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Executive Functioning and Memory Performance in ADHD and Asperger's Syndrome

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EXECUTIVE FUNCTIONING AND MEMORY PERFORMANCE IN ADHD AND ASPERGER'S SYNDROME

by

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This thesis, submitted by Kristi A. Walen in partial fulfillment of the requirements for the Degree of Master of Arts from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

Thomas V Petros
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This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Signature Kristi Walk

Date 11-30-07

TABLE OF CONTENTS

LIST OF TABLES

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ABSTRACT

The diagnosis of ADHD requires the exclusionary criteria for any Pervasive Developmental Disorder (PDD), making it impossible to have comorbid disorders. This study investigated executive function and memory differences between 11 children with Asperger's syndrome, 13 children with ADHD, and 36 controls, all ranging in age from 7-16 years. Executive function was assessed using Conner's Continuous Performance Test (CPT), Wisconsin Card Sorting Task (WCST), Tower of London Task (TOL), Trail Making Test, Rey-Osterrieth Complex Figure (ROCF), Grooved Pegboard Test, and the Controlled Oral Word Association Test (COWAT). Memory was assessed using a subtest from the Wide Range Assessment of Memory and Learning (WRAML). The children were also given subtests from the Wechsler Intelligence Scale for Children-IV (WISC IV) and Wechsler Individual Achievement Test (WIAT). Their parents were given the Child Behavior Checklist, ADHD Rating Scale, and a parental interview. On some measures of executive function the ADHD, Asperger, and Control groups did not significantly differ on measures such as Trials A & B, COWAT, Grooved Pegboard, TOL, or most measures of the ROCF. Our findings suggest that the Asperger group and Control group differed on a number of different measures on the CPT and the WCST. On measures of memory Asperger and Control children were significantly better than the ADHD group on the Story Memory from the WRAMML When looking at the other measures the Asperger children performed poorly on the Symbol Search and Coding

subtests of the WISC IV when compared to the ADHD and Control children. The data on the WAIT suggests that reading comprehension differences are found between ADHD children and the Control and Asperger children. Based on parental report ADHD and Asperger children both exhibit similar symptoms found on the CBCL. Our findings suggest the difficulty of children with ADHD seems to rest on sustained attention and memory. Asperger children seem to have more difficulty on processing speed, visual-scanning abilities, and cognitive flexibility. The results of this study may be able to help discriminate between the diagnostic groups of ADHD and Asperger's Syndrome. It is recommended that future research expands the test measures and looks at the areas where discrepancies were.

CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

Attention Deficit/Hyperactivity Disorder (ADHD) is one of the most commonly diagnosed and researched childhood disorders in school age children. A considerable amount of recent interest has been directed toward Asperger's syndrome, one of several Pervasive Developmental Disorders. Pervasive Developmental Disorders are characterized by varying degrees of impairment in communication skills, social interactions, and restricted, repetitive, and stereotyped patterns of behavior (DSM IV, 1994). Symptoms of inattention and hyperactivity may be common in individuals with Asperger's syndrome. The diagnosis of ADHD requires the exclusionary criteria for any Pervasive Developmental Disorder (PDD), making it impossible to have comorbid disorders (DSM IV, 1994). Questions and controversy have arisen on the cormorbidity of the two disorders. Recently, researchers have argued that there should not be the exclusionary criteria of PDD in the diagnosis of ADHD (Ghaziuddin, Tsai, & Alessi, 1992).

Since comorbidity is not an option for clinicians, how are the two disorders similar? If they are two separate disorders do they share similar deficits? The similarities of these two disorders may complicate the diagnosis of either Asperger's Syndrome or ADHD. To render a proper diagnosis more research is needed to focus on similarities of these two disorders.

ADHD

Attention Deficit Hyperactivity Disorder (ADHD) is a behavioral disorder commonly diagnosed in childhood. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM IV, 1994), ADHD occurs in 3-7% of school age children. Characteristics of the disorder can first be seen during the preschool years, but a diagnosis is usually not rendered until the child begins to attend school. It is there where their deficits seem to become detrimental. The primary characteristics of these children are problems with attention span, impulse control, and their activity level. These characteristics can affect almost every aspect of their life not only in childhood, but also in adulthood.

The DSM IV classifies the symptoms into two broad categories; Inattention and Hyperactivity–Impulsivity. The symptoms that compromise these two categories are presented below.

Inattention

- Often fails to give close attention to details or makes careles mistakes in schoolwork, work, or other activities
- Often has difficulty sustaining attention in tasks or play activities
- Often does not seem to listen when spoken to directly
- Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
- Often has difficulty organizing tasks and activities

- Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
- Often loses things necessary for tasks or activities (e.g. toys, school assignments, pencils, books, or tools)
- Is often easily distracted by extraneous stimuli
- Is often forgetful in daily activities

Hyperactivity-Impulsivity

- Often fidgets with hands and feet or squirms in seat
- Often leaves seat in classroom or in other situations in which remaining seated is expected
- Often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
- Often has difficulty playing or engaging in leisure activities quietly
- Is often "on the go" or often acts as if "driven by a motor"
- Often talks excessively
- Often blurts out answers before questions have been completed
- Often has difficulty awaiting turn
- Often interrupts or intrudes on others (e.g. butts into conversations or games)

A child will usually be diagnosed with one of three subtypes of ADHD, Combined Type, Predominately Inattentive Type, or Predominately Hyperactive/Impulsive Type. A diagnosis of ADHD Combined Type is usually given if 6 or more symptoms of Inattention and Hyperactive/ Impulsivity are present. A diagnosis

of Predominately Inattentive Type is usually given if 6 or more symptoms are present from the Inattentive dimension and 5 or fewer symptoms are present from the Hyperactivity/Impulsivity dimension. Finally, a diagnosis of ADHD Predominantly Hyperactive/Impulsive Type is usually given if 5 or fewer symptoms are present from the Inattention Dimension while 6 or more symptoms are present from the Hyperactivity/Impulsivity dimensions. A diagnosis of ADHD requires that the symptoms of ADHD have persisted for at least six months to a degree that is maladaptive and inappropriate for their developmental level. Further, the symptoms must have been present before the child was 7 years old. The impairments must be present in two or more settings, commonly in the home and at the school. Clear evidence of significant impairment should be apparent in their social or academic functioning. The symptoms must not exclusively appear during the course of any other mental disorder (DSM IV, 1994).

Individuals diagnosed with ADHD demonstrate difficulties in many functions presumed to be under the control of the frontal lobe (executive functions). These difficulties could include the organization of complex behaviors, ability to pay attention to several components at once, easily distracted by erroneous stimuli, and an inability to sustain attention for relatively long periods of time. Individuals with frontal lobe dysfunction demonstrate similar symptoms to those exhibited by individuals diagnosed with ADHD. Research has linked hyperactivity and inattention to lesions of the frontal lobes (Pineda, Alfredo, Mo'nica, Clemencia, Silvia, & Mejia, 1998). The frontal lobe is thought to be responsible for executive, regulatory, and social functioning. Individuals

with frontal lobe lesions will also frequently exhibit deficits in reservation, disinhibition, and an inability to use environmental cues.

A number of studies have examined executive function performance on children with ADHD and non-impaired children. The studies have utilized a number of different measures of executive function. Pineda et al. (1998) administered the Wisconsin Card Sorting Test (WCST), Verbal Fluency, and Picture Arrangement subtest from the WISC-R. The WCST is a test that contains 128 different cards with different geometric shapes, in different colors, and with a variable number. The child is asked to sort the cards based on the categories of color, number, or shape. The child is only given feedback of correct or incorrect from the examiner, after the child correctly sorts 10 consecutive cards, the sorting rule changes. The ability to switch the sorting rule is of importance to this test. The Verbal Fluency test measures how many words a child can produce that start with F, A, or S in response to a one minute time period. Finally, Picture Arrangement is a series of pictures that are to be arranged in the order that tells a story.

The participants included one hundred and twenty four male children between the ages of seven and twelve. Half of the participants were diagnosed with ADHD and the other half were children without a diagnosis and exhibited no behavioral problems. The subjects were matched using the WISC-R full scale IQ, Spanish Version.

The results indicated that ADHD children performed significantly worse than controls on all measures of executive functions. The study supports the assumption of the presence of executive function deficits in children with ADHD. The ADHD children performed significantly lower on the verbal fluency test when compared with the control

children. This may indicate that the ADHD children had a lower word production, which would be consistent with frontal lobe lesions. The WISC-R Picture Arrangement subtest scores for the ADHD group were statistically lower than that of the control group. The lower scores may be a result of some under performing cognitive areas.

Sami (2003) examined the performance of ADHD children on the Rey Complex Figure, which has been known to be sensitive to frontal lobe deficits. The Rey-Osterrieth Complex Figure (ROCF) is a two-dimensional line drawing. Reproduction of the figure is assumed to require visual-motor representation, spatial planning, organizational skills, and long-term memory. When given the test the child is shown a complex figure and asked to copy the design. The time it takes to copy the design is recorded, although there is no time limit. The figure is than taken away and the child is asked to reproduce the figure from memory after three minutes and 30 minutes. Sami et al. (2003) found that children with ADHD perform poorly and have more errors of accuracy, planning, neatness, and preservation on the ROCF.

