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Differential performance on tasks of executive function between Asperger's Syndrome and Attention Deficit Hyperactivity Disorder in middle school children

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**Differential Performance on Tasks of Executive Function between Asperger's
Syndrome and Attention Deficit Hyperactivity Disorder in Middle School Children**

A dissertation presented

by

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Differential Performance on Tasks of Executive Function

Abstract

Asperger's Syndrome (AS) and Attention Deficit Hyperactivity Disorder (ADHD) are neurodevelopmental conditions for which impaired executive functions have been found to be central to their symptomatology (Happé et al., 2006). A major limitation to the explanatory power of extant accounts of executive dysfunction in AS and ADHD is lack of specificity in the use of this term (Geurts et al., 2004). Executive Function (EF) has historically been used as an umbrella term for abilities such as planning, working memory, impulse control, inhibition and shifting set, as well as the initiation and monitoring of action (Stuss & Knight, 2002). Evidence of EF deficits in individuals with ADHD is extensive, yet there is still some dissent as to how this is manifested. Similarly, for Asperger's Syndrome, also labeled an executive function disorder, there is no consensus regarding what specific tasks of EF are affected.

This study sought to identify profiles of EF that could assist in the characterization of AS vis-a-vis ADHD, thereby facilitating differential diagnosis and helping guide the selection and implementation of best practice interventions to address those. To this end, tasks that tap on two dimensions of EF were utilized. One is modality (verbal vs. nonverbal), the second the cognitive operation employed, i.e., fluency, inhibition, categorization, and strategic problem solving. Four components of the D-KEFS were used to evaluate these aspects of EF: the Sorting, Design Fluency, Verbal Fluency, and Color-Word Interference tests. AS children performed less well than ADHD children on the set-shifting and cognitive flexibility task (Sorting), and the generation of novel visual patterns (Design Fluency). ADHD children performed less

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well than AS children on tasks requiring rapid access to the lexicon (Verbal Fluency) and inhibition (Color-Word Interference).

Implications for the development and implementation of effective educational services to facilitate not only greater academic achievement but also to further self-understanding, personal development, and to enhance day-to-day functioning and coping skills in these children are discussed.

DEDICATION

This study is dedicated to my mother and father, for their inspiration and unconditional love and support throughout my life. Also, for instilling the importance of hard work and higher education and demonstrating strength in the face of obstacles and adversity.

This is also dedicated to the families who participated in this study. Hopefully this study can shed some light on how we, as professionals and educators, can help children with Asperger's Syndrome and Attention Deficit Hyperactivity Disorder.

Finally, I would like to thank my husband for his support and encouragement. I could not have succeeded in completing this undertaking without his assistance, tolerance, and enthusiasm.

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Chapter 1

Asperger's Syndrome (AS) and Attention Deficit Hyperactivity Disorder (ADHD) are neurodevelopmental conditions for which impaired executive functions (EF) have been found to be central to their symptomatology (Happé et al., 2006). While the pivotal role of frontal dysfunction in both disorders is indisputable, the usefulness of this global construct in telling them apart is limited. A major limitation to the explanatory power of executive dysfunction accounts of AS is lack of specificity in the use of this term (Geurts et al., 2004). Several other developmental disorders, most notably ADHD, show significant deficits on EF tests. This casts doubt on whether EF problems underpin the characteristic social, communicative and rigid/repetitive difficulties in AS (Happé et al., 2006).

Executive Function has long been used as an umbrella term for abilities such as planning, working memory, impulse control, inhibition and shifting set, as well as the initiation and monitoring of action (Stuss & Knight, 2002). Ozonoff et al. (1991a) have described executive functions as “the ability to maintain an appropriate problem solving set for attainment of a future goal; it includes behaviors such as planning, impulse control, inhibition, set maintenance, and flexibility of thought and action.” These are complex cognitive processes that are mediated mainly by the frontal lobes. There is evidence that other brain structures, especially the basal ganglia, also assist in mediating these skills (Chow & Cummings, 1999).

Other factors must be considered in the study of executive functions. In order to accomplish the task of planning for future goals and actions as well as to inhibit

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impulsive behavior and guessing, the assistance of other brain areas is required, notable those involved in alertness, memory, and learning. It is also important to take into account developmental factors. As Denckla (2001) states, “A great deal of the differences between child and adult reside in the unfolding of executive functioning” (p. 264).

Evidence of EF deficits in individuals with ADHD is extensive, yet there is still some dissention as to how this is manifested. Inhibition dysfunction has been considered the core deficit in ADHD by a number of theorists (Tannock, 1998; Barkley, 1997a, b). Barkeley (1997 a,b) has argued that poor behavioral causes secondary deficiencies in other EFs, such as working memory, cognitive flexibility, planning and fluency. Pennington and Ozonoff (1996), on the other hand, found that while the core problem in ADHD is a deficit in, support for the notion that other EFs are involved was inconclusive.

Asperger’s Syndrome has also been labeled an executive disorder. A systematic review of the literature, however, reveals a lack of consensus on the EFs involved in this condition. Specific deficits in the areas of cognitive flexibility, planning, and working memory are well documented (Pennington & Ozonoff, 1996). In contrast, inhibitory control seems to be spared (Ozonoff & Strayer, 1997). In a more recent study, Hill (2006) found response initiation and intentionality to be the significant executive dysfunction in AS. This deficit was most evident in the ability to engage and disengage actions in the service of overarching goals. Other studies have shown executive function in children with AS in the areas of: social comprehension, problem solving, and gross and fine motor coordination (Pennington & Ozonoff, 1996).

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Gillberg & Ehlers (1998) have raised the issue that much overlap in symptomatology exists between ADHD and AS. Gillberg & Ehlers point out that children who meet criteria for ADHD may also meet the full criteria for AS, and vice-versa., citing a study, in which 21% of children with severe ADHD met the full criteria for AS. Overlapping presenting characteristics are inattention, impulse control problems, and poor comprehension of social situations.

Regarding social skills, lack of attention to underlying causes of overt behaviors may be at the root of some of the diagnostic confusion. Children with ADHD have difficulty with social skills, especially at a young age. In these children impulsivity can interfere with social relationships, making them appear unempathic and isolated. They can be so easily distracted that they appear to be in a world of their own, adding to the impression of aloofness and social disconnection. Since disconnectedness with the social world is a major hallmark of AS, it is not surprising that children with ADHD are at times misdiagnosed as having AS.

There have been a number of studies that are related to evaluation of these issues, most of them focusing on the use of executive functions as a way to distinguish ADHD from Autistic Disorder (Guerts et al., 2004). To date only four studies have attempted to identify executive function tasks that are more specific to either ADHD or AS (Geurts et al., 2004; Happe et. al., 2006; Nyden, 1999; Ozonoff and Jensen, 1999). Consensus has yet to emerge regarding differential attributes between the two groups.

Ozonoff and Jensen (1999) found that on tasks of EF administered the ADHD group did better than AS group (only on the Stroop test where they worse than controls).

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By contrast, Nyden (1999), who used a number of attention and executive function tasks found little in the way of differences between the two groups. Geurts et al. (2004) study concludes that the AS group had more severe EF problems. Happe et al.'s (2006) did provide support for distinct EF profiles in ADHD and AS: the ADHD group showed striking deficits of response selection/inhibition on a Go-no-Go task, and planning on a spatial working memory task, while the ASD group showed poor response selection/monitoring on a cognitive estimates task. Given the lack of consensus regarding the typical performance of individuals with AS versus those with ADHD on EF tasks, further research is necessary. The need to provide further clarity is of particular importance among middle school children given the curriculum demands of these school grades. School grades, which coincide with the maturation of neuronal structures subserving executive functions.

The purpose the study was an attempt to identify profiles of EF that could assist in the differential diagnosis of AS versus ADHD. If the domain of EF is central to these disorders, it is important to determine which specific executive deficits characterize each disorder and distinguish each from the other. Disorder-specific patterns of strengths and weaknesses on neuropsychological tests will be useful aides in identification of specific executive profiles. Such executive profiles will be useful for diagnostic purposes, as well as in determining best practices for their mediation. To this end, tasks that tap on two dimensions of EF were utilized. One was modality (verbal vs. nonverbal), and the second was cognitive operation employed: fluency, inhibition, categorization, inhibition and strategic problem solving.

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Background support for this study is provided in chapter 2. Here, a discussion of theoretical formulations of ADHD and AS over time is presented. This is followed by a discussion of EF and their measurement. Finally, issues raised by this review, and specific hypotheses to be addressed in this study will be derived from the literature is presented.

In chapter 3 the methodology to be utilized to evaluate those hypotheses is detailed. In the fourth chapter, the data analysis used to analyze data gathered is described.

The relevance of this study ultimately resides in the importance of an accurate diagnosis of the specific areas of EF deficits with which a child with ADHD or AS presents. Not only is this important in distinguishing diagnostically between the groups. Ultimately, this could lead to the utilization and development of effective educational services to facilitate not only greater academic achievement, but also further self-understanding, personal development, and enhance daily living and coping skills in these children. For the family and support system, a more precise and accurate diagnosis can offer a better grasp on the specific characteristics of the syndrome, gaining a deeper insight into their loved ones' strengths, deficits and way of being in the world.

CHAPTER 2

LITERATURE REVIEW

Introduction

Individuals with Asperger's Syndrome (AS) encounter much difficulty in daily functioning throughout their lives. These difficulties include trouble learning, difficulties in motor coordination and social communication and executive dysfunction. Many children with ADHD have similar problems, however, the cause differs. Children with ADHD are characterized by symptoms of inattention, hyperactivity, and impulsivity (APA, 1994). The triad of characteristics that defines the syndrome of autistic disorders is the following: social abnormalities, communication abnormalities, and stereotyped repetitive patterns of behavior (APA, 1994). Both ADHD and Autistic Spectrum Disorders are characterized by behavior similar to that found in patients with frontal lobe damage (Damasio & Maurer, 1978; Stuss & Benson, 1984). EFs are strongly related to the prefrontal cortex and its related networks (Cabeza & Nyberg, 2000; Fuster, 1997). Neural imaging studies show involvement of prefrontal and connected structures in both ADHD (Faraone & Biederman, 1998) and Austistic Spectrum Disorders (e.g., Eliez & Reiss, 2000; Minshew, 1996). The above findings gave rise to the idea that ADHD and AS are associated with EF deficits.

A review of the literature is necessary, in order to fully understand the range of difficulties, the trouble with diagnostic differentiation and the variations in executive functioning. Given the focus of this research, a thorough literature review of AS will be presented. It is important to review the theories, DSM-IV criteria, distinguishing

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characteristics, biological factors, brain/MRI studies, developmental history, cognitive and neuropsychological profile of AS to fully comprehend the pervasiveness of this disorder. This will be followed by a brief review of ADHD, including a description, the DSM-IV criteria and the characteristics. These characteristics will include social interaction, biological factors, Brain/MRI studies, and neuropsychological profile.

Following the review of AS and ADHD, Executive Functioning (EF) will be defined. An overview of the developmental theories and biological factors of EF will be followed by its impact on AS compared to ADHD. In addition, the psychometric assessment of EF using the Delis-Kaplan Executive Functions System (D-KEFS) will be provided. This chapter will conclude with the Statement of Purpose and Hypotheses for this study.

Theories of Asperger's Syndrome

Asperger's first paper on the disorder that bears his name was published in 1944. In it he described children who presented with severe problems of social integration (Asperger, 1944). He called this syndrome "autistic psychopathy;" he derived the name from Bleuler's description of autism. Autism is a term that was coined by Bleuler to describe a "...fundamental disturbance of contact..." (Asperger, 1991, p. 38). Asperger stated that neurotypical human beings, "...live in constant interaction with their environment, and react to it constantly" (Asperger, 1991, p. 38). The disordered children that Asperger described, on the other hand, had little social contact with the outside environment, and did not seem to be interested in social contact with others. He gave a detailed clinical picture of four children with "autistic psychopathy," which was later

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named Asperger's Syndrome. In his paper he noted the main characteristics that were seen in individuals with AS. They are: little eye contact, fascination with objects or a subject of interest, rigid routine, pedantic speaking style, difficulties with social interaction, and school problems. Asperger described these children as either becoming aggressive around their peers or isolating themselves. The limitations of social relationships of these children were considered by Asperger to be the "fundamental disorder" of their developing personality.

Asperger noted that, "The autistic personality is highly distinctive despite individual differences" (Asperger, 1991, p. 69). He considered "autistic psychopathy" to be a developmental personality disorder, since certain abnormal features of the personality of these individuals were formed in their first two years of life and were persistent over time. Specifically, he noted that they were uninterested in nonverbal communication or interpersonal eye contact when they were as young as two years of age. This trait remained the same throughout childhood and Adolescence. Asperger noted that, "...the children we are discussing lack contact from the start" (Asperger, 1991, p. 39). While these children had certain similar personality features, Asperger noted that their special interests, intellectual ability and degree of "contact disturbance" varied, which makes each of them unique.

Developmental delays in either speech or motor skills were reported in this initial sample of four children. All four children were described as clumsy and uncoordinated, one of these four children has delayed motor development. Fritz V., for example, was described as extremely clumsy and unable to do things for himself, though he spoke his

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first words very early. Once he learned to speak, he was quickly able to express himself in sentences and was described as “talking like a little adult.” Another child had delayed speech and motor development, as well as severe asphyxia at birth. Each child had a parent or family member who has displayed similar clinical characteristics during their childhood, which Asperger believed demonstrated a genetic component to this syndrome.

Asperger (1944) also noted a unique learning style among these children, in which they did not learn through rote learning, but through original ideas and thinking. He stated that, “What they find difficult are the mechanical aspects of learning which the least clever...pupils find easy, in other words, reading, writing, and arithmetic” (Asperger, 1991, p. 75). According to Asperger (1944) they could not learn from others, and performed poorly in the classroom. Interestingly, all of these children that Asperger described were referred to the clinic for learning difficulties, despite their intelligence and impressive vocabulary (Asperger, 1944). Asperger noted that, “Obeying only spontaneous impulses and never paying attention to social demands may well lead to originality but will also lead to learning failure” (Asperger, 1991, p. 75).

There was little interest in Asperger’s paper until Wing (1981) translated his work into English and began to conduct research on similar children. Her sample consisted of 34 cases of children and adults who ranged from 5 to 35 years old. Wing noted many of the same characteristics that Asperger described in his sample (i.e. - problems with speech and nonverbal communication, lack of social interaction, repetitive activities and resistance to change, lack of motor coordination, excellent rote memory skills, intense interest in one or two subjects, and learning difficulties). Wing’s sample also showed

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developmental delays in either speech or motor skills, or in both (Asperger's sample has the same developmental delays). She noted speech peculiarities, which became more apparent when she was observing the child's conversation over an extended period of time. She noted that these children's thought processes were very narrow, pedantic, literal, and logical. She argued that these children were not necessarily more creative. She believed that creative ideas were rarer in these children than Asperger has stated. According to Wing these children's lack of absorption of cultural attitudes sometimes gave them a unique and often eccentric way of looking at a particular problem or situation. She felt that this cognitive style was creative only in rare cases. Usually their thought processes were considered to be inappropriate and they were often misunderstood.

