHD, some medicated and some non-medicated. The Friedman and McLaughlin combined samples produced two groups for study. The first group consisted of children who were being treated with medication for the symptoms of ADHD. The second group consisted of children with ADHD who were not being

treated with medication for the symptoms of ADHD. As was the case with the Friedman study, McLaughlin used the WISC-IV standardization sample data to obtain WISC-IV scores for a sample of matched controls of non-ADHD children.

McLaughlin posed two sets of research questions. The first set re-examined Friedman's research questions, largely finding consistent results. Specifically, McLaughlin did not find significant differences between the mean FSIQ scores of the two ADHD groups and their matched controls. In addition, McLaughlin did not find any significant differences between the mean VCI and PRI scores of the ADHD groups, compared with their matched controls. However, when examining the WMI and PSI scores, statistical comparisons did indicate that the medicated ADHD group has significantly lower scores than their matched controls. In addition, McLaughlin's findings revealed that there were no significant differences found between groups on the verbal reasoning or perceptual reasoning subtests. Also, McLaughlin found that ADHD medicated and non-medicated groups performed comparably on the WISC-IV FSIQ, VCI, PRI, WMI and PSI. Again, these findings were consistent with Friedman's findings. Finally, McLaughlin found that there were no significant differences between the mean subtest scores of the ADHD medicated and non-medicated groups for any of the 10 core WISC-IV subtests.

McLaughlin also posed a second set of questions, based on additional literature review, focusing on executive control deficits as related to working memory, processing speed and ADHD. McLaughlin did not find significant differences between medicated ADHD subjects and their matched controls on the WMI and PSI factors. Regarding comparisons of the WMI score with other index scores, however, McLaughlin found that the non-medicated ADHD group had significantly more cases of VCI scores at least 10 points greater than WMI scores than their

matched controls. In addition, the medicated ADHD group also demonstrated significantly more cases of VCI scores at least 10 points greater than WMI scores when compared with their matched controls. McLaughlin found more cases of PRI scores that were at least 15 points greater than PSI scores in the medicated ADHD group, relative to their non-ADHD matches. McLaughlin also found that there were significantly more participants in the medicated ADHD group with GAI scores (an index score based on the combination of the VCI and PRI scores) that were at least 10 points higher than PSI scores, relative to the non-ADHD matches.

Further, McLaughlin suggested that there may also be differences among cognitive tasks, rather than an overarching relationship of the effect of ADHD on cognitive functioning. This could account for the lack of mean differences in the research. For example, children and adolescents with ADHD may perform better on VCI tasks than on WMI tasks, which would increase the chance of a greater VCI-WMI score split.

McLaughlin also found that among groups, the proportion of students with WMI scores greater than or less than PSI scores were statistically similar. However, the medicated ADHD group was found to have a greater proportion of individuals with VCI scores at least 15 points higher than PRI scores, as compared with the non-ADHD control group. McLaughlin's results did not support one of her hypotheses; she discovered that the proportion of subjects in the non-medicated ADHD group with VCI scores greater than WMI scores was comparable with the proportion of subjects with this difference in the medicated ADHD group. In addition, there were significantly more non-medicated ADHD participants than medicated participants with GAI scores that were at least 30 points greater than WMI scores. Finally, McLaughlin found that there

were significantly more children in the medicated ADHD group with PRI scores greater than PSI scores by at least 10 points.

McLaughlin made recommendations for future research, including further investigation of the VCI/WMI, GAI/WMI, PRI/PSI, GAI/PSI, GAI/PSI split in the sample of children with ADHD by analyzing the frequency of occurrence of subtest score differences.

Research Hypotheses

The present study will replicate and expand on the studies of Friedman (2006) and McLaughlin (2009), who examined mean differences between children with ADHD and non-ADHD controls on a measure of cognitive functioning, and also compared mean differences between medicated ADHD students and non-medicated ADHD students. Friedman's (2006) study was an expansion of work completed during the standardization of the WISC-IV. McLaughlin's study added to the subject pool and expanded on Friedman's work especially as it pertained to the finding that children diagnosed with ADHD demonstrated a higher proportion of VCI-WMI score differences than matched controls.

In the present study, Friedman's and McLaughlin's hypotheses will be evaluated with an enhanced data set. Unlike the Friedman and McLaughlin studies, the current study will examine Subtest pair score differences to determine whether or not ADHD students display a greater proportion of large subtest differences than non-ADHD students. In addition, the current study will examine the Subtest pair score differences of individuals with ADHD who are medicated, versus individuals with ADHD who are not medicated in an effort to explore further the impact of medication on cognitive performance. Results of research conducted to explore the effects of medication on cognitive performance are equivocal, and thus further investigation in this area is

needed. This information could have implication both for the medical and for the educational treatment of children diagnosed with ADHD.

Research Questions

1. Do WISC-IV FSIQ scores differ significantly, based on ADHD diagnosis and medication use?
    a. Is there a significant difference between the mean FSIQ scores of individuals diagnosed with ADHD who are not medicated and their non-ADHD matched controls?
    b. Is there a significant difference between the mean FSIQ scores of individuals diagnosed with ADHD who are medicated and their non-ADHD matched controls?
    c. Is there a significant difference between the mean FSIQ scores of individuals diagnosed with ADHD who are not medicated and individuals diagnosed with ADHD who are medicated?
2. Do WISC-IV Index scores differ significantly, based on ADHD diagnosis and medication use?
    a. Are there significant differences among the mean Index scores of individuals diagnosed with ADHD who are not medicated and their non-ADHD matched controls?
    b. Are there significant differences among the mean Index scores of individuals diagnosed with ADHD who are medicated and their non-ADHD matched controls?

   c. Are there significant differences among the mean Index scores of individuals diagnosed with ADHD who are not medicated and individuals diagnosed with ADHD who are medicated?

3. Do WISC-IV Subtest scores differ significantly, based on ADHD diagnosis and medication use?
   a. Are there significant differences among the mean Subtest scores of individuals diagnosed with ADHD who are not medicated and their non-ADHD matched controls?
   b. Are there significant differences among the mean Subtest scores of individuals diagnosed with ADHD who are medicated and their non-ADHD matched controls?
   c. Are there significant differences among the mean Subtest scores of individuals diagnosed with ADHD who are not medicated and individuals diagnosed with ADHD who are medicated?
4. Do individuals diagnosed with ADHD show a different pattern of score differences than their matched controls when scores on specific WISC-IV Indexes are compared with scores on other WISC-IV Indexes?
   a. How do individuals with ADHD perform on Index level cognitive measures of verbal and perceptual reasoning, relative to their performances on an Index level measure of working memory? (That is, comparing difference between VCI scores and WMI scores and comparing the difference between PRI scores and WMI scores for the ADHD groups and their matched controls.)

b. How do individuals with ADHD perform on Index level cognitive measures of verbal and perceptual reasoning, relative to their performances on measures of processing speed? (That is, comparing the difference between PRI scores and PSI scores and comparing the difference between VCI scores and PSI scores for the ADHD groups and their matched controls.)

c. How do individuals with ADHD perform on Index level cognitive measures of verbal reasoning, relative to their performances on measures of perceptual reasoning? (That is, comparing the differences between VCI scores and PRI scores for the ADHD groups and their matched controls.)

d. How do individuals with ADHD perform on Index level cognitive measures of working memory, relative to their performances on measures of processing speed? (That is, comparing the differences between WMI scores and PSI scores for the ADHD groups and their matched controls.)

5. Do individuals diagnosed with ADHD who are not medicated show a different pattern of score differences than individuals diagnosed with ADHD who are not medicated when scores on specific WISC-IV Indexes are compared with scores on other WISC-IV Indexes?

    a. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting VCI scores with WMI scores and PRI scores with WMI scores?

    b. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting PRI scores with PSI scores and VCI scores with PSI scores?

c. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting VCI scores with PRI scores?

d. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting WMI scores with PSI scores?

6. Do individuals diagnosed with ADHD show a different pattern of score differences than their matched controls when scores on specific WISC-IV Subtests are compared with scores on other WISC-IV Subtests?

    a. How do individuals with ADHD perform on Subtest level cognitive measures of verbal and perceptual reasoning, relative to their performances on Subtest level measures of working memory? (That is, comparing the difference between VCI Subtest scores and WMI Subtest scores and comparing the difference between PRI Subtest scores and WMI Subtest scores for the ADHD groups and their matched controls.)

    b. How do individuals with ADHD perform on Subtest level cognitive measures of verbal and perceptual reasoning, relative to their performances on measures of processing speed? (That is, comparing difference between PRI Subtest scores and PSI Subtest scores and comparing the difference between VCI Subtest scores and PSI Subtest scores for the ADHD groups and their matched controls.)

    c. How do individuals with ADHD perform on Subtest level cognitive measures of verbal reasoning, relative to their performances on measures of perceptual

reasoning? (That is, comparing the differences between VCI Subtest scores and PRI Subtest scores for the ADHD groups and their matched controls.)

   d. How do individuals with ADHD perform on Subtest level cognitive measures of working memory, relative to their performances on Subtest level measures of processing speed? (That is, comparing the differences between WMI Subtest scores and PSI Subtest scores for the ADHD groups and their matched controls.)

7. Do individuals diagnosed with ADHD who are not medicated show a different pattern of score differences than individuals diagnosed with ADHD who are not medicated when scores on specific WISC-IV Subtests are compared with scores on other WISC-IV Subtests?

   a. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting VCI Subtest scores to WMI Subtest scores and PRI Subtest scores with WMI Subtest scores?

   b. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting PRI Subtest scores to PSI Subtest scores and VCI Subtest scores with PSI Subtest scores?

   c. How do non-medicated individuals diagnosed with ADHD perform, relative to medicated individuals diagnosed with ADHD when contrasting VCI Subtest scores to PRI Subtest scores?

   d. How do non-medicated individuals diagnosed with ADHD perform relative to medicated individuals diagnosed with ADHD when contrasting WMI Subtest scores to PSI Subtest scores?

Chapter 2

Method

Because this study is following the research of Friedman (2006) and McLaughlin (2009), the current study will have similar methodology. This study primarily followed the methodologies described in McLaughlin (2009).

Data Source

The current study made use of the archival data set used in the McLaughlin (2009) study, as well as additional data collected for the current study. To obtain the additional data, student files from public school settings were reviewed to obtain WISC-IV scores for students diagnosed with ADHD by a physician or psychologist, who also received a psychoeducational assessment as a part of the school district's educational referral process. Data were collected primarily from the northeastern region of the United States, including Pennsylvania, New Jersey, Delaware and Maryland. Data on students identified as having comorbid disabilities were not systematically excluded from this study. In addition, students with all three subtypes of ADHD (ADHD-IT, ADHD-HIT, and ADHD-CT) were included in the sample.

When the sample was assembled (previous data set and the additional cases collected for this study), the participants were divided into two groups. The first group consisted of students who were not being pharmacologically treated for ADHD at the time of their WISC-IV testing (i.e., the non-medicated group). Students in this group must have had a diagnosis of ADHD, have a WISC-IV Verbal Comprehension Index (VCI) standard score greater than 80, and an indication that medication prescribed for treatment of ADHD was not being taken at the time of

WISC-IV testing. The second group consisted of students who were taking medication for ADHD at the time of the WISC-IV testing. Students in this group must have had a diagnosis of ADHD, had a WISC-IV VCI standard score of 80 or higher and an indication that medication prescribed for the treatment of ADHD was being taken at the time of WISC-IV testing. Medication status was based on information provided in the student's file or parent report. Students taking stimulants, non-stimulants or combinations or medication were included in the study.

Along with the ADHD group, a non-ADHD sample provided additional data. This non-ADHD sample was obtained from The Psychological Corporation's WISC-IV and WISC-Integrated standardization samples. The non-ADHD group was further divided into two groups. One group consisted of non-ADHD subjects that was be matched as closely as possible with the ADHD non-medicated group on the basis of the following variables: chronological age, gender, ethnicity, parent education level (when available), geographic region and Verbal Comprehension Index. The second group was matched with the ADHD medicated group on the same variables.

Confidentiality was assured by removing identifying information including name and date of birth. Only archived data were used. Information was collected using data collection forms, which were secured in a locked file cabinet at all times. Test scores and protocols were collected by the examiner and protected from unauthorized release and access. Since parent(s) of participants already made the decision on medication versus non-medication before the study began, the withholding of treatment to a non-medicated was not an issue. Test scores were interpreted with consideration of contextual and cultural variables, as well as of the limitations of current research and practice related to ADHD.

Variables

Independent Variables. The two independent variables included in this study are: ADHD diagnostic status (ADHD or non-ADHD) and treatment status (ADHD medicated or ADHD non-medicated).

Dependent Variables. Dependent variables will include the 10 WISC-IV core Subtest scaled scores and the differences between specific pairs of Subtest scaled scores.

Overview of the Research Design

WISC-IV scores were assigned to groups, based on the student diagnosis and treatment status. The non-medicated group consisted of students diagnosed with ADHD who were not receiving medication at the time of administration of the WISC-IV. The medicated group consisted of students diagnosed with ADHD who were receiving medication at the time of administration of the WISC-IV.

All cases in the sample were also matched with a control case drawn from the WISC-IV and WISC-Integrated standardization and clinical sample cases. Controls were matched as closely as possible on the basis of VCI Standard Score, age at time of testing, gender, and ethnicity.

Measure and Procedure. Each school psychologist from selected schools was sent a letter requesting participation in the study. Those who opted to participate received permission from their school districts and signed letters of agreement. The school psychologists recorded WISC-IV test scores and demographic information from ADHD students' records on data collection forms that were provided to them. The information requested on the data collection

form includes the following: raw and standard scores of the 10 core WISC-IV subtests, as well as index scores; chronological age of the child; gender; ethnicity; parent education level; diagnosis; treatment status; brand name of medication; dosage and time of medication treatment ADHD subtype; and additional diagnoses. Raw scores were requested so that the accuracy of the reported standard scores could be checked.

The WISC-IV subtest and composite score data were considered interval data and allowed for the comparison of the four groups (medicated, non-medicated, and two control groups) among several variables (mean Index scores, mean Subtest scaled scores and Index and subtest score differences).

The WISC-IV is considered a valid and reliable instrument with sufficient test sensitivity to assess the construct of working memory and processing speed (Sattler, 2001). The theoretical basis of the Wechsler Scales is further supported by its high correlation with the other measures of cognitive abilities, as well as by the appearance of similar subtests on other measures of intelligence (Wechsler, 2003).

Statistical Analysis

Control groups were matched to the ADHD groups as closely as possible on the variables of chronological age, parent education level, ethnicity and Verbal Comprehension Index so that there would be no significant differences on these variables between the controls and their ADHD counterparts.

The ADHD sample was divided into two groups. The first group consisted of students who were taking medication to manage their ADHD symptoms (medicated group) at the time of

testing. The second group consisted of students who were not taking medication to manage their ADHD symptoms (non-medicated group) at the time of testing. Two non-ADHD control groups were created by selecting samples from the archived WISC-IV and WISC-Integrated standardization data sets obtained from The Psychological Corporation. The first non-ADHD sample (Control 1) was matched with the ADHD medicated group, and the second non-ADHD sample (Control 2) was matched with the ADHD non-medicated group.

The data were then combined into a Microsoft Excel spreadsheet, and then exported into an SPSS file. Data were analyzed using the Statistical Package for the Social Sciences (SPSS - 18.0). The significance level for testing was set at .05. Wang's (1996) online significance test for comparing two proportions was utilized for the Fisher's Exact test calculations.