There are many different scoring criteria used to measure different aspects of the ROCF. The developmental scoring system is a system that looks at the copy condition (CC) and the delayed recall copy (DRC). The scores looked at are the Organizational Score (OS), Style Rating, Accuracy, and Categories of Errors. The organizational score is a measure of how well they reproduce under a functional analysis. Style is based on scoring of continuity points. Accuracy is a straightforward sum of segments represented correctly when the drawing is divided into 64 segments. The error scoring system also uses the 64 segments. Misplacement, rotations, and preservations are looked at. An Error Proportion Score converts total errors and total preservations into rations.

Sami et al. (2003) wanted to determine if planning efficiency identifies executive functioning deficits on the ROCF in a female sample. They employed the developmental scoring system. Diagnostic evaluations were given to determine each participant's current diagnosis. The participants included preadolescent girls that were ADHD-Combined (n=93), ADHD-Inattentive (n=47), and comparison girls (n=88). The girls were given the ROCF, the WISC-III Performance IQ subscale, Porteus Maze Test, Grooved Pegboard, and the Conners Continuous Performance Test (CPT).

The results indicated that there were significant differences. Across the CC to DRC administrations both the ADHD groups and the control group performed poorly. The CC is expected to be better since the child is allowed to copy the figure. Within the CC the ADHD-Combined type scored worse than the control group on the OS and the EPS. The same results were found for the DRC only for the EPS. The Inattentive type performed worse on the EPS for the CC then control group, but the combined type performed worse than the Inattentive type on the EPS in DRC. Preservation errors were found to contribute most toward EPS for ADHD comparison differences (Sami, Carte, Hinshaw, & Zupan, 2003).

Numerous studies have demonstrated that children with ADHD perform worse than controls on tests presumed to assess frontal lobe function. Barkley et al (1994) noted that group differences in neuropsychological test performance might not be useful for clinical diagnosis. Barkley argued that the question in whether the presence of an abnormal score on the test is reliably associated with or predictive of specific diagnoses on etiology or whether a score on the normal range on such a test can reliably rule them out. Barkley et al took nine tests presumed to assess various frontal lobe functions to

evaluate their effectiveness in the diagnosis of children with attention deficit disorders. The nine tests were as follows: Conner's Performance Test (CPT), Controlled Word Association Test (CWAT), Hand Movements Scale, Porteus Mazes, Rey Complex Figure, Stroop Color Word Association Test, Trail Making Test, Wisconsin Card Sorting Test (WCST), and the Grooved Pegboard. The CPT requires the participant to respond each time a letter appears on the screen except if the letter is an X, at witch time no response is correct. The COWAT involves the child to make verbal associations and to categorize different letters of the alphabet; one minute is allowed before the next stimulus is presented. The Hand Movements Scale requires the child to copy a series of skilled hand movements from the examiner. The Porteus is a pencil and paper maze that requires planning and organizational skills. During the Stroop Color Test the child is asked to read a list of colors in black ink and list the color of different colored blocks as quickly as possible. Than the child is asked to read another list were the color of ink used for the word is what the examiner wants. The color of ink used is different then the color name. The Trail Making Test is very similar to connect the dots. Two forms were used, Trail A and Trail B. Trail A is a pencil and paper test of simply connected the dots numbered 1-12. Trail B is the same as Trail A except letters are introduced and the child should alternate between number and letter. Finally, the Grooved Pegboard is a test of fine motor ability and agility. The child is asked to place pegs in a pegboard containing 25 holes with their dominant hand, then they will repeat this task with their non-dominant hand.

Each test was evaluated on positive and negative predictive power of abnormal and normal tests scores. Positive Predictive Power (PPP) refers to the probability of a

child having a disorder given abnormal test scores. Negative Predictive Power (NPP) refers to the probability of a child not having the disorder given a normal score. The four groups of children were assessed. The four groups included 12 boys with ADD+H, 12 boys with ADD-H, 11 boys with LD, and 12 controls with no known diagnosis. The criteria for ADD-H are similar to ADHD Predominantly Inattentive Type. The criteria ADD+H is similar to ADHD combined type. The groups were compared on the nine tests using an ANOVA. The results indicated that when combining ADD+H and ADD-H the CPT had the best PPP (100% PPP on the commission). Meaning an abnormal number of commissions correctly identified those with either type of ADD. The Rey Complex Figure had the poorest results of all the tests. When both types of ADD were combined the hit rates improved to acceptable levels for the CPT and COWAT, but the NPP decreased. The authors conclude that a presence of an abnormal score may indicate ADHD, but a normal score cannot exclude the disorder (Barkley & Grodzinsky, 1994).

Problems in impulse control and sustained attention are major contributors to ADHD. There are many different variations of how to measure attention and impulsivity. The most widely used method is the continuous performance methods, such as the Conners Continuous Performance Test or the TOVA. Most methods will require the child to observe a screen while individual letters or numbers will appear on the screen in a rapid pace. The child is required to press a button when a certain letter or number appears. The number of correct responses, omissions, and number of stimuli missed, may reflect sustained attention. The number of commissions and incorrect responses may reflect the degree of impulse control. Cancellation methods may also aid in assessing impulse control.

The Conners Continuous Performance Test (CPT) requires the participant to respond each time a letter appears on the screen except if the letter is an X, at which time no response is correct. McGee et al. (2000) examined factors that contribute to CPT performance to better understand circumstances that may lead to misdiagnosis of ADHD using CPT performance. One factor is visual motor speed and integration. McGee et al (2004) measured visual motor speed and integration using The Wide Range Assessment of Visual-Motor Abilities (WRAVMA), and related measures of visual motor speed and integration to CPT performance. The WRAVMA is composed of three subtests. Two of these subtests, the drawing and pegboard subtests, were used in the study. The Drawing subtest requires the child to copy line drawings and the Pegboard subtest requires the child to put pegs in a square pegboard. A second potential influence on CPT performance, visual processing speed, was also measured by McGee et al. (2000) using the Visual Matching subtest of the Woodcock-Johnson Psycho educational battery – Revised (WJ; Woodcock & Johnson, 1989/1990). The Visual Matching subtest requires the child to locate and circle similar objects mixed within six objects as quickly as possible. Because the Connor's CPT requires rapid letter identification, a third potential influence on CPT performance measured by McGee et al. (2000) was phonological awareness. The Incomplete Words and the Sound Blending subtests of the W-JR measured auditory phonological awareness while the Letter-Word Identification and Word Attack Subtests of the WJ-R measured visual phonological awareness. Finally, both the visual Connor's CPT and an auditory CPT measure were included. The auditory CPT consisted of a series of one syllable words recorded at a rate of one word per second,

lasting for 10 minutes. During this time, the client hat to raise their thumb every time they heard the word dog. The word dog occurred 20 times in every 100 words.

The participants were 6-11 year olds that were referred to a mental health clinic. There were four groups studied over a two-year period. Participants were divided into groups based upon their diagnosis. The groups were ADHD only, Reading Disordered (RD) only, ADHD and RD, and a group of Clinical Controls. The clinical controls consisted of children who had family relational problems, anxiety disorder, adjustment reactions or behavior disorders other than ADHD.

The results indicated that the Conner's CPT overall index was not associated with age, SES, or parent or teacher behavioral ratings of internalizing or externalizing behaviors. The overall index is used for attention difficulties; it is derived from a regression equation. In other words, the overall index of the Connor's CPT did not distinguish children with AD D from controls. The results also indicated that CPT performance was not correlated with visual processing speed or visual motor competence. Performance on the WJ subtests Word Attack, Incomplete Words, and Sound Blending and the CPT Index discriminated between RD children from ADHD children and controls. However, the overall Connor's Index, commission errors, omission errors, or hit reaction time did not distinguish ADHD subjects from RD or clinical controls (McGee, Clark, & Symons, 2000). The CPT scores do not consistently identify attention problems in ADHD; however the overall index score was highest among subjects with RD.

In addition to problems with executive function, children with ADHD are presumed to have deficits in working memory (Barkley, 1997). Working memory is the

ability to store information for a short period of time. It is involved in mental activities such as reading, arithmetic, and problem solving. Westerberg et al. (2004) examined a Visuo-Spatial Working Memory (VSWM) and a Choice Reaction Test (CRT) in children with ADHD. The CRT measures speed of processing. The task was to press a button as quickly as possible when a warning sign (gray circle) switched to a target (yellow circle). The child was required to first use their left index finger while the symbols were displayed on the left side, this then switched to the rights side and the right index finger was to be used. Subsequently a decision task was employed where the child used one of two fingers and pressed the appropriate button depending on which side of the screen the symbol was presented on. The VSWM was a task in which circles (memory stimuli) were presented one at a time in a four by four grid on a computer screen. Responses were made by pointing with the index finger in the same locations as the memory stimuli on an empty grid. The response was made after all stimuli in each trial were presented. Working memory load increased after every second trial, starting at two and ranging to nine circles.

The study included 80 participants all of whom were boys who ranged in age from 8-15 years old. Of the 80 participants 27 had a diagnosis of ADHD. The other 53 boys were used as controls. The results indicated that the groups were significantly different for both the VSWM test and all measures on the CRT test. ADHD children performed significantly worse on the VSWM. The differences between the children with and without ADHD were larger at older ages. The reaction time was longer on the CRT for children with ADHD compared to controls (Westerberg, Hirvikoske, Forssberg, & Klingberg, 2004).