Wing (1981) built on Asperger's pioneering work and obtained a more thorough developmental history of each child or adult in her sample. She noted that in their first year of life they seemed to have a lack of interest in human company (which usually is present from birth). There was less interest than is normal in the urge to communicate in babble, gestures, movement, smiles, laughter and speech. There was a decrease in the amount of imaginative play when they were compared to normally developing babies. These children were described as less interested in communicating in general. Wing noted the same trouble with non-verbal communication, however she stated that this was not necessarily due to a lack of interest in others, but rather to a lack of ability to understand and use social rules. Since the publication of Wing's paper in 1981, there has been a great deal of research on Asperger's Syndrome.

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Autistic Spectrum Disorders

Wing (1988) described Asperger's Syndrome and Autistic Disorder as poles on a diagnostic continuum, with Asperger's Syndrome on one end of the spectrum, and children with severe autism on the opposite end. Children with high-functioning autism are considered somewhere in between the other two disorders on this continuum. In her research she followed the same group of children that she described in 1979 from southeast London and re-tested them almost ten years later (Wing & Gould, 1979). The original cohort who were studied as children were then adolescents and adults. All of them were drawn from a population of children who had used social services for physical or mental handicap or behavior disturbances. They were categorized into four distinct subgroups that differed in the severity of their symptoms. Wing (1988) categorized their main areas of impairment as deficits in social recognition, social communication, social imagination and social understanding, and repetitive patterns of activity. Wing (1988) described lack of "development in the ability to engage in reciprocal social interaction" (p. 92) as the central problem in these autistic spectrum disorders.

Social recognition refers to how interested or how much effort is placed into interaction with others (Wing, 1988). Impairments in social recognition may also be understood as a continuum. At one extreme is social aloofness and indifference to people, at the other extreme subtle impairments are seen in AS adults who were socially impaired as children. These AS adults often give the impression that all of their knowledge is learned from books and intellectual learning, rather than through instinct or experience. Impaired social communication is described as a deficit in reciprocal

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learning that involves the giving and receiving of communication. This deficit starts in infancy with trouble communicating with their caregivers through gestures and facial expressions. At one extreme are cases where the child has no desire to communicate. At the other extreme are children and AS adults who talk a great deal, but do not engage in reciprocal communication (i.e. delivering long monologues or asking questions repetitively). Deficits in social imagination and understanding can vary from absence of imitation or imaginative play to children and adults who can recognize other people's feelings on an intellectual level without any real empathy or understanding of others' emotions. Repetitive patterns of activity include repetitive body movements at one extreme (such as rocking), to absorption in a particular idiosyncratic topic, such as railway timetables (Wing, 1988).

Wing (1988) chose a diagnostic continuum model to compare Autistic Disorder and Asperger's Syndrome since there is so much overlap between the two syndromes that it is often difficult to distinguish which diagnosis is more appropriate. The idea of a diagnostic continuum acknowledges the presence of similarities between the two disorders while also recognizing their distinct differences. Wing also stated that some of these children have shown developmental improvement in functioning; some of them may become less impaired as they mature. Some of the adolescents and adults in this study were considered "normal" ten years later, so much so that few differences were seen between them and their age peers.

Tsai (2000) stated that "autistic spectrum disorder" is a better title for this group of syndromes, as many individuals with either HFA or AS are so similar that it is difficult

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to distinguish between the two syndromes. Eaves, Ho and Eaves (1994) categorized children with autistic spectrum disorders into four distinct clinical syndrome groups: a typically autistic group, a low-functioning autistic group, a group who has both some autistic features as well as symptoms of Attention Deficit/Hyperactivity Disorder, and a high-functioning group (children with AS or schizoid features). This model is consistent with the theory that an autistic spectrum disorder might describe these children more accurately than a discreet syndrome model.

Definitions and diagnosis of Asperger's Syndrome

Asperger syndrome (AS) is a developmental disability that is defined by impairments in social relationships and verbal and nonverbal communication and by restrictive, repetitive patterns of behavior, interests and activities. Although controversy still exists among professionals and researchers as to whether high-functioning autism and AS are the same or two different conditions, AS is frequently considered to be part of the spectrum of autism disorders (Attwood, 1998; Tantam, 1991; Wing, 2000). Similar to Wing (2000), Attwood contends that the major differences between AS and autism appear to be evidenced in symptom severity, with AS considered to be on the higher end of the autism spectrum. Despite the view of AS as a milder form of autism, it is "clearly, still a highly disabling social condition" (Tantam, 1991, p. 178). Furthermore, AS may cause the greatest disability in adolescence and young adulthood when social relationships are the key to almost every achievement (Tantam, 1991).

Although Hans Asperger of Austria first recognized this syndrome in 1944, the American Psychiatric Association did not recognize AS as a specific pervasive

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developmental disability until 1994. The incidence of AS is still uncertain, with estimates of 8.4 per 10,000 in a total population study of preschool children (Chakrabarti & Fombonne, 2001) and 48 per 10,000 in a total population study of seven-year-old children (Kaesjo, Gillberg, & Hagberg, 1999), to upwards of 71 per 10,000 children ages 7-16 years when considering suspected and possible cases (Ehlers & Gillberg, 1993). As awareness of this condition increases, many families are requesting appropriate educational services to meet their children's social, communication, academic and behavioral needs. Professionals are also now realizing that AS is not a rare disability and that more information regarding interventions in the classroom is desperately needed.

The new DSM-4 criteria for a diagnosis of AS, with much of the language carrying over from the diagnostic criteria for autism include the presence of:

Qualitative impairment in social interaction involving some or all of the following:

- impaired use of non-verbal behaviors to regulate social interaction,
- failure to develop age-appropriate peer relationships,
- lack of spontaneous interest in sharing experiences with others,
- and lack of social or emotional reciprocity.

Restricted, repetitive, and stereotyped patterns of behavior, interests, and activities involving:

- preoccupation with one or more stereotyped and restricted pattern of interest,
- inflexible adherence to specific non-functional routines or rituals,

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- stereotyped or repetitive motor mannerisms, or preoccupation with parts of objects.

These behaviors must be sufficient to interfere significantly with social or other areas of functioning. Furthermore, there must be no significant associated delay in general cognitive function, self-help/adaptive skills, interest in the environment or overall language development. The most obvious hallmark of Asperger syndrome and the characteristic that makes these children so unique and fascinating, is their peculiar, idiosyncratic areas of "special interest". In contrast to more typical autism, where the interests are more likely to be objects or parts of objects, in AS the interests appear most often to be specific intellectual areas. Often, when they enter school, or even before, these children will show an obsessive interest in an area such as math, aspects of science, reading (some have a history of hyperlexia--rote reading at a precocious age) or some aspect of history or geography, wanting to learn everything possible about that subject and tending to dwell on it in conversations and free play. Interestingly, as far back as Asperger's original clinical description in 1944, the area of transport has seemed to be a particularly common fascination (he described children who memorized the tram lines in Vienna down to the last stop). Many children with AS, as young as three years old, seem to be unusually aware of things such as the route taken on car trips. Sometimes the areas of fascination represent exaggerations of interests common to children in our culture, such as Nina Turtles, Power Rangers, dinosaurs, etc. In many children the areas of special interest will change over time, with one preoccupation replaced by another. In

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some children, however, the interests may persist into Adulthood and there are many cases where the childhood fascinations have formed the basis for an Adult career, including a good number of college professors.

The other major characteristic of AS is the socialization deficit, and this, too, tends to be somewhat different than that seen in typical autism. Although children with AS are frequently noted by teachers and parents to be somewhat "in their own world" and preoccupied with their own agenda, they are seldom as aloof as children with autism. In fact, most children with AS, at least once they get to school age, express a desire to fit in socially and have friends. They are often deeply frustrated and disappointed by their social difficulties. Their problem is not a lack of interaction so much as lack of effectiveness in interactions. They seem to have difficulty knowing how to "make connections" socially. Gillberg has described this as a "disorder of empathy", the inability to effectively "read" others' needs and perspectives and respond appropriately. As a result, children with AS tend to misread social situations and their interactions and responses are frequently viewed by others as "odd" (Gillberg, 2000).

Although "normal" language skills are a feature distinguishing AS from other forms of autism, there are usually some observable differences in how Adults with AS use language. It is the more rote skills that are strong, sometimes very strong. Their prosody--those aspects of spoken language such as volume of speech, intonation, inflection, rate, etc.--is frequently unusual. Sometimes the language sounds overly formal or pedantic, idioms and slang are often not used or are misused, and things are often taken too literally. Language comprehension tends toward the concrete, with

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increasing problems often arising as language becomes more abstract in the upper grades. Pragmatic, or conversational, language skills often are weak because of problems with turn-taking, a tendency to revert to areas of special interest or difficulty sustaining the "give and take" of conversations. Many adults with AS have difficulties dealing with humor, tending not to "get" jokes or laughing at the wrong time; this is in spite of the fact that quite a few show an interest in humor and jokes, particularly things such as puns or word games. The common belief that children with Autistic Spectrum Disorders are humorless is frequently mistaken. Some adults with AS tend to be hyperverbal, not understanding that this interferes with their interactions with others and puts others off. These higher-order language skills can be related to deficits in executive skills that may then interfere with everyday functioning.

DSM-IV-TR Diagnosis

Due to the abundant research on Asperger's Syndrome over the past fifteen years, the latest version of the DSM (the DSM-IV-TR, 2000) gives a much more detailed picture of this syndrome. No changes were made to the core diagnostic criteria with this latest version. According to the DSM-IV-TR criteria, AS and Autistic Disorder are still considered to be separate diagnoses. Associated features were added to the diagnostic criteria for AS: motor clumsiness, awkwardness, symptoms of overactivity, and inattention. Though no developmental delays in language are noted in individuals with AS, more subtle language and communication problems are seen, such as: preoccupation with narrow personal topics of interest, failure to appreciate and utilize conventional rules of conversation (i.e. - one-sided conversations with others), and failure to appreciate

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nonverbal communication cues. These language and communication problems were added to the clinical diagnostic description in the DSM-IV-TR (2000).

The DSM-IV-TR (2000) states that while the diagnostic criteria are the same for several features of Asperger's Syndrome and Autistic Disorder, there are subtle differences between the two syndromes that can help to distinguish between them. According to Criterion A for AS (same as Criterion A1 for Autistic Disorder), individuals with AS usually show eccentric, one-sided social approaches to others rather than social and emotional indifference (which is seen more typically with autistic individuals). Individuals with AS are also less likely to isolate themselves socially; they are more likely to try to approach others, though it is done in an eccentric, one-sided manner. With regard to Criterion B (or Criterion A3 in Autistic Disorder), individuals with AS are likely to become intensely preoccupied with a specific topic of interest. Typically they do not present with ritualized, repetitive motor mannerisms that are seen more often among autistic individuals.

Classification of Asperger's Syndrome (AS) has been very difficult, and as stated above, there has been much debate over this issue. The latest changes in the DSM-IV-TR (2000) give a more detailed and accurate description of AS. This description distinguished key differences between Asperger's and Autistic Disorder that were not as clear in the previous version of the DSM-IV (American Psychiatric Association, 1997).

Distinguishing Characteristics of Asperger's Syndrome

The DSM-IV-TR (2000) notes that conclusive data regarding the prevalence rate of Asperger's Syndrome is lacking. Gillberg and Coleman (2000) have noted that four

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epidemiological studies (completed in Sweden and Iceland) have concluded that the rate of AS in a population was found to be 26 to 48 in 10,000 (or about 0.3 to 0.5%). It is unclear whether this same prevalence rate would be found in the United States. AS occurs much more commonly in males than females, reportedly either in a 5-to-1 or 4-to-1 ratio (DSM-IV-TR, 2000; Ehlers & Gillberg, 1993; Gillberg & Coleman, 2000). There is also a high comorbidity of other diagnoses that are associated with both AS and Autism. Attention problems, major depression and Bipolar Disorder are commonly seen for individuals with AS (DSM-IV-TR, 2000; Gillberg & Billstedt, 2000).

There has long been speculation that Asperger's Syndrome is a genetic condition. Asperger (1944) noted in his original work that often one parent or another relative of the child displayed some of the same cognitive and behavioral peculiarities. Kanner (1943) also noted religious obsessions, somatic obsessions, repetitive handwashing and tics in family members of autistic children. In Gillberg's study of six families (1991), two of the clients has a first degree relative with AS, one has a grandfather with AS, and the remaining three had parents with AS traits.

According to most researchers (Asperger, 1944; Gillberg & Gillberg, 1989; Wing, 1988), the key features of Asperger's Syndrome are considered to be: difficulty with social interactions and dysfunctional communication style, repetitive or circumscribed interests, motor incoordination. These key features used to distinguish AS from Autistic Disorder will now be described in depth.

Social Interaction and Dysfunctional Communication

Individuals with Asperger's Syndrome often have trouble with social interactions.

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As stated above, they have difficulty interpreting nonverbal cues and they can be seen as aloof or unempathetic. Many people (Asperger, 1944; Wing, 1981) consider this feature to be the key criterion for diagnosis of AS. Both Asperger and Kanner used autism as a symptomatic way of describing these children who seemed more comfortable alone than with other people. Most people with AS report having few friends, although they are interested in making friends. AS individuals, unlike children with autism, are interested in interacting socially with others; however they often give up this attempt because of their frequent social failures (Klin et al., 2000). Individuals with AS often have been described as rude, hurtful, egocentric, insensitive, and tactless because they frequently misinterpret social cues (Barnhill, Cook, Tebbenkemp & Myles, 2002).

Both Asperger (1944) and Wing (1981) have noted that when their children were infants and toddlers, parents of AS individuals described these children as not interested in social interaction. They also had little eye contact with others, would not point out objects to their parents, and did not engage their parents in social interaction as much as most infants would do. As Asperger stated, "...the children we are discussing lack contact from the start" (Asperger, 1991, p. 39).

Baron-Cohen, O'Riordan, Stone, Jones and Plaisted (1999) used the concept of "theory of mind" to explain the communication style that is seen in individuals with Asperger's Syndrome. "Theory of mind" describes the ability to infer the mental state of others, or their capacity for empathy (Ozonoff et al., 1991a). Ozonoff and Griffith (2000) explained theory of mind as, "...a person's ability to think about and act on information about his or her own and other's mental states (beliefs, intentions, desires, etc.)" (p. 83-

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84). As both individuals with Asperger's Syndrome and Autistic Disorder demonstrate a lack of interest or focus on others (DSM-IV-TR, 2000), empathy and inferring the thoughts and feelings of others is considered a skill these individuals lack. "Theory of mind" tests were hypothesized to be difficult for individuals with AS and with autism. Theory of mind was tested using what were called first order beliefs and second order beliefs. First order beliefs were tested using such tasks as: showing children an M & Ms candy box, then asking them to identify what was in the box. After the children replied, "M & Ms," the box was opened and they were shown that it contained a pencil. They were then asked to predict what another child who has never seen the box would think it contained. This is considered a second order belief.

Second order beliefs require the individual not just to predict one person's thoughts, but also to predict one person's thoughts about another person. For these tasks, normally developing children were found to understand first order beliefs at four years old, and second order beliefs at six years (Baron-Cohen et al., 1999). With the difficulty that both AS and autistic individuals display with social interest from an early age, this was proposed to be a challenging concept for them to grasp. This has been proposed as a way to distinguish AS from HFA individuals. AS individuals were hypothesized to perform better, since they have more general interest in social interaction when compared to autistic individuals, yet they lack social skills (Baron-Cohen et al., 1999; Meyer & Minshew, 2002; Ozonoff, Rogers & Pennington, 1991b). Ozonoff et al. (1991b) showed in their study of theory of mind that individuals with AS did not differ from controls in their performance on these tasks, and did not differ from HFA individuals

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significantly either. AS individuals were compared to both normally developing controls and HFA children. The HFA individuals performed significantly different than controls on both first and second order beliefs on theory of mind tasks. The performance of participants with AS did not significantly differ from that of either normal controls or participants with HFA. One could speculate that AS individuals' performance in this study might have demonstrated some differences from the performance of individuals with HFA, though not enough to reach statistical significance.