Chapter 3

Results

The results of the statistical tests described in the Statistical Analysis section of Chapter 2 are presented in this chapter. This chapter also includes demographic information of the participants.

Demographics

The sample for this study consisted of 103 males between the ages of 8 and 16 who had been diagnosed with ADHD. These individuals had also received a school district's evaluation, which included the WISC-IV test. The ADHD sample was further separated into two groups. The first group consisted of 50 male participants who were not medicated at the time of WISC-IV testing. The second group consisted of 53 male participants who were medicated for the treatment of ADHD symptomatology at the time of WISC-IV testing.

The Psychological Corporation standardization samples for the WISC-IV and WISC-Integrated served as the data set for the matched controls. This archived sample provided two non-ADHD control groups, consisting of 103 male students between the ages of 8 and 16, residing in the northeast region of the United States of America. Similar to the division of the ADHD group was, the non-ADHD group was divided into two groups. The first group consisted of 50 males who were matched to the non-medicated ADHD group (Control 1). The second group consisted of 53 males and was matched to the ADHD medicated group (Control 2). The control groups were matched as closely as possible in terms of chronological age, gender, ethnicity, level of parent education, and Verbal Comprehension Standard Score.

The data collection sheet included a section in which to select the ADHD subtype for each student. A selection of "unknown" also was included. Of the 103 ADHD students, 24 were identified as ADHD, Inattentive type (23.3%); 9 students were identified as ADHD, Hyperactive-Impulsive type (8.7%), and 51 students were identified as ADHD, Combined type (49.5%). Nineteen students were listed as subtype unknown (18.4%). Table 1 provides a breakdown of ADHD diagnosis by sample group.

Table 1

ADHD Subtypes by Sample Group

	ADHD Subtype			
	Inattentive	Hyperactive-Impulsive	Combined	Unknown
ADHD Non-medicated				
n	19.00	4.00	26.00	1.00
%	38.00	8.00	52.00	2.00
ADHD Medicated				
n	5.00	5.00	25.00	18.00
%	9.40	9.40	47.20	34.00

Brand of medication was indicated for 43 (81%) of the 53 cases reported as medicated ADHD. More than half of the medicated participants were prescribed stimulant medications, including Concerta and Adderall. The breakdown of the ADHD medications were as follows: 16 participants were taking Concerta (37%); 23 participants were taking Adderall (23%); 8 participants were taking Ritalin (18%); 3 participants were taking Straterra (7%); 2 participants

were taking Vyanese (4%); 2 participants were taking Daytrana (4.6%) and one participant took Metadate (2%). Minimal information was provided regarding the times when the students would take their medication and whether or not the medication was immediate release or long-acting. Twenty data forms provided data on the time of day when students would take their medication. Sixteen students were reported to take their medication in the morning and three both in the morning and in the afternoon. One data sheet stated that the medication was taken one time per day, but did not specify the time. Eight data forms provided information on release. Four students received immediate release medication, and four received long-acting medication.

In reviewing the entire ADHD sample, the distribution across ages was fairly even, although the greatest concentration was between ages 8 and 14. The largest proportion of the sample was age 13 (n = 23, 22%). One half (n = 52, 50.2%) of the sample was aged 12 to 16. The controls were matched as closely as possible with their non-ADHD counterparts on chronological age. All subjects were matched within the same year of age. Table 2 provides the frequency distributions for chronological age in each of the four groups (ADHD Non-medicated, Control 1, ADHD Medicated, and Control 2).

Table 2

Frequency Distributions for Age

		Age								
Group		8	9	10	11	12	13	14	15	16
ADHD Non-Medicated										
	n	7.00	6.00	6.00	4.00	7.00	12.00	6.00	2.00	0.00
	%	14.00	12.00	12.00	8.00	14.00	24.00	12.00	4.00	0.00
Control 1□										
	n	7.00	6.00	6.00	4.00	7.00	12.00	6.00	2.00	0.00
	%	14.00	12.00	12.00	8.00	14.00	24.00	12.00	4.00	0.00
ADHD Medicated										
	n	11.00	8.00	6.00	3.00	6.00	11.00	4.00	2.00	2.00
	%	20.80	15.10	11.30	5.70	11.30	20.80	7.50	3.80	3.80
Control 2□										
	n	11.00	8.00	6.00	3.00	6.00	11.00	4.00	2.00	2.00
	%	20.80	15.10	11.30	5.70	11.30	20.80	7.50	3.80	3.80

Note. Age range from 8 to 16 years.

□Control 1 = non-ADHD group matched to ADHD non-medicated group

□Control 2 = non-ADHD group matched to ADHD medicated group

Level of Parent Education was measured in five levels, which ranged from 0-8 years to a college or graduate degree. Parent Education levels were reported for 55 (53.4%) of the ADHD cases. The frequency distributions for Parent Education Levels by group are provided in Table 3.

Table 3

Frequency Distribution for Parent Education Level

	Years of Parent Education					
Group	0-8	9-11	12	13-15	16+	Not Reported
ADHD Non-medicated						
n	0	3	9	8	10	20
%	0.00	6.00	18.00	16.00	20.00	40
Control 1						
n	2	1	14	17	16	0
%	4.00	2.00	28.00	34.00	32.00	0.00
ADHD Medicated						
n	0	3	8	7	7	28
%	0.00	5.70	15.10	13.20	13.20	52.80
Control 2						
n	1	5	14	19	14	0
%	1.90	9.40	26.40	35.80	26.40	0.00

Note. 0-8 = eighth grade education or less; 9-11 = some high school; 12 years = high school or equivalent; 13-15 years = some college or associates degree; 16 or more years = college or graduate degree. Control 1 = ADHD non-medicated control; Control 2 =ADHD medicated control.

In the ADHD non-medicated group, parents were most frequently listed as having a college or graduate degree (20.00%). The highest concentration of parents in the ADHD non-medicated group reported earning a high school diploma or higher (n = 27). Among the ADHD medicated group, parent education levels were slightly lower, with 13.20% of the sample earning college or graduate degrees. Still, the majority of the ADHD medicated group also reported earning a high school diploma or higher (n = 22). Across both groups, no parents indicated that they had an eighth grade education or less. As previously noted, parent education level was collected for 55 of the 103 participants.

The ADHD groups were also matched with the control groups, based on ethnicity. Ethnicity was separated into five groups: Caucasian, African-American, Hispanic, Asian and Other. If no ethnicity was provided, it was counted under "other." Table 4 is a summary of the ethnicity for each of the four groups.

Table 4

Frequency Distribution for Ethnicity

	Ethnicity				
Group	Caucasian	African American	Hispanic	Asian	Other
ADHD Non-medicated					
n	19	21	3	0	10
%	36	40	5	0	19
Control 1					
n	29	11	6	3	1
%	58	22	12	6	2
ADHD Medicated					
n	19	24	0	1	5
%	34	43	0	2	21
Control 2					
n	31	10	8	3	1
%	58	19	15	6	2

As noted in Table 4, between the ADHD groups, Caucasian and African-American individuals composed the majority of the participants in the study. Among the non-medicated ADHD group, African-American individuals presented the highest number of participants (n = 21), with Caucasian individuals presenting just two fewer (n = 19). In the medicated ADHD

group there was a slightly larger spread among the African-American and Caucasian participants, with 24 and 19, respectively. The participants coded as "Other" totaled 10 participants in the non-medicated ADHD sample and 5 participants in the medicated ADHD sample. The Hispanic and Asian participants represented 3 or fewer in each of the ADHD groups.

The ADHD groups were also matched with controls, based on Verbal Comprehension Index scores on the WISC-IV. VCI scores had wide ranges from a low of a standard score of 81 to a standard score of 134. Students who earned a VCI standard score below 80 were not included. VCI means and standard deviations for the four groups are summarized in Table 5.

Table 5

Verbal Comprehension Index Scores by Group

Group	*M*	*SD*
ADHD Non-medicated	97.36	10.91
Control 1	97.86	11.21
ADHD Medicated	101.30	10.28
Control 2	101.30	10.00

Statistical Analysis

The control groups were matched to ADHD groups on the basis of WISC-IV Verbal Comprehension Index score and age. In most cases, ethnicity was matched as well, and in some cases parent education levels also were matched. As noted above, matches were made as closely as possible and no significant differences were found among these variables and the ADHD

counterparts. The data met the assumption of homogeneity of group variances for all study variables. No significant differences were found among the variable variances of the ADHD groups or the ADHD groups and matched controls, which allowed for the use of parametric inferential statistical procedures.

Hypotheses Tests

To test the hypotheses related to mean levels of performances on different Indexes and Subtests, three analyses were conducted:

1. An ANOVA test was conducted to examine the differences among the FSIQ scores of the ADHD non-medicated group and the ADHD medicated group and their respective matched controls.

2. A series of ANOVA tests was conducted to examine the mean differences of the VCI, PRI, WMI, and PSI Index scores of the ADHD non-medicated group and the ADHD medicated group and their respective matched controls.

3. A MANOVA was used to investigate whether or not there were significant differences among the ADHD non-medicated group and the ADHD medicated group and their respective matched controls for the 10 core subtests of the WISC-IV (SI, CO, VO, BD, PCN, MR, DS, LNS, CD, and SS).

To test hypotheses regarding specific Index and Subtest score contrasts among ADHD groups and their respective matched controls, additional procedures were employed consistent with those applied by McLaughlin (2009):

1. Differences between various pairs of Indexes and Subtest were calculated as specified in research questions 4 through 7 to generate separate cumulative frequencies of Index or Subtest score differences (for example, VCI > WMI, WMI > VCI, VO >DS, DS > VO) for the ADHD medicated, ADHD non-medicated, and their matched control groups.

2. From these cumulative percentage frequencies of Index and Subtest differences, n values were tabled for cumulative frequencies of differences at specific values: 10, 15, 20 and 25 point differences for Indexes and 3, 6 and 9 point differences for the ADHD medicated, ADHD non-medicated groups and their matched control groups.

3. Fisher's Exact Test was used to analyze the score differences at each of the specific values (10, 15, 20 and 25 for Indexes; 3, 6, and 9 for Subtests) between the ADHD groups and their matched controls (i.e., non-medicated ADHD and Control Group 1, and medicated ADHD Group and Control Group 2) and between the non-medicated ADHD and medicated ADHD groups.

Results of Statistical Analyses by Research Question

The following section provides the results obtained, organized by research question. Comparisons of mean score performance at the Index level and at the Subtest are presented first, followed by comparisons of relative levels of performance at the Index level and Subtest level.

Research Question 1: Do WISC-IV FSIQ scores differ significantly based on ADHD diagnosis and medication use?

The FSIQ means and standard deviations of the ADHD groups and the matched control groups are presented in Table 6 and the results of the ANOVA are presented in Table 7. The

results of this analysis indicated that there were significant differences in mean FSIQ scores among the groups.

Table 6

FSIQ and Index Score Means and Standard Deviations by Group

	Diagnostic Group							
Index Scores	ADHD-Non Med (N=50)		Control 1 (N=50)		ADHD Med (N=53)		Control 2 (N=53)	
	M	SD	*M*	SD	*M*	SD	*M*	SD
VCI	97.36	10.91	97.86	11.21	101.30	10.28	101.30	10.00
PRI	93.46	11.92	98.68	14.78	100.81	13.72	104.30	13.59
WMI	90.88	12.10	97.10	13.59	96.83	11.69	99.68	13.42
PSI	87.52	12.50	94.06	13.13	93.23	14.54	100. 62	13.44
FSIQ	90.90	11.20	96.54	12.35	98.26	11.34	102.43	11.80

Table 7

Analysis of Variance for FSIQ

$SS_{between}$	SS_{within}	*Df*	$MS_{between}$	MS_{within}	*F*	*Sig*
3157.220	27516.241	3	1172.407	136.219	8.607	.001

Based on the results of the overall ANOVA indicating significant differences among groups, post hoc analyses were conducted using the Least Squares Difference (LSD) test of significance at the .05 level to determine which group means were significantly different. Table 8 contains the results of the post hoc analyses.

Table 8

FSIQ Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-7.36	2.30	0.002*
ADHD non-med vs. Control 1	-5.64	2.33	0.017*
ADHD med vs. Control 2	-4.17	2.27	0.067

Note. Items with an asterisk are statistically significant.

Post hoc analyses indicated a significant difference between ADHD medicated and non-medicated groups, with the ADHD medicated FSIQ group mean of 98.26 being significantly higher than the ADHD non-medicated FSIQ group mean of 90.90. Post hoc analyses also indicated that the matched Control Group 1 FSIQ group mean of 96.54 is significantly higher than the ADHD non-medicated FSIQ group mean of 90.90. Although Control Group 2 FSIQ group mean was higher than the ADHD medicated group by four points, this difference did not reach statistical significance.

Research Question 2: Do WISC-IV Index scores differ significantly based on ADHD diagnosis and medication use?

The Index score means and standard deviations of the ADHD groups and the matched control groups are presented in Table 6 and the results of the ANOVAs are presented in Table 9. The results of these analyses indicated that there were significant differences in mean scores among the groups for the Perceptual Reasoning, Working Memory, and Processing Speed scores. No significant difference was found between the mean scores of the ADHD non-medicated and ADHD medicated groups. As expected, no significant differences were found in the mean scores

of the VCI when comparing ADHD groups with their matched controls because the VCI score was one of the variables used to match control groups with the ADHD groups.

Table 9

Analysis of Variance for WISC-IV Index Scores

	$SS_{between}$	SS_{within}	*Df*	$MS_{between}$	MS_{within}	*F*	*Sig*
VCI	707.60	22687.88	3	235.86	112.32	2.10	.101
PRI	3159.17	37056.58	3	1056.39	183.45	5.76	.001*
WMI	2118.19	32666.80	3	706.06	161.72	4.37	.005*
PSI	4455.38	37887.04	3	1485.13	187.56	7.92	.001*

Note. Items with an asterisk are statistically significant.

Based on the results of the overall ANOVAs indicating significant differences among groups for the PRI, WMI, and PSI, post hoc analyses were conducted using the Least Squares Difference (LSD) test of significance at the .05 level to determine which group means were significantly different. Table 10 contains the results of the post hoc analyses.

Table 10

Index Score Mean Difference Comparisons

PRI Group Comparisons	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-7.35	2.67	0.006*
ADHD non-med vs. Control 1	-5.22	2.71	0.055
ADHD med vs. Control 2	-3.491	2.63	0.186
WMI Group Comparisons	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-5.95	2.51	0.019*
ADHD non-med vs. Control 1	-6.22	2.54	0.015*
ADHD med vs. Control 2	-2.89	2.47	0.250
PSI Group Comparisons	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-5.71	2.70	0.036*
ADHD non-med vs. Control 1	-6.54	2.74	0.018*
ADHD med vs. Control 2	-7.40	2.66	0.006*

Note. Items with an asterisk are statistically significant.

Post hoc analyses of the PRI scores indicated a significant difference between ADHD medicated and non-medicated groups, with the ADHD medicated PRI group mean of 100.81 being significantly higher than the ADHD non-medicated PRI group mean of 93.46. Although the two ADHD groups differed significantly in comparison with each other, neither ADHD groups mean PRI scores differed significantly from the mean PRI scores of their respective matched control groups.