ADHD children generally have an average intelligence. Wechsler Intelligence Scale for Children-fourth Edition (WISC-IV) can provide a comprehensive picture of the child. Flanagan (2004) found that children with ADHD generally have an average full scale IQ of 97.6. Their strengths are in verbal and perceptual reasoning areas. Their weakness may be in arithmetic, cancellation and coding. These tasks are related to attention, concentration, and speed (Flanagan, 2004).

Asperger's Disorder

Asperger's Disorder is an autism spectrum disorder. An autism spectrum disorder is one of several types of disorders characterized by varying degrees of impairment in communication skills, social interactions, and restricted, repetitive and stereotyped patterns of behavior (DSM IV). Asperger's Syndrome is characterized by mild intellectual impairment, social deficits and relatively good language skills (Gilotty, 2002). The syndrome is difficult to differentiate from other high functioning autism disorders, learning disabilities, and other psychiatric conditions as they share school related social, behavioral/emotional, intellectual/cognitive, and academic characteristics (Barnhill, 2000). Children with Asperger's syndrome differ from autistic children in that they usually do not demonstrate a significant language delay, though this is debated among professionals. Asperger children usually have well developed language skills at a young age. By age three, these children often use communicative phrases and they often speak fluently by age five. However, their language may be noticeable odd due to problems with inflection, rhythm and a repetitive pattern. Clumsiness is prominent both in their fine and gross motor behavior. Asperger's children usually have a circumscribed area of interest (Myles & Simpson, 2002).

The impairment in social interaction is profound. Children with Asperger's Syndrome have trouble regulating social interactions and communication. For example, they may have impairment in eye-to-eye contact. They also have difficulty in understanding social conventions. Difficulties in transitions may be evident. These children usually prefer sameness. In addition, sensitivity to certain clothing, food, lights, or noise may be apparent (Myles & Simpson, 2002).

The DSM IV classifies the symptoms of Asperger's into two categories impairment in social interaction and restricted repetitive behaviors or interests. The symptoms that compromise these two categories are presented below.

Impairment in Social Interaction

- Marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
- Failure to develop peer relationships appropriate to developmental level
- A lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest to other people)
- Lack of social or emotional reciprocity

Restricted Repetitive and Stereotyped Patterns of Behavior, Interests, and Activities

- Encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
- Apparently inflexible adherence to specific, nonfunctional routines or rituals

- Stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole-body movements)
- Persistent preoccupation with parts of objects

In general children may have Asperger's Disorder if they have two of the symptoms on impairment in social interaction and one symptom of restricted patterns of behavior. The child must have no significant delays in cognitive development or in the development of appropriate self-help behavior or adaptive behavior. There also must not have been a significant delay in language. The symptoms must cause significant impairment in social or other important areas of functioning. Criteria for another specific pervasive developmental disorder or schizophrenia cannot be met (DSM IV, 1994).

Children with Asperger's syndrome generally have average intelligence. Wechsler Intelligence Scale for Children-fourth Edition (WISC-IV) can provide a comprehensive picture of the child and aid in the diagnosis. Flanagan & Kaufman (2004) found that children with Asperger's Syndrome generally have a full scale IQ of 99.2. Their strengths are usually exhibited in the subtests of Similarities, Information and Picture Completion. These subtests generally rely on language and are not sensitive to social interaction. Weakness may be found in Symbol Search, Cancellations, and Coding subtests. These subtests require the use of fine motor movement, which may contribute to the lower scores (Flannagan & Kaufman, 2004).

Barnhill et al. (2000) wanted to investigate the cognitive profiles of children with Asperger's syndrome. The authors were interested if the profiles could discriminate Asperger Syndrome from other disorders. Barnhill et al recognized the importance of identifying Asperger characteristics that may help aid in diagnosing the syndrome. The

researchers wanted to develop a cognitive profile for Asperger's Syndrome using the WISC-R. The WISC-R contains two groups of subtests, performance and verbal.

Barnhill et al. (2000) discovered more than 20 studies had used Wechsler subtest scales to identify cognitive profiles for autism spectrum disorders. Only four of those studies included individuals diagnosed with Asperger Syndrome (Bowler, 1992, Dennis et al., 1999, Ehlers et al., 1997, Szatmari, Tuff, Finlayson, & Bartolucci, 1990). Most of the studies revealed a strong performance on the Block Design subtest of the performance scale and a weak performance on the Comprehension subtest of the verbal scale for individuals with Asperger's Syndrome. Block Design is considered a nonverbal formation task. It requires perceptual organization, spatial visualization, and abstract conceptualization. Comprehension is designed to assess social judgment and interpersonal situations. It requires that an individual understands social judgment and social conventionality.

Barnhill et al. (2000) investigated the cognitive profile of Asperger's Syndrome. The participants included thirty-five boys and two girls that ranged in age from 3 to 14 years. All the participants had a diagnosis of Asperger's syndrome determined by a physician, psychologist, or psychiatrist. They also had previously completed one of the Wechsler intelligence scales prior to the study. The WISC-III was given to thirty-one of the participants, two participants were given the WISC-R, and two participants were given the WIPPSI-R.

The results did not yield a significant difference between the VIQ and the PIQ. A reliable pattern of subtest performance was not observed from the results. However, the results indicated that Asperger children performed lowest on the Coding/Digit Symbol

subtest of the performance scale and highest on Block Design. This suggests that Asperger children have good nonverbal reasoning ability or good visual-motor spatial integration. Information, Similarities, and Vocabulary were among the highest scores on the verbal subtests. This suggests a good range of knowledge or information and good memory. This study did not support the finding of a low score on the Comprehension subtest. Comprehension subtests scores were not significantly different from the other subtests (Barnhill, Hagiwara, Myles, & Simpson, 2000).

Executed function deficits have been noted in Asperger's Syndrome. Social, cognitive, and executive function impairments that follow frontal lobe damage are similar to symptoms of pervasive developmental disorders (Ozonoff, 1998). Problems with interpersonal interactions are commonly seen in individuals with frontal lobe damage and pervasive developmental disorders. Both groups seem to have difficultly taking the mental perspective of others. Simple social rules are difficult for both groups to follow. The similarities between pervasive disorders and frontal lobe deficits have stimulated much research, but little research has focused specifically on the deficits in Asperger's Syndrome.

Ozonoff et al. (1991) examined executive functions in a group of participants diagnosed with Autism with an age range of 8-20 years old. Of the autistic group 13 had High Functioning Autism (HFA) and 10 had Asperger's Syndrome. A control group of non autistic individuals were also examined. The groups were given different measures including two tests of executive functioning, the WCST and the Tower of Hanoi. The Tower of Hanoi was used to look at planning ability. The subject was given a board with three vertical pegs and three different sized and colored disks. The disks were arranged

on the tower, with the largest on the bottom to smallest disk on the top. The subject was required to move the disks to a specified goal state in the fewest moves possible. The primary rule on how the disks are moved is that the largest disk can never be placed on a smaller disk and you can only move one disk at a time.

The results indicated that the HFA and the Asperper's group performed significantly worse than their control group on the executive functioning tests. A universality analysis was performed where the proportion of subjects performing below the control mean were calculated for each domain, where the group was significantly different from the controls. The results indicated that 100% of the HFA and 90% of the Asperger subjects performed below the control mean. However, there was no significant difference between the participants diagnosed with HFA and Asperger's Syndrome on performance on the WCST and Tower of Hanoi (Ozonoff, Rogers, & Pennington, 1991).

ADHD and Asperger's Syndrome

The DSM IV conceptualizes ADHD and Asperger's Syndrome as two independent disorders. The diagnostic criterion states that an individual cannot have a comorbid diagnosis of ADHD and Asperger's Syndrome (DSM IV, 1994). Because of this exclusionary criterion few studies have looked at the overlap of symptoms of ADHD and any Pervasive Developmental Disorders. Pervasive Developmental Disorders (PDD) include Asperger Syndrome, PDD not otherwise specified (PD-NOS), and High functioning Autism. Criteria for diagnosis are clearly stated in the DSM-IV, but the clinical variability in diagnosing these PDD's is marked.

Sturm et al (2004) wanted to re-analyze children with PDD NOS, Asperger's Syndrome, and HFA for clinical description and comorbidity. The participants were 101

children from North Stockholm. The sample consisted of 91 children having a previous diagnosis of Asperger's Syndrome, 9 with PDD'NOS, and 1 with High Functioning Autism. The subjects included 71 males and 30 females. The age range was 5 years to 12 years, but the mean age was 9.8 years. The children's medical and psychiatric records from neuropsychiatrists, pediatric neurologists and child neuropsychologist were analyzed. Also additional information from teachers, speech pathologists, and occupational therapist were available. The information that was clearly stated in the records was rated on the degree of severity of the symptoms. The ratings were determined by the International Classification of Functioning, Disability and Health Classification System of the World Health Organization (World Health Organization, 2001). The categories used was "no", minor/mild" or "definite/severe" problems or deviations. Areas looked at included auditory and tactile perceptual dysfunction, gross and fine motor function, autism symptoms, activity level, impulse control, intellectual level, obsessive-compulsive behaviors, attention, affective dysregulation, thought disturbance, depressive states, learning, speech development, and tics.