Baron-Cohen et al. (1999) expanded on the idea of theory of mind model and designed a test for children 9-11 years old. This task assessed one's ability to understand 'faux pas,' or the situation that occurs when someone has made a social blunder in conversation. This requires a more subtle understanding of another's point of view than the M & Ms study. The children in this study were to read the story, and therefore were not given any clues as to how each character was reacting. Baron-Cohen et al. (1999) chose to combine children with AS and HFA into the same group, and compared their performance with that of controls. Individuals with HFA and AS were found to have more difficulty than controls on the ability to detect when one of the characters in the story said a 'faux pas,' or something that was socially inappropriate to the other person in the story. As Baron-Cohen's task involves more subtle social understanding, it would be important to separate the two groups (AS and HFA) to note any subtle differences. This may assist with explaining any differences between individuals with AS and HFA, and assess whether these should be considered separate syndromes or on a spectrum, as hypothesized by Wing (1988).

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Asperger's Syndrome is considered by Gutstein and Whitney (2002) to be partially due to a failure to develop social competence skills. Social competence is based on skills and strategies that allow individuals to interact successfully with others. This ability is described as success in the following areas: formation of a secure attachment, instrumental social learning, and experience-sharing relationships with others.

Attachment is described as "...the specific affiliate tie of the infant to his or her parent(s)..." (Gutstein & Whitney, 2002, p. 162). Once an infant has formed a secure attachment they can feel competent to explore the world as they develop. Instrumental social learning requires the use of social skills to obtain a goal, i.e. – pointing to a toy that is out of reach. These are both skills that children with AS are able to master. The third element, however, is one that is believed to be extremely difficult for children in this population to learn. Experience-sharing relationships involve learning how to develop a deeper understanding of someone else's experience. This interaction requires the ability to understand someone else's emotions. This is a difficult task for individuals with AS to do, as they have trouble understanding another person's point of view due to their difficulty comprehending nonverbal social cues.

Circumscribed Interests

One similarity that is seen between individuals with Asperger's Syndrome and Autistic Disorder is their circumscribed range of interests. In children with Autistic Disorder, this may be seen as a fascination with watching specific objects for hours. However, children with AS usually demonstrate more of a fascination with specific topics of interest, which they talk about repeatedly (DSM-IV-TR, 2000). They often

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gather facts or specific objects related to one narrow, idiosyncratic topic of interest. Myles and Simpson (2002) noted that the chosen topic of interest varied considerably from one child to the next. Barnhill, Hagiwara, Myles and Simpson (2002) stated that individuals with AS may use these topics as a way to facilitate conversation or to fit in with peers, or as a relaxing activity. Repetitive thought and behavior are “integral clinical characteristics of the classification of PDD’s...” (McDougle, 1998, p. 294). For this reason, there also have been studies linking Asperger’s Syndrome with Obsessive Compulsive Disorder (OCD).

As noted in the DSM-IV-TR (2000), for individuals with AS, these repetitive thoughts and behavior often involve an obsessive involvement with a specific topic of interest. The topic is different for each child, from train schedules to transportation vehicles to vacuum cleaners, for example. This topic will be the focus of conversations, and much time is invested towards analysis and study of this topic. One of the differences between AS and OCD is that with OCD the recurrent thoughts cause the individual distress and anxiety. Individuals with OCD realize that the intensity of their thoughts is inappropriate, and this feature often causes anxiety. Individuals with AS, however, seem to be unaware of the inappropriateness of their obsessions. This could be due to greater or more intense focus of AS individuals on their own internal states, and their lack of emphasis on attention to the external environment. There is a high rate of comorbidity between individuals with AS and OCD. OCD also involves dysfunction of the frontal lobe, as well as the cingulate gyrus and basal ganglia (Carlson, 1998). Meyer and Minshew (2002) noted that these repetitive thoughts could explain learning difficulties

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that individuals with AS demonstrate. Abstract reasoning involves “...the propensity toward meaning making, or organizing simultaneous events or parts into a meaningful whole.” (Meyer & Minshew, 2002, p. 155). Individuals with AS focus on details when they are given cognitive tests, and they have trouble integrating complex material (Meyer & Minshew, 2002). Instead they usually focus on the details (or parts of objects, in the case of individuals with autism) without thinking of the relevance or meaning of the information as a whole.

Motor Incoordination

Many researchers have also noted a lack of motor coordination in children with Asperger’s Syndrome (Asperger, 1944; Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994; Wing, 1981). The DSM-IV-TR diagnostic criteria for AS describes motor coordination problems as an associated feature of AD. Smith (2000) stated in a review that an obstacle to research in motor coordination is the variable definition of motor clumsiness. While some researchers have described this symptom as awkward gross motor movements (Asperger, 1944), others have noted more specific poor fine motor incoordination, as may be seen with graphomotor difficulties. Other investigators have described both gross and fine motor deficits (Wing, 1981).

Manjiova and Prior (1995) tested 21 participants with Asperger’s Syndrome using the Test of Motor Impairment - Henderson revision (TOMI-H). This test assesses manual dexterity, static and dynamic balance, and ball manipulation skills. Manual dexterity was tested using speed and accuracy of movement for each hand, hand-eye coordination for the dominant hand, and coordination for both hands on a single task. Ball manipulation

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skills tested the abilities to aim and catch a ball using both hands. Balance tasks included static ability (holding a position), as well as dynamic ability (making spatially precise movements slowly, with control and momentum). Half of the individuals with AS had definite motor problems, and performed at a much lower level than their peers. These children had impairments in both fine motor and gross motor skills. Miyahara, Tsujii, Hori, Nakanishi, Kageyama and Sugiyama (1997) tested 26 individuals with AS using the Movement Assessment Battery for Children (Movement ABC). This instrument tests manual dexterity, ball skills and balance skills. These children again demonstrated motor difficulties in all areas tested. Both fine and gross motor skills seem to be affected in individuals with AD.

Biological Factors of Asperger's Syndrome

There has been some research on the biological factors, or potential biological factors present in Asperger's Syndrome. Blakemore-Brown (2002) discussed a commonality that has been described in children with AS and other executive functioning disorders (Autistic Disorder, ADHD & nonverbal learning disability). She noted that children with these disorders often have breathing, sleeping, and digestive problems. There is also a high rate of premature birth and other birth problems among children with ADHD and AS (Blakemore-Brown, 2002). Rickarby et al. (1991) also found that in their sample of 12 boys with AS, most of them had a history of an obstetric crisis or of neonatal problems (or of both). Blakemore-Brown (2002) reported that children with AS and Autistic Disorder have early problems from infancy with rhythmic sensory and perceptual self-regulatory processes.

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Brain/MRI Studies of Asperger's Syndrome

Research on potential brain differences and/or abnormalities in AS versus control participants is slowly developing. Most studies in this area can only speculate about their findings, as their sample size typically is quite small (i.e., case studies on less than five individuals). In Lincoln et al.'s (1998) review of magnetic resonance imaging (MRI) studies with AS individuals, 13 of 35 participants with Asperger's Syndrome demonstrated some type of brain abnormality. The best defined findings included abnormalities in the frontal, temporal, parietal or occipital lobes, as well as thinning of the posterior corpus callosum and increased volume of the lateral ventricles (Lincoln et al., 1998). These findings were considered, "...gross, nonspecific neuroradiological brain abnormalities." (Lincoln et al., 1998, p. 158).

Most research in this area has focused on structural and physiological differences found when AS participants are compared to controls, as well as head circumference differences. Berthier et al. (1990) began looking for potential brain differences in individuals with AS. Though their case study only included two individuals, they found abnormalities in both the left and right hemispheres. Both were found to have small, irregularly formed gyri in different parts of the brain. According to Berthier et al. (1990), "developmental cortical anomalies result from a derangement of neuronal neuronal migration from the germinal matrix in the ventricular and subventricular zones to the superficial cortical layers and deep gray structures" (p. 200). This process normally takes place between the third and fifth month of gestation. Another study (McKelvey et al., 1995) found right hemispheric abnormalities in all three of their participants with AS.

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In a comparison of head circumference in individuals with Asperger's Syndrome and Autistic Disorder, AS individuals in this study had abnormal head enlargement at a rate of one in five (Gillberg & deSouza, 2002). With autistic individuals in this study, only one in every ten had macrocephalus. The autistic individuals who also developed macrocephalus presented as higher functioning on the symptom spectrum and appeared diagnostically closer to Asperger's Syndrome. This finding lends support to the inference that different neurobiological mechanisms may be involved with lower and higher functioning individuals on the Autistic Disorder spectrum. According to Gillberg and de Souza (2002), there are theoretical questions as to whether macrocephalus is caused by an overproduction of nerve cells, synapse pruning failure during development, or other problems that may affect nerve cell development.

There has been debate as to whether there are lateralized brain structure differences that may be associated with potential deficits to explain the distinction between HFA and AD. In Rinehart et al.'s study (2002b), individuals with AS and HFA were assessed for differences related to right or left brain dysfunction specific to AS and HFA individuals. Individuals with autism have been hypothesized to show deficits in the left frontostriatal system of the brain. Due to mixed results of previous studies of lateralization deficits, Rinehart et al. (2002b) proposed that left hemisphere deficits may be specific to the left frontostriatal system of the brain. To assess for lateralization differences, AS and HFA individuals were tested on two tasks which assessed for differences in response time with stimuli presented on either the left or right side. They were also assessed with a task in which they were presented two faces at the same time,

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and asked to assess which of the faces looked happier. They were monitored on reaction time, correct or incorrect responses and whether they demonstrated a left or right-side bias with their responses. In Rinehart et al.'s study (2002b) the individuals with HFA demonstrated a left hemispheric function deficit that was associated specifically with executive function skills. In other words, they demonstrated a performance deficit that was consistent with left frontostriatal dysfunction. Individuals with Asperger's Syndrome have been shown to have greater deficit with right than left hemispheric functions. It was hypothesized that individuals with AS and HFA both may suffer from diffuse right hemispheric damage, however autistic individuals may also suffer some left hemisphere dysfunction.

Murphy et al. (2002) studied 14 men (ranging from 21-39 years old) with Asperger's Syndrome with in vivo proton magnetic resonance spectroscopy (MRS). Metabolite levels of N-acetylaspartate (NAA), creatine (Cho) and creatine with phosphocreatine (Cr+PCr) were measured in the frontal and parietal lobes of AS participants and matched controls. Individuals with AS showed a significant increase in the concentration of NAA, Cho, and Cr+PCr in their frontal lobes. During normal childhood development there are increased brain concentrations of NAA, Cho, and Cr+PCr, which usually reduce to adult levels when a person reaches their late teenage years. This study suggests that AS may be related to a failure of the protein levels to decrease as one's frontal lobe develops.

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Many of these studies demonstrate some differences in the frontal lobe region, which could be associated with the distinct behaviors and difficulties that are seen in individuals with Asperger's Syndrome.

Developmental History of Asperger's Syndrome

As research on Asperger's Syndrome has progressed, there has been more of an emphasis on understanding developmental changes in the child with Asperger's Syndrome.

Wing (1981) provided much material on early development of AS individuals. She noted that AS children often displayed less of an urge to communicate than is seen in neurotypical babies. Research on infants with autism has shown a deficit in what is called "joint attention" during their first year of life (Meyer & Minshew, 2002). Joint attention is described as "...the capacity to share attention between other individuals and objects" (Meyer & Minshew, 2002, p. 156). For example, individuals who develop autism do not follow their mother's gaze as normal infants will do. Most infants learn communication skills and social norms by attending to how adults interact socially. Before they develop language skills, they spend hours observing how people around them communicate. Infants with autism apparently are more focused inwards, or are just not focused at all, and therefore do not spend time learning these social skills. They spend less time attending to others, and may miss out on many opportunities to learn nonverbal communication skills. It is possible that this is also a similar deficit in infants with Asperger's Syndrome, although it may occur to a lesser degree than as seen in autistic individuals.

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A high proportion of AS children had motor delays, and began walking later than was normatively expected. As they developed, their posture and gait were described as 'odd'; they were described as clumsy and ill coordinated (Wing, 1981). Most children with Asperger's Syndrome are not diagnosed until they are in grade school (Rickaby et al., 1991). Blakemore-Brown (2002) has noted that many AS children are often diagnosed with ADHD at an earlier age, and only later diagnosed with Asperger's Syndrome. This usually occurs around early adolescence, as social difficulties become more prominent (Meyer & Minshew, 2002).

When the child begins to attend school, the difficulties with social interaction become much more apparent (Myles & Simpson, 2002). Children with Asperger's Disorder often will have only a few friends, as they do not understand nonverbal cues and rules of social interaction. They are often bullied and teased by other children because of their unusual behavior. Childhood can often be a very lonely time for these children (Myles & Simpson, 2002). As stated previously, AS children often do not know how to interact socially with others, since they do not understand nonverbal communication (Wing, 1981). Myles and Simpson stated that, "Although they are well known for their lack of social awareness, many students with AS are aware enough to sense that they are different from their peers" (Myles & Simpson, 2002, p.133). This becomes particularly difficult as these individuals approach adolescence and young adulthood, and they become aware of their social deficits (Myles & Simpson, 2002). Especially during adolescence, when most young people experience an increase in social growth and social

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awareness, the social deficits in AS individuals become even more apparent (Myles & Simpson, 2002).

Along with social difficulties, many individuals with Asperger's Syndrome also experience academic problems or failure at school due to learning difficulties. Despite their typically average or above average intelligence level, they often have poor problem solving skills, poor organizational skills, and an inflexible, literal thinking style (Siegel, Minshew & Goldstein, 1996). According to Myles and Simpson (2002), individuals with AS are generally thought to have difficulties with comprehension of abstract material, the application of cognitive skills and formal knowledge to problem-solving.

Cognitive Profile of Asperger's Syndrome

Most of the studies that have been done on the IQ scores of children with Asperger's Syndrome has yielded mixed results. The most common finding is that these children usually have a large scatter of IQ subtest scores, as is also seen in children with ADHD. Children with AS show relative strengths and weaknesses in both performance and verbal IQ subtests as a general rule. The DSM-IV-TR (2000) notes a prototypical pattern of cognitive variability, with relative cognitive strengths in verbal abilities (especially vocabulary and rote auditory memory). Cognitive weaknesses usually occur in nonverbal abilities. Lincoln et al. (1998) performed a review of seven different studies of mean IQ scores of individuals with Asperger's Syndrome. The number of AS individuals in each study ranged between 10 to 40 participants. Taken together this review compiled IQ scores from 117 AS individuals. The performance level of the group showed average intelligence ability. Overall, the mean VIQ was 95, the mean PIQ was 90

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and the mean Full Scale IQ was 92. Most individuals with AS demonstrate an overall IQ of average to superior ability level, although most are in the average range. This is the same profile that is seen with normally developing children (Kaufman & Lichtenberger, 1999). They tend to have a range of scores that demonstrate relative strengths and weaknesses. Most of the studies reviewed found strengths of the AS group to be in the Information, Vocabulary and Block Design subtests of the Wechsler Intelligence Scale for Children (WISC-R and WISC-III). Coding usually seems to be their lowest subtest score (Barnhill et al., 2000; Ehlers et al., 1997; Nyden et al., 2001 & Szatmari et al., 1990), as well as Digit Span (Manjiviona & Prior, 1999 & Nyden et al., 2001). Most of these studies have noted that no distinct cognitive profile could be found to distinguish individuals with Asperger's Syndrome from individuals with other psychiatric disorders.