Post hoc analyses of the WMI scores indicated a significant difference between ADHD medicated and non-medicated groups with the ADHD medicated WMI group mean of 96.83 being significantly higher than the ADHD non-medicated WMI group mean of 90.88. Post hoc analyses also indicated that the matched Control Group 1 WMI group mean of 97.10 is significantly higher than the ADHD non-medicated WMI group mean of 90.88. Although Control Group 2 FSIQ group mean was higher than the ADHD medicated group by three points, this difference did not reach statistical significance.

Post hoc analyses of the PSI scores indicated a significant difference between ADHD medicated and non-medicated groups with the ADHD medicated WMI group mean of 93.23 being significantly higher than the ADHD non-medicated WMI group mean of 87.52. Post hoc analyses also indicated that the matched Control Group 1 PSI group mean of 94.06 is significantly higher than the ADHD non-medicated PSI group mean of 87.52 and the matched Control Group 2 PSI group mean of 100.62 is significantly higher than the ADHD non-medicated PSI group mean of 93.23.

Research Question 3: Do WISC-IV Subtest scores differ significantly, based on ADHD diagnosis and medication use?

The Subtest score means and standard deviations of the ADHD groups and the matched control groups are presented in Table 11 and the results of the MANOVA for subtests is presented in Table 12. The results of these analyses indicated that there were significant differences in mean scores among the groups for 6 of the 10 WISC-IV Subtests. Within the Verbal Comprehension Index, a significant difference was found for the Similarities Subtest. Within the Perceptual Reasoning Index, the Block Design and Matrix Reasoning Subtests both

demonstrated significant differences. The Digit Span Subtest of the Working Memory Index demonstrated significant differences as did both the Coding and Symbol Search Subtests of the Processing Speed Index.

Table 11

Subtest Score Means and Standard Deviations by Group

	Diagnostic Group							
	ADHD-Non Med (N=50)		Control 1 (N=50)		ADHD Med (N=53)		Control 2 (N=53)	
Subtest Scores	*M*	SD	*M*	SD	*M*	SD	*M*	SD
SI	10.06	2.60	9.52	2.40	11.02	2.37	10.25	2.39
VO	9.04	2.27	10.08	2.40	9.85	2.19	10.47	2.25
CO	9.78	2.13	9.48	2.61	10.08	2.36	10.23	2.52
BD	8.18	2.63	9.48	2.41	9.42	3.33	11.23	2.74
PCN	9.50	2.30	10.04	2.81	10.64	2.74	10.26	2.60
MR	8.94	2.23	9.78	3.34	10.13	2.67	10.55	2.74
DS	8.60	2.63	9.50	2.63	9.62	2.60	10.49	2.85
DSF	8.03	1.88	10.18	2.97	8.22	1.54	10.65	3.33
DSB	6.21	1.66	9.04	2.53	6.14	1.55	9.94	2.62
LNS	8.52	2.94	9.68	2.92	9.51	1.83	9.62	2.77
CD	7.32	2.41	8.78	2.68	7.83	2.65	9.75	3.06
SS	8.26	2.70	9.12	2.64	9.58	3.23	10.40	2.91

Table 12

Multivariate Analysis of Variance for Subtest Scores

Subtest Scores	*SS*	*Df*	*MS*	*F*	*Sig.*	η^2
SI	59.636	3	19.879	3.374	0.019*	0.048
CO	16.818	3	5.606	0.965	0.410	0.014
VO	55.861	3	18.620	3.597	0.14	0.051
BD	243.547	3	81.182	10.314	0.000*	0.133
MR	71.587	3	23.862	3.113	0.027*	0.044
PCN	35.055	3	11.685	1.704	0.167	0.025
DS	92.350	3	30.783	4.282	0.006*	0.060
LNS	45.155	3	15.052	1.899	0.131	0.027
CD	179.806	3	59.935	8.143	0.000*	0.108
SS	122.970	3	40.990	4.921	0.003*	0.068

Note. Items with an asterisk are statistically significant.

Although these six subtests yielded significant results, effect sizes were small. Tables 13 through 18 provide the results of follow-up analyses to determine which specific group differences reached significance. For each subtest that reflected an overall significant F value in the multivariate analysis, Least Squares Difference analyses were conducted in order to test pair-wise comparisons among group subtest means.

Table 13

SI Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-0.96	0.479	0.046*
ADHD non-med vs. Control 1	0.54	0.485	0.267
ADHD med vs. Control 2	0.77	0.472	0.102

Note. Items with an asterisk are statistically significant.

Table 13 shows the follow-up analyses for the Similarities Subtest. Statistically significant differences were noted among the medicated and non-medicated groups. No significant differences were noted between ADHD non-medicated and Control Group 1 or ADHD medicated and Control Group 2.

Table 14

BD Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-1.24	0.553	0.027*
ADHD non-med vs. Control 1	-1.30	0.561	0.022*
ADHD med vs. Control 2	-1.81	0.545	0.001*

Note. Items with an asterisk are statistically significant.

Table 14 shows the results of the follow-up tests for the Block Design Subtest. Statistically significant differences were noted among all three groups: medicated and non-medicated ADHD groups, the non-medicated ADHD group and their matched controls, and the medicated ADHD group and their matched controls.

Table 15

MR Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-1.19	0.546	0.030*
ADHD non-med vs. Control 1	-0.840	0.554	0.131
ADHD med vs. Control 2	-0.420	0.538	0.441

Note. Items with an asterisk are statistically significant.

Table 15 shows the follow-up analyses for the Matrix Reasoning Subtest. Statistically significant differences were noted among the medicated and non-medicated ADHD groups. No statistically significant results were noted among the non-medicated ADHD group and their matched controls or the medicated ADHD group and their matched controls.

Table 16

DS Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-1.02	0.529	0.054
ADHD non-med vs. Control 1	-0.90	0.536	0.950
ADHD med vs. Control 2	-0.870	0.521	0.097

Table 16 shows the follow-up analyses for the Digit Span Subtest. Statistically significant differences were not noted among any of the group comparisons.

Table 17

CD Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-0.51	0.535	0.341
ADHD non-med vs. Control 1	-1.46	0.543	0.008*
ADHD med vs. Control 2	-1.92	0.527	0.000*

Note. Items with an asterisk are statistically significant.

Table 17 shows the follow-up analyses for the Coding Subtest. Statistically significant differences were noted for the ADHD medicated and non-medicated groups and their matched controls. Statistically significant differences were not noted for the medicated and non-medicated ADHD group.

Table 18

SS Mean Difference Comparisons

Group Comparison	*M Dif.*	*SE*	*Sig.*
ADHD med vs. ADHD non-med	-1.32	0.569	0.021*
ADHD non-med vs. Control 1	-0.86	0.577	0.138
ADHD med vs. Control 2	-0.81	0.561	0.149

Note. Items with an asterisk are statistically significant.

Table 18 shows the follow-up analyses for the Symbol Search Subtest. Statistically significant differences were noted between the medicated and non-medicated ADHD group, but not noted for the ADHD medicated and non-medicated groups compared to their respective matched controls.

Research Question 4: Do individuals diagnosed with ADHD show a different pattern of score differences than their matched controls when scores on specific WISC-IV Indexes are compared with scores on other WISC-IV Indexes compared with *matched controls?*

Research Question 5: Do individuals diagnosed with ADHD who are not medicated show a pattern of score differences different from individuals diagnosed with ADHD who are not medicated when scores on specific WISC-IV Indexes are compared with scores on other WISC-IV Indexes?

To test research questions 4 and 5 involving Index score differences, the following difference scores were calculated: VCI-WMI, PRI-WMI, PRI-PSI, VCI-PSI, VCI-PRI, and WMI-PSI. Cumulative percentiles were then tabled for the differences at the following magnitudes: 10 points, 15 points, 20 points, and 25 points. The cumulative percentiles were converted into n values, which were used to compare for significant differences between group proportions, using Fisher's Exact test. Tables 19 shows the resulting table of cumulative frequencies by group, and Table 20 shows the Fisher's Exact Test results when comparing the difference proportions of the ADHD groups with their respective matched control groups.

Table 19

Cumulative Frequency Percentages of Index Score Differences by Group

	Diagnostic Group			
Index Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
VCI > WMI		Cumulative Percentages		
10 points	62.00	22.00	69.80	22.60
15 points	28.00	16.00	22.60	18.90
20 points	18.00	8.00	13.20	13.20
25 Points	8.00	2.00	7.50	3.80
WMI > VCI				
10 points	8.00	22.00	13.20	24.50
15 points	4.00	10.00	3.80	17.00
20 points	0.00	8.00	0.00	5.70
25 Points	0.00	6.00	0.00	0.00
PRI > PSI				
10 points	40.00	34.00	43.40	34.00
15 points	30.00	24.00	34.00	15.10
20 points	16.00	16.00	22.60	7.50
25 Points	8.00	16.00	15.10	3.80
PSI > PRI				
10 points	6.00	16.00	15.10	15.10
15 points	4.00	10.00	7.50	7.50
20 points	2.00	6.00	5.70	5.70
25 Points	2.00	2.00	3.80	3.80
VCI > PSI				
10 points	52.00	32.00	54.70	24.50
15 points	44.00	20.00	35.80	17.00
20 points	30.00	14.00	24.50	9.40
25 Points	10.00	8.00	13.20	5.70

PSI > VCI				
10 points	8.00	20.00	11.30	30.20
15 points	4.00	12.00	5.70	11.30
20 points	4.00	6.00	5.70	7.50
25 Points	2.00	2.00	0.00	1.90
PRI > WMI				
10 points	28.00	24.00	30.20	32.10
15 points	16.00	20.00	18.90	24.50
20 points	8.00	16.00	13.20	22.60
25 Points	6.00	16.00	7.50	13.20
WMI > PRI				
10 points	20.00	24.00	17.00	22.60
15 points	8.00	16.00	7.50	11.30
20 points	8.00	10.00	1.90	3.80
25 Points	6.00	8.00	0.00	1.90
VCI > PRI				
10 points	26.00	22.00	18.90	11.30
15 points	14.00	6.00	15.10	5.70
20 points	10.00	2.00	7.50	5.70
25 Points	6.00	2.00	7.50	1.90
PRI > VCI				
10 points	10.00	28.00	24.50	28.30
15 points	6.00	18.00	11.30	24.50
20 points	2.00	6.00	5.70	7.50
25 Points	0.00	2.00	3.80	5.70
WMI > PSI				
10 points	34.00	34.00	34.00	20.80
15 points	26.00	22.00	17.00	11.30
20 points	14.00	16.00	11.30	9.40
25 Points	4.00	14.00	9.40	5.70

PSI > WMI				
10 points	14.00	24.00	15.10	32.10
15 points	8.00	14.00	13.20	22.60
20 points	4.00	8.00	11.30	15.10
25 Points	2.00	6.00	7.50	3.80

Table 20

Fisher's z Test of Significance for Index Score Differences by Group

	Diagnostic Group					
Index Score Differences	ADHD Non-Med vs. Control 1 (n= 50)		ADHD Med vs. Control 2 (n = 53)		ADHD Non-Med vs. ADHD Med	
	z value	*p value*	*z value*	*p value*	*z value*	*p value*
VCI > WMI						
10 points	1.75	0.08	4.87	0.01*	-3.25	0.01*
15 points	1.45	0.15	0.48	0.63	0.63	0.53
20 points	1.49	0.14	0.00	1.00	0.67	0.50
25 points	1.38	0.17	0.84	0.40	0.00	1.00
WMI > VCI						
10 points	-1.96	0.05*	-1.49	0.14	-0.86	0.14
15 points	-1.18	0.24	-2.22	0.03*	0.00	1.00
20 points	-1.81	0.05*	-1.76	0.08	--	--
25 points	-1.76	0.08	--	--	--	--
PRI > PSI						
10 points	0.62	0.53	0.99	0.32	-0.35	0.73
15 points	0.67	0.50	2.26	0.02*	-0.43	0.67
20 points	0.00	1.00	2.17	0.03*	-0.85	0.39
25 points	-1.23	0.22	1.99	.046*	-1.12	0.26
PSI > PRI						
10 points	-1.60	0.11	0.00	1.00	-1.60	0.11

15 points	-1.18	0.24	0.00	1.00	-0.77	0.44
20 points	-1.02	0.31	0.00	1.00	-1.02	0.31
25 points	0.00	1.00	0.00	1.00	-0.54	0.59
VCI > PSI						
10 points	2.03	0.04*	3.18	0.01*	-0.28	0.78
15 points	2.57	0.01*	2.20	0.03*	0.84	0.40
20 points	1.93	0.05*	2.07	0.04*	0.62	0.53
25 points	0.35	0.73	1.33	0.18	-0.51	0.61
PSI > VCI						
10 points	-1.73	0.09	-2.40	0.02*	-0.57	0.57
15 points	-1.47	0.14	-1.04	0.30	-0.38	0.70
20 points	-0.46	0.65	-0.39	0.70	-0.38	0.70
25 points	0.00	1.00	-1.05	0.31	1.04	0.30
PRI > WMI						
10 points	0.46	0.65	-0.21	0.83	-0.24	0.81
15 points	-0.52	0.60	-0.71	0.48	-0.38	0.70
20 points	-1.23	0.22	-1.27	0.21	-0.86	0.38
25 points	-1.60	0.11	-0.96	0.34	0.31	0.76
WMI > PRI						
10 points	-0.48	0.63	-0.73	0.47	0.35	0.70
15 points	-1.23	0.22	-0.67	0.51	0.00	1.00
20 points	-0.35	0.73	-0.59	0.56	1.44	0.15
25 points	-0.39	0.70	-1.01	0.32	1.81	0.70
VCI> PRI						
10 points	0.47	0.64	1.09	0.28	0.87	0.39
15 points	1.33	0.18	1.59	0.11	-0.16	0.88
20 points	1.68	0.09	0.39	0.70	0.44	0.64
25 points	1.02	0.31	1.37	0.17	-0.31	0.76
PRI > VCI						
10 points	-2.29	0.02*	-0.44	0.66	-1.94	0.05*

15 points	-1.85	0.07	-1.73	0.08	-0.96	0.34
20 points	-1.02	0.31	-0.39	0.70	-0/96	0.34
25 points	-1.01	0.32	-0.46	0.65	-1.39	0.17
WMI > PSI						
10 points	0.00	1.00	1.53	0.13	0.42	0.67
15 points	0.47	0.64	0.84	0.40	1.16	0.26
20 points	-0.28	0.78	0.32	0.75	0.41	0.68
25 points	-1.74	0.08	0.74	0.46	-1.10	0.27
PSI > WMI						
10 points	-1.28	0.20	-2.06	0.04*	-0.16	0.88
15 points	-0.95	0.34	-1.27	0.21	-0.86	0.39
20 points	-0.84	0.40	-0.57	0.57	-1.39	0.17
25 points	-1.02	0.31	-0.84	0.40	-1.31	0.19

Note. Items with an asterisk are statistically significant.

In terms of scores patterns, some clear trends emerge when the percentages of cases at each difference level are considered. When comparing the VCI-WMI difference scores, ADHD groups consistently had larger percentages of cases showing VCI>WMI than did control groups at each level of analysis (10, 15, 20 and 25 points). The opposite pattern was apparent for WMI>VCI differences, with the control groups consistently showing larger percentages of cases at each level, although the differences were not as large as the VCI>WMI differences in favor of the ADHD groups. When these differences were tested for statistical significance, however, only the VCI>WMI differences at the 10 point level were statistically significant for the ADHD medicated group showing proportionately more cases with VCI>WMI differences than their control group and the ADHD non-medicated group showing proportionately more differences than the medicated group.