The results indicated that 75 children had motor difficulties, of the 75, 36 children had severe problems. Attention deficits were found in 95 of the 101 children, mild attention deficits were found in 27 children, and severe attention deficits in 68 children. Hyperactivity was in 57 cases and hypoactivity was found in 23 of the cases. A combination of mild and severe problems with attention, hyperactivity, and impulse control were found in 38 children, 72 children had indicators of both motor problems and attention deficits. A measure of intellectual level was available for 95 of the children. A low IQ (85<) was found for 30 of the children, 4 children had an IQ above 115, and the

rest had an IQ in the normal range (85-115). The speech onset was early for 14 children, late for 45 children and with in normal limits for the remaining children (5 cases were not reported). Tics were found in 22 children and obsessive-compulsive behaviors we were found in 49 children. While 36 children had problems with tactile perception, 21 children had the combination of auditory and perceptual dysfunction. All the children had problems with social interaction and 99 children had problems with communication. A few children (17) had been treated for a variety of medical problems; all of these children had high functioning PDD (Strum, Fernel, & Gillberg, 2004).

The characteristics of Asperger's Syndrome, as having a narrow rage of interests, clumsiness, and stilted language were only seen in 20% of all children with the clinical diagnosis. This suggests that this clinical description is not common. Almost half of the children had a late onset of speech, suggesting that the "D" criterion (no significant general delay in language) from the DSM IV may not be valid for typical cases of Asperger's Syndrome. Also, about half of the children had the combination for attention deficits, hyperactivity and impulsivity. This suggests that ADHD may be a common comorbid disorder for many of the PDD subtypes (Strum, Fernel, & Gillberg, 2004).

Goldstein and Swebach (2004) wanted to investigate the comorbidity of pervasive developmental disorders and ADHD. They performed a retrospective chart review to determine if children diagnosed with PDD exhibited symptoms of ADHD. They also wanted to determine whether their symptoms could constitute a diagnosis of ADHD.

The review was performed on children who were evaluated at a university affiliated neuropsychological center since 1997. The data was collected for 57 subjects who had PDD (n=37), which included children with Autism (n=9) and PDD-NOS (n=28), also

twenty children were identified who had a diagnosis of ADHD, which included Inattentive Type (n=10) and Combined Type (n=10). Of these 57 children the mean age was 8.4 years and there were 50 males and 7 females.

The materials included in this study were test data obtained from parents, teachers, and subjects. Test data was evaluated for subscales of the Wechsler Intelligence Scale for Children, Cognitive Assessment System, Conners Parent and Teacher Rating Scales –Revised, Long Version, Home and School Situations Questionnaires, and the Achenbach Parent and Teacher Child Behavior Checklist. The data was analyzed and the subjects were placed in various subgroup categories based on symptom profiles. For the PDD group the subjects were divided into PDD+ADHD inattentive type (for subjects displaying significant ADHD inattentive symptoms), PDD+ADHD combined type (for subjects displaying significant combined type symptoms), or just PDD (for subjects that did not display a significant degree of ADHD symptoms). For the ADHD group the subjects were placed in either ADHD-Inattentive Type or ADHD-Combined Type. In order to be placed in a subgroup the subjects had to have significant elevated scores (1.5 Standard Deviations above the norm).

The results indicated that 26% of subjects that had a diagnosis of PDD met DSM-IV criteria for ADHD-Combined Type and 33% of subjects that had a diagnosis of PDD met DSM-IV criteria for ADHD-Inattentive Type. However, 41% of subjects that had PDD did not demonstrate significant ADHD symptoms. Children with PDD that meet diagnostic criteria for ADHD may represent a distinct group from children with PDD alone (Golstein & Schwebach, 2004).

Research has shown that in some cases a diagnosis of ADHD may be appropriate for some children with PDD's including Asperger's Syndrome. The similarities and differences between ADHD and Asperger's Syndrome have never been outlined. Deficits in flexibility, planning, organization, inhibition, and other executive functioning can be seen in both groups.

To date little research has investigated the specific differences or similarities of ADHD and Asperger's Syndrome on neuropsychological measures. Are neuropsychological tests sensitive to different measures of executive function for ADHD and Asperger children? Further research needs to focus on the specific areas of similarity. Since the symptoms of ADHD may be prevalent in Asperger's Syndrome the proper diagnosis must be made for the correct treatment plan to be implemented.

The proposed study tested children with a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD), Asperger's Syndrome, and a Control group with no psychological diagnosis. Participants were administered a large group of tests that were presumed to measure executive function, memory, and reading and listening comprehension. The purpose of the study was to identify those measures that differentiate children with ADHD and Asperger's Syndrome from non-clinical participants and from each other.

CHAPTER II

METHODS

Participants

Sixty children between the ages of 7 and 16 years old from the Grand Forks and Fargo areas were recruited to participate in this study. Thirteen children met the DMS IV diagnostic criteria for ADHD, as determined by a semi structured clinical interview. In addition the children for the ADHD group scored above the 92nd percentile on the Inattentive subscale of the ADHD Rating Scale IV (DuPaul et al., 1998) and above the 89th percentile on the Hyperactive Impulsivity subscale. The ADHD Rating Scale - IV is a parent rating scale. The 18 items cover the 9 symptoms of hyperactivity-impulsivity and the 9 items of inattention that are listed in the DSM-IV. The items are rated on a 4-point scale (0 – rarely, not at all; 1 – sometimes; 2 – often; 3 – very often). Eleven children met the diagnostic criteria for Asperger's Syndrome, as it is stated in the DSM IV. It is important to note that two of the children in the Asperger group met these inclusion criteria for ADHD. The other thirty six children had no psychological diagnosis and were placed in the control group. These children scored below the 75th percentile on both the Inattentive and Hyperactive subscales of the ADHD Rating Scale. All participants were tested between the hours of 9 A.M to 3 P.M. Children with ADHD who participated were asked to abstain from their medication at least 15 hours before participation with the permission of their physician.

Measures

A reduced version of the Clinical Interview – Parent Report Form from Barkley (1997) was administered to the parent of the child. The interview covers DSM-IV symptoms for internalizing and externalizing disorders in children. The reduced version covered Oppositional Defiant Disorder, Conduct Disorder, ADHD, Anxiety Disorders, and Mood Disorders.

Wechsler Intelligence Scale for Children – IV

The Vocabulary subtest from the Wechsler Intelligence Scale for Children-IV (WISC-IV; Wechsler 2003) was administered. This test consists of 30 words in which the examiner states the word and the participant provides a brief definition. Each response is given 0, 1, or 2 points depending on the accuracy of the response and testing continues until the participant produces four consecutive 0-point responses. This subtest assesses the child's verbal ability.

The Digit Span subtest from the WISC-IV consists of Digits Forward and Digits Backward sections. For the Digit Forward section, subjects were presented with sequences of numbers and were required to repeat the number sequences in the exact order they are presented. The sequences range from two to nine digits long with two sequences at each length. Participants were tested until they fail both sequences of a particular length. The Digits Backward section required subjects to repeat the number sequences in reverse order. Digit Span assesses attention and short-term memory.

The Symbol Search Subtest from the WISC IV was given to all the subjects for the study. Symbol Search requires the child to look at a symbol and scan through a serious of 5 symbols to determine if the target symbol is one of the five symbols. The

child works as quickly as they can for two minutes. Symbols Search assesses visual motor speed and visual scanning speed.

The Coding subtest from the WISC IV was given to all the subjects. This measure had the child copy geometric symbols that are pared with a number using a key as quickly as they can in two minutes. Coding assesses visual motor speed and visual scanning speed.

ADHD Measures

The Child Behavior Checklist (Achenbach, 1991) assesses several domains of children's emotional and behavioral functioning. It consists of 112 items in which the parents report, on a three-point scale, their child's functioning. The syndromes that can be identified are Social Problems, Attention Problems, Withdrawn, Anxious/Depressed, Aggressive Behavior, Thought Problems, Somatic Complaints, Delinquent Behavior, and Sex Problems.

The ADHD Rating Scale - IV (DuPaul et al., 1998) is a parent rating scale. The 18 items cover the 9 symptoms of hyperactivity-impulsivity and the 9 items of inattention that are listed in the DSM-IV. The items are rated on a 4-point scale (0 – rarely, not at all; 1 – sometimes; 2 – often; 3 – very often).

Executive Function Measures

The Conner's Continuous Performance Test (CPT) measures sustained attention (Conners, 1995). The CPT consists of ten upper-case letters including the letter X, which is designated as the target stimulus. Three hundred and sixty letters are presented on a computer screen one at a time. The CPT is divided into 18 consecutive blocks with 20 trials in each block. The 18 blocks contain different time delays between the

presentations of successive numbers (interstimulus interval, ISI). The ISI is 1, 2, or 4 seconds. The participant is asked to press the spacebar every time a letter appears except when the letter is "X".

The Wisconsin Card Sorting Task (WCST; Grant & Berg, 1980) assesses executive function. It consists of 128 cards that have designs that present a different number of geometric form and in a different color. The subject is given four stimulus cards and is asked to sort the deck of cards corresponding with the stimulus cards. After ten consecutive cards have been matched correctly, the category for sorting the cards is switched without warning. The WCST examines the number of perseverative errors, set breaks, and number of categories completed.

The Tower of London task (TOL; Krikorian, 1994) contains a block of wood with three wooden pegs of varying heights, three wooden balls of different colors (blue, red, and green) that can be placed on the pegs, and pictures of specific arrangements of the balls on the pegs. The balls are placed in the "start position", which is the same arrangement of the balls when starting a new subtest. The subject is shown an arrangement of the balls and is asked to match the picture in a certain number of moves. The subjects can only move one ball at a time and cannot hold one ball in their hand while moving another ball. The subjects are allowed three trials on each picture arrangement. Three points are awarded for correctly completing the arrangement on the first trial, two points for the second trial, one point for the third trial, and zero points for not correctly matching the arrangement. The examiner records the amount of time to complete the arrangement and the number of correct responses.