AS individuals were compared to individuals with HFA in a majority of these studies (Ehlers et al., 1997; Klin et al., 1995; Manjiviona & Prior, 1999; Miller & Ozonoff, 2000; Ozonoff et al., 1991b; Rinehart et al., 2000 & Szatmari et al., 1990). Some of these studies also focused on comparison of AS individuals with cases diagnosed with nonverbal learning disability (Klin et al., 1995) or Attention-Deficit/Hyperactivity Disorder (Nyden et al., 2001).

Neuropsychological Profile of Asperger's Syndrome

Some studies have been conducted to seek a neuropsychological profile of individuals with AS that would differentiate them from persons with high functioning autism. Manjiova and Prior (1999) have shown that tests of executive functioning are not always good discriminators of the cognitive differences between patients in these

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diagnostic groups. If these disorders are organized on a diagnostic continuum (as hypothesized by Wing, 1988), then there may not be a distinctive cognitive profile to distinguish them. There may only be performance level differences in scores that could depend on where each person lies on the hypothesized spectrum between Asperger's Syndrome and Autistic Disorder.

Although these studies did not provide a consistent profile that could distinguish Asperger's Syndrome from high functioning autism, they may provide information about possible cognitive and executive function deficits of children with AD. Manjiova and Prior (1999) tested 35 children with AS and 21 children with high functioning autism in their study of neuropsychological measures. Manjiova and Prior (1999) compared the performance of children with high functioning autism versus Asperger's Syndrome on the Controlled Oral Word Association Test, Tower of London, Rey Complex Figure Test, and the Verbal Absurdities, Picture Absurdities and Problem Situations subtests of the Stanford-Binet Intelligence Scale, Third Revision. The only distinguishable cognitive difference between these diagnostic groups was found in the FSIQ scores. Children with Asperger's Syndrome scored in the average range (FSIQ = 102.6), while high functioning autistic children scored in the low average range (FSIQ = 88.6). It was noted that a proportion of AS children showed poor planning, lack of organizational skills, and an inability to develop strategies without being cued (Manjiova & Prior, 1999).

In Manjiova and Prior's study (1999), the poorest performance level for AS children was on the Freedom From Distractibility Index on the WISC-R. Manjiova and

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Prior (1999) noted in this study that both groups (children with AS and HFA) had difficulty with inhibition during the Tower of London task. This is a task in which the examinee is instructed to build a “tower” they are shown. They are to build this ‘tower’ using a certain number of pegs, and are given a certain number of moves to accomplish this task. They are given rules in which they are only to move each peg one at a time. Each peg move consists of one “move.” The moves are calculated and they are given points for how few moves they can do to accomplish this task without breaking any rules. Both groups (AD and HFA individuals) had trouble following the rule to use only one hand to respond. The examiner had to repeat these instructions many times. One potential weakness that was noted in this study was that they chose three problem-solving tasks that were normed for neurotypical children ages 7-12, although they included children older than 12 in their study.

Szatmari et al. (1990) found in their tests of neuropsychological skills of children with AS and HFA, there were small differences in performance level between the two groups. Both groups showed approximately the same level of impairment in the areas of: language comprehension, motor coordination and nonverbal problem solving. On nonverbal problem solving tasks they had specific difficulty on the Picture Completion, Picture Arrangement and Object Assembly subtests of the WAIS-R or WISC-R, as well as the Benton Test of Facial Recognition. The individuals with HFA made more perseverative errors than AS individuals on the Wisconsin Card Sorting Test. However both groups performed less well than their matched controls (Szatmari et al., 1990). Individuals with HFA performed slightly better than AS individuals on the Purdue

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Pegboard, which is a test of fine motor coordination. These differences were small, and were only minimally significant. These trend differences may reach more robust significance if they are replicated with a larger sample size.

Ozonoff et al. (1991b) found in their study that children with AS performed poorly on the Tower of Hanoi and Wisconsin Card Sorting Test measures of nonverbal executive function. Individuals with AS again were compared to individuals with high functioning autism. In this study both individuals with AS ($n = 10$), and high functioning autism ($n = 13$) demonstrated difficulty with planning efficiency on the Tower of Hanoi, and they had difficulty solving the problem using the minimum number of responses that were necessary to do this task. They also demonstrated difficulty with perseverations and failure to maintain cognitive set on the WCST. The individuals with AS did have slightly higher T scores on the overall measures of executive functioning ($T = 48$) than individuals with high functioning autism ($T = 43.1$), though these differences did not reach a significant level. This result is consistent with Wing's theory of an autistic spectrum continuum (1988), in which Asperger's Syndrome and Autistic Disorder are placed at different points on a continuum.

Klin et al. (1995) found in their study that individuals with AS performed more similarly to individuals with nonverbal learning disability than to those with HFA. For this study AD, HFA and nonverbal learning disability (NVLD) individuals were assessed on skills usually associated with a nonverbal learning disability. Individuals with AS demonstrated deficits in specific cognitive and sensorimotor areas, such as: fine motor skills, visual motor integration, visual spatial perception, nonverbal concept formation,

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gross motor skills and visual memory. They also demonstrated strengths in articulation, verbal output, auditory perception, vocabulary and verbal memory. HFA individuals demonstrated the opposite profile of strengths and weaknesses, as they had no fine motor difficulties, good visual motor integration and good visual spatial perception, but more difficulties with vocabulary and verbal memory.

Currently, there is a great deal of literature that discusses the variability in the performance of individuals with AS on neuropsychological tasks, especially in the areas of Executive Functioning (EF). Similarly, individuals with ADHD have been shown to display variations in their performance on neuropsychological tasks of EF. Findings from these studies will be discussed following a brief review of ADHD. This review will include a description, the DSM-IV criteria, characteristics of social interaction, biological factors, Brain/MRI studies, and neuropsychological profile.

Attention Deficit Hyperactivity Disorder: Description

Attention-Deficit/Hyperactivity Disorder (ADHD) is a prevalent neurobehavioral disorder that affects individuals in early childhood and is characterized by cognitive impairments associated with executive functions. ADHD symptoms are described by three main constructs: inattention, impulsivity and hyperactivity. This disorder is usually first diagnosed in children and adolescents. Though our understanding of the disorder is still developing, medical science first noticed children exhibiting inattentiveness, impulsivity, and hyperactivity in 1902. Since that time, the disorder has been given numerous names, including *Minimal Brain Dysfunction or Minimal Brain Damage*, and *Hyperkinesis, the Hyperkinetic Reaction of Childhood or Hyperactivity*. In 1980, the diagnosis of Attention

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Deficit Disorder was formally recognized in the Diagnostic and Statistical Manual, 3rd edition (DSM III), the official diagnostic manual of the American Psychiatric Association (APA). It is estimated that ADHD affects 3-5% of the school-age population, which means as many as 3.5 million children. ADHD symptoms often lead to significant impairment in social, academic or occupational functioning. The clinical presentation has suggested that ADHD is a neuropsychological disorder, and current theories emphasize the central role of attentional and executive dysfunctions (Barkley, 1997).

Attention Deficit Hyperactivity Disorder (ADHD), formerly called “hyperkinesis disorder of childhood” or “minimal brain dysfunction,” was first described 100 years ago as a childhood disorder found mainly in boys. Revisions in the diagnostic construct have been made a number of times over the past century. The most important shift occurred in the 1970s, when the concept of attention dysfunction was introduced as the core defining-feature and the disorder was re-named accordingly (Douglas, 1972). At this time, the key symptoms for diagnosis were behavioral descriptions of motor and attentional problems rather than indirect cognitive measure of attention.

The diagnosis of ADHD is currently made on the basis of developmentally inappropriate symptoms of inattention, impulsivity, and motor restlessness (APA, 1994). And three subtypes are recognized: “inattentive”, “hyperactive-impulsive”, and “combined” (reflecting a combination of the other two types). Symptoms must be: 1) observed early in life (before age 7); 2) pervasive across situations; and 3) chronic. The symptoms lead to significant impairment in social, academic or occupational functioning.

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Symptoms are not exclusively due to other mental disorders. The clinical presentation has suggested that ADHD is a neuropsychological disorder, and current theories emphasize the central role of attentional and executive dysfunctions, as well as disinhibition (Barkley, 1997).

DSM-IV TR Criteria for ADHD

The year 2000 Diagnostic & Statistical Manual for Mental Disorders (DSM-IV-TR) provides criteria for diagnosing ADHD. The criteria are presented here in modified form in order to make them more accessible to the general public. They are listed here for information purposes and should be used only by trained health care providers to diagnose or treat ADHD. American Psychiatric Association:

I. Either A or B:

- A. Six or more of the following symptoms of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level:

Inattention

1. Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
2. Often has trouble keeping attention on tasks or play activities.
3. Often does not seem to listen when spoken to directly.

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4. Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions).
 5. Often have trouble organizing activities.
 6. Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework).
 7. Often loses things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools).
 8. Is often easily distracted.
 9. Is often forgetful in daily activities.
- B. Six or more of the following symptoms of hyperactivity-impulsivity have been present for at least 6 months to an extent that is disruptive and inappropriate for developmental level:

Hyperactivity

1. Often fidgets with hands or feet or squirms in seat.
2. Often gets up from seat when remaining in seat is expected.
3. Often runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless).
4. Often has trouble playing or enjoying leisure activities quietly.
5. Is often "on the go" or often acts as if "driven by a motor".

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6. Often talks excessively.

Impulsivity

1. Often blurts out answers before questions have been finished.
 2. Often has trouble waiting one's turn.
 3. Often interrupts or intrudes on others (e.g., butts into conversations or games).
- II. Some symptoms that cause impairment were present before age 7 years.
- III. Some impairment from the symptoms is present in two or more settings (e.g. at school/work and at home).
- IV. There must be clear evidence of significant impairment in social, school, or work functioning.
- V. The symptoms do not happen only during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder. The symptoms are not better accounted for by another mental disorder (e.g. Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

Based on these criteria, three types of ADHD are identified:

1. ADHD, *Combined Type*: if both criteria 1A and 1B are met for the past 6 months

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2. ADHD, *Predominantly Inattentive Type*: if criterion 1A is met but criterion 1B is not met for the past six months
3. ADHD, *Predominantly Hyperactive-Impulsive Type*: if Criterion 1B is met but Criterion 1A is not met for the past six months. (American Psychiatric Association, 2000)

Biological Factors

Brain/MRI Studies for ADHD

Several lines of evidence link ADHD to poor executive control and dysfunction of the frontal-subcortical systems. It has been suggested that tests which are more heavily dependent on Prefrontal Cortex (PFC) systems are more likely than other tests to reveal deficits between ADHD and normal children (Chelune, Ferguson, Koon, & Dickey, 1986). Deficits in sustained attention, inhibitory control, organization, and motivation have been observed in children and adults with damage to the prefrontal circuits (Tranel et al., 1994; Stuss and Benson, 1986). Primate and neuropsychological studies have implicated the PFC in impaired performance on tasks of planning or working memory (Fuster, 1999) and in the modulation of basal ganglia circuits (Alexander et al., 1986). Neuroanatomical and lesion evidence reveal that the frontal-lobes have a protracted course of development (Fuster, 1999; Thatcher, 1991) and that proficiency on traditional EF tasks improves through late adolescence (Tranel et al., 1994; Welsh et al., 1991).

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Casey, Castellanos, Giedd & Marsh (1997) suggest that the right PFC has a role in suppressing attentional and behavioral responses to salient, but irrelevant distractors, while basal ganglia play a role in the execution of these behavioral responses.

Efforts to assess these executive functions with neuropsychological “tests of executive function” have produced mixed results. Willcutt, Doyle, Nigg, Faraone, and Pennington (2005) recently provided a meta-analysis of 83 studies that administered function measures such as the Stop-Signal Task, Porteus Mazes, Tower of Hanoi, and the Wisconsin Card Sorting Task, to groups of children and adolescents with ($N = 3,374$) and without ($N = 2,969$) ADHD. Their analysis indicated that groups with ADHD exhibited significant impairment on neuropsychological measures of response inhibition, vigilance, working memory, and planning. Effect sizes from meta-analytic analysis of these studies were generally in the medium range (0.46–0.49). Willcutt’s group concluded that while their results “clearly indicate that EF weaknesses are significantly associated with ADHD, they do not support the hypothesis that EF deficits are the single necessary and sufficient cause of ADHD in all individuals with the disorder” (Willcutt et al., 2002, p. 13).

Current theories posit that symptoms of ADHD result from dysfunction of the cortico-striatal-thalamo-cortical network due to structural abnormalities of PFC, basal ganglia, and cerebellum; or result from abnormalities in dopaminergic and noradrenergic pathways originating in brainstem nuclei (locus ceruleus, substantia nigra, and ventral tegmental area). Investigators have proposed a variety of prefrontal cortex models for ADHD, including frontal-lobe dysfunction (Castellanos, Giedd, Hamburger, & Marsh

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1996), delayed frontal maturation (Chelune et al., 1986), and dysfunctional subcortical-frontal motor systems (Castellanos, Giedd, Eckburg, & Marsh 1994; Giedd, Castellanos, Casey, & Kozuch, 1994). In a review of neuroimaging findings, Hendren, De Backer, & Pandina (2000) found that abnormalities in basal ganglia have been consistently observed in children with symptoms of ADHD, especially those with impulsivity (Casey et al., 1997; Lou, Henriksen, Bruhn, & Borner, 1989). In addition, many MRI studies have reported decreased caudate volumes and reversed asymmetries, although the laterality of these differences and direction of asymmetry have not been consistent across studies (Castellanos, 1997; Hynd, Hern, Novey, & Eliopulos, 1993). Reduced frontal volume and glucose metabolism has also been identified, but results have been inconsistent as to whether frontal-lobes are reduced bilaterally or in the right or left hemispheres selectively. Some have also suggested that the behavioral symptoms of ADHD stem from right frontal-lobe and basal ganglia dysfunction (Castellanos, Giedd, Eckburg, & Marsh, 1994, Castellanos, Giedd, Hamburger, & Marsh 1996; Voeller & Heilman, 1988). Heilman and colleagues (1991) posited an anterior (frontal) – posterior (parietal) gradient that may result in differential effects on attention and motor control.

ADHD: Neuropsychological Profile

It is often the goal of developmental neuropsychology studies to identify the primary and core neurocognitive deficits of disorders. Many researchers have noted similarities between children with ADHD and patients with EF deficits or prefrontal cortex lesions (Benton, 1991; Heilman et al., 1991), and studies of children with ADHD have consistently demonstrated deficits in one or more domains of EF, including

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sustained attention, working memory, inhibitory control, and planning (Harris, Schuerholz, Singer, & Reader 1995; Grodinsky & Diamond, 1992; Reader, Harris, Schuerholz, & Denckla, 1994).