When comparing the PRI scores with the PSI scores, the ADHD groups tended to have larger PRI>PSI proportions of cases at each difference level, whereas the groups were very similar in proportions of cases having PSI>PRI differences. When these differences were tested for statistical significance, only the PRI>PSI differences between the ADHD medicated and their control group were found to be significant at the 15, 20 and 25 point levels. None of the PSI>PRI differences reached statistical significance.

When comparing the VCI scores with the PSI scores, the ADHD groups typically demonstrated larger VCI>PSI percentages at most difference levels and the control groups demonstrated larger PSI>VCI proportions in some instances. When tested for statistical significance, both the non-medicated and the medicated ADHD groups showed significantly more VCI>PSI score differences than their respective controls at the 10, 15, and 20 point levels. In contrast, the controls demonstrated a significantly larger proportion of PSI>VCI score differences only at the 10 point level for controls, compared with medicated ADHD.

When comparing the PRI scores with the WMI scores, most of the proportions were roughly equivalent for ADHD and control groups and there were no statistically significant findings. Comparison of the VCI scores with the PRI scores reflected some small differences in proportions in favor of ADHD groups over controls for VCI>PRI and some small differences in proportions in favor of the control groups over the ADHD groups for PRI>VCI, but only the comparison of ADHD non-medicated with ADHD medicate showed a statistically significant result at the PRI>VCI 10 point difference level in favor of ADHD medicated group.

When comparing WMI scores with PSI scores, most of the WMI>PSI difference proportions were roughly equivalent for all groups and only a few of the PSI>WMI comparisons

favored the control groups over the ADHD groups. When tested for statistical significance however, only the PSI>WMI at the 10 point difference level demonstrated a statistically significant proportion in favor of the control group over the medicated ADHD group.

Research Question 6: Do individuals diagnosed with ADHD show a different pattern of score differences than their matched controls when scores on specific WISC-IV Subtests are compared with scores on other WISC-IV Subtests?

Research Question 7: Do individuals diagnosed with ADHD who are not medicated show a different pattern of score differences than individuals diagnosed with ADHD who are not medicated when scores on specific WISC-IV Subtests are compared with scores on other WISC-IV Subtests?

To test the research questions 6 and 7 involving subtest score splits, the following subtest score differences were calculated: VO-DS, SI-DS, CO-DS, VO-LNS, SI-LNS, CO-LNS and BD-DS, BD-LNS, PCN-DS, PCN-LNS, MR-DS, MR-LNS. Cumulative percentiles were then obtained for the differences at the following magnitudes: 3 points, 6 points and 9 points. The cumulative percentiles were converted into n values, which were used to compare for significant differences between group proportions, using Fisher's Exact test. Tables 21 through 28 present the results by group.

Table 21

Frequency of VCI Subtests > WMI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
VO > DS	Cumulative Percentages			
3 points	36.00	26.00	26.40	17.00
6 points	4.00	4.00	3.80	5.70
9 points	0.00	0.00	0.00	0.00
SI > DS				
3 points	40.00	24.00	34.00	22.60
6 points	8.00	2.00	9.40	0.00
9 points	2.00	0.00	1.90	1.90
CO > DS				
3 points	38.00	24.00	22.60	22.60
6 points	8.00	2.00	5.60	9.40
9 points	0.00	0.00	0.00	1.90
VO > LNS				
3 points	22.00	24.00	18.90	30.20
6 points	4.00	6.00	5.70	3.80
9 points	0.00	0.00	1.90	0.00
SI > LNS				
3 points	34.00	20.00	26.40	20.80
6 points	10.00	6.00	13.20	5.70
9 points	0.00	8.00	0.00	0.00
CO > LNS				
3 points	32.00	22.00	30.20	18.90
6 points	6.00	6.00	3.80	9.40
9 points	0.00	0.00	0.00	1.90

Table 22

Fisher's z Test of Significance for VCI Subtests > WMI Subtests by Group

Subtest Score Differences	Diagnostic Group: ADHD Non-Med vs. Control 1 (n= 53)		ADHD Med vs. Control 2 (n = 53)	
	z value	*p value*	*z value*	*p value*
VO > DS				
3 points	1.08	0.28	1.14	0.28
6 points	0.00	1.00	0.46	0.65
9 points	--	--	--	--
SI > DS				
3 points	1.72	0.04*	1.29	0.10
6 points	1.38	0.08	2.29	0.01*
9 points	1.01	0.16	0.00	0.50
CO > DS				
3 points	-0.24	0.59	0.00	0.50
6 points	0.59	0.28	-0.74	0.77
9 points	--	--	-1.01	-0.84
VO > LNS				
3 points	-0.24	0.59	-1.34	0.91
6 points	-0.46	0.68	0.46	0.32
9 points	--	--	1.01	0.16
SI > LNS				
3 points	1.58	0.58	0.69	0.25
6 points	0.74	0.23	1.33	0.10
9 points	-2.04	0.99	--	--
CO > LNS				
3 points	1.13	0.13	1.35	0.09
6 points	0.00	0.50	-1.17	0.88
9 points	--	--	-1.01	0.88

Note. Items with an asterisk are statistically significant.

Table 23

Frequency of WMI Subtests > VCI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
DS > VO	Cumulative Percentages			
3 points	24.40	16.00	20.80	17.00
6 points	4.00	2.00	3.80	3.80
9 points	2.00	0.00	0.00	0.00
DS > SI				
3 points	12.00	16.00	13.20	28.30
6 points	2.00	4.00	1.90	5.70
9 points	0.00	0.00	0.00	0.00
DS > CO				
3 points	10.00	20.00	18.90	35.80
6 points	4.00	4.00	0.00	5.70
9 points	2.00	2.00	0.00	0.00
LNS > VO				
3 points	8.00	16.00	11.30	11.30
6 points	0.00	2.00	0.00	0.00
9 points	0.00	0.00	0.00	0.00
LNS > SI				
3 points	14.00	22.00	5.70	17.30
6 points	0.00	4.00	0.00	3.80
9 points	0.00	2.00	0.00	0.00
LNS > CO				
3 points	12.00	30.00	17.00	11.30
6 points	0.00	4.00	0.00	3.80
9 points	0.00	0.00	0.00	0.00

Table 24

Fisher's z Test of Significance for WMI Subtests > VCI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med vs. Control 1 (n= 53)		ADHD Med vs. Control 2 (n = 53)	
	z value	*p value*	*z value*	*p value*
DS > VO				
3 points	0.10	0.84	0.50	0.69
6 points	0.59	0.72	0.00	0.50
9 points	1.00	0.84	--	--
DS > SI				
3 points	-0.58	0.28	-1.12	0.03*
6 points	-0.59	0.28	-1.02	0.15
9 points	--	--	--	--
DS > CO				
3 points	-1.40	0.08*	-1.96	0.03*
6 points	-0.84	0.20	-1.76	0.04*
9 points	0.00	0.50	--	--
LNS > VO				
3 points	-1.23	0.11	0.00	0.50
6 points	-1.01	0.16	--	--
9 points	--	--	--	--
LNS > SI				
3 points	-1.04	-0.15	-1.84	0.03*
6 points	-1.43	0.08	-1.43	0.08
9 points	-1.01	0.16	--	--
LNS > CO				
3 points	-2.21	0.01*	0.84	0.80
6 points	-1.43	0.08	-1.43	0.08
9 points	--	--	--	--

Note. Items with an asterisk are statistically significant.

As shown in Table 21, and as anticipated, larger proportions of individuals with ADHD displayed VCI subtest greater than WMI subtest score splits of 3 points or more than their matched controls. At the 6 point difference level, there were still more comparisons, with larger proportions of VCI subtests greater than WMI subtests for the ADHD groups than for their matched controls, although fewer than at the 3 point level. At the 9 point difference, there were few individuals who reached this level of difference either in the ADHD group or in their matched controls and, as a result, the ADHD and matched control proportions were close to identical at this level for nearly all subtest pair comparisons.

In Table 23, also as anticipated, Control Groups 1 and 2 displayed larger proportions of WMI subtest greater than VCI subtest score splits of 3 points or more than the ADHD groups. At the 6 point difference level, there were still more comparisons, with larger proportions of WMI subtest scores greater than VCI subtest scores for the matched controls than for the ADHD groups, although fewer than at the 3 point level. At the 9 point difference, there were few individuals who reached this level of difference either in the ADHD groups or in their matched controls. As a result, the ADHD and matched control proportions were close to identical for almost all subtest pair comparisons.

Although trends in the differences of proportions for the ADHD and control groups are consistent with expected differences, Tables 22 and 24 show that most of the differences did not reach statistical significance. The Fisher's Exact Test was utilized in Table 22 to compare the proportion of subjects in each group who displayed greater subtest scores on the VCI than on the WMI at each level (i.e., 3, 6, or 9 points). Two significant scores were found in the Similarities versus Digit Span analysis: one in the non-medicated ADHD group, as compared with Control

Group 1, and one in the medicated ADHD group, as compared with Control Group 2. First, 40% of the non-medicated ADHD group evidenced at least a 3 point split, as compared with 24% of Control Group 1. Second, 9.40% of the individuals in the medicated ADHD group displayed splits of at least 6 points, as compared with zero percent of Control Group 2.

The Fisher's Exact Test was also used to compare the proportion of subjects in each group who displayed greater WMI than VCI subtest score differences, at each level (i.e., 3, 6, or 9 points) as shown in Table 24. This analysis indicated that there were two significant scores in the ADHD non-medicated group as compared with Control 1: First, 10% of the individuals displayed more splits of at least 3 points on the Digit Span versus Comprehension comparison, as compared with 20% of the Control Group 1. Second, on the Letter Number Sequencing versus Comprehension comparison, 12% of the ADHD non-medicated group evidenced at least a 3 point split, as compared with 30% of the Control Group 1.

In the medicated ADHD group, four subtest comparisons were noted as significant. First, in the Digit Span versus Similarities comparison, 13.20% of the medicated ADHD group evidenced at least a 3 point split, as compared with 28.30% of Control Group 2. In the Digit Span versus Comprehension analysis, two significant relationships were found: 18.90% of the medicated ADHD group evidenced at least a 3 point split, as compared with 35.80% of the Control Group 2, and zero percent of the medicated ADHD group evidenced at least a 6 point split, as compared with 5.70% of Control Group 2. Finally, in the Letter Number Sequencing versus Similarities comparison indicated that 5.70% of the medicated ADHD participants evidenced at least a 3 point split, as compared with 17.30% of the Control Group 2.

Table 25

Frequency of PRI Subtests > WMI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
BD > DS	Cumulative Percentages			
3 points	14.00	24.00	13.20	32.10
6 points	0.00	2.00	5.70	9.20
6 points	2.00	0.00	1.90	0.00
BD > LNS				
3 points	20.00	22.00	18.90	41.50
6 points	4.00	8.00	7.50	15.10
9 points	0.00	0.00	1.90	3.80
PCN > DS				
3 points	32.00	28.00	35.80	30.20
6 points	2.00	10.00	7.50	7.50
9 points	0.00	0.00	0.00	0.00
PCN > LNS				
3 points	32.00	28.00	35.80	30.20
6 points	2.00	10.00	7.50	7.50
9 points	0.00	0.00	1.90	1.90
MR > DS				
3 points	22.00	28.00	22.60	24.50
6 points	4.00	2.00	9.40	3.80
9 points	2.00	0.00	0.00	0.00
MR > LNS				
3 points	26.00	22.00	24.50	24.50
6 points	6.00	6.00	9.40	11.30
9 points	2.00	6.00	3.80	3.80

Table 26

Fisher's z Test of Significance for PRI Subtests > WMI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med vs. Control 1 (n = 50)		ADHD Med vs. Control 2 (n = 53)	
	z value	*p value*	*z value*	*p value*
BD > DS				
3 points	1.27	0.20	2.32	0.02*
6 points	1.01	0.32	0.74	0.74
9 points	1.01	0.32	1.00	0.32
BD > LNS				
3 points	0.25	0.81	2.54	0.01*
6 points	0.84	0.40	1.23	0.22
9 points	--	--	0.59	0.56
PCN > DS				
3 points	0.44	0.66	0.62	0.54
6 points	1.68	0.09	0.00	1.00
9 points	--	--	--	--
PCN > LNS				
3 points	0.44	0.66	0.62	0.54
6 points	1.68	0.09	0.00	1.00
9 points	--	--	0.00	1.00
MR > DS				
3 points	0.69	0.49	0.23	0.82
6 points	0.59	0.59	1.27	0.24
9 points	1.01	0.32	--	--
MR > LNS				
3 points	0.47	0.64	0.00	1.00
6 points	0.00	1.00	0.32	0.75
9 points	1.02	0.31	0.00	1.00

Table 27

Frequency of WMI Subtests > PRI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
DS > BD		Cumulative Percentages		
3 points	24.00	18.00	24.50	15.10
6 points	10.00	6.00	3.80	1.90
9 points	2.00	0.00	0.00	0.00
LNS > BD				
3 points	24.00	24.00	22.60	11.30
6 points	2.00	6.00	7.50	1.90
9 points	0.00	2.00	0.00	0.00
DS > PCN				
3 points	12.00	24.00	9.40	26.40
6 points	2.00	4.00	1.90	5.70
9 points	0.00	2.00	0.00	1.90
LNS > PCN				
3 points	14.00	22.00	11.30	22.60
6 points	0.00	8.00	0.00	3.80
9 points	2.00	2.00	0.00	0.00
DS > MR				
3 points	20.00	28.00	20.80	22.60
6 points	0.00	2.00	0.00	1.90
9 points	2.00	0.00	0.00	0.00
LNS > MR				
3 points	18.00	22.00	15.10	11.30
6 points	0.00	4.00	0.00	1.90
9 points	0.00	0.00	0.00	0.00

Table 28

Fisher's z Test of Significance for WMI Subtests > PRI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med vs. Control 1 (n = 50)		ADHD Med vs. Control 2 (n = 53)	
	z value	*p value*	*z value*	*p value*
DS > BD				
3 points	0.74	0.77	1.22	0.89
6 points	0.77	0.77	0.58	0.72
9 points	1.01	0.84	--	--
LNS > BD				
3 points	0.00	0.05	1.55	0.94
6 points	-1.02	0.15	1.37	0.92
9 points	-1.00	0.16	--	--
DS > PCN				
3 points	-1.56	0.06	-2.28	0.01*
6 points	-0.59	0.28	-1.02	0.15
9 points	-1.00	0.16	-1.00	-0.16
LNS > PCN				
3 points	-1.04	0.15	-1.55	0.60
6 points	-2.04	0.02*	-1.43	0.08
9 points	0.00	0.50	--	--
DS > MR				
3 points	-0.94	0.17	-0.24	0.41
6 points	-1.00	0.16	-1.00	0.16
9 points	1.01	0.84	--	--
LNS > MR				
3 points	-0.50	0.31	0.57	0.72
6 points	-1.43	-0.08	-1.00	-0.16
9 points	--	--	--	--

Table 25 presents the results of the PRI subtest and WMI subtest score splits, which were anticipated to be equivalent. In the medicated ADHD group, several proportions met this expectation across all levels (3, 6 and 9 points). Also, there were additional proportions in both ADHD groups where the proportions were roughly equivalent to their matched controls. Again, this occurred across all levels – 3, 6 and 9 points. Only two comparisons were found to deviate significantly from the expected pattern of results. In the medicated ADHD group, the Block Design > Digit Span comparison, 13.20% of the medicated ADHD group exhibited at least a 3 point split, as compared with 32.10% of Control Group 2. In the Block Design > Letter Number Sequencing comparison, 18.90% of the medicated sample displayed at least a 3 point split, as compared with 41.50% of Control Group 2.