Trail Making Test (Reitan & Wolfson, 1985) is very similar to connect the dots. Two forms were used, Trail A and Trail B. Trail A is a pencil and paper test of simply connecting the dots numbered 1-12 in sequential order. Trail B is the same as Trail A except letters and numbers are used and the child should alternate between number and letter in sequential and alphabetical order.

The Rey-Osterrieth Complex Figure (ROCF; Waber et al., 1985) was given to the participants. This measure requires the reproduction and memory of a two-dimensional line drawing. Reproduction of the figure is assumed to require visual-motor representation and is thought to measure spatial planning, organizational skills, and long-term figural memory. When given the test the child is shown the figure and is asked to copy the design. The figure is than taken away and the child is asked to reproduce the figure from memory after three minutes and 30 minutes. There is also a recognition task that consists of different geometric shapes, some of which are part of the large figure. The child is to circle the figures that were part of the larger figure they were asked to copy.

Motor Tests

The Grooved Pegboard Test (Lafayette Instrument Company, 1997) was given to participants. This test requires the participant to insert 25 pegs into small keyholes as quickly as possible. The time taken to complete the test (in seconds) is obtained for the dominant hand and the non dominant hand.

Memory Tests

The three prose passages from the Wide Range Assessment of Memory and Learning (WRAML) were used as stimulus materials. The passages contain 80 words,

75 words, and 115 words. The WRAML manual suggests that one of the passages is appropriate for children ages 8 and younger, one is appropriate for children of all ages, and one is appropriate for children ages 9 and older.

Procedure

The participants were tested throughout the day from 9 A.M. to 5 P.M. but a majority of the participants were tested at either 9 A.M or 3 P.M. The children were tested individually in a private room. Subjects first filled out a demographic sheet requesting their name, age, sex, and grade in school. They were given a consent form that was signed by the parent and an assent form signed by the child, if both were in agreement the child would participate. The experiment was explained to the subjects. The parent would fill out the Child Behavior Checklist and the ADHD Rating Scale IV. In addition, each parent was administered a reduced version of the Diagnostic Interview for Children and Adolescents fourth edition (Barkley & Murphy, 1998). This will consists of a review of symptoms related to ADHD, Conduct Disorder, Anxiety, Depression and Bipolar Disorder. The Vocabulary, Digit Span, Symbol Search, and Coding subtests from the WISC-IV were administered first to the child. Next, the child took the Conner's CPT. After a short break following the Conner's CPT, the child was given the Wisconsin Card Sorting Test (WCST). Then, the child was given the Tower of London, Trails, Grooved Peg Board, ROCF, COWAT, and the Story Memory from the Wramml. The final test that was administered to the child was the Reading, Listening, and Psuedoword subtests from the WIAT.

CHAPTER III

RESULTS

The Vocabulary subtest of the Wechsler Intelligence Scale for Children Fourth Edition (WISC-IV) was scored according to standard procedures and raw scores were converted to scaled scores. The average age and vocabulary scores are presented in Table 1 for all three groups. A one-way Analysis of Variance (ANOVA) was conducted on age and revealed a significant main effect of Group, $F(2, 57) = 12.64, p<.01$. A subsequent Tukey test (Myers & Wells, 2003) indicated that the Control and ADHD groups were significantly younger than the Asperger group, but not different from each other.

A similar ANOVA was conducted on the Vocabulary subtest scores. A significant effect of Group was found, $F(2, 57) = 8.53, p<.01$. A subsequent Tukey test indicated that the Asperger and Control groups were significantly higher than the ADHD group, but not different from each other. This means that the Control and Asperger group performed higher on the vocabulary subtest than the ADHD group.

In light of the significant Group differences on Age and Vocabulary scores, all further analyses were conducted using Age and Vocabulary scores as covariates in a one-way analyses of covariance (ANCOVA). It is important to note that significant differences are based on the current data and not based on the norming data of the different tests.

Table 1. Demographics.

	Control	ADHD	Aspergers
Age	9.9167	10.31	13.45
Vocabulary	11.111	8.56	12.73

The Symbol Search, Coding, and Digit Span subtests from the WISC IV were scored according to standardized procedures and then converted to scaled scores. These measures were analyzed in a series of one-way ANCOVAs. The adjusted means for Symbol Search, Digit Span, and Coding are presented in Table 2; the unadjusted means are presented for comparison procedures

A significant effect was found for Symbol Search $F(2, 55) = 3.680$, $p<.01$. Symbol Search requires the child to scan different symbols and discriminate if one of the symbols is the target symbol in a given amount of time. A subsequent Tukey test indicated that the ADHD and Control group performed significantly better than the Asperger group, but not different from each other on this measure. That is, ADHD group and the control group were able to correctly discriminate more symbols than the Asperger group according to the current scores.

A main effect was found for Coding, $F(2, 54) = 4.903$, $p<.01$. Coding subtest requires the child to copy symbols that are paired with different numbers within a specific amount of time. A subsequent Tukey test indicated that the Control group performed significantly higher than the Asperger group. The control group had a significantly higher processing speed than the Asperger group according to the current scores. The

Control Group was not different from the ADHD group and the ADHD group was not significantly different from the Asperger group.

The analyses of the Digit Span scores did not produce significant group differences.

Table 2. WISC IV Subtests as a Function of Group.

		Controls	ADHD	Asperger
Symsea	Unadjusted	11.17	10.54	9.82
	Adjusted	11.01	11.45	9.24
Coding	Unadjusted	10.14	7.54	8.18
	Adjusted	10.08	8.36	7.40
Digit span	Unadjusted	10.64	7.92	9.00
	Adjusted	10.97	8.40	9.32

Abbreviation of terms: Symbol Search (Symsea)

Several of the measures on the Wisconsin Card Sort were converted to standard scores using a mean of 100 and a standard deviation of 15. Adjusted means for the performance measures on the total trials administered (TTA), total correct trials (TTC), total errors (TES), number of perseverative responses (NPR), number of perseverative errors (PES), nonperseverative errors (NPES), the number of categories completed (CC), the number of trails required to complete the first category (C1C), and the number of times the participant failed to maintain set (FMS) are presented in Table 3, the unadjusted means are presented for comparison procedures.

No significant group differences were found on the, TTA, TTC, TES, NPES, TTC, and FMS.

A significant difference was found for NPR, F (2, 52) = 2.094, p <.01. A subsequent Tukey test indicated that the ADHD and Control group had fewer perseverative responses than the Asperger group, but they were not different from each other. According to the current data the Asperger group had difficulty switching their mindset as they continued to pick the wrong category despite it being wrong.

A significant difference was found for PES, F (2, 52) = 2.111, p <.01. A subsequent Tukey test indicated that the ADHD and Control group had fewer perseverative errors than the Asperger group, but they were not different from each other.

A significant difference between the groups was found for C1C, F(2, 52) = 1.583, p <.01. A subsequent Tukey test indicated that the Asperger group took more trials to complete the first category than the ADHD group. According to the current data there was no differences found for the Control group and the ADHD group or the Asperger group and Control group.

An ANCOVA was conducted on the measures produced from the Conners Performance Test (CPT). All measures on the CPT were converted to T scores, with a mean of 50 and a standard deviation of 10. Adjusted means for Omissions (OMIS), Commissions (COMS), Hit Reaction Time (HIT RT), Standard Error (HIT RT SE), Variability of Standard Error (VSE), Detectability (DET), Response Style Indicator (RSI), Perseverations (PSV), Hit Reaction Time by Block (HIT RT BC), Standard Error by Block (HIT SE BC), Reaction time by Inter-Stimulus Interval (HIT RT ISI), Standard Error by Inter-Stimulus Interval (HIT SE ISI) are presented in Table 4, the unadjusted means are presented for comparison procedures. A description of each measure follows. Omissions (OMIS) are items that the child did not respond to. Commissions (COMS) are

Table 3. Wisconsin Card Sort Results as a Function of Group.

		Control	ADHD	Aspergers
TTA	Unadjusted	108.39	117.69	105.73
	Adjusted	106.98	113.85	114.52
TTC	Unadjusted	75.39	80.69	72.09
	Adjusted	74.87	80.25	74.19
TES	Unadjusted	103.82	98.54	94.18
	Adjusted	103.58	101.61	91.28
NPR	Unadjusted	105.85	103.77	96.18
	Adjusted	106.52	106.19	91.31
PES	Unadjusted	106.09	103.46	95.55
	Adjusted	106.64	105.83	91.10
NPES	Unadjusted	100.58	93.62	90.91
	Adjusted	99.81	97.21	88.93
CC	Unadjusted	4.85	4.77	12.09
	Adjusted	5.42	4.68	10.49
C1C	Unadjusted	22.33	17.31	33.55
	Adjusted	21.85	14.32	38.54
FMS	Unadjusted	1.30	1.85	1.45
	Adjusted	1.20	1.77	1.85

Abbreviation of terms: Total Trials Administered (TTA), Trials Correct Trails (TTC), Total Errors (TES), Number of Perseverative Responses (NPR), Number of Perseverative Errors (PES), Nonperseverative Errors (NPES), the Number of Categories Completed (CC), the Number of Trails Required to Complete the First Category (C1C), and the Number of Times the Participant Failed to Maintain Set (FMS)

errors made when the child responded to items that were not the target. Hit Reaction Time (HIT RT) is the average speed for correct responses. Standard error (HIT RT SE) is the measure of the consistency of the response latencies. Variability of the Standard

Table 4. Conners Performance Test as a Function of Group.