In a review of 18 studies of EF in children with ADHD, Pennington and Ozonoff (1996) reported that 15 of 18 studies found a significant difference between children with and without ADHD on one or more EF measures, with ADHD children performing worse on 40 of the 60 (67%) EF measures. Measures that were most sensitive to differentiating between groups (based upon average effect sizes and consistency of findings across the studies) included the Tower of Hanoi, Stroop, Matching Familiar Figures Test errors, and Trailmaking Test – Part B. Purer measures of inhibitory control of motor output (such as the GoNo-Go, Anti-saccade, Conflict Motor Task, and NEPSY Inhibition) also consistently detected group differences, as did two measures of working memory (Sequential Memory Task and Self-Ordered Pointing Task). ADHD children also performed more poorly on measures of vigilance and perceptual speed (6 of 8 measures). In addition to findings of EF deficits across studies, Pennington and Ozonoff (1996) identified consistencies in measures that did not differentiate between ADHD children and controls. In particular, their review of studies failed to find significant differences on 10 of 13 measures of verbal memory tests, and 15 of 19 measures of visual-spatial ability.

A review of the similarities and differences of the performance of individuals with ADHD on tasks of EF varies widely. Similarly, individuals with AS show inconsistencies in their performance on EF tasks. Therefore, the next section will provide a description of EF including the biological aspects. Given the overlap and

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variations in the performance of ADHD and AS individuals on tasks of EF, this description will be followed by a review of the studies that compare the performance of individuals with AS to ADHD on tasks of EF.

Description of Executive Functions

Denckla (2001) stated that: “A great deal of the differences between child and adult resides in the unfolding of executive functioning” (p. 264). Ozonoff et al. (1991a) have described executive functions as “the ability to maintain an appropriate problem solving set for attainment of a future goal; it includes behaviors such as planning, impulse control, inhibition, set maintenance, and flexibility of thought and action.” These are complex cognitive processes that are mediated mainly the frontal lobes. There is evidence that other brain structures, especially the basal ganglia, also assist with mediating these skills (Chow & Cummings, 1999). Executive functioning requires the integration of such skills as memory, learning and attention, in order to plan future goals and actions as well as to inhibit impulsive behavior and guessing.

The earliest work that was done to attempt to understand mental abilities began in the field of philosophy (see Luria, 1966 for a review). This initial theory of executive function, or “higher mental functions” attempted to associate specific brain structures with specific cognitive skills. While this was possible with some elementary mental abilities (i.e. – basic memory processes and specific language areas), the model of higher cortical functions was far from complete. Luria (1966) described the modular brain regions that were involved in the performance of a particular biological task as a “functional system.” Each functional system is based, according to Luria, on a complex

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dynamic ‘constellation’ of connections, which work together to perform a more complicated act. Luria described the modular systems of the brain as “a highly differentiated system whose parts are responsible for different aspects of the unified whole” (Luria, 1980, p. 33).

Executive function skills are multidimensional, and can be considered from a number of different theoretical perspectives (Barkley, 2001). Luria (1966) described these skills as based on the ability of humans to self-regulate their own behavior. The frontal cortex has complex connections to different brain structures in order to integrate various modalities of information. For the purpose of this study, this review focuses on biological and developmental theories of executive function that inform our understanding of frontal lobe function.

Biological Aspects of Executive Functions

As stated above, executive functions are mediated mainly by the frontal lobes, specifically the prefrontal cortex (Chow & Cummings, 1999). The prefrontal cortex is one of the last regions to develop ontogenetically and phylogenetically, and is also the most highly interconnected of all neocortical regions (Fuster, 1999). It is also not fully mature until a person reaches late adolescence (Fuster, 1999).

Luria (1980) noted that “In man the zones in which there is “overlapping” of the cortical boundaries...comprise 43% of the total mass of the cortex” (p. 26). The frontal lobes integrate information from both the external world and internal states, and receive information from many different areas of the brain. Information is received from the temporal, parietal and occipital cortices about higher-level auditory, somatosensory, and

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visual information. The frontal lobes also have connections with limbic structures (namely, the hippocampus and amygdala), that mediate learning and memory, emotional and affective tone, autonomic regulation, drive and motivation (Kaufer & Lewis, 1999). These connections integrate information from both internal states and the external world. The dorsolateral prefrontal subcortical circuit mediates executive functions. Executive function activities include, “the ability to organize a behavioral response to solve a complex problem, activation of remote memories, independence from environmental contingencies, shifting and maintaining behavioral sets, generating motor programs, and using verbal skills to guide behavior” (Chow & Cummings, 1999, p. 4). Conversely, dysfunction in this area of the brain is coined the “dysexecutive syndrome” (Duffy & Campbell, 2001). Though this cognitive dysfunction syndrome can be seen in a variety of different ways, people with this syndrome often have difficulty with cognitive set shifting or redirecting their behavior. They show signs of distractibility, perseveration and impersistence (Duffy & Campbell, 2001).

The orbitofrontal subcortical circuit mediates socially critical restraint and object affect associations. Personality changes are considered to be the hallmark of orbitofrontal dysfunction (Mega & Cummings, 2001). The orbitofrontal cortex has connections with the paralimbic cortex, and therefore it mediates function of the limbic system and emotional expression (Duffy & Campbell, 2001). Patients with lesions in this area can be irritable or labile, and often they do not respond appropriately to social cues. They also show undue familiarity in interpersonal relationships, and they have trouble empathizing with other people’s feelings (Mega & Cummings, 2001). Goldberg (2001)

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stated that for patients with dysfunction in this circuit the capacity for restraint is compromised, which leads to impulsive behavior.

Executive Functioning in ADHD and Asperger's Disorder

Blakemore-Black (2002) and Gillberg et al. (1982) have noted cognitive similarities between individuals with Asperger's Disorder and children with ADHD. Many individuals with Asperger's and Autistic Disorder also have attention deficit problems. Eisenmajer, Prior, Leekman, Wing, Gould, Welham, et al. (1996) found in their study that individuals with AS showed a high rate of comorbidity with ADHD.

Gillberg et al. (1982) studied a group of children who showed "minimal brain dysfunction" (MBD). These children showed signs of attention problems and "clumsiness" or motor incoordination. These children constituted a "fairly distinct problem group" (p. 132). Gillberg (1983) posed the question in a follow-up study of whether "... 'minor neurological dysfunction' and psychiatric disorder are two aspects of underlying brain dysfunction, or whether they represent interacting variables" (p. 377). Blakemore-Brown (2002) described AD, autism, nonverbal learning disability and ADHD as related syndromes, as they all have common features that include executive skill dysfunction. Eaves et al. (1994) found in their study of autistic spectrum disorders, that a high percentage of these children had a short attention span. The children in two of their four subtypes (Asperger's Disorder and PDD-NOS) also were considered to be hyperactive, distractible and impulsive. According to Tsai (2000), about 60% of individuals with autistic spectrum disorders have poor attention and concentration.

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This overlap is not surprising, as AS, Autistic Disorder and ADHD all involve deficits (i.e. - inattention, impulse control problems, and poor comprehension of social situations) that are mediated by the frontal lobes. These are the common components of ADHD, as well as Asperger's Disorder and Autistic Disorder. One difference between ADHD and AS is that with ADHD, the most striking features are lack of ability to sustain attention, impulsivity and distractibility. Individuals with Asperger's Disorder do not have difficulty sustaining attention on topics that interest them, yet may demonstrate inattention or impulsivity on topics they find more difficult or of lesser interest. ADHD individuals may have social difficulties, yet not from misinterpreting social cues (as seen with individuals with Asperger's Disorder and Autistic Disorder). ADHD individuals may have social difficulties that are related to failure to pay attention and therefore may miss pieces of conversation or social exchanges. The frontal lobe mediates such skills as impulse control, attention, planning, flexibility of thought, integration of language, and social comprehension.

EF deficits have been postulated as being the core cause of ADHD and Autistic Spectrum Disorders (ASD) (Barkley, 1997a). To date only four studies have attempted to identify executive function tasks that are more specific to either ADHD or AS (Geurts et al., 2004; Happe et. al., 2006; Nyden, 1999; Ozonoff and Jensen, 1999). Ozonoff and Jensen (1999) studied children ages 6 to 18 with ADHD, autism and Tourette Syndrome, as well as controls with typical development. The authors found that children with autism showed difficulties in planning and cognitive flexibility, but not in inhibitory control, where as children with ADHD showed the reverse pattern. In the Nyden et al.

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(1999) study however the conclusion was that little evidence could be obtained were disorder specific characteristics using attention and executive function tasks. This study which included children aged 8 to 12 with a mean age of 10 years, had some methodological imperfections such as not excluding subjects with comorbid externalizing disorders and not controlling for the non-EF demands of EF tasks. Ozonoff and Jensen did, Geurts et al. (2004) found that the AS group overall had more severe EF problems. Subjects included three diagnosed groups of children between ages of 6 and 12 years (54 ADHD, 41 HFA, 41 normal controls) that were tested on a wide range of tasks related to five major domains of EF: inhibition, visual working memory, planning, cognitive flexibility and verbal fluency. According to this study, ADHD was associated with EF deficits in inhibiting a prepotent response and verbal fluency. Children with HFA demonstrated deficits in all EF domains, except interference control and working memory.

By contrast the Happe et al. (2006) study, supported the findings that the AS group presented with less severe and persistent EF deficits than the ADHD group. This study included three groups: the Autism Spectrum Disorder (ASD) group, the Attention-Deficit/Hyperactivity Disorder (ADHD) group and the typically developing (TD) group. The children were aged between 8 and 16 years. The ASD group comprised 32 boys with a formal diagnosis of either high-functioning Autistic disorder (N=6) or Asperger Disorder (N=26). The ADHD group was comprised of 30 boys with a formal diagnosis of ADHD and the TD comparison group comprised 32 boys. The authors findings did provide support for distinct EF profiles in ADHD and AS: the ADHD group showed

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striking deficits of response selection/inhibition on a Go-no-Go task, and planning on a spatial working memory task, while the ASD group showed poor response selection/monitoring on a cognitive estimates task. The authors cautioned that careful matching on IQ, while always important, may be critical in studies of EF, given the close overlap between the constructs of EF and fluid intelligence (Duncan, 2001).

Given the complexities of the frontal lobes including the measurements of its Executive Function, many different tests have been developed attempting to accurately assess these function. An overview of the psychometric assessment of Executive Functions will now be provided followed by a description of the Delis-Kaplan Executive Function System (D-KEFS) that will be used in this study.

Psychometric Assessment of Executive Functions

Delis, Kaplan & Kramer (2001a) describe how much research has focused on isolating skills, such as reading, memory and attention in order to understand how each skill contributes to a person. Executive functions involve utilizing basic skills to initiate an action, and therefore have been difficult to specify. Goldberg (2001) states the importance of studying executive, or higher order cognitive functions as though these basic skills may be intact the ability to initiate these cognitive skills may be impaired. The impairment or lack of initiation would be an executive skill. With executive function, these skills need to be studied in their true complexity in order to fully assess for difficulties. As Luria (1966) has noted, 43 % of the total mass of the cerebral cortex has the physical capacity to integrate information, and has an overlap in functions. A great deal of the cortex is essentially involved in integration of information.

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Morris (2001) has described the difficulty with assessment of executive function, as he noted that many of the same tests that are used to measure these skills also are used to measure other abilities such as memory and learning. There are more than 60 tests of cognitive executive function; most of them measure either response inhibition or working memory (Samango-Sprouse, 1999). Most tests try to assess only one aspect of executive functions (i.e. - impulsivity), as opposed to testing multiple constructs at once (i.e. - impulsivity, cognitive flexibility, and planning). This is based on the theory that each task only taps one aspect of cognitive functioning. Delis et al. (2001a) stated that contrary to that theory, most executive function tests do tap more than one construct of higher level cognitive function, and require a person to utilize several higher-level abilities at once to perform successfully.

With this model in mind, Delis et al. (2001a) developed a battery of executive function tests that have multiple achievement scores that coincide with the many different executive skills that each test samples. Their battery of tests, called the Delis-Kaplan Executive Function System (D-KEFS), is made up of nine separate subtests that assess aspects of attention, language, perception, creativity, cognitive flexibility, inhibition, planning, concept formation, abstract thinking, memory, and learning. This set of tests is standardized to evaluate performance of individuals ranging from 8 to 89 years on varied aspects of executive functioning. The nine D-KEFS subtests can be used jointly or separately. The nine subtests include: Trail Making, Verbal Fluency, Design Fluency, Color-Word Interference, Sorting, Twenty Questions, Word Context, Tower and Proverbs.

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For the purpose of this study, four of the subtests of the D-KEFS will be used to evaluate specific executive function skills. They are: the Sorting Test, Design Fluency, Verbal Fluency and the Color-Word Interference Test. These D-KEFS subtests all are modifications of earlier developed tests that have been found to be reliable and valid for evaluation of specific executive function skills. Each of these four tasks taps one aspect of EF in each domain Delis et al. (2001a)

Given the difficulties in diagnostic differentiation between AS and ADHD using an executive functioning model, the following Statement of Purpose and Hypotheses for the current study are provided.

Statement of Purpose and Hypothesis

The purpose of this study was to differentiate executive functioning deficits in children who have been diagnosed with AS according to DSM-IV TR (2000) criteria vs. children who have been diagnosed with ADHD according to the DSM-IV TR (2000) criteria. EF deficits have been postulated as being the core cause of ADHD and Aspergers Syndrome. Further investigation of specific levels and variations of EF deficits in AS and ADHD will allow for more diagnostic differentiation and effective intervention.

Executive functions were examined in this study with measures designed to assess the following constructs: verbal fluency, nonverbal/spatial fluency, cognitive flexibility, cognitive set-shifting and inhibition.

Hypothesis I

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Hypothesis I states that children with Asperger's Syndrome will perform less well than ADHD children on tasks of nonverbal/spatial fluency. Nonverbal/Spatial fluency was assessed using the overall score of the D-KEFS Design Fluency Test.

Hypothesis II

Hypothesis II states that children with ADHD will perform less well than AS children on tasks of verbal fluency. Verbal fluency was assessed using the overall score of the D-KEFS Letter Fluency Test.

Hypothesis III

Hypothesis III states that children with Asperger's Syndrome will perform less well than ADHD children on tasks of nonverbal/spatial conceptual reasoning. Cognitive flexibility and cognitive set-shifting was assessed using the D-KEFS Sorting Test measure of Confirmed Correct Sorts. As AS individuals have difficulty with integration of information, they were hypothesized to score below age-matched controls on measures of nonverbal conceptual reasoning.

Hypothesis IV

Hypothesis IV states that children with ADHD will perform less well than ADHD on tasks of and inhibition. Inhibition was assessed using the D-KEFS Color-Word Interference Test measures of: 1) Inhibition measure.

Overall, AS children were expected to perform less well than ADHD children on tasks of: nonverbal/spatial conceptual reasoning, cognitive set-shifting and cognitive flexibility (Sorting), Nonverbal Fluency (Design Fluency). ADHD children were

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expected to perform less well than AS children on tasks of verbal conceptual reasoning,

Verbal Fluency tasks (Letter fluency) and inhibition (Color-Word Interference).

CHAPTER 3

METHODS

Design

This study utilized a quasi-experimental, 2 group, between-subjects design. Participants were not be randomly assigned to treatment and diagnostic groups. Middle school aged children with a primary diagnosis of Asperger's Syndrome were compared to demographically matched, children with the primary diagnosis of ADHD.