Table 27 presents the results from the WMI subtest greater than the PRI subtest score splits. As expected, the ADHD groups and their matched controls generally displayed equivalent proportions of WMI subtest score minus PRI subtest score splits. This pattern was displayed relatively equally across all three levels (3, 6 and 9 points). As a result, the ADHD and matched control proportions were close to identical for many of the subtest pair comparisons. As shown in Table 25, only a few of the comparisons were not consistent with expectations. The Fisher's Exact Test yielded one significant result for the non-medicated ADHD group. In the Letter Number Sequencing > Picture Concepts comparison, zero percent of the non-medicated ADHD group displayed at least a 6 point split, as compared with 8% of Control Group 1. In the Digit Span > Picture Concepts comparison, 9.40% of the medicated ADHD group displayed a 6 point split, as compared with 26.40% of Control Group 2.

To further test the research questions and hypotheses of ADHD diagnosis and subtest score splits related to PRI and PSI, the following variables were calculated: BD-CD, BD-SS, PCN-CD, PCN-SS, MR-CD, MR-SS. To reflect the differences between the VCI and PSI, the following variables were also calculated: SI-CD, SI-SS, VO-CD, VO-SS, CO-CD, CO-SS. Cumulative percentiles were then obtained for the differences at the following magnitudes: 3 points, 6 points, and 9 points. The cumulative percentiles were converted into n values, which were used to compare the significance between proportions, using Fisher's Exact test. Tables 29 through 32 present the results with z values and significant levels by group.

Table 29

Frequency of PRI Subtests > PSI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
BD > CD	Cumulative Percentages			
3 points	30.00	30.00	39.60	37.70
6 points	6.00	4.00	11.30	7.70
9 points	0.00	0.00	1.90	1.90
BD > SS				
3 points	22.00	18.00	24.50	24.50
6 points	4.00	2.00	7.50	3.80
9 points	0.00	0.00	1.90	1.90
PCN > CD				
3 points	48.00	34.00	43.40	28.30
6 points	12.00	10.00	26.40	3.80
9 points	0.00	0.00	3.80	0.00
PCN > SS				
3 points	40.00	28.00	35.80	22.60
6 points	6.00	10.00	13.20	5.70
9 points	2.00	0.00	1.90	1.90
MR > CD				
3 points	36.00	34.00	47.20	28.30
6 points	0.00	12.00	17.00	9.40
9 points	0.00	0.00	1.90	3.80
MR > SS				
3 points	30.00	26.00	30.20	32.60
6 points	6.00	14.00	13.20	0.00
9 points	0.00	2.00	3.80	1.90

Table 30

Fisher's z Test of Significance for PRI Subtests > PSI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
BD > CD				
3 points	0.00	0.50	0.20	0.42
6 points	0.46	0.32	0.66	0.25
9 points	--	--	0.00	1.00
BD > SS				
3 points	0.76	0.22	0.00	1.00
6 points	0.59	0.28	0.84	0.40
9 points	--	--	0.00	1.00
PCN > CD				
3 points	1.21	0.01*	1.62	0.11
6 points	0.32	0.37	3.25	0.00*
9 points	--	--	1.43	0.15
PCN > SS				
3 points	1.21	0.01*	1.49	0.14
6 points	-0.74	0.77	1.33	0.18
9 points	--	--	0.00	1.00
MR > CD				
3 points	0.21	0.42	2.01	0.05
6 points	-2.53	0.99	1.15	0.25
9 points	--	--	0.59	0.56
MR > SS				
3 points	0.45	0.33	0.21	0.83
6 points	-1.33	0.91	2.74	0.01*
9 points	-1.00	0.84	0.59	0.56

Note. Items with an asterisk are statistically significant.

Table 31

Frequency of PSI Subtests > PRI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
CD > BD	Cumulative Percentages			
3 points	6.00	14.00	17.00	9.40
6 points	0.00	0.00	1.90	1.90
9 points	2.00	0.00	0.00	0.00
SS > BD				
3 points	14.00	14.00	30.20	9.40
6 points	4.00	4.00	11.30	1.90
9 points	2.00	0.00	1.90	0.00
CD > PCN				
3 points	8.00	14.00	7.50	18.90
6 points	2.00	0.00	0.00	0.00
9 points	0.00	0.00	0.00	3.80
SS > PCN				
3 points	12.00	12.00	17.00	22.60
6 points	0.00	6.00	5.70	5.70
9 points	2.00	0.00	1.90	1.90
CD > MR				
3 points	4.00	12.00	3.80	17.00
6 points	2.00	6.00	0.00	0.00
9 points	0.00	0.00	0.00	0.00
SS > MR				
3 points	12.00	22.00	24.50	24.50
6 points	0.00	6.00	3.80	1.90
9 points	2.00	0.00	1.90	0.00

Table 32

Fisher's z Test of Significance for PSI Subtests > PRI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
CD > BD				
3 points	-1.33	0.09	1.16	0.88
6 points	--	--	0.00	0.50
9 points	1.01	0.84	--	--
SS > BD				
3 points	0.00	0.50	2.69	0.99
6 points	0.00	0.50	1.95	0.97
9 points	1.01	0.84	1.01	0.84
CD > PCN				
3 points	-0.96	0.17	-1.73	0.04*
6 points	1.01	0.84	--	--
9 points	--	--	-1.43	0.08
SS > PCN				
3 points	0.00	0.50	-0.72	0.24
6 points	-1.76	0.40	--	--
9 points	1.01	0.84	-1.43	0.08
CD > MR				
3 points	-1.47	0.07	-2.23	0.01*
6 points	-1.02	0.15	--	--
9 points	--	--	--	--
SS > MR				
3 points	-1.33	0.09	0.00	0.50
6 points	-1.76	0.04	0.58	0.72
9 points	1.01	0.84	1.01	0.84

Note. Items with an asterisk are statistically significant.

In Table 29, as anticipated, larger proportions of individuals with ADHD displayed PRI subtest scores greater than PSI subtest score differences of 3 points or more than their matched controls. At the 6 point difference level there were still more comparisons with larger proportions of PRI subtest greater than PSI subtest for the ADHD groups than for their matched controls. There were several individuals who met the 9 point difference either in the ADHD group or in the matched controls. As a result, the ADHD and matched control proportion were either almost identical in proportion or met the expectation that the ADHD group displayed a greater proportion of 9 point score splits than the matched control.

Although the results in Table 29 were generally consistent with expectations, most of the subtest difference proportions did not reach a level of statistical significance. In the case of the Picture Concepts > Coding subtest score differences, 48% of the non-medicated ADHD group evidenced at least a 3 point split, and 34% of Control Group 1 evidenced the same split. Then, in the case of the Picture Concepts > Symbol Search subtest score differences, 40% and 28% of the non-medicated ADHD and Control Group 1 evidenced the 3 point split or greater, respectively. In the medicated ADHD group, one score split was found to be significant. In the case of the Matrix Reasoning > Symbol Search comparison, 13.20% of the medicated ADHD sample evidenced at least a 6 point split, as compared with zero percent of Control Group 2.

In Table 31, also as anticipated, Control Groups 1 and 2 displayed larger proportions of PSI subtest greater than PRI subtest score splits of 3 points or more than did the ADHD groups. When Control Groups 1 and 2 did not display a greater score split than the ADHD groups, the scores were often equivalent. At the 6 point difference level, there were still comparisons, with larger proportions of PSI subtest greater than PRI subtest differences for the matched controls

than for the ADHD groups, although far fewer than at the 3 point level. At the 9 point difference level, only one subtest pair met the expected relationship either in the ADHD groups or in their matched controls. The remaining subtest pair comparisons were close to identical for almost all subtest pair comparisons.

Follow-up Fisher's Exact Test, presented in Table 32, found statistically significant results in two areas. First, for the Coding > Picture Concepts, 7.50% of the medicated ADHD group demonstrated at least a 3 point split, as compared with 18.90% of Control Group 1. Second, for the Coding > Matrix Reasoning comparison, 3.80% of the medicated ADHD group demonstrated at least a 3 point split, as compared with 17.00% of Control Group 2.

Table 33

Frequency of VCI Subtests > PSI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
SI > CD	Cumulative Percentages			
3 points	56.00	26.00	52.80	30.20
6 points	28.00	6.00	28.30	7.50
9 points	0.00	0.00	3.80	3.80
SI > SS				
3 points	44.00	30.00	37.70	22.60
6 points	16.00	8.00	17.00	9.40
9 points	0.00	0.00	3.80	1.90
VO > CD				
3 points	36.00	32.00	39.60	34.00
6 points	8.00	8.00	22.60	7.50
9 points	2.00	0.00	0.00	0.00
VO > SS				
3 points	26.00	28.00	24.50	20.80
6 points	2.00	6.00	11.30	0.00
9 points	0.00	0.00	1.90	1.90
CO > CD				
3 points	50.00	30.00	49.10	22.60
6 points	16.00	8.00	11.30	11.30
9 points	0.00	0.00	1.90	0.00
CO > SS				
3 points	36.00	30.00	26.40	26.40
6 points	8.00	6.00	13.20	5.70
9 points	0.00	2.00	0.00	3.80

Table 34

Fisher's z Test of Significance for VCI Subtests > PSI Subtests by Group

Subtest Score Differences	Diagnostic Group: ADHD Non-Med vs. Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
SI > CD				
3 points	3.05	0.00*	2.36	0.02*
6 points	2.93	0.00*	2.38	0.02*
9 points	--	--	0.00	1.00
SI > SS				
3 points	1.45	1.15	1.69	0.09
6 points	1.23	0.22	1.15	0.25
9 points	--	--	0.58	0.56
VO > CD				
3 points	0.42	0.67	0.60	0.55
6 points	0.00	1.00	2.17	0.03*
9 points	1.43	0.15	--	--
VO > SS				
3 points	0.23	0.82	2.84	0.01*
6 points	1.02	0.31	0.00	1.00
9 points	--	--	1.01	0.32
CO > CD				
3 points	2.04	0.04*	2.84	0.01*
6 points	1.23	0.22	0.00	1.00
9 points	--	--	1.01	0.32
CO > SS				
3 points	0.64	0.52	0.00	1.00
6 points	0.39	0.69	1.33	0.18
9 points	1.01	0.32	1.43	0.15

Note. Items with an asterisk are statistically significant.

Table 35

Frequency of PSI Subtests > VCI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
CD > SI	Cumulative Percentages			
3 points	10.00	10.00	0.00	20.80
6 points	0.00	6.00	0.00	3.80
9 points	0.00	0.00	0.00	0.00
SS > SI				
3 points	12.00	24.00	7.50	28.50
6 points	4.00	2.00	1.90	5.70
9 points	0.00	0.00	0.00	0.00
CD > VO				
3 points	8.00	10.00	7.50	11.30
6 points	4.00	2.00	0.00	1.90
9 points	0.00	0.00	0.00	0.00
SS > VO				
3 points	10.00	14.00	20.80	22.60
6 points	0.00	2.00	1.90	3.80
9 points	2.00	0.00	0.00	0.00
CD > CO				
3 points	4.00	14.00	20.80	22.60
6 points	0.00	2.00	1.90	3.80
9 points	2.00	0.00	0.00	0.00
SS > CO				
3 points	0.00	20.00	18.90	24.50
6 points	4.00	2.00	5.70	9.40
9 points	0.00	0.00	1.90	0.00

Table 36

Fisher's z Test of Significance for PSI Subtests > VCI Subtests by Group

Subtest Score Differences	Diagnostic Group: ADHD Non-Med vs. Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
CD > SI				
3 points	0.00	1.00	3.51	0.00*
6 points	1.76	0.08	1.43	0.15
9 points	--	--	--	--
SS > SI				
3 points	1.56	0.12	2.79	0.01*
6 points	0.59	0.58	1.02	0.31
9 points	--	--	--	--
CD > VO				
3 points	0.35	0.73	0.67	0.50
6 points	0.59	0.58	1.76	0.80
9 points	--	--	--	--
SS > VO				
3 points	0.62	0.54	0.23	0.82
6 points	1.00	0.32	0.00	1.00
9 points	1.00	0.32	--	--
CD > CO				
3 points	1.75	0.08	0.67	0.50
6 points	1.43	0.15	1.01	0.31
9 points	--	--	--	--
SS > CO				
3 points	3.33	0.00*	0.70	0.48
6 points	0.58	0.58	0.70	0.48
9 points	--	--	1.01	0.31

Note. Items with an asterisk are statistically significant.

Table 33 presents the comparison between VCI subtest scores greater than PSI subtest scores. As predicted, many of these subtest score pairs are roughly equivalent. At the 3 point difference level, several subtest pairs met expectations and presented with nearly equal proportions between the ADHD groups and their matched controls for the VCI subtest > PSI subtest comparisons. At the 6 point difference level, there were still a number that met this expectation, although only half as many as at the 3 point difference level. A similar trend occurred at the 9 point difference level, such that the ADHD groups and matched control proportions met expectations and were either equal to or roughly equivalent for nearly all subtest pair comparisons.

Fisher's Exact Test found three comparisons reaching statistical significance in each of the ADHD groups for the data presented in Table 33. The significance data is presented in Table 34. In the non-medicated group, a significance difference was found for the Similarities > Coding score comparison at both the 3 and the 6 point levels. At the 3 point level, 56% of the non-medicated ADHD group evidenced the split, as compared with 26% of Control Group 1. At the 6 point level, 28% of the non-medicated ADHD group evidenced the split, as compared with 6% of Control Group 1. In the Comprehension > Coding score comparisons, 16% of the non-medicated ADHD group evidenced a 6 point split, as compared with 8% of Control 1. In the medicated ADHD group, the Similarities > Coding comparison again yielded two significant results. At the 3 point level, 52.80% of the medicated ADHD group displayed the split, as compared to 30.20% of Control Group 2. At the 6 point level, 24.50% of the medicated ADHD group displayed the split, as compared with 20.80% of Control Group 2.

In Table 35, also as anticipated, both ADHD groups and Control Groups displayed roughly equivalent proportions of individuals demonstrating PSI subtest > VCI subtest and equivalent proportions of VCI subtests > PSI subtests. This expected pattern of results occurred with great frequency at the 3, 6 and 9 point difference level. Although the expected pattern was evident at all point difference levels, it occurred most frequently at the 6 point level. At the 9 point difference, there were fewer occurrences, although the comparisons of ADHD and matched control proportions that were equivalent still fit the expected pattern.

The follow up Fisher's Exact Test results, presented in Table 36, indicated that three statistically significant relationships were found. For the Symbol Search > Coding comparison, zero percent of the non-medicated ADHD group displayed a 3 point split or greater, as compared with 20.00% of Control Group 1. For the Coding > Similarities comparison, zero percent of the medicated ADHD group displayed a 3 point split or greater, as compared with 20.80% of Control Group 2. Finally, for the Symbol Search > Similarities comparison, 7.50% of the medicated ADHD group evidenced a 3 point split or greater, as compared with 28.50% of Control Group 2.