		Control	ADHD	Aspergers
OMIS	Unadjusted	49.43	62.96	47.97
	Adjusted	49.48	59.78	51.55
COMS	Unadjusted	46.79	49.74	51.89
	Adjusted	46.58	51.46	50.50
HIT RT	Unadjusted	49.69	63.55	49.78
	Adjusted	49.98	59.47	53.49
HIT RT SE	Unadjusted	48.12	64.58	48.25
	Adjusted	48.07	61.78	51.74
VSE	Unadjusted	46.90	60.86	47.06
	Adjusted	46.86	58.55	49.93
DET	Unadjusted	48.33	49.85	54.36
	Adjusted	47.94	51.34	53.83
RSI	Unadjusted	49.48	54.20	49.87
	Adjusted	48.38	54.54	52.75
PSV	Unadjusted	47.47	60.52	48.98
	Adjusted	46.91	59.46	51.99
HIT RT BC	Unadjusted	48.91	53.16	47.81
	Adjusted	49.01	52.22	48.61
HIT SE BC	Unadjusted	48.02	50.35	46.94
	Adjusted	48.34	50.25	46.03
HIT RT ISI	Unadjusted	51.71	65.79	48.46
	Adjusted	51.02	64.97	51.62
HIT SE ISI	Unadjusted	49.07	58.36	50.24
	Adjusted	48.66	58.21	51.74

Abbreviation of terms: Omissions (OMIS), Commissions (COMS), Hit Reaction Time (HIT RT), Standard Error (HIT RT SE), Variability of Standard Error (VSE), Detectability (DET), Response Style Indicator (RSI), Perseverations (PSV), Hit Reaction Time by Block (HIT RT BC), Standard Error by Block (HIT SE BC), Reaction time by Inter-Stimulus Interval (HIT RT ISI), Standard Error by Inter-Stimulus Interval (HIT SE ISI)

Error (VSE) is the amount of variability in the response latencies within the different segments of the test in relation to the overall standard error. Detectability (DET) is a measure of target detection accuracy connected for guessing. Response Style Indicator (RSI) is the child's response tendency, as some tend to make sure they are correct before answering while others respond more often, making sure they hit all targets. Perseverations (PSV) are responses that are less than 100 ms. Hit Reaction Time by Block (HIT SE BC) is the change in reaction time across the length of the test. Standard Error by Block (HIT SE BC) measures changes in response consistency across the duration of the test. Reaction Time by Inter-Stimulus Interval (HIT RT ISI) looks at the change in reaction time at the different inter-stimulus time intervals. Standard Error by Inter-Stimulus Interval (HIT SE ISI) examines change in the standard error of reaction times at the different time intervals.

A series of one-way ANCOVAs was conducted on these measures. A significant effect was found for OMIS, $F(2,54)=5.107$, $p<.01$. and HIT RT $F(2,54)=6.024$, $p<.01$. A subsequent Tukey test for the effect of errors of omissions indicated that the ADHD group had significantly higher errors of omissions than the Control or Asperger group which themselves were not significantly different from each other. Also a Tukey test of the significant effect of the Hit Reaction Time indicated that the ADHD group had significantly longer response latencies to correct responses than the Control or Asperger group which themselves did not differ.

A significant difference was found for HIT RT SE $F(2, 54) = 8.164$, $p<.01$ and VSE, $F(2, 54) = 6.845$, $p<.01$. Standard error for the Hit Response Times (HIT RT SE) revealed that the ADHD group had significantly more response time inconsistency than

the Control and Asperger group, which themselves did not differ. A similar analysis for the Variability of Standard Error measure (VSE) produced the same results, response latency was significantly more inconsistent in the ADHD group compared to the Control and the Asperger group.

In the analyses of the measures of COMS, DET, RSI, HIT SE BC and HIT RT BC, no significant effects were observed.

Significant effects were found for perseverations (PSV), $F(2, 54) = 8.569$, $p<.01$. According to the current data a Subsequent Tukey test indicated that the Control and Asperger group had fewer perseverative responses than the ADHD group.

Significant effects were found for HIT RT ISI, $F(2, 54) = 5.66$, $p<.01$ and HIT SE ISI $F(2,54)= 4.916$, $p<01$. A subsequent Tukey test indicated that the Control and Asperger group were significantly different from the ADHD group, but not different from each other. The current scores indicate that for the ADHD group response time increased as the Inter-Stimulus Interval increased while for the Control and Asperger groups response latency remained relatively consistent across the different Inter-Stimulus Intervals. Similarly, the Control and Asperger group were significantly different on the HIT SE ISI when compared to the ADHD group. The response variability did not change across the Inter-Stimulus Intervals for the Control and Asperger group, while response time variability increased for longer Inter-Stimulus Intervals for the ADHD group.

An ANCOVA was conducted on the COWAT which included that "FAS" trial (FAS) and the Animal trial (AN), Trials A and B, Grooved Pegboard which included the dominate hand (GPBDOM) and the non dominate hand (GPBNONDOM), and the Tower of London which included the total score and the total time needed to complete all trails.

All measures on the COWAT, TRIALS, and Grooved Pegboard were converted to standard scores with a mean of 100 and a standard deviation of 15, using norms by Spreen and Strauss, (1998). The measures from Tower of London are raw scores. Adjusted means for the COWAT, TRIALS, Grooved Pegboard, and Tower of London are presented in Table 5; the unadjusted means are presented for comparison procedures.

A series of one-way ANCOVAS conducted on the FAS, AN, TRAIL A, TRIAL B, GPBDOM, GPBNONDOM, TOLTOTAL, and TOLTIME revealed no significant differences.

An ANCOVA was conducted on the Story Memory subtests on the WRAMMEL. The subtests included Immediate Story Memory (SMEM), Story Memory Delayed (SDELAY), and Story Memory Recognition (SRECOG). All measures on the Story Memory were converted to standard scores with a mean of 10 and a standard deviation of 3. Adjusted means for the SMEM, SDELAY, and SRECOG are presented in Table 6; the unadjusted means are presented for comparison procedures.

Significant effects were observed for SMEM $F\,(2, 55) = 3.327, p < .01$ and SDELAY, $F\,(2, 50) = 5.817, p < .01$. Subsequent Tukey tests indicated that the Asperger and Control groups were significantly different from the ADHD group on SMEM and SDELAY, but not different from each other. According to the current data this indicates that the Control and Asperger group were able to remember more details from the stories presented than the ADHD group immediately after the story was read and twenty minutes after the story was read. There was not a difference between the ADHD, Asperger or Control group for SRECOG.

Table 5. COWAT, Trails A and B, Grooved Pegboard, and Tower of London as a Function of Group.

		Control	ADHD	Asperger
FAS	Unadjusted	93.24	92.85	80.96
	Adjusted	92.09	92.95	84.48
AN	Unadjusted	92.78	92.92	89.89
	Adjusted	92.13	93.89	90.70
TRAIL A	Unadjusted	96.83	100.15	98.67
	Adjusted	94.16	106.36	99.84
TRAIL B	Unadjusted	106.25	98.77	93.06
	Adjusted	104.83	103.02	92.56
GPBDOM	Unadjusted	100.30	92.62	92.75
	Adjusted	98.74	94.81	95.03
GPBNONDOM	Unadjusted	90.40	78.31	78.69
	Adjusted	88.58	81.67	80.06
TOLTOTAL	Unadjusted	28.42	27.15	29.64
	Adjusted	28.60	27.33	28.83
TOLTIME	Unadjusted	238.42	235.31	234.00
	Adjusted	233.28	216.81	272.69

Abbreviation of terms: COWAT :"FAS" trial (FAS) and the Animal trial (AN), Trials A and B, Grooved Pegboard: dominate hand (GPBDOM), the non dominate hand (GPBNONDOM), Tower of London: total score (TOlTOTAL) and the total time (TOLTIME)

A series of one-way analyses of variance were conducted on the Child Behavior Check List (CBCL). All measures on the CBCL were converted to T scores, with a mean of 50 and a standard deviation of 10. Means for Anxious/Depressed (ANXD), Withdrawn/Depressed (WDEP), Somatic Complaints (SOM), Social Problems (SOCP), Thought Problems (TP), Attention Problems (ATTN), Rule-Breaking Behavior (RULE),

Table 6. Story Memory as a Function of Group.

		Control	ADHD	Asperger
SMEM	Unadjusted	11.73	8.73	12.18
	Adjusted	11.76	9.56	11.24
SDELAY	Unadjusted	11.52	7.91	11.64
	Adjusted	11.36	8.69	11.31
SRECOG	Unadjusted	11.25	11.33	10.91
	Adjusted	11.16	11.60	10.95

Abbreviation of terms: Story Memory (SMEM), Story Memory Delayed (SDELAY), Story Memory Recognition (SRECOG)

Aggressive Behavior (AGG), Internalizing Problems (INT), and Externalizing (EXT) are presented in Table 7.