Independent Variable

The independent variable was the diagnostic status with two conditions: a diagnosis of Asperger's Syndrome and ADHD.

Dependent Variables

The dependent variables were measures of executive functioning from the DKEFs Executive Function System (Letter fluency, nonverbal fluency, inhibition and cognitive flexibility).

Participants

The participants were 40 middle school students (4th to 8th graders) between the ages of 9 and 13, twenty carrying a primary diagnosis of Asperger's Syndrome (the AS group), and twenty with a primary diagnosis of ADHD without co morbid psychiatric or neurological conditions (the ADHD group). All children with ADHD predominately inattentive type will be excluded. They were recruited from the Marblehead Public Schools. The AS group was drawn from pupils who receive special education in inclusion or in self-contained programs with inclusion specifically designed to serve students with

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autistic spectrum disorders. Participants with a history of a Pervasive Developmental Disorder (other than Asperger's Syndrome) were excluded. The ADHD group was drawn from pupils who are on a 504 education plan or who receive special education through inclusion. Participants in the ADHD group were not in self-contained programs. Only boys were recruited for this study. The participants were drawn from children in middle to high socio-economic families. Although no one was excluded from this study based on their ethnic or cultural background, the participants were all Caucasian.

Exclusion criteria for both groups included: (1) Below average intelligence; (2) Any medical disorders with potential neuropsychological consequences, such as cancer or diabetes; (3) Any history of neurological brain disorders such as; meningitis, encephalitis, stroke, brain injury/head trauma, HIV infection, epilepsy/seizure disorder or brain tumor; and (4) Substance abuse or substance dependence disorders. The two groups were matched for gender, grade, ethnicity and socioeconomic status.

Instruments

In order to determine appropriateness for inclusion in the study as well as to obtain demographic variables, two types of measures were used.

Screening Instruments

The purpose of the screening process was to identify potential participants who fully satisfy the inclusion/exclusion criteria. The study used three screening instruments: research intake to determine primary diagnosis, previous cognitive assessment, and two-subtest version of Wechsler Abbreviated Scale of Intelligence (WASI) consisting of Vocabulary and Matrix Reasoning. The research intake was used to collect demographic,

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medical and psychiatric history of the participating child covering all aspects of functioning relevant to the study. A review of the previous cognitive assessment within the last three years or the two-subtest (short form) of the Wechsler Abbreviated Scale of Intelligence (WASI) provided an estimate of intellectual functioning. This information was used to rule out mental retardation and match participants across groups on intellectual level.

Measures of Executive Functions

Delis-Kaplan Executive Function System (Delis et al., 2001a)

Selected subtests from the Delis-Kaplan Executive Function System (D-KEFS) were used to assess executive functioning. The D-KEFS assesses various aspects of executive functions such as attention, language, perception, creativity, cognitive flexibility, inhibition, planning, concept formation, abstract thinking, memory and learning. The D-KEFS component tests are for the most part modifications of instruments that were developed earlier, and that have been found to be reliable and valid measures of executive function. Improvements were made to the original form of each test. The difficulty and complexity of each test at the high end of the scale was increased over the original version to challenge participants who performed well on these measures.

The D-KEFS was designed to test individuals who range from those of very limited cognitive ability and very low performance levels, to very bright people who may display only subtle cognitive deficits. The D-KEFS sample consisted of roughly equal populations of men and women at each age group. The demographic characteristics of the D-KEFS standardization sample closely paralleled those of the US population

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according to the 2000 US Census figures. For each age group in the D-KEFS standardization sample, the proportions of African-American, Hispanic, white and other racial/ethnic groups sampled were stratified to approximate the 2000 US Census population estimates (Delis et al., 2001b). From each age group a subtest raw score is obtained and are converted into scaled scores. The scaled scores range from 1 through 19. These scaled scores have a mean value of 10, and a standard deviation value of 3. The scale extends from +3.0 standard deviations through -3.0 standard deviations. The descriptive breakdown of scores is as follows: 1-3 (extremely low), 4-5 (borderline), 6-7 (low average), 8-11 (average), 12-13 (high average), 14-15 (superior), 16-19 (very superior). Norms are available for 8 to 89 year olds.

Four of the nine D-KEFS subtests were used in this study. They were: the Sorting Test, Design Fluency, Verbal Letter Fluency (Conditions 1-3) and the Color-Word Interference Test (Conditions 1-3). These subtests were chosen due to their specific sensitivity to EF domains identified as the independent variable in this study.

D-KEFS Verbal Fluency Test: A Description

The D-KEFS Verbal Fluency Test measures the examinee's ability to generate words under various task demands: phonemically (Letter Fluency), according to overlearned concepts (Category Fluency), and while alternating between overlearned concepts (Category Switching). Both Letter and Category Fluency require adequate fundamental verbal skills (e.g., vocabulary knowledge) and higher level abilities (e.g., rapid retrieval of lexical items). Internal consistency rates for the Letter Fluency measure were in the range of 0.76 to 0.80 for adolescents who were in the age cohorts 11,

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13-14, and 16-19 years. Overall, internal consistency rates were high for most middle school age cohort groups. The test-retest reliability measures for Letter fluency were also good to high (Delis et al., 2001b). Only D-KEFS conditions one through three (Letter Fluency) was used in this study.

D-KEFS Design Fluency Test: A Description

The D-KEFS Design Fluency Test is the nonverbal counterpart to the Verbal Fluency Test. This test measures the examinee's ability to generate as many different designs utilizing grids of dots (some filled, some empty) within 60 seconds. There are three testing conditions: Filled Dots, Utilize Empty Dots only while ignoring filled dots, and Switching. Condition 1 aims to provide a basic test of design fluency. Condition 2 measures both design fluency and response inhibition. Condition 3 measures both design fluency and cognitive flexibility. The Design Fluency Test is a time-constrained, speed-of-responding task, without time-interval scores. Item interdependence precluded the use of internal consistency procedures, and reliability was investigated with test-retest procedures. Test-retest reliability was moderate; the values between 0.32 and 0.58 (Delis et al., 2001b). The total score of all three measures was used in this study.

D-KEFS Color-Word Interference Test: A Description

The D-KEFS Color-Word Interference Test is an adaptation of the Stroop Color-Word Test developed by Hans Stroop in 1935. The first version of this test dates back to 1886, when it was developed as a doctoral thesis by Cattell (Jensen & Rohwer, 1966). In this original version two experimental conditions were included, color-naming and color-word reading. It was noted that participants took longer to complete the color-naming

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condition color-word reading trial (Cattell, 1886 & Stroop, 1935). This has proven to be true for most people, as we read familiar words automatically, where naming colors require greater effort. Naming the color of the ink a word is printed in when the ink color and the color the word refers to are discrepant (e.g., the word red printed in blue ink) is even more difficult, and hence it takes longer. Much has been written about the Stroop task, and many clinical and experimental versions of it exist. Similarly, theories abound as to what is the process that accounts for the greater difficulty in performing this task. While this discussion is beyond the scope of this dissertation, the reader is referred to excellent reviews on the subject. The D-KEFS Color-Word Interference Test is a modification of a commonly used clinical version of the Stroop task, the Comali-Kaplan Stroop (Cattell, 1886 & Stroop, 1935) which consists of 3 cards containing 100 items each: color patches (red, blue, green), color words (red, green blue) printed in black, and color words printed in an incompatible color ink (e.g., red in blue ink). Performance speed and errors are measured. The D-KEFS color-word test are similar to the original 3 described above, but with only 50 items are presented in each page. This task purports to measure one component of executive function: inhibition. Inhibition involves the ability to focus on the task at hand without becoming distracted, specifically, on this task, this requires to override an over-learned response (i.e. reading), in favor of a more difficult one (i.e., color naming). (Delis et al., 2001a, p.5). Internal consistency of these measures ranged from 0.62 to 0.75 for age cohorts 11 to 19 years old. Test-retest reliability was high; the values were 0.79 and 0.77 for Color Naming and Word Reading, respectively

(Delis et al., 2001b). Only D-KEFS conditions one through three were used in the present study.

D-KEFS Sorting Test: A Description

The D-KEFS Sorting Test was developed by Delis and his associates in the late 1980's, and was originally called the California Card Sorting Test. Delis developed the idea for sorting partly from early work described Vygotsky in 1962. In this early work Vygotsky used an individual's approach to sorting real objects into categories as a way to analyze that person's thinking strategy. Objects could be sorted in on the basis of nonverbal cues (i.e. – by color, shape or size). Delis et al. (2001a) modified this version of this classical test to include verbal as well as nonverbal attributes to be utilized in sorting objects. Indeed, one of the strengths of the D-KEFS Sorting Test is the ability to assess both verbal and nonverbal abilities with respect to planning and abstract reasoning.

As stated earlier, many tests of executive function do not provide ways to partial out component skills. For instance, the most commonly utilized test of executive functioning, the Wisconsin Card Sorting Test, while the WCST provides separate measures for correct sort solutions and perseverative errors, it does not allow one to specify which specific executive function ability is impaired, as it measures so many skills simultaneously (Delis et al., 1992). In support of this contention, in a factor analytic study of the WCST by Greve, Brooks, Crouch, Williams & Rice (1997) two factors loading on dimensions of executive function were identified. Factor I was considered to be an undifferentiated executive function construct, while Factor II involved primarily memory, motivation and attention components.

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As a consequence of its lack of specificity regarding components of executive functioning, the WCST does not permit an analysis of determinants of impaired performance. Thus, a high score on an index score of perseveration could be due to due to impulsivity, inability to benefit from feedback, or inability to shift set; the WCST does not provide sufficient information to make such determination. Overall, if one were only interested in measurement of the presence or absence of an executive function deficit such as perseverative error, then the WCST would be a good screening measure to use. If instead it is important to separate different components of executive functions, then the D-KEFS Sorting Test is a more suitable measure.

The D-KEFS (Delis et al., 2001a) allows for a modular analysis of operationally defined executive function components. This was demonstrated in a study by Delis, Squire, Bihrlé and Massman (1992), where patients with frontal lobe damage were administered this instrument. Impairments were found in specific executive function skills such as concept formation, abstract thinking, cognitive flexibility and the use of knowledge to regulate behavior. These results underscore the importance of assessing the many skills that contribute to the concept of executive functions, and the necessity for a modular analysis of each specific skill.

The D-KEFS Sorting Test assesses the executive function skills of concept formation and problem-solving abilities in the verbal and nonverbal (visual) modalities, which allows for a comparison of modality-specific problem-solving skills. It also assesses the ability to initiate problem solving (Delis et al., 2001a). The total Confirmed Correct Sorts score was used as the comparison measure in the present study. This index

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measures an examinee's ability to initiate problem solving behavior in the visual-spatial realm. Internal consistency rates for this measure were in the range of 0.72 to 0.82 for adolescents who were in the age cohorts 11, 13-14, and 16-19 years. The reliability rates were lower for adolescents age 12 and 15 (0.62 and 0.55, respectively). Overall, internal consistency rates were moderate to high for most middle school age cohort groups (Delis et al., 2001b).

Procedures

Recruitment: Pre-screening Phase

The author, a doctoral candidate in school and counseling psychology and the primary investigator discussed the plans with the administrators and treatment teams at the participating schools. Upon approval from the Institutional Review Board (IRB) at Northeastern University, the schools were provided with copies the research intake form (Appendix A) and the informed consent form (Appendix B) to be administered by the primary investigator.

Recruitment: Screening Phase

Informed Consent Procedure. After identifying prospective participants, each parent was sent a copy of the Informed Consent Document, which introduces the basic concepts, research purpose, plan and procedures. The parents were also asked to complete the Research Intake Form. The researcher provided further details if necessary and answer any questions. After making sure that the participant understood the information fully, the primary investigator collected the consent forms appropriately signed by all parties. A copy of the signed consent form was given to each parent.

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Administration of Screening Instruments. After receiving signed consent forms, previous cognitive evaluations were reviewed. If unavailable, the child was first administered the shorter, two-test version of the Wechsler Abbreviated Scale of Intelligence, which took approximately 15-20 minutes.

Administration of Assessment Instruments. After determining that the child met the inclusionary criterion of intelligence in at least the scores in the average range, the child was administered the measures of executive functioning. These included four subtests from the Delis-Kaplan Executive Function System including; Verbal fluency, Design fluency, Sorting, and Color-Word Interference. Each child was tested individually in their school building by the primary investigator. The scoring was rechecked by the primary investigators research assistants who were school psychology internships students. Administration of these tests lasted approximately 30-40 minutes.

Debriefing. At the conclusion of the testing, the participants were presented with a brief review of the activities. This time also served as an additional opportunity to ask questions and to address concerns they might have related to the study.

Analyses

Data analysis consisted of quantitative measures of AS that can reliably be distinguished from the ADHD profile on the basis of EF. A t test was used to determine evidence of statistical significance ($p \leq .05$) on any individual subtest scoring method, as all the D-KEFS Tests are scored independently with separate scoring criteria measures previously described.

CHAPTER 4

The present study compares the differential profiles in executive functioning performance between two clinical populations, AS and ADHD. This chapter is divided into two sections. The first part presents demographic data from the sample of the present study. In the second section the hypotheses will be presented with statistically significant findings. Table 1 presents the demographic data. Table 2 presents four t-tests that were conducted on the dependent variable by each group.

Demographic Data

The study included 40 comparable, middle school students (4th to 8th graders) between the ages of 9 and 13, twenty carrying a primary diagnosis of Asperger's Syndrome (the AS group), and twenty with a primary diagnosis of ADHD without co morbid psychiatric or neurological conditions (the ADHD group). For the ADHD group there were 16 boys diagnosed with ADHD combined type, 4 boys diagnosed with ADHD Hyperactive/Impulsive Type.

The two groups were matched for age, gender and IQ. The AS group had a mean age= 13.55 and the ADHD group mean age= 13.2. They attend the Marblehead Public Schools. All participants completed the WASI screener. The AS group WASI Full scale IQ had a mean score= 113.15 and the ADHD group WASI Full Scale IQ had a mean score = 122.6. The AS participants were drawn from pupils who receive special education in inclusion or in self-contained programs with inclusion specifically designed to serve students with autistic spectrum disorders. The ADHD group participants were drawn from pupils who are on a 504 education plan or who receive special education through inclusion. Only boys were recruited for this study. No one was excluded from

this study based on their ethnic or cultural background. They were all tested in their school buildings and each completed all tests.

Table 1

Demographic Information by Group

	Aspergers	ADHD
	M	M
AGE	13.55	13.2
Full-Scale IQ	113.15	122.6

Since the D-KEFS are scored independently, individual subtest scores were used to determine the difference between the 2 groups in Executive Functioning measures. For each subtest raw scores are converted into scaled scores. The scaled scores range from 1 through 19. These scaled scores have a mean value of 10, and a standard deviation value of 3. The scale extends from +3.0 standard deviations through -3.0 standard deviations. Results of the analyses are presented below by hypothesis.

Hypotheses and statistically Significant Findings

Four t-tests were conducted on the dependent variables by group (Aspergers vs. ADHD). The t-tests were statistically significant (Table 2) with the means and standard deviations for each group.

Hypothesis I

Hypothesis I which stated that children with Asperger’s Syndrome would perform less well than ADHD children on tasks of nonverbal/spatial fluency was supported. On the D-KEFS Design Fluency subtest the AS group achieved a mean scaled score of 9.50

(SD= 1.96) and the ADHD group achieved a mean scaled score of 12.30 (SD= 1.59).