To further test the research questions and hypotheses of ADHD diagnosis and subtest score splits related to VCI and PRI, the following variables were calculated: SI-BD, SI-PCN, SI-MR, VO-BD, VO-PCN, VO-MR, CO-BD, CO-PCN, CO-MR. Cumulative percentiles were then obtained for the differences at the following magnitudes: 3 points, 6 points and 9 points. The cumulative percentiles were converted into n values, which were used to compare the significance between proportions, using Fisher's Exact test. Tables 37 through 40 present the results with z values and significant levels by group.

Table 37

Frequency of VCI Subtests > PRI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
SI > BD		Cumulative Percentages		
3 points	36.00	16.00	41.50	11.30
6 points	12.00	0.00	11.30	3.80
9 points	9.00	0.00	1.90	1.90
SI > PCN				
3 points	24.00	10.00	22.60	22.60
6 points	6.00	4.00	9.40	9.40
9 points	0.00	0.00	0.00	1.90
SI > MR				
3 points	36.00	24.00	28.30	11.30
6 points	4.00	0.00	11.30	5.70
9 points	0.00	2.00	0.00	1.90
VO > BD				
3 points	26.00	24.00	28.30	11.30
6 points	4.00	2.00	7.50	1.90
9 points	0.00	0.00	1.90	0.00
VO > PCN				
3 points	12.00	16.00	13.20	22.60
6 points	0.00	4.00	1.90	1.90
9 points	0.00	2.00	0.00	0.00
VO > MR				
3 points	16.00	26.00	17.00	11.30
6 points	2.00	2.00	1.90	3.80
9 points	0.00	0.00	0.00	1.90

CO > BD				
3 points	32.00	26.00	30.20	17.00
6 points	10.00	2.00	9.20	5.70
9 points	0.00	0.00	1.90	0.00
CO > PCN				
3 points	20.00	12.00	20.80	22.60
6 points	0.00	4.00	1.90	5.70
9 points	0.00	0.00	0.00	0.00
CO > MR				
3 points	26.00	26.00	26.40	11.30
6 points	0.00	2.00	1.90	3.80
9 points	0.00	0.00	0.00	1.90

Table 38

Fisher's z Test of Significance for VCI Subtests > PRI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med vs. Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
SI > BD				
3 points	2.28	0.02*	3.53	0.00*
6 points	2.53	0.01*	1.46	0.14
9 points	2.17	0.03*	0.00	1.00
SI > PCN				
3 points	1.86	0.06	0.00	1.00
6 points	0.46	0.65	0.00	1.00
9 points	--	--	1.00	0.32
SI > MR				
3 points	1.31	0.19	2.19	0.03*
6 points	1.42	0.15	1.03	0.30
9 points	1.01	0.32	1.01	0.32
VO > BD				
3 points	0.23	0.82	2.19	0.03*
6 points	0.59	0.56	1.36	0.17
9 points	--	--	1.01	0.32
VO > PCN				
3 points	0.58	0.56	1.26	0.21
6 points	1.42	0.15	0.00	1.00
9 points	1.01	0.32	--	--
VO > MR				
3 points	1.22	0.22	0.84	0.40
6 points	0.00	1.00	0.58	0.56
9 points	--	--	1.01	0.32

CO> BD				
3 points	0.66	0.51	1.60	0.11
6 points	1.68	0.09	0.69	0.49
9 points	--	--	1.01	0.32
CO > PCN				
3 points	1.09	0.28	0.23	0.82
6 points	1.42	0.15	2.29	0.02*
9 points	--	--	--	--
CO > MR				
3 points	0.00	1.00	1.99	0.04*
6 points	1.01	0.32	0.60	0.56
9 points	--	--	1.01	0.32

Note. Items with an asterisk are statistically significant.

Table 39

Frequency of PRI Subtests > VCI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
BD > SI		Cumulative Percentages		
3 points	6.00	16.00	9.40	35.80
6 points	0.00	4.00	3.80	5.70
9 points	0.00	0.00	1.90	1.90
PCN > SI				
3 points	8.00	22.00	20.80	22.60
6 points	0.00	0.00	3.80	5.70
9 points	0.00	0.00	0.00	0.00
MR > SI				
3 points	12.00	10.00	15.10	20.80
6 points	4.00	6.00	3.80	5.70
9 points	0.00	0.00	0.00	0.00
BD > VO				
3 points	12.00	10.00	15.10	20.80
6 points	0.00	2.00	5.70	7.50
9 points	0.00	0.00	1.90	0.00
PCN> VO				
3 points	28.00	14.00	30.20	18.90
6 points	0.00	4.00	1.90	1.90
9 points	0.00	0.00	0.00	0.00
MR > VO				
3 points	8.00	20.00	24.50	15.10
6 points	0.00	2.00	5.70	1.90
9 points	0.00	0.00	0.00	0.00

BD > CO				
3 points	14.00	28.00	26.40	20.80
6 points	0.00	6.00	7.40	5.70
9 points	0.00	0.00	3.80	0.00
PCN > CO				
3 points	14.00	28.00	26.40	20.80
6 points	0.00	6.00	7.40	5.70
9 points	0.00	0.00	0.00	0.00
MR > CO				
3 points	8.00	28.00	20.80	24.50
6 points	0.00	8.00	7.40	9.40
9 points	0.00	0.00	0.00	1.90

Table 40

Fisher's z Test of Significance for PRI Subtests > VCI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med vs. Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
BD > SI				
3 points	1.60	0.11	3.25	0.00*
6 points	1.42	0.15	0.46	0.65
9 points	1.42	0.15	0.00	1.00
PCN > SI				
3 points	1.96	0.05	0.23	0.82
6 points	--	--	0.46	0.65
9 points	--	--	--	--
MR > SI				
3 points	0.32	0.75	0.50	0.62
6 points	0.46	0.65	0.46	0.65
9 points	--	--	--	--
BD > VO				
3 points	0.32	0.75	0.50	0.62
6 points	1.01	0.32	0.38	0.71
9 points	--	--	1.01	0.32
PCN > VO				
3 points	1.72	0.08	1.35	0.18
6 points	1.43	0.15	0.00	1.00
9 points	--	--	--	--
MR > VO				
3 points	1.73	0.08	1.22	0.22
6 points	1.01	0.32	1.02	0.31
9 points	--	--	--	--

BD > CO				
3 points	1.72	0.09	0.68	0.50
6 points	1.76	0.08	0.35	0.72
9 points	--	--	1.43	0.15
PCN > CO				
3 points	1.72	0.09	0.68	0.50
6 points	1.76	0.08	0.35	0.72
9 points	--	--	1.43	0.15
MR > CO				
3 points	2.60	0.01*	0.46	0.65
6 points	2.04	0.04*	0.37	0.71
9 points	--	--	1.01	0.32

Note. Items with an asterisk are statistically significant.

Table 37 presents the comparison between VCI subtest scores greater than PRI subtest scores. As predicted, many of these subtest score comparisons produced proportions of VCI subtest > PRI subtest and PRI subtest > VCI subtest score differences that were roughly equivalent. At the 3 point difference level, several subtest pairs met expectations and presented with equal or close to equal proportions among the ADHD groups and their matched controls for the VCI subtest > PRI subtest comparisons. At the 6 point difference level, many comparisons also displayed the expected pattern of results. A similar trend occurred at the 9 point difference, such that the ADHD and matched control proportions met expectations and were either equal to or close to equal for all subtest pair comparisons.

As expected, most of the proportion comparisons did not reach statistical significance; however, a few exceptions to this pattern are reported in Table 38. Results of the Fisher's Exact Test indicated that six significant differences were found; there were three in each ADHD group.

In the non-medicated ADHD group, the three significant relationships were found for the Similarities > Block Design comparison. First, 36% of the non-medicated ADHD group evidenced at least a 3 point split, as compared with 16% of Control Group 1. Second, 12% of the non-medicated ADHD group evidenced at least a 6 point split, as compared with zero percent of Control Group 1. Finally, 9% of the non-medicated group evidenced at least a 9 point split, as compared with zero percent of Control group 2.

In the medicated ADHD group, the significant relationships occurred in three different subtest pairings. First, 41.50% of the medicated ADHD group evidenced at least a 3 point split with the Similarities > Block Design comparison, as compared with 11.30% of Control Group 2. Second, 28.30% of the medicated ADHD group evidenced at least a 3 point split for the Similarities > Matrix Reasoning comparison, as compared with 11.30% of Control Group 2. Finally, 28.30% of the medicated ADHD group displayed at least a 3 point split for the Vocabulary > Block Design comparison, as compared with 11.30% of Control Group 2.

Table 39 followed a trend similar to Table 37. As anticipated, the ADHD groups displayed similar proportions of PRI subtest score > VCI subtest scores as their matched controls. This occurred at all levels (3, 6 and 9 point differences). At the 3 point level, slightly more than half of the subtest pairs displayed nearly equal proportions of ADHD groups and their matched controls for the PRI subtest > VCI subtest comparisons. A similar pattern was observed at the 6 and 9 point levels as well.

The Fisher's Exact Test was conducted to determine if any statistically significant relationships existed among the data. Three statistically significant relationships were found: two with the non-medicated ADHD group and one with the medicated ADHD group. The two

significant relationships in the non-medicated ADHD group occurred for the Matrix Reasoning > Comprehension comparison. First, 8.00% of the non-medicated group evidenced at least a 3 point split, as compared with 28.00% of their matched controls. Second, zero percent of the non-medicated ADHD group evidenced at least a 6 point split, as compared with 8.00% of their matched controls.

The remaining statistically significant relationship was found with the Block Design > Similarities comparison, in which 9.40% of the medicated ADHD group displayed at least a 3 point split, as compared with 35.80% of Control Group 2.

To further test the research questions and hypotheses of ADHD diagnosis and subtest score splits related to WMI and PSI, the following variables were calculated: DS-CD, DS-SS, LNS-CD, LNS-SS. Cumulative percentiles were then obtained for the differences at the following magnitudes: 3 points, 6 points and 9 points. The cumulative percentiles were converted into n values, which were used to compare the significance between proportions, using Fisher's Exact test. Tables 41 through 44 present the results with cumulative percentiles by group.

Table 41

Frequency of WMI Subtests > PSI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
DS > CD	Cumulative Percentages			
3 points	36.00	28.00	43.40	30.20
6 points	10.00	8.00	13.20	9.40
9 points	2.00	4.00	1.90	1.90
DS > SS				
3 points	33.00	32.00	18.90	24.50
6 points	4.00	4.00	9.40	9.40
9 points	4.00	2.00	3.80	1.90
LNS > CD				
3 points	38.00	3.00	43.40	18.90
6 points	8.00	12.00	15.10	3.80
9 points	0.00	4.00	0.00	1.90
LNS > SS				
3 points	33.00	30.00	18.90	9.40
6 points	6.00	4.00	7.50	3.80
9 points	0.00	0.00	0.00	1.90

Table 42

Fisher's z Test of Significance for WMI Subtests > PSI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
DS > CD				
3 points	0.86	0.36	1.43	0.15
6 points	0.35	0.73	0.62	0.54
9 points	0.59	0.56	0.00	1.00
DS > SS				
3 points	0.11	0.92	0.71	0.47
6 points	0.00	1.00	0.00	1.00
9 points	0.59	0.56	0.58	0.56
LNS > CD				
3 points	4.33	0.00*	2.76	0.01*
6 points	0.67	0.51	2.00	0.05
9 points	1.43	0.15	1.01	0.31
LNS > SS				
3 points	0.33	0.75	1.41	0.16
6 points	0.46	0.65	0.83	0.41
9 points	--	--	1.01	0.31

Note. Items with an asterisk are statistically significant.

Table 43

Frequency of PSI Subtests > WMI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med (N=50)	Control 1 (N=50)	ADHD Med (N=53)	Control 2 (N=53)
CD > DS	Cumulative Percentages			
3 points	12.00	18.00	11.30	20.80
6 points	2.00	4.00	1.90	3.80
9 points	0.00	0.00	0.00	0.00
SS > DS				
3 points	24.00	18.00	24.50	22.60
6 points	2.00	4.00	5.70	7.50
9 points	0.00	2.00	1.90	1.90
CD > LNS				
3 points	16.00	12.00	13.20	28.30
6 points	2.00	8.00	3.80	7.50
9 points	0.00	4.00	0.00	0.00
SS > LNS				
3 points	24.00	26.00	24.50	30.20
6 points	4.00	6.00	9.40	11.30
9 points	2.00	0.00	3.80	0.00

Table 44

Fisher's z Test of Significance for PSI Subtests > WMI Subtests by Group

	Diagnostic Group			
Subtest Score Differences	ADHD Non-Med Control 1 (N=50)		ADHD Med vs. Control 2 (N=53)	
	z value	*p value*	*z value*	*p value*
CD > DS				
3 points	0.84	0.40	1.33	0.18
6 points	0.59	0.56	0.58	0.56
9 points	--	--	--	--
SS > DS				
3 points	0.74	0.46	0.23	0.82
6 points	0.59	0.56	0.38	0.72
9 points	1.01	0.32	0.00	1.00
CD > LNS				
3 points	0.58	0.56	1.92	0.05
6 points	1.38	0.17	0.83	0.41
9 points	1.43	0.15	--	--
SS > LNS				
3 points	0.23	0.82	0.66	0.51
6 points	0.23	0.82	0.66	0.51
9 points	1.01	0.32	1.43	0.15

Note. Items with an asterisk are statistically significant.

Table 41 presents the proportions of WMI subtest scores > PSI subtest scores. As predicted, most of these score pairs are roughly equivalent. At the 3 point difference, several subtest pairs met expectations, displaying proportions between the ADHD groups and their matched controls within several points of one another. At the 6 point difference, the same trend continued, although with more than twice as many occurrences than at the 3 point difference.

Similarly, at the 9 point difference, the ADHD groups and their matched controls continued to display equal or close to equal proportions for nearly all subtest pair comparisons.

Although the results followed the expected pattern of results, a few of the comparisons reached statistical significance. Follow up analyses were conducted, using Fisher's Exact Test to test for significance and these are presented in Table 42. These results indicated two statistically significant results; one in each of the ADHD groups. Both of these significant findings occurred on the same subtest split: Letter Number Sequencing > Coding. First, it was noted that 38.00% of the non-medicated ADHD group displayed a 3 point or greater split on this subtest pair, as compared with 3% of Control Group 1. Similarly, 43.40% of the medicated ADHD group evidenced a 3 point or greater split on the same subtest pair, as compared with 18.90% of Control Group 2.

Table 43 presents the comparison between the PSI subtest scores greater than the WMI subtest scores. The same trends continued, and as predicted, many of these score pairs are roughly equivalent. This trend occurred at the 3, 6 and 9 point levels. At the 3 point difference, one half of the subtest pair comparisons evidenced equivalent proportions between the ADHD groups and their matched controls on the PSI subtests greater than the WMI subtests. At the 6 point level, this number increased, continuing the expectation. A similar trend continued for the 9 point difference, although there were fewer individual who reached this level of difference either in the ADHD groups or in their matched controls than in previous levels.

Fisher's Exact Test calculations were performed on the PSI > WMI comparisons and are presented in Table 44. No statistically significant results were reported between any of the subtest pairs.

To test the research question regarding the medication status of students related to their performances on working memory, processing speed, perceptual reasoning and verbal comprehension, comparisons were made among the subtests of the Indexes as follows: VCI-WMI, WMI-VCI, PRI-PSI, PSI-PRI, PRI-WMI, WMI-PRI, VCI-PSI, and PSI-VCI. Cumulative percentiles were then obtained for the differences between subtest pairs within Indexes at the following magnitudes: 3 points, 6 points and 9 points. The cumulative percentiles were converted into n values, which were used to compare the significance between proportions, using Fisher's Exact test. Tables 46 through 53 present the results with z values and significant levels by group.