According to the current data significant group differences were found for all measures on the CBCL. Significant differences were found for ANXD $F(2,55)=12.87$, $p<.01$, WDEP $F(2,55)=18.77$, $p<.01$, SOM $F(2,55)=5.68$, $p<.01$, SOCP $F(2,55)=43.603$, $p<.01$ and INT $F(2,55)=21.25$, $p<.01$. Subsequent Tukey tests indicated the Asperger and ADHD children's parents reported more symptoms than the Control children's parents on symptoms of Anxiety, Depression, Withdrawn, Somatic Complaints and Social Problems. Asperger and ADHD groups were not different from each other.

Significant effects were found for ATTN $F(2,55)=76.09$, $p<.01$, RULE $F(2,55)=40.83$, $p<.01$, AGG $F(2,55)=58.39$, $p<.01$., and EXT $F(2,55)=59.09$, $p<.01$. Subsequent Tukey tests indicated that the parents of the ADHD and Asperger children reported more symptoms of attention problems, rule-breaking behavior, aggressive behavior, and externalizing problems than the Control parents. In addition the ADHD

Table 7. Child Behavior Check List (CBCL) as a Function of Group.

		Control	ADHD	Asperger
ANXD	Unadjusted	52.94	61.54	65.00
WDEP	Unadjusted	52.72	61.92	66.22
SOM	Unadjusted	52.64	58.92	58.11
SOCP	Unadjusted	51.67	65.23	68.78
TP	Unadjusted	51.72	64.15	69.88
ATTN	Unadjusted	51.71	73.69	63.67
RULE	Unadjusted	51.23	63.85	57.67
AGG	Unadjusted	51.14	70.23	58.22
INT	Unadjusted	46.23	60.85	65.78
EXT	Unadjusted	43.57	67.85	58.33
TOTA	Unadjusted	41.94	68.39	65.44

Abbreviation of terms: Anxious/Depressed (ANXD), Withdrawn/Depressed (WDEP), Somatic Complaints (SOM), Social Problems (SOCP), Thought Problems (TP), Attention Problems (ATTN), Rule-Breaking Behavior (RULE), Aggressive Behavior (AGG), Internalizing Problems (INT), Externalizing (EXT).

parents reported more symptoms of attention problems, rule-breaking behavior, aggressive behavior, and externalizing problems than the Asperger parents.

A significant difference was found for TP $F(2,55)=64.90$, $p<.01$. A subsequent Tukey test indicated that the parents of the Control children reported significantly less thought problems than the parents of the ADHD or Asperger children. In addition the

parents of ADHD children reported less thought problems than the parents of the Asperger children.

An ANCOVA was conducted on subtests from the WIAT. All measures on the WIAT were converted to standard scores, with a mean of 100 and a standard deviation of 15. Adjusted means for Reading Comprehension by age (RAGE), Reading comprehension by grade (RGRADE), Listening Comprehension by age (LAGE), Listening Comprehension by grade (LGRADE), Pesudoword Decoding my age (PWAGE), and Pesudoword Decoding by grade (PWGRADE) are presented in Table 8, the unadjusted means are presented for comparison procedures.

According to the current data significant group effects were found for RCAGE $F(2, 54) = 14.653, p<.01$, and RGRADE $F(2, 54) = 13.121, p<.01$. A Subsequent Tukey test indicated that on both measures of Reading Comprehension (RAGE, RGRADE) children with ADHD scored significantly lower than the Control and Asperger groups which themselves did not differ.

A series of one-way ANCOVAS conducted on the LCAGE, LGRADE, PWAGE, and PWGRADE revealed no significant differences.

An ANCOVA was conducted on the Rey-Osterrieth Complex Figure (ROCF). All measures on the ROCF were converted to standard scores, with a mean of 100 and a standard deviation of 15. Adjusted means for Rey Copy (COPY), Rey Time (TIME), Rey Immediate (IMMED), Rey Delayed (DELAYED), and Rey Recognition (RECOG) are presented in Table 9, the unadjusted means are presented for comparison procedures.

A series of One way ANCOVAs did not result in significant group differences with the COPY, IMMED, DELAYED, and RECOG.

Table 8. WIAT Reading Comprehension, Listening Comprehension, and Pseudoword as a Function of Group.

		Control	ADHD	Asperger
RCAGE	Unadjusted	109.83	89.31	111.40
	Adjusted	108.21	94.72	110.20
RGRADE	Unadjusted	110.67	90.46	111.70
	Adjusted	109.07	95.43	111.00
LAGE	Unadjusted	105.03	99.46	105.55
	Adjusted	103.60	105.05	103.63
LGRADE	Unadjusted	107.00	100.54	106.46
	Adjusted	105.35	105.86	105.57
PWAGE	Unadjusted	107.50	94.85	105.64
	Adjusted	105.56	96.91	109.55
PWGRADE	Unadjusted	107.81	95.15	104.27
	Adjusted	105.76	97.22	108.54

Abbreviation of terms: Reading Comprehension by age (RAGE), Reading comprehension by grade (RGRADE), Listening Comprehension by age (LAGE), Listening Comprehension by grade (LGRADE), Pesudoword Decoding my age (PWAGE), and Pesudoword Decoding by grade (PWGRADE)

A significant difference for TIME $F(2,55)=3.59$, $p<.01$ was found. A subsequent Tukey test on Rey Time indicated that the ADHD and Asperger group took significantly longer to copy the figure than the Control group. The ADHD and Asperger group were not significantly different from each other.

Table 9. Rey-Osterrieth Complex Figure (ROCF) as a Function of Group.

		Control	ADHD	Asperger
COPY	Unadjusted	89.11	77.54	108.02
	Adjusted	89.67	79.80	103.07
TIME	Unadjusted	98.78	119.77	113.57
	Adjusted	99.33	124.10	105.95
IMMED	Unadjusted	85.97	84.69	105.10
	Adjusted	85.89	87.56	101.66
DELAYED	Unadjusted	85.97	80.77	105.68
	Adjusted	85.24	84.36	103.65
RECOG	Unadjusted	95.89	96.54	92.45
	Adjusted	94.94	97.39	94.78

Abbreviation of terms: Rey Copy (COPY), Rey Time (TIME), Rey Immediate (IMMED), Rey Delayed (DELAYED), Rey Recognition (RECOG)

CHAPTER IV

DISCUSSION

The diagnostic criterion in the DSM IV states that an individual cannot have a comorbid diagnosis of ADHD and Asperger's Syndrome (DSM IV, 1994). Because of this exclusionary criterion few studies have looked at the overlap of symptoms of ADHD and Asperger's Syndrome. Criteria for diagnosis are clearly stated in the DSM-IV, but the clinical variability in diagnosing Asperger's Syndrome is marked. Research has shown that in some cases a diagnosis of ADHD may be appropriate for some children with PDD's including Asperger's Syndrome. The similarities and differences between ADHD and Asperger's Syndrome have never been outlined. The research has shown that both diagnostic groups demonstrate executive function deficits. Deficits in flexibility, planning, organization, inhibition, and other executive functioning can be seen in both groups (Goldstein & Schwebach, 2004). The results of the present study provide some insights as to the areas of similarity and areas of differences.

When looking at measures of sustained attention the ADHD group performed significantly different than the Asperger group and Control group on a number of different measures on the Connors Performance Test (CPT). These children diagnosed with ADHD performed significantly worse on several measures on the CPT (Omissions, Hit Reaction Time, Hit Rate Standard Error, Variability of Standard Error, Reaction Time by inter-stimulus interval, and Standard Error by Inter-Stimulus Interval) than the

Controls and the Asperger's group. The ADHD group had more omissions through out the test and this group responded slower overall throughout the test than the Control and Asperger groups. This difference in the Hit Reaction Time may be an indication that ADHD group was more inattentive when responding. The ADHD group also had more Perseverative responses, indicating greater impulsivity when responding than the Asperger or Control group. In addition the ADHD group was more inconsistent in their response speed throughout the test, as measured by the Hit Rate Standard Error and the Variability of Standard Error. The ADHD group had a higher T-Score on the Reaction Time by Inter-Stimulus Interval. This indicates that the response time of children with ADHD significantly increased for longer inter stimulus intervals. The Control and Asperger group either maintained or had faster response speed as the length of the inter-stimulus interval increased. The variability increased with longer Inter-Stimulus Intervals for the ADHD group. No differences were found between the Commissions, Detectability, Response Style Indicator, and the Hit Reaction Time by Block. In accordance with a study done by Barkley et al. (1994) the CPT was more successful in differentiating ADHD from control children and Asperger children. The CPT did not differentiate Asperger children from Control children.

On some measures of executive function the ADHD, Asperger, and Control groups did not significantly differ on measures such as Trials A & B, Controlled Oral Word Association Test (COWAT), Grooved Pegboard, Tower of London, or Rey-Osterrieth Complex Figure (ROCF). However, on several performance measures on the Wisconsin Card Sort (WCST) the Asperger children performed worse than ADHD and Control children. These measures include perseverative responses (NPR), number of

perseverative errors (PES), and number of trails required to complete the first category (C1C) on the WCST. Asperger children took more trials to complete the first category, had more preservative responses and made more preservative errors when responding. This may indicate a rigid way of thinking or an inability to switch their mindset. This indicates that the Asperger group had difficulty switching their mindset as they continued to pick the wrong category despite it being wrong. Children with Asperger Syndrome may need more time on tasks where they are required to switch their mindset. Similarly to the current study, a study by Ozonoff et al. (1991) also found impaired performance for Asperger children when compared to Control children on the WCST.