These results are statistically significant at the .001 level.

Hypothesis II

Hypothesis II which stated that children with ADHD would perform less well than AS children on tasks of verbal fluency was supported. On the D-KEFS Verbal Fluency subtest the AS group achieved a mean scaled score of 13.55 (SD= 1.73) and the ADHD group achieved a mean scaled score of 9.40 (SD= 1.64). These results are statistically significant at the .001 level.

Hypothesis III

Hypothesis III which stated that children with Asperger's Syndrome would perform less well than ADHD children on tasks of nonverbal/spatial cognitive set-shifting was supported. On the Confirmed Correct Sorts measure of the D-KEFS Sorting Test the AS group achieved a mean scaled score of 8.35 (SD= 1.69) and the ADHD group achieved a mean scaled score of 11.70 (SD= 0.98). These results are statistically significant at the .001 level.

Hypothesis IV

Hypothesis IV stated that children with ADHD would perform less well than ADHD on tasks of inhibition. On the Inhibition measure of the D-KEFS Color-Word Interference Test the AS group achieved a mean scaled score of 11.20 (SD= 1.99) and the ADHD group achieved a mean scaled score of 8.40 (SD= 1.50). These results are statistically significant at the .001 level.

Overall, each of the four hypotheses were supported: the Asperger's group had statistically significant greater scores on Verbal fluency and C-W inhibition compared to

the ADHD group, and the ADHD group with statistically greater scores on Design fluency and Sorting compared to the Asperger's group.

Table 2

T-tests, Means, and Standard Deviations on Four Variables by Group

	T	df	Sig.	Aspergers		ADHD	
				M	SD	M	SD
Verbal Fluency	7.793	38	.001	13.55	1.73	9.40	1.64
Design fluency	-4.958	38	.001	9.50	1.96	12.30	1.59
C-W inhibition	5.025	38	.001	11.20	1.99	8.40	1.50
Sorting	-7.656	30.4	.001	8.35	1.69	11.70	0.98

Chapter 5

The present study offered support to the contention that there are specific EF profiles that differentiates AS and ADHD. At the outset of this study, scientific literature on the neuropsychological bases of ADHD and AS identified EF difficulties as their primary underlying dysfunction. EF was also found to be compromised in many other clinical conditions, e.g., Obsessive Compulsive Disorder, Alzheimer's, Schizophrenia. Little had been done to ascertain what aspect(s) of EF was affected in each individual in particular or each clinical condition in general.

Ascertaining that a particular individual presenting with a given clinical condition has an EF disorder is not very useful in informing clinicians in designing intervention strategies. As most everybody will agree, EF is not unitary, but comprises diverse higher cognitive functions whose disruption has been associated with damage to the prefrontal cortices. Determining which of these is affected is, no doubt, critical. A case in point is AS, which has been found to frequently overlap with ADHD (Eisenmajer, Prior, Leekman, Wing, Gould, Welham, et al., 1996; Blakemore-Brown, 2002; Constantino, Hudziak & Todd, 2003; Goldstein & Schwabach, 2004). Determining which aspects of EF are differentially affected is essential aspect of differential diagnosis (Kovelson, 2007).

For many years, few standardized tests were available to assess EF. The WCST, Trailmaking Test, Stroop Test, were among those. Clinical observations along with non-standardized tasks were utilized to further document the presence of EF (Royal, Lauterbach, Cummings et al., 2002). More recently, given the greater focus on the

assessment of EF, more instruments have been developed. Some, acknowledging that tests are multifunctional, have addressed the need to separate the contribution of those to an individual performance on those. The D-KEFS, designed to address those issues, is a comprehensive instrument comprising an array of tests, providing the opportunity to conduct an in-depth exploration of EF.

This study was an attempt to dissociate components of EF using standardized, well normed tasks. To this end, four tasks selected from the D-KEFS, which have been found to be compromised in AS and ADHD, to determine whether they were differentially present in ADHD and AS. A review of studies addressing EF in AS and ADHD (see Chapter 2) suggested that in AS word list generation and were commonly affected. Tasks were ADHD individuals show impairment included the Stroop Test and Verbal Fluency.

This informed the choice of the 4 D-KEFS tasks utilized here: It was hypothesized that children with ADHD would perform less well than AS children on tasks of verbal fluency and inhibition, while AS children would perform less well than those with ADHD on tasks of design fluency and card sorting. Data generated in this study support each of the four hypotheses: the Asperger's group had statistically significant greater scores on Verbal fluency and C-W inhibition compared to the ADHD group, and the ADHD group with statistically greater scores on Design fluency and Sorting compared to the Asperger's group. In other words, AS children had difficulty specifically on tasks of cognitive switching and nonverbal fluency. Children with ADHD had difficulty inhibiting prepotent responses and generating word lists. The specific

profiles obtained in each group's performance on the four tasks achieved the main goals of the study: to determine whether differential patterns of EF abilities could be found for ADHD and AS, and whether these could be identified through the use of standardized tasks of EF.

The findings from this study suggest, as does the literature, (that individuals with Asperger's Syndrome present with frontal lobe dysfunction, primarily in the areas of information integration and cognitive flexibility. Specifically, in the sample studied, middle school children with AS had difficulty with cognitive switching and nonverbal fluency. These deficits interfere with effective social functioning, as well as performance on some academic tasks. As discussed earlier, they did not perceive cues in context, missing an important component in processing information. Their focus on detail also prevents them from shifting their attention from details in isolation to the overall context of the stimulus. Cognitive switching becomes increasingly important as one develops, and is considered to be necessary to construct new ideas, for social awareness, empathy, creative thought, and the development of personal identity.

Factors that help understand these differences have been discussed in the clinical and experimental literature on both disorders. In the case of AS, descriptions in the clinical and experimental literature refer to an 'over-focus', which prevents them from shifting mental set when problem-solving, which presents as perseveration or reduced capacity to generate alternatives (Asperger, 1944; DSM-IV-TR, 2000; Wing 1988). The type of narrow focus in AS children can be useful in some situations that require very close attention to detail, yet it cannot be used as the only or primary problem solving

strategy, particularly in social contexts. A hallmark impairment in AS individuals is their difficulty with interpersonal interactions (DSM-IV-TR, 2000). A sine-qua-non of effective functioning in social situations is the ability to attend to various factors and to place things in context. This requires an ability to integrate details into a gestalt, which cannot be done by focusing exclusively on detail, as is the case in individuals with AS.

As for children with ADHD, contrary to those with AS, a primary manifestation of the disorder is the inability to focus. They orient to novel stimuli, which results in distractibility or, seen from an adaptive perspective, a better ability to attend to various aspects of the environment. Not myriad by detail, they grasp salient aspects of tasks, an advantage in social situations, but at the cost of attending to detail, which may result in “impulsive” actions. It comes as no surprise that they would perform better on the design fluency task, where recombination of stimuli into novel configurations is aided by *moving on* to novel solutions. In this study ADHD children did well on design fluency, but poorly on verbal fluency. Verbal fluency, as administered in the D-KEFS requires, for a successful performance, that responses be restricted to a phonemic characteristic of words, which requires segmentation and focus to detail, not strength with this clinical group. As for the C-W interference task, sustained attention is a must, as is the capacity to resist interference, a tall order for an individual whose cognitive style is to 'let it be'.

In sum, differential profiles of strength and deficit on four aspects of EF were manifest in the groups assessed, providing specificity to the term EF disorder has important implications for academic planning, targeted intervention and counseling in specific clinical populations, as is the case with AS and ADHD. The next section will

present examples of ways in which knowledge about a student's profile of EF deficits and strengths can lead to a better understanding of his needs so as to aid their teachers and families in helping them succeed in their academic and daily activities.

Clinical and Educational Implications

Accommodations and interventions for children with AS and ADHD must take into account their specific difficulties with EF and the ways in which they might interfere with their performance. For instance, EF impairment may be manifested in difficulty organizing thoughts for writing tasks, or in organizing materials or possessions, or in adopting efficient and effective ways to tackle lessons or homework. Carrying out lengthy instructions and time management are tasks that require the use of various types of EF skills; understanding which of these prevent a student from succeeding in those endeavors will go a long way in devising ways to assist them.

An approach for a child with AS may consist in enhancing particular aspects of language use by teaching him an algorithm which serves as a blueprint to better integration and organization of his output. Such an approach has been utilized to enhance performance in interpersonal situations with some degree of success. Below, an intervention adopted with an AS student based on his EF profile is contrasted with the approach that would better fit an ADHD student with a different EF profile.

A fourteen-year-old child named Scott, diagnosed with AS, demonstrates significant social deficits when interacting with peers. Specifically, he talks endlessly about one topic and does not know when to move on, or fails to attend to his peers' reactions,

including the failure to realize that peers are not listening to him. An understanding that this behavior results from poor information integration ability, along with a limited capacity for cognitive shifting will play a major role on the intervention adopted. Scott loves to talk about history and politics. He is in a Health class and currently they are discussing athletic performance and cardiac fitness. He enjoys being part of a class, and would love to interact and participate in discussion. However, he does not know how to engage in interactions, unable to just jump in. The teacher's job here, seeing that Scott has his hand up but is likely to be off topic, is to help Scott join the discussion by giving him cues, for instance, in the form of a multiple choice opening such as: "Scott, let me ask you, if you were trying to maintain good fitness, would you choose running, swimming, or skiing?" Then, the teacher could guide him from there. This provides Scott with the necessary information and structure to facilitate an appropriate participation in class. This approach could be practiced several times in a social skills group, and then tried in similar situations with the goal of facilitating his spontaneous use of the strategy, and generalizing it to other environments. A specific task that may be used to reinforce this skill is, to have him (and students with similar difficulties), compose transition statements to move from one topic to another. Another would consist in giving him a list of three topics, and on this basis, to compose the transition statement. Using a timer as a cue to shift topics every 5 minutes within a group session is a way of rehearsing the need to shift. It is important to remember that, as with any new skill that must be learned, rehearsal is very important, a significant component of success in developing new cognitive strategies.

In contrast, the intervention for an ADHD child, Jim, would be quite different. The EF skills targeted, along with the specific intervention used would be reflect deficits commonly observed in ADHD. He, like Scott, may also have trouble interacting with peers and participating in class. For him, however, the difficulty lies not in being unable to utilize social cues or to shifting topics, but, due to impulsivity, speak out of turn or without thinking; his inattention may also be responsible for his talking off topic. The teacher, aware of Jim's ADHD, would fully expect him to be bound to blurt-out an answer without raising his hand. She could intervene by instructing him in a “Stop, Think and Answer strategy” (preferably not during class), which he could be reminded of in class while she redirects him to raise his hand.

A very important factor to remember is that, while a number of interventions have been suggested for “cognitive training”; there is no cookie cutter to address the needs of a specific student. When the “true and tried” suggestions are ineffective, an alternative must be generated. More often than not, teachers and other members of the school team feel insecure in this, as if they are “flying by the seat of their pants”. Innovation is part and parcel of intervention, which is geared towards an individual, not a clinical condition.

Limitations of the Study

The findings of this study were limited by several factors. A larger sample size would have provided greater power and more reliable findings. As most of the sample consisted of highly educated families from high socioeconomic status from the same geographic area, it may not be generalizable to families from different socioeconomic status groups. A follow-up study which had families represented from more diverse

backgrounds would be beneficial to increase generalizability to the population of AS and ADHD individuals. Another difficulty with this study was the lack of ethnic diversity in the sample. As this sample consistent of all Caucasians, there is also difficulty with generalizing these findings to other ethnicities. A follow-up study focusing on AS and ADHD individuals from different cultural backgrounds would be useful. Finally, the sample contained all male participates so there would be difficulty generalizing the results to female middle school children. It may be useful to study gender differences across EF functions in children diagnosed with AS. Although difficult due to the high number of males diagnosed with AS when compared to females, a follow-up study could

Implications for Future Research

The current study was considered a preliminary analysis that utilized specific measures within subtests of the D-KEFS. There are many other possible scoring comparisons and measures within these D-KEFS subtests that could be used to differentiate AS and ADHD. A follow-up study might well focus on different measures within these D-KEFS subtests. Without substantial and quantitative data to validate the diagnosis, AS has been primarily diagnosed based on clinical judgment. Although the D-KEFS are not and will not be a pure instrument for diagnosis, it will provide patterns of EF strengths and weaknesses which can provide more specific and effective intervention. An EF profile can also allow a clinician to confirm or differentiate a diagnosis. In conclusion, this study found that individuals with Asperger's Syndrome demonstrated specific deficits with cognitive shifting and nonverbal fluency. Future research focusing on additional deficits impacting social issues, such as seen with "theory of mind" and

deficits and research on empathy could also provide important information on the social deficits in AS as well as a wide variety of neuro-behavioral.

In conclusion, the present study provided a more specific profile of executive functioning between Asperger's Syndrome (AS) and Attention Deficit Hyperactivity Disorder (ADHD). This finding can be used to help expand the explanatory power of executive dysfunction in specific disorders. Several other developmental, mental and learning disorders show deficits on EF tests. It is hoped that this study will be replicated with other clinical populations in order to help provide better diagnostic clarity and more effective interventions to these complex problems. For family members, a more precise and accurate diagnosis can offer a better grasp on the specific characteristics of the syndrome, gaining a deeper insight into their loved ones' strengths, deficits and way of being in the world. Ultimately, specific EF profile could lead to the utilization and development of effective educational services to facilitate not only greater academic achievement, but also further self-understanding, personal development, and enhance daily living and coping skills in these children.

References

- American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.
- American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders (4th ed., text rev.). Washington, DC: Author.
- Asperger, H. (1944). Die autischen Psychopathen im kindersalter. *Archiv fur Psychiatrie und Nervenkrankheiten*, 117, 76-136.
- Asperger, H. (1991). Autistic psychopathy in childhood. In U. Frith (Ed. and Trans.), *Autism and asperger syndrome* (pp. 37-92). Cambridge, MA: Cambridge University Press. (Original work published 1944).
- Attwood, T. (1998). *Asperger's Syndrome: A guide for parents and professionals*. London: Jessica Kingsley Publishers.
- Barkley, R. A. (2001). Linkages between attention and executive functions. In G. R. Lyon & N.A Krasenigor (Eds.), *Attention, memory and executive function* (pp. 307-325). Baltimore: Paul H. Brookes Publishing Co.
- Barnhill, G. P., Cook, K. T., Tebbenkamp, K., & Myles, B. S. (2002). The effectiveness of social skills interventions targeting nonverbal communication for adolescents with

asperger syndrome and related pervasive developmental delays. Focus on Autism and Other Developmental Disabilities, 17(2), 112-118.

Barkley, R. A. (1997). ADHD and the nature of self-control. New York: The Guilford Press.

Barkley, R. A. (2001). Genetics of childhood disorders: XVII. Part I: The executive functions and ADHD. Journal of the American Academy of Child and Adolescent Psychiatry, 39, 1064-1068.

Baron-Cohen, S., O'Riordan, M., Stone, V., Jones, R., & Plaisted, K. (1999). Recognition of faux pas by normally developing children and adolescents with asperger syndrome or high-functioning autism. Journal of Autism and Developmental Disorders, 29(5), 407-418.

Benton A. (1991). Prefrontal injury and behavior in children. Developmental Neuropsychology, 7, 275-282.