Table 45

Fisher's z Test of Significance for VCI Subtests > WMI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
VO > DS			
	3 points	1.05	0.15
	6 points	0.06	0.48
	9 points	--	--
SI > DS			
	3 points	0.63	0.26
	6 points	-0.26	0.60
	9 points	0.04	0.48
CO > DS			
	3 points	0.08	0.53
	6 points	-0.39	0.65
	9 points	--	--
VO > LNS			
	3 points	0.39	0.35
	6 points	-0.39	0.65
	9 points	-0.98	0.84
SI > LNS			
	3 points	0.84	0.20
	6 points	-0.51	0.69
	9 points	--	--
CO > LNS			
	3 points	0.20	0.42
	6 points	0.53	0.30
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 46

Fisher's z Test of Significance for WMI Subtests > VCI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
DS > VO			
	3 points	0.40	0.69
	6 points	0.60	0.95
	9 points	10.03	0.85
DS > SI			
	3 points	-0.18	0.43
	6 points	0.40	0.52
	9 points	--	--
DS > CO			
	3 points	-1.30	0.10
	6 points	1.47	0.93
	9 points	1.03	0.85
LNS > VO			
	3 points	-0.57	0.28
	6 points	--	--
	9 points	--	--
LNS > SI			
	3 points	1.43	0.92
	6 points	--	--
	9 points	--	--
LNS > CO			
	3 points	1.43	1.43
	6 points	--	--
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 47

Fisher's z Test of Significance for PRI Subtests > PSI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
BD > CD			
	3 points	-1.02	0.84
	6 points	-0.96	0.83
	9 points	0.98	0.84
BD > SS			
	3 points	-0.30	0.62
	6 points	-0.77	0.78
	9 points	-0.98	0.84
PCN > CD			
	3 points	0.47	0.32
	6 points	-1.85	0.98
	9 points	-1.39	0.92
PCN > SS			
	3 points	0.43	0.33
	6 points	-1.24	0.89
	9 points	0.04	0.48
MR > CD			
	3 points	-1.15	0.85
	6 points	-3.05	0.99
	9 points	-0.98	0.84
MR > SS			
	3 points	-0.02	0.51
	6 points	-1.23	0.89
	9 points	-1.39	0.92

Note. Items with an asterisk are statistically significant.

Table 48

Fisher's z Test of Significance for PSI Subtests > PRI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
CD > BD			
	3 points	0.73	0.23
	6 points	-0.98	0.84
	9 points	--	--
SS > BD			
	3 points	0.73	0.23
	6 points	0.63	0.26
	9 points	--	--
CD > PCN			
	3 points	-0.67	0.75
	6 points	--	--
	9 points	-1.39	0.92
SS > PCN			
	3 points	-1.42	0.92
	6 points	1.81	0.03*
	9 points	--	--
CD > MR			
	3 points	-0.72	0.76
	6 points	1.81	0.04
	9 points	--	--
SS > MR			
	3 points	-0.30	0.62
	6 points	1.07	0.14
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 49

Fisher's z Test of Significance for PRI Subtests > WMI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
BD > DS			
	3 points	0.12	0.91
	6 points	1.71	0.09
	9 points	0.04	0.97
BD > LNS			
	3 points	0.15	0.88
	6 points	0.77	0.44
	9 points	0.04	0.97
PCN > DS			
	3 points	0.41	0.62
	6 points	1.31	0.19
	9 points	--	--
PCN > LNS			
	3 points	0.41	0.62
	6 points	1.31	0.19
	9 points	0.04	0.97
MR > DS			
	3 points	0.08	0.94
	6 points	1.10	0.28
	9 points	1.03	0.30
MR > LNS			
	3 points	0.17	0.86
	6 points	0.65	0.52
	9 points	0.54	0.59

Note. Items with an asterisk are statistically significant.

Table 50

Fisher's z Test of Significance for WMI Subtests > PRI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
DS > BD			
	3 points	0.06	0.95
	6 points	1.25	0.21
	9 points	1.03	0.30
DS > MR			
	3 points	0.16	0.87
	6 points	1.31	0.19
	9 points	--	--
DS > PCN			
	3 points	0.42	0.67
	6 points	0.04	0.96
	9 points	--	--
LNS > PCN			
	3 points	0.41	0.68
	6 points	--	--
	9 points	1.03	0.30
LNS > MR			
	3 points	0.09	0.92
	6 points	--	--
	9 points	1.03	0.30
LNS > PCN			
	3 points	0.39	0.69
	6 points	--	--
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 51

Fisher's z Test of Significance for VCI Subtests > PSI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
SI > CD			
	3 points	0.32	0.75
	6 points	0.40	0.69
	9 points	1.39	0.16
SI > SS			
	3 points	0.65	0.52
	6 points	0.13	0.89
	9 points	1.39	0.16
VO > CD			
	3 points	0.38	0.70
	6 points	2.05	0.04*
	9 points	1.47	0.14
VO > SS			
	3 points	2.41	0.02*
	6 points	1.88	0.06
	9 points	0.98	0.33
CO > CD			
	3 points	0.09	0.92
	6 points	0.69	0.48
	9 points	0.98	0.33
CO > SS			
	3 points	1.05	0.30
	6 points	0.85	0.40
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 52

Fisher's z Test of Significance for PSI Subtests > VCI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
CD > SI			
	3 points	-1.51	0.93
	6 points	-1.39	0.92
	9 points	--	--
SS > SI			
	3 points	-2.05	0.98
	6 points	-0.40	0.66
	9 points	--	--
CD > VO			
	3 points	-0.56	0.71
	6 points	-0.40	0.60
	9 points	--	--
SS > VO			
	3 points	-1.72	0.96
	6 points	-0.98	0.84
	9 points	1.03	0.15
CD > CO			
	3 points	-1.38	0.92
	6 points	-0.98	0.84
	9 points	--	--
SS > CO			
	3 points	-3.75	0.99
	6 points	-1.10	0.86
	9 points	--	--

Note. Items with an asterisk are statistically significant.

The Fisher's Exact Test was used to compare the non-medicated with the medicated ADHD groups. No statistically significant results were found in the following relationships: VCI subtests > WMI subtests, WMI subtests > VCI subtests, PRI subtests > PSI subtests, PRI subtests > WMI subtests, WMI subtests > PRI subtests, VCI subtests > PSI subtests, and PSI subtests > VCI subtests (Tables 45, 46, 47, 48, 49, 50, 51, and 52, respectively). However, statistical significance was found with the Fisher's Exact Test for some of the PSI subtests > PRI subtests comparisons and some of the VCI subtests > PRI subtests comparisons.

Table 48 shows the PSI subtest > PRI subtest comparisons. Fisher's Exact Test indicated one statistically significant relationship, which occurred for the Symbol Search > Picture Concepts comparison. The significant relationship occurred at the 6 point level.

Table 51 shows the VCI subtest > PSI subtest comparisons. Statistical significance was found with the Vocabulary > Coding at the 6 point split level. Statistical Significance was also found for the Vocabulary > Symbol Search Subtest at the 3 point difference level.

To further test the research question concerning the impact of medication status of students with ADHD related to their performances on perceptual reasoning and verbal reasoning tasks, comparisons were made between the VCI subtests and PRI subtests. Cumulative percentiles were then obtained for the differences at the following magnitudes: 3 points, 6 points and 9 points. The cumulative percentiles were converted into n values, which were used to compare the significance between proportions, using Fisher's Exact test. Tables 53 and 54 present the results with z values and significant levels by group.

Table 53

Fisher's z Test of Significance for VCI Subtests > PRI Subtests

		Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences		*z value*	*p value*
SI > BD			
	3 points	0.57	0.57
	6 points	0.11	0.91
	9 points	1.60	0.11
SI > PCN			
	3 points	0.17	0.87
	6 points	0.64	0.51
	9 points	--	--
SI > MR			
	3 points	0.84	0.40
	6 points	1.38	0.16
	9 points	--	--
VO > BD			
	3 points	0.26	0.79
	6 points	0.76	0.45
	9 points	0.98	0.33
VO > PCN			
	3 points	0.18	0.86
	6 points	0.98	0.33
	9 points	--	--
VO > MR			
	3 points	0.14	0.89
	6 points	0.03	0.97
	9 points	--	--

CO > BD			
	3 points	0.19	0.84
	6 points	0.14	0.89
	9 points	0.98	0.33
CO > PCN			
	3 points	0.10	0.92
	6 points	3.41	0.00*
	9 points	--	--
CO > MR			
	3 points	0.05	0.96
	6 points	0.98	0.33
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 54

Fisher's z Test of Significance for PRI Subtests > VCI Subtests

	Non-medicated vs. Medicated (n = 50; n = 53)	
Subtest Score Differences	*z value*	*p value*
BD > SI		
3 points	0.64	0.52
6 points	1.39	0.16
9 points	0.98	0.33
PCN > SI		
3 points	1.84	0.07
6 points	1.39	0.16
9 points	--	--
MR > SI		
3 points	0.46	0.65
6 points	1.39	0.16
9 points	--	--
BD > VO		
3 points	0.46	0.65
6 points	0.05	0.96
9 points	0.98	0.33
PCN > VO		
3 points	0.46	0.65
6 points	0.98	0.33
9 points	--	--
MR > VO		
3 points	2.26	0.02*
6 points	1.71	0.09
9 points	--	--

BD > CO			
	3 points	1.56	0.12
	6 points	1.96	0.05
	9 points	--	--
PCN > CO			
	3 points	0.85	0.39
	6 points	1.96	0.05
	9 points	--	--
MR > CO			
	3 points	1.84	0.06
	6 points	1.96	0.05
	9 points	--	--

Note. Items with an asterisk are statistically significant.

Table 53 presents the results of the VCI subtest > PRI subtest score comparisons. In this analysis, the Fisher's Exact Test results indicated that there is only one statistically significant relationship. This relationship was displayed for the Comprehension > Picture Concepts comparison at the 6 point level. Table 54 presents the PRI subtest > VCI subtest scores. In this analysis, the Fisher's Exact Test indicated only one statistically significant relationship, which was exhibited at the 3 point level for the Matrix Reasoning > Vocabulary comparison.

Chapter 4
Discussion

Summary of the Results

This study examined the cognitive profiles of ADHD and non-ADHD children and the impact of medication use on cognitive processing of children diagnosed with ADHD. This chapter presents a discussion of the results presented in Chapter 3, the potential contributions of this study to the field of psychology, limitations of the study and recommendations for future research.

The current study extended the research of Friedman (2006) and McLaughlin (2009) in analyzing the cognitive profiles of medicated and non-medicated children with ADHD, as compared with their non-medicated counterparts. Friedman and McLaughlin's studies focused on comparisons of the FSIQ, Index and GAI scores of the WISC-IV. The current study replicated several of the same research questions from the Friedman and McLaughlin studies, using FSIQ and Index scores.

In addition, the current study extended beyond the previous research studies to consider the 10 core subtest scores of the WISC-IV. The current study examined whether or not significant differences existed in the proportions of WISC-IV subtest pair score differences in the ADHD and non-ADHD groups and in the proportions of subtest pair score differences in the ADHD groups and their matched control groups. The study compared the performance of these groups on WISC-IV subtest level measures of working memory and processing speed relative to performance on subtest level measures of vocabulary, reasoning with verbal information and reasoning with nonverbal visual information.

The first set of research questions replicated several of the research questions addressed in the Friedman (2006) and McLaughlin (2009) research studies. The first research question examined whether or not WISC-IV FSIQ scores differ significantly, based on ADHD diagnosis and use of medication to treat symptoms. The current study found that there were significant differences in the mean FSIQ scores among groups. It was found that individuals taking medications to treat the symptoms of ADHD earned significantly higher FSIQ scores on the WISC-IV, as compared with non-medicated individuals who have ADHD, with standard scores of 98.26 compared with scores of 90.90, respectively. In addition, it was found that Control Group 1 earned significantly higher FSIQ than the non-medicated ADHD group, with standard scores of 96.54 and 90.90, respectively.

Regarding the findings for the first question, as compared with the findings of Friedman (2006) and McLaughlin (2009), there were some differences. Friedman and McLaughlin did not find significant differences between the WISC-IV FSIQ scores of the ADHD groups and their matched controls, whereas the current study did. As noted, the current study evidenced significant differences in FSIQ between the ADHD groups and between the non-medicated ADHD group and their matched control group.

The second research question examined whether or not the index scores on the WISC-IV differed significantly, based on ADHD diagnosis and medication use. Results indicated significant differences for performance on the Perceptual Reasoning, Working Memory and Processing Speed Indexes. Further analyses were conducted on each of these Indexes to determine the impact of ADHD diagnosis and medication use status. In the case of the Perceptual Reasoning Index, a significant difference was found between the individuals medicated for

symptoms of ADHD and those not medicated for symptoms of ADHD, with the medicated ADHD group performing significantly higher, but no significant differences were found between the ADHD groups and their matched controls.

In the case of the Working Memory Index, significant differences were found between the medicated ADHD group and the non-medicated ADHD group, to the degree that the medicated group earned significantly higher standard scores. In addition, it was found that Control Group 1 scored significantly higher than the non-medicated ADHD group on the Working Memory Index.

In the case of the Processing Speed Index, significant differences were found among all three group pairings. First, significant differences were found between the medicated ADHD group and the non-medicated group with the medicated ADHD group producing a significantly higher mean PSI score than the non-medicated group. Second, it was found that Control Group 1 produced a significantly higher group mean score on the PSI than the non-medicated ADHD group. Third, it was also found that Control Group 2 produced a significantly higher mean score on the PSI than the medicated ADHD group.

Regarding the second research question, Friedman and McLaughlin differed from the current study; they did not find significant PRI mean score differences between the ADHD groups and their matched controls. Consistent with Friedman and McLaughlin, however, the current research indicated that the ADHD groups demonstrated significantly lower WMI and PSI mean scores than their matched controls.

The third research question was designed to determine whether or not the WISC-IV subtest score group means differed significantly, based on ADHD diagnosis and use of medication. Across all 10 core subtests, comparisons yielded statistically significant differences in group means for 6 subtests: Similarities, Block Design, Matrix Reasoning, Digit Span, Coding, and Symbol Search. Follow up analyses were conducted for each subtest to determine which groups mean scores differed significant.

For the Similarities subtest, significant mean score differences were found between the medicated and non-medicated ADHD groups, with the mean score of the medicated group being higher than the mean score of the non-medicated group. For the Block Design subtest, significant differences were found among all three group pairings: the ADHD medicated group mean was significantly higher than the ADHD non-medicated group mean; The ADHD non-medicated group mean was lower than the Control Group 1 mean, and the ADHD medicated group mean was lower that the Control Group 2 mean. On the Matrix Reasoning subtest, a significant difference was found between the medicated and non-medicated ADHD groups, with the mean of the medicated group being significantly higher than the mean of the non-medicated group. For the Digit Span subtest, no significant differences were found for any of the group pairings. For the Coding subtest, the ADHD non-medicated group mean was significantly lower than the mean of Control Group 1 and the ADHD medicated group mean was significantly lower than the mean of Control Group 2. Finally, for the Symbol Search subtest, the ADHD medicated group mean was significantly higher than the ADHD non-medicated group mean.

In contrast to the current study, Friedman (2006) and McLaughlin's (2009) research found no significant differences between group for any of the subtest from the VCI or PRI.