In accordance with previous findings by Barkley et al (1994) the ROCF did had the worst predictive power for ADHD. They concluded that the abnormal scores on the WCST, COWAT, ROCF, and Grooved Pegboard may indicate ADHD, however average scores on these measures could not exclude the presence of the disorder. Our study did not replicate these results. Sami et al. (2003) found that girls with ADHD had more difficulty on the planning portion of the ROCF. Similarly, the present study found that Control children were able to copy the figure faster than the ADHD and Asperger children. There was not a difference in the time it took to copy the figure between Asperger and ADHD children. This may indicate that both ADHD and Asperger children have difficulties in planning abilities.

Despite previous research finding that Asperger children perform poorly on tests of executive function such as the Tower of Hanoi (Ozonoff, Rogers, & Pennington, 1991), the current study did not find such evidence. There were no differences in performance on the Tower of London between the ADHD, Asperger, and Control groups.

In accordance with previous literature (Barnhill, Hagiwara, Myles, & Simpson, 2000), the Asperger children performed poorly on the Symbol Search and Coding subtests of the WISC IV when compared to the ADHD and Control children. This may indicate that children with Asperger's syndrome have difficulty with their processing speed or their visual-scanning coordination. However, no deficits were found on the Grooved Pegboard, which requires visual-motor abilities. However, the writing requirements of the Coding subtest may increase the processing demand of the task. Asperger children may need more time to process information than other children.

On measures of memory Asperger and Control children were significantly better than the ADHD group on the Story Memory from the WRAMML. The Asperger and Control children remembered significantly more details from the story immediately after and 20 minutes after the story was read. This may indicate that the ADHD children had difficulty remembering details of the story. The groups were not different on their story recognition. This may lead individuals to believe that ADHD children will need recognition cues when asked to remember details.

The analysis of the WIAT data suggests that reading comprehension differences are found between ADHD children and the Control and Asperger children. This suggests that children with ADHD are poor readers when compared to Asperger and Control children. Barkley (1997) reported that a higher percentage of children with ADHD were poor readers. The current study indicates the reading ability of children with Asperger's Syndrome is not different from Control children, but significantly higher than children with ADHD. Reading problems are associated with school failure and thus pose a significant problem for educational success and later occupational success. The present

results suggest that children with Asperger's Syndrome have the necessary reading skills to complete formal school, while children with ADHD have problems in this area.

Based on parental report ADHD and Asperger children both exhibit symptoms of Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior, Aggressive Behavior, Internalizing Problems, and Externalizing Problems when compared to Control Children. When looking further it was determined that the ADHD children's parents reported more symptoms than the Asperger parents on Attention Problems, Rule Breaking Behavior, Aggressive Behavior and Externalizing Problems. The Asperger children's parents reported more symptoms on thought problems than the ADHD children's parents. This indicates that based on parental report it is difficult to distinguish ADHD and Asperger children on some symptoms. However, although the Asperger children appear to have difficulties on Attention, Rule Breaking Behavior, Aggressiveness and Externalizing problems it is more pronounced in the ADHD children. This may be a direct result of the ADHD child's difficulty in sustaining attention and impulsivity. In addition, although the ADHD children have difficulty with thought problems the Asperger children seem to exhibit more symptoms.

Children with ADHD and Asperger children perform significantly differently on some measures of sustained attention, memory, and executive function. Both diagnostic groups have demonstrated executive function deficits. These deficits have been in flexibility, planning, organization, inhibition, and other executive functioning (Schwebach, 2004). The current study has replicated some of these results however, ADHD and Asperger children do not perform similarly on these tests. The difficulty of

children with ADHD seems to rest on sustained attention and memory. Asperger children seem to have more difficulty on processing speed, visual-scanning abilities, and cognitive flexibility. The results of this study may be able to help discriminate between the diagnostic groups of ADHD and Asperger's Syndrome.

Although age and vocabulary scores were accounted for, the Asperger children in the present study were significantly older than the ADHD and Control children. Future research should try to match the children on age. Younger Asperger children may exhibit different symptoms than older Asperger children. Asperger Syndrome and ADHD may manifest itself differently at different ages. Due to difficulty in recruiting subjects, the sample size of the ADHD and Asperger group were relatively small 13 and 11 respectively compared to the 36 Controls. A bigger sample size may lead to different results.

It is recommended that future research expands the test measures and looks at the areas where discrepancies were. Specifically, at processing speed for the Asperger group. More measures of sustained attention should be given to both ADHD and Asperger children. Since parents seem to report similar symptoms in ADHD children and Asperger children it may be necessary to look at teacher's reports.

REFERENCES

American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, D.C.: Author.

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

Barkley, R., Grodzinsky, G. (1994). Are Tests of Frontal Lobe Functions Useful in the Diagnosis of Attention Deficit Disorders? *The Clinical Neuropsychologist, 2,* 121-139

Barnhill, G., Hagiwara, T., Myles, B., & Simpson, R. (2000). Asperger syndrome: A study of the cognitive profiles of 37 children and adolescents. *Focus on Autism and Other Developmental Disabilities, 15*(3), 146.

Bowler, D. M., & Cox, A. (1992). "Theory of mind" in Asperger's sundrome. Journal ot Child Psychology and Psychiatry and Allied Disciplines, *33,* 877-893.

Conners, C. K. (1995). *Conners' Continuous Performance Test.* Toronto: Multi-Health Systems.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1987). The California Verbal Learning Test. San Antonio, TX: Psychological Corporation.

Dennis, M., Lockyer, L., Lazenby, A., L., Donnelly, R. E., Wilkinson, M., & Schoonheyt, W. (1999). Intelligence patterns among children with high functioning autism, phenylketonuria, and childhood head injury. *Journal of Autism and Developmental Disorders, 29,* 5-17.

Ehlers, S., Nyden, A., Gillberg, C., Sandberg, A. D., Dahlgren, S., Hjelmquist, E., & Oden, A. (1997). Asperger syndrome, autism and attention deficit disorders: A comparative study of cognitive profiles of 120 children. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 38,* 207-217.

Flanagan, P., D., & Kaufman, S. A. (2004). Essentials of WISC-IV Assessment. Hoboken, New Jersey, John Wiley & Sons, Inc.

Ghaziuddin, M., Tsai, L., & Alessi, N. (1992). AHDH and PDD. *Journal of the American Academy of Child and Adolescent Psychiatry, 31,* 567.

Gilotty, L., Kenworth, L., Sirian, L. O. Black, D., & Wagner, A. (2002). Adaptive Skills and Executive Function in Autism Spectrum Disorders. *Child Neuropsychology, 8,* 241-248.

Goldstein, S., & Schwebach, J. A. (2004). The Comorbidity of Pervasive Developmental Disorder and Attention Deficit Hyperactivity Disorder: Results of a Retrospective Chart Review. *Journal of Autistic and Developmental Disorders. 34*(3), 329-339.

Grant, D. A., & Berg, E. A. (1980). *Wisconsin Card Sorting Test.* San Antonio, TX: Psychological Corporation.

McGee R., A., Clark S., E., & Symons D., K. (2000). Does the Conner's Continuous Performance Test Aid in ADHD Diagnosis? *Journal of Abnormal Psychology, 28,* 415-424.

Ozonoff, S. (1998). Assessment and Remediation of Executive Dysfunction in Autism and Asperger Syndrome. New York, Plenum Press.

Ozonoff, S., Rogers, J. S., & Pennington, F. B. (1991). Asperger's Syndrome: Evidence of an Empirical Distinction from High-Functioning Autism. Journal of Child Psychology and Psychiatry and Allied Disciplines, *32*(7), 1107-1122

Pineda, D., Alfredo, A., Mo'nica, R., Clemencia, C., Silvia, M., & Mejia, S. (1998). Executive Dysfunctions in Children with Attention Deficit Hyperactivity Disorder. *Intern J. Neuroscience, 96,* 177-196.

Reitain, R. M., & Wolfson, D. (1985). *The Halstead-Reitan neuropsychological test battery.* Tucson: Neuropsychological Ress.

Sami, N., Carte, E., Hinshaw, S., & Zupan, B. (2003). Performance of Girls with ADH and Comparisons Girls On the Rey-Osterrieth Complex Figure: Evidence for Executive Processing Deficits. *Child Neuropsychology, 9*(4), 237-254.

Sturm, H., Fernell, E., & Gillberg, C. (2004). Autism Spectrum Disorders in Children: Associated Impairments and Subgroups. *Developmental Medicine and Child Neurology, 46*(7), 444-447.

Szatmari, P., Tuff, L., Finlayson, M. A. J., & Bartolucci, G. (1990). Asperger's Syndrome and autism: Neurcognitive aspects. *Journal of the American Academy of Child and Adolescent Psychiatry, 29,* 130-136.

Waber, D. P., Mann, M. B., & Merola, J. (1985). *Assessing children's copy production of the Rey-Osterrieth Complex Figure. Journal of Clinical and Experimental Neuropsychology, 7,* 264-280.

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) administration and scoring manual*. San Antonio, TX: The Psychological Cooperation.

Westerberg, H., Hirvikoske, T, Forssberg, H., & Klingberg, T. (2004). Visuo-Spatial Working Memory Span: A Sensitive Measure of Cognitive Deficits in Children With ADHD. *Child Neuropsychology, 10,* 155-161

World Health Organization. (2001). International Classification of Functioning, Disability and Health. Geneva: World Health Organization