Consistent with McLaughlin's findings, significant differences between some groups were found for the Coding and the Symbol Search subtests.

The second set of research questions expanded from Friedman's research and continued McLaughlin's research. The fourth and fifth research questions addressed whether or not individuals with ADHD performed differently from their matched controls in terms of differences in performance on pairs of Index scores. In the case of VCI-WMI comparisons, individuals with ADHD generally showed larger proportions of VCI>WMI at all levels (10, 15, 20, and 25 point differences) compared with matched controls, indicating that greater numbers of individuals with ADHD were better at completing tasks involving reasoning with verbal information and providing word definitions than at completing verbal tasks requiring the use of working memory. When the WMI-VCI comparisons were examined, as predicted, the matched controls usually demonstrated higher proportions of WMI>VCI than the ADHD groups. Although most of the VCI > WMI differences were more frequent in the ADHD groups than in the control groups and the WMI > VCI differences were more frequent in the control groups than in the ADHD groups, statistically significant results were found only in 4 of 16 comparisons between ADHD and control groups.

When the PRI and PSI scores were compared, the ADHD groups typically had larger percentages of PRI>PSI differences than the control groups at each point value level. These proportional differences were statistically significant at the 15, 20 and 25 point levels for the medicated ADHD group and their matched controls. In the PSI>PRI comparisons, the control group consistently demonstrated larger proportions of differences than the non-medicated ADHD group, but none of the proportional differences reached statistical significance. In the case of the

Medicated ADHD group and their controls, the proportions of PSI > PRI differences were roughly equivalent and none of the differences reached statistical significance.

In the VCI-PSI index score comparison, the ADHD groups displayed more proportions of VCI>PSI differences at most point value levels. Statistical significance was found in these results at the 10, 15 and 20 point levels both for the medicated and for non-medicated ADHD groups, compared with their control groups. In addition, as expected, the control groups also displayed greater proportions of PSI>VCI differences in all comparisons, but statistical significance was found only in the case of the medicated ADHD group's controls at the 10 point level.

The PRI-WMI comparisons yielded results that were roughly equivalent for the ADHD groups and their matched controls, without significant findings. When the VCI and PRI scores were compared, marginal differences were displayed in the VCI>PRI proportions in favor of the ADHD groups. In contrast, the control groups evidenced larger proportions in the PRI>VCI comparisons. Statistical significance was found only in the latter comparisons at the 10 point difference level in favor of the medicated ADHD group.

The final comparison at the index level was for the WMI-PSI index pair. In the WMI>PSI comparisons, the proportions were roughly equivalent across all groups. In the PSI>WMI comparisons, the control groups evidenced greater proportions of differences than the ADHD groups in all but one comparison, but statistical significance was found for comparison only at the 10 point level, in favor of the control group of the medicated ADHD group.

Many of these WISC-IV Index score comparison findings were consistent with the findings from McLaughlin's 2009 analyses. In the case of the VCI-WMI comparisons, the

findings of the current study were consistent with McLaughlin's findings in 2009, although McLaughlin's results reached statistical significance at more levels.

Regarding the PRI-PSI comparisons, these findings also were consistent with McLaughlin's findings. In both sets of analyses, statistically significant results were found in the PRI>PSI comparisons, although no significant results were found in the PSI>PRI comparisons.

In the case of the VCI-PRI comparisons, the results of the current study varied with McLaughlin's findings regarding the VCI>PRI comparison. McLaughlin found that all groups yielded similar results, but the results of the current study noted that the ADHD groups yielded slightly higher proportions of VCI > PRI score differences. However, in the case of the PRI>VCI comparisons, the results were consistent between both studies.

McLaughlin's findings for the WMI-PSI comparisons also were different from the findings of the current study. McLaughlin found that the ADHD groups demonstrated WMI scores greater than PSI scores at all levels. Findings from the two studies also varied for the PSI>WMI comparisons; McLaughlin's results noted that the ADHD groups and their controls were comparable in proportions of difference scores at each level, whereas the current study noted that the control groups displayed greater proportions of PSI > WMI score differences.

The current study expanded on McLaughlin's research by further analyzing the WISC-IV score differences for ADHD groups and their matched controls at the subtest level. Research question six sought to determine whether or not individuals with ADHD display different subtest pair difference score patterns on the WISC-IV, as compared with their matched controls.

In comparing the VCI > WMI subtest scores, as expected, the ADHD groups typically performed better on subtests of verbal reasoning than on subtests of working memory. Some statistically significant results were found to support these results. In the WMI > VCI subtest comparison, the control groups also performed as expected, displaying larger proportions of WMI subtest greater than VCI subtest scores. Again, statistically significant results were found in some, but not all, comparisons.

In comparing the PRI > WMI subtest scores, as expected, the pattern of scores was roughly equivalent between the ADHD groups and their matched controls, indicating that the individuals with ADHD typically performed comparably with their matched controls on subtest pair comparisons. There were some exceptions to this, however, in cases in which the control groups outperformed the ADHD groups. In two instances, statistical significance was reached. Both times, this occurred in the medicated ADHD group as compared with Control Group 2. In the WMI > PRI subtest comparison, the trend continued, and most of the subtest pair comparisons were equal or relatively equal. There were a few exceptions to this, in cases in which the control groups outperformed their matched ADHD groups. Two instances reached statistical significance.

In the PRI > PSI subtest comparison, the ADHD groups typically performed better on subtests which required nonverbal reasoning than on subtests which required processing speed. Although these results were anticipated, only several instances reached statistical significance. Again, the results for the PSI > PRI subtest analysis were also in line with expectations. In this direction, some results reached statistical significance, although the remainder still supported the expected pattern.

The VCI > PSI subtest and PSI > VCI subtest comparisons were expected to show that the ADHD groups and their matched controls would be roughly equivalent. This was confirmed, indicating that individuals with ADHD and their matched controls displayed comparable proportions of differences on subtest measures of verbal reasoning, contrasted with subtest measures of processing speed. On both the VCI > PSI and on the PSI > VCI a large majority of subtest pair comparisons fit the expected pattern. On the VCI > PSI, nearly all of the subtest pair comparisons displayed the expected pattern in which the ADHD groups evidenced higher proportions of VCI > PSI subtest scores, with eight of these comparisons reaching statistical significance, with 3 favoring the ADHD non-medicated over their controls and 5 favoring the ADHD medicated group over their controls. For the PSI > VCI subtest comparisons, the control groups displayed greater proportions of score differences than the ADHD groups and three instances of statistical significance were found; two favored the control group over the ADHD medicated group and one favored the control group over the ADHD non-medicated group.

The VCI > PRI and PRI > VCI subtest comparisons produced similar proportions of score differences for the ADHD and control groups at most point levels.. In on the case of the VCI > PRI subtest comparisons, several exceptions occurred in which the ADHD groups displayed higher proportions of VCI subtest scores greater than PRI subtest scores than the matched controls. Several of these instances reached statistical significance. On the PRI > VCI subtest comparisons, a number of cases occurred in which the control groups evidenced greater proportions of VCI subtests greater than the PRI subtests. Again, a few of these comparisons in favor of the control groups reached statistical significance.

The final subtest score comparison related to the WMI > PSI and PSI > WMI. These comparisons were expected to show that the subtest scores associated with these Indexes would be roughly equivalent. These results were confirmed, suggesting that individuals with ADHD performed comparably with their matched controls on subtests of working memory and processing speed. On the WMI > PSI, there were some exceptions to this, including two which reached a level of statistical significance. On the PSI > WMI subtest comparison, there were again exceptions, although none reached a level of significance.

Research question seven addressed WISC-IV subtest pair score differences based on medication status of individuals diagnosed with ADHD. Subtest pair differences identical to those used to compare ADHD groups with control groups were tested in both directions.

In the case of VCI-WMI subtest comparisons, a larger proportion of non-medicated ADHD individuals had VCI > WMI subtest differences than did medicated individuals, but WMI > VCI differences were distributed relatively evenly between the two groups. None of the VCI-WMI subtest comparisons reached statistical significance.

In the case PRI-PSI subtest differences, a large majority of PRI > PSI subtest comparisons reflected larger proportions of differences in the medicated group than in the non-medicated group, whereas PSI > PRI proportions of subtest differences were distributed relatively evenly between the medicated and non-medicated groups. Although the trend favoring the medicated group for PRI > PSI subtest difference proportions was quite strong, none of the comparisons reached statistical significance.

Regarding PRI-WMI subtest differences, many of the PRI > WMI comparisons reflected larger proportions of differences in the medicated group than in the non-medicated group, whereas WMI > PRI comparisons showed the opposite pattern; larger proportions of differences occurred in the non-medicated group. Although the trends favoring the medicated group for PRI > WMI difference proportions and favoring the non-medicated group for WMI > PRI were quite strong, none of the comparisons reached statistical significance.

In the case of VCI-PSI subtest differences, many of the VCI > PSI as well as many of the PSI > VCI comparisons reflected larger proportions of differences in the medicated group than in the non-medicated group. Although the trends were quite strong, only two of the comparisons reflecting greater subtest difference proportions of VCI > PSI reached statistical significance.

In the case of VCI-PRI subtest differences, many of the VCI > PRI and a large majority of the PRI > VCI comparisons reflected larger proportions of differences in the medicated group than in the non-medicated group. Although these trends were quite strong, only one of the comparisons reflecting greater subtest difference proportions of VCI > PRI in the medicated group and one of the comparisons reflecting greater subtest difference proportions of PRI > VCI in the medicated group reached statistical significance.

Regarding WMI-PSI subtest differences, many of the WMI > PSI as well as many of the PSI > WMI comparisons reflected larger proportions of differences in the medicated group than in the non-medicated group. Although the trends favoring the medicated group for both WMI > PSI and PSI > WMI subtest difference proportions were quite strong, none of the comparisons reached statistical significance.

Comparison of Results with Previous Studies

Results from both Friedman's (2006) and McLaughlin's (2009) studies noted that there were no significant differences in FSIQ, VCI, PRI or PSI of the ADHD groups and their matched controls. The current study, however, contradicted these results, finding significant differences in FSIQ, PRI, and PSI for the ADHD groups, compared with their matched controls. The findings of this study do not support previous research in the field, including research of Barkley (1997, 1997, 2006). Because of this, it would be beneficial to replicate the current study to determine whether or not the current findings are more generalizable than the findings from the previous two studies.

Consistent with Friedman and McLaughlin, the current study found differences in the ADHD groups and their matched controls on the WMI, such that the ADHD groups' mean scores were significantly lower than the control groups' mean scores. These findings are also consistent with previous research in the field (Alloway, Gathercole & Elliot, 2010; Dehn, 2008; Martinussen et al., 2005).

Contributions to the Field

For school psychologists, the continued support for deficits in working memory for individuals with ADHD is important. School psychologists serve as liaisons between research and current practice in the school setting. School psychologists should continue to share the research on working memory deficits in students who have ADHD with teachers and support staff in schools. Interventions should be developed to support students who may struggle in these areas. However, it should also be noted that not all students with ADHD may demonstrate this

weakness. Individual cognitive profiles should be considered while developing appropriate interventions that keep the student's personal strengths and needs in mind.

Although additional research would be needed to confirm or disconfirm these findings, it appears that this information could be easily communicated to parents in the school setting. The current research on cognitive profiles of children with ADHD can be shared with parents during Multi-Disciplinary Team meetings and Individualized Education Plan meetings. In much the same way, as this forthcoming research is expanded and confirmed, the role of medication on cognitive processing of a child with ADHD can also be shared with a parent in a jargon-free manner. This information can be shared in a non-biased way, in the event that a parent seek out a professional opinion from the school psychologist to assist the parent in making an informed decision about medication for the treatment of his or her child's ADHD.

Limitations

As with all research, this study had several limitations. First, this study utilized cross-sectional data rather than longitudinal data, which could better be used for comparisons of treatment and control groups. Because some of the subjects in the study are prescribed medication, a longitudinal study would allow the researcher to monitor for any issues associated with the medication use.

Additionally, some psychologists who contributed data to this study reported qualitatively to the researcher that the student's medication changed every few months. A longitudinal study would provide an opportunity to monitor which medication may have a greater impact on cognitive functioning.

The pool for matched controls could also have impacted the results of this study. The WISC-IV standardization sample was used in this study, but was also previously used as matched controls in the studies conducted by Friedman (2006) and McLaughlin (2009). Since matched controls could not be repeated, there was a smaller pool in the WISC-IV from which to select the matched controls for the current study. Given this, the standardization sample from the WISC-Integrated was also used to match controls. This could have compromised the results of the study, and separated this study from the work completed by Friedman (2006) and McLaughlin (2009).

The results of the current study indicate that there were many significant results. There were many similarities at the subtest level; however, fewer subtest pairs than expected met significance levels. This could have been due to the 3, 6 and 9 point splits that were utilized in the methodology. More significant results could have been found if the splits were analyzed at the 2, 3, 4 and 5 point level.

An additional limitation includes the diagnosis of ADHD for the subjects involved. Diagnosis could have been made by the same professional administering the WISC-IV (i.e., school psychologist), or the diagnosis may have already been made before the student was tested. This inconsistency of diagnostic skills among participants may have impacted the results of the study. An additional check point on the data collection sheet in which the psychologist could provide information on who diagnosed the student would provide data that could be used in analyses to determine if source of diagnosis would affect results.

Another limitation of the study is that the ADHD group included diagnoses of all types of ADHD (ADHD-IT, ADHD-HIT, and ADHD-CT); possible variability in the cognitive profiles

of these various subtypes may have greatly impacted WISC-IV performance and subsequent score comparisons.

A final limitation relates to the types, combinations or even dosages of medications on cognitive functioning. The medicated ADHD group included students taking medications for the treatment of ADHD, but the exact type of medication and the dosage varied greatly among the group. This inconsistency in type of medication and dosage may have greatly impacted WISC-IV performance and subsequent analyses of score comparisons.

Future Directions for Research

As previously noted, all subtypes of ADHD (ADHD-IT, ADHD-HIT, and ADHD-CT) were included in the study and were grouped together. The Data Collection Worksheet provided a space for the psychologist to include the ADHD subtype, if known. However, in some instances, this was not known. In a future study, it may be beneficial to expand the study sample and separate the ADHD subtypes to determine if the results found in this and previous studies are also supported.

In addition, the Data Collection Worksheets provided for this study often included additional diagnoses and disabilities including Asperger's Disorder, Oppositional Defiant Disorder, Mood Disorder and Depression. Future research could consider these comorbid diagnoses and how these may be impacting cognitive functioning. Similarly, additional medications to treat symptoms associated with these diagnoses (i.e., mood stabilizers such as Abilify or Seroquel) also may have had an impact on areas of cognitive performance.

Future studies on this topic could assess the subtest level comparisons by utilizing 2, 3, 4 and 5 point splits. This adjustment in the study's methodology could produce more significant results at the subtest level analysis.

A future direction for this research could include incorporating a cognitive measure such as the Kaufman Assessment Battery for Children, Second Edition (KABC-II), that separates long-term and short-term memory ability. As working memory is greatly impacted in children with ADHD, using a tool such as the KABC-II could add an interesting level of analysis to the current research to determine if long-term memory may be an area of personal strength for this population.

Finally, including larger sample sizes in future studies would strengthen the study design and impact the results. The inclusion of female participants would provide results that could be generalized to a larger population. In addition, separating the sample to include each ADHD subtype would also provide greater insight into the similarities and differences between each subtype.

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