Berthier, M. L., Starkstein, S. E. & Leiguarda, R. (1990). Developmental cortical anomalies in asperger's syndrome: Neuroradiological findings from two patients. Journal of Neuropsychiatry and Clinical Neurosciences, 2(2), 197-201.

Biederman, J., Mick, E., & Faraone, J.V. (2000). Age-dependent decline of symptoms of adhd: Impact of remission definition and symptom type. *American Journal of Psychiatry*, 157, 816-818.

Blakemore-Brown, L. (2002). *Reweaving the autistic tapestry: Autism, asperger syndrome and ADHD*. Philadelphia: Jessica Kingsley Publishers, Ltd.

Borkowski, J. G., & Burke, J. E. (2001). Theories, models, and measurements of executive functioning. In G. R. Lyon & N. A. Krasenigor (Eds.), *Attention, memory and executive function* (pp. 235-261). Baltimore: Paul H. Brookes Publishing Co.

Carlson, N. R. (1998). *Physiology of behavior* (6th ed.). Boston: Allyn & Bacon.

Casey B.J., Castellanos F.X., Giedd J.N., Marsh W.L., Hamburger S.D., Schubert A.B., Vauss Y.C., Vaituzis A..C., Dickstein D.P., Sarfatti S.E., Rapoport J.L. (1997a). Implication of right frontostriatal circuitry in response inhibition and attention-deficit/hyperactivity disorder. *Journal of Amereican Academy of Child and Adolescent Psychiatry*, 6, 374-383.

Castellanos, F. X. (1997). Toward a pathophysiology of attention-deficit/hyperactivity disorder. *Clinical Pediatrics*, 36(7), 381-393.

Castellanos F. X., Giedd J. N., Eckburg P., et al. (1994). Quantitative morphology of the caudate nucleus in attention deficit hyperactivity disorder. *The American Journal of Psychiatry*, 151, 1791-1796.

Castellanos F.X., Giedd J.N., Marsh W.L., Hamburger S.D., Vaituzis A.C., Dickstein D.P., Sarfatti S.E., Vauss Y.C., Snell J.W., Lange N., Kaysen D., Krain A.L., Ritchie G.F., Rajapakse J.C., Rapoport J.L. (1996). Quantitative brain magnetic resonance imaging in attention-deficit hyperactivity disorder. *Archives of General Psychiatry*, 53, 607-616.

Cattell, J. M. (1886). The time it takes to see and name objects. *Mind*, 11, 63-65.

Chakrabarti, S., & Fombonne, E. (2001). Pervasive developmental disorders in preschool children. *Journal of the American Medical Association*, 285, 3093-3099.

Chelune, G. J., Ferguson, W., Koon, R., & Dickey, T. O. (1986). Frontal lobe disinhibition in attention deficit disorder. *Child Psychiatry and Human Development*, 16(4), 221-234.

Chow, T. W., & Cummings, J. L. (1999). Frontal-subcortical circuits. In B. L. Miller & J. L. Cummings, *The human frontal lobes: Functions and disorders* (pp. 3-26). New York: The Guilford Press.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001a). Delis-kaplan executive function system: Examiner's manual. San Antonio, TX, The Psychological Corporation.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001b). Delis-kaplan executive function system: Technical manual. San Antonio, TX, The Psychological Corporation.

Delis, D. C., Kramer, J. H., Kaplan, E. & Ober, B. A. (1994). California verbal learning test: Children's version. San Antonio, TX, The Psychological Co

Delis, D. C., Squire, L. R., Bihrlle, A. & Massman, P. (1992). Componential analysis of problem solving ability: Performance of patients with frontal lobe damage and amnesic patients on a new sorting test. *Neuropsychologia*, 30(8), 683-697.

Denckla, M. B. (2001). A theory and model of executive function: A neuropsychological perspective. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory and executive function* (pp. 263-278). Baltimore: Paul H. Brookes Publishing Co.

Douglas, V. L. (1972). Stop, look and listen: The problem of sustained attention and impulse control in hyperactive and normal children. *Canadian Journal of Behavioural Science*, 4, 259-282.

Duffy, J. D. & Campbell, J. J. (2001). Regional prefrontal syndromes: A theoretical and clinical overview. In Salloway, S. P., Malloy, P. F. & Duffy, J. D. (Eds.), *The Frontal*

Lobes and Neuropsychiatric Illness (pp. 113-123). Washington DC, American Psychiatric Publishing, Inc.

Duncan, J. (2001). Frontal lobe function and the control of visual attention. In J. Braun, C. Koch, & J. L. Davis (Eds.), *Visual attention and cortical circuits* (pp. 69- 88). Cambridge, MA: The MIT Press.

Eaves, L. C., Ho, H. H., & Eaves, D. M. (1994). Subtypes of autism by cluster analysis. *Journal of Autism and Developmental Disorders*, 24(1), 3-22.

Ehlers, S. & Gillberg, C. (1993). The epidemiology of Asperger syndrome: A total population study. *Journal of Child Psychology, Psychiatry and Allied Disciplines*, 34(8), 1327-1350.

Ehlers, S., Nyden, A., Gillberg, C., Sandberg, A. D., Dahlgren, S. O., Hjelmquist, E. & Oden, A. (1997). Asperger syndrome, autism and attention disorders: A comparative study of the cognitive profiles of 120 children. *Journal of Child Psychology & Psychiatry and Allied Disciplines*, 38(2), 207-217.

Eisenmajer, R., Prior, M., Leekman, S., Wing, L., Gould, J., Welham, M., & Ong, B. (1996). Comparison of clinical symptoms in autism and asperger's disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, 35(11), 1523-1531.

- Fuster, J. M. (1999). Cognitive functions of the frontal lobes. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders* (pp. 187-195). Baltimore: Paul H. Brookes Publishing Co.
- Geurts, H. M., Verte, S., Oosterlaan, J., Roeyers, H., Sergeant, J. (2004). How specific are executive functioning deficits in attention deficit hyperactivity disorder and autism? *Journal of Child Psychology*, 45(4), 836-854.
- Ghaziuddin, M., Butler, E., Tsai, L., & Ghaziuddin, N. (1994). Is clumsiness a marker for asperger syndrome? *Journal of Intellectual Disability Research*, 38, 519-527.
- Giedd J.N., Castellanos F.X., Casey B.J., Kozuch P., King A.C., Hamburger S.D., Rapoport J.L. (1994). Quantitative morphology of the corpus callosum in attention deficit hyperactivity disorder. *American Journal of Psychiatry*, 151(5), 665–669.
- Gillberg, C. (1991). Clinical and neurobiological aspects of asperger syndrome in six family studies. In U. Frith (Ed.), *Autism and asperger syndrome* (pp. 122-146). Cambridge, MA: Cambridge University Press.
- Gillberg, C. & Billstedt, E. (2000). Autism and asperger syndrome: Coexistence with other clinical disorders. *Acta Psychiatrica Scandanavia*, 102, 321-330.

Gillberg, C. & Coleman, M. (Eds.). (2000). Asperger syndrome. Clinics in developmental medicine (3rd ed.). London: Cambridge University Press.

Gillberg, C. & DeSouza, L. (2002). Head circumference in autism, asperger syndrome, and ADHD: A comparative study. *Developmental Medicine & Child Neurology*, 44, 296-300.

Gillberg, C., & Ehlers, S. (1998). High-functioning people with autism and Asperger syndrome: A literature review. In E. Schopler, G. B. Mesibov, & L. J. Kunce (Eds.), *Asperger syndrome or high-functioning autism?* (pp. 79-100). New York: Plenum.

Gillberg, C., & Gillberg, C. (1989). Asperger syndrome - Some epidemiological considerations: A research note. *Journal of Child Psychology & Psychiatry*, 30(4), 631-638.

Gillberg, C., Rasmussen, P., Carlstrom, G., Svenson, B. & Waldenstrom, E. (1982). Perceptual, motor and attentional deficits in six-year old children: Epidemiological aspects. *Journal of Psychology & Psychiatry*, 23(2), 131-144.

Goldberg, E. (2001). *The executive brain: Frontal lobes and the civilized mind*. New York: Oxford University Press.

Greve, K. W., Love, J. M., Dickens Jr, T. J. & Williams, M. C. (2000). Developmental changes in california card sorting test performance. *Archives of Clinical Neuropsychology*, 15(3), 243-249.

Grodinsky, G. M., & Diamond, R. (1992). Frontal lobe functioning in boys with attention-deficit hyperactivity disorder. *Developmental Neuropsychology*, 8, 427-445.

Gutstein, S. E. & Whitney, T. (2002). Asperger syndrome and the development of social competence. *Focus On Autism and Other Developmental Disabilities*, 17(3), 161- 171.

Happe, F., Booth, R., Charlton, R., & Hughes, C. (2006). Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: Examining profiles across domains and ages. *Brain and Cognition*, 61, 25-39.

Harris E.L., Schuerholz L.J., Singer H.S., Reader M.J., Brown J.E., Cox C., Mohr J., Chase G.A., Denckla M.B. (1995). Executive function in children with Tourette syndrome and/or attention deficit hyperactivity disorder. *Journal of International Neuropsychological Society*, 1, 511-516.

Hendren, R. L., DeBacker, I., & Pandina, G. J. (2000). Review of neuroimaging studies of child and adolescent psychiatric disorders from the past 10 years. *Journal of the American Academy of Child & Adolescent Psychiatry*, 39(1), 815-828.

Hill, E. (2004). Evaluating the theory of executive dysfunction in autism. *Developmental Review*, 24, 189-233.

Hynd, G. W., Hern, K. L., Novey, E. S., Eliopoulos, D., Marshall, R., Gonzalez, J. J., & Voeller, K. K. (1993). Attention deficit-hyperactivity disorder and asymmetry of the caudate nucleus. *Journal of Child Neurology*, 8, 339-347.

Jensen, A. R. & Rohwer, W. D. (1966). The stroop color-word test: A review. *Acta Psychologica*, 25, 36-93.

Kadesjo, B., Gillberg, C., & Hagberg, B. (1999). Brief report: Autism and Asperger Syndrome in seven-year-old children: A total population children. *Journal of Autism and Developmental Disorders*, 29, 327-331.

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, 2, 217-250.

Kanner, L & Eisenberg, L. (1956). Early infantile autism 1943-1955. *American Journal of Orthopsychiatry*, 26, 55-65.

Kaufer, D. I. & Lewis, D. A. (1999). Frontal lobe anatomy and cortical connectivity. In B. L. Miller & J. L. Cummings, *The human frontal lobes: Functions and disorders* (pp. 27-44). New York: The Guilford Press.

Kaufman, A. S. & Lichtenberger, E. O. (1999). *Essential of WAIS-III assessment*. New York: John Wiley & Sons, Inc.

Klin, A., Volkmar, F. R., & Sparrow, S. S. (2000). *Asperger syndrome*. New York: The Guilford Press.

Klin, A., Volkmar, F. R., Sparrow, S. S., Cicchetti, D. V. & Rourke, B. P. (1995). Validity and neuropsychological characterization of asperger syndrome: Convergence with nonverbal learning disabilities syndrome. *Journal of Child Psychology & Psychiatry and Allied Disciplines*, 36(7), 1127-1140.

Lincoln, A., Courchese, E., Allen, M., Hanson, E. & Ene, M. (1998). Neurobiology of asperger syndrome: Seven case studies and qualitative magnetic resonance imaging findings. In Schopler, E., Mesibov, G. B. & Kunce, L. J. (Eds.), *Asperger syndrome or high functioning autism?* (pp. 145-163). New York, Plenum Press.

Lou H.C., Henriksen L., Bruhn P., Borner H., Nielsen J.B. (1989). Striatal dysfunction in attention deficit and hyperkinetic disorder. *Archives of Neurology*, 46, 48–52.

Luria, A. R. (1966). *Higher cortical functions in man*. (B. Haigh, Trans.). New York: Basic Books.

Luria, A. R. (1980). *Higher cortical functions in man*. (2nd ed.). (B. Haigh, Trans.).

New York: Basic Books. (Original work published in 1966).

Manjiviona, J. & Prior, M. (1995). Comparison of asperger syndrome and high functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disorders*, 25(1), 23-39.

Manjiviona, J., & Prior, M. (1999). Neuropsychological profiles of children with asperger syndrome and autism. *Autism*, 3(4), 327-356.

McDougle, C. J. (1998). Repetitive thoughts and behavior in pervasive developmental disorders: Phenomenology and pharmacotherapy. In Schopler, E., Mesibov, G. B. & Kunce, L. J. (Eds.), *Asperger syndrome or high functioning autism?* (pp. 293-317). NY: Plenum Press.

McKelvey, R. J., Lambert, R., Mottron, L. & Shevell, M. I. (1995). Right-hemispheric dysfunction in asperger's syndrome. *Journal of Child Neurology*, 10(4), 310-314.

Mega, M. S., & Cummings, J. L. (2001). Frontal subcortical circuits: Anatomy and Function. In S. P. Salloway, P. F. Malloy & J. D. Duffy (Eds.), *The frontal lobes and neuropsychiatric illness* (pp. 15-32). Washington, DC: American Psychiatric Publishing.

Meyer, J. A. & Minshew, N. J. (2002). An update on neurocognitive profiles in asperger syndrome and high-functioning autism. *Focus on Autism and Other Developmental Disabilities*, 17(3), 152-160.

Miller, J. N. & Ozonoff, S. (2000). The external validity of asperger disorder: Lack of evidence from the domain of neuropsychology. *Journal of Abnormal Psychology*, 109(2), 227-238.

Miyahara, M., Tsuji, M., Hori, M., Nakanishi, K., Kageyama, H., & Sugiyama, T. (1997). Brief report: Motor incoordination in children with asperger syndrome and learning disabilities. *Journal of Autism and Developmental Disorders*, 27(5), 595-603.

Morris, R. D. (2001). Relationships and distinctions among concepts of attention, memory, and executive function: A developmental perspective. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory and executive function* (pp. 11-16), Baltimore: Paul Brookes Publishing Co.

Murphy, D. G., Critchly, H. D., Scmitz, N., McAlonan, G., van Amelsvoort, T., Robertson, D., Daly, E., Rowe, A., Russell, A., Simmons, A., Murphy, K. C. & Howlin, P. (2002). Asperger syndrome: A proton magnetic resonance spectroscopy study of the brain. *Archives of General Psychiatry*, 59, 885-891.

Myles, B. S. & Simpson, R. L. (2002). Asperger syndrome: An overview of characteristics. *Focus On Autism and Developmental Disabilities*, 17(3), 132-137.

Nyden, A, Gillberg, C., Hjelmquist, E., & Heiman, M. (1999). Executive function/attention deficits in boys with Asperger Syndrom, attention disorder and reading/writing disorder. *Autism*, 3, 213-228.

Nyden, A., Billstedt, E., Hjemlquist, E. & Gillberg, C. (2001). Neurocognitive stability in asperger syndrome, ADHD, and reading and writing disorder: A pilot study. *Developmental Medicine & Child Neurology*, 43, 165-171.

Ozonoff, S. & Griffith, E.M. (2000). Neuropsychological function and the external validity of asperger syndrome. In A. Klin, F. R. Volkmar & S. S. Sparrow (Eds.), *Asperger syndrome* (pp. 72-96), New York: Guilford Press.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991a). Executive function deficits in high-functioning autistic individuals: Relation to theory of mind. *Journal of Child Psychology & Psychiatry*, 32(7), 1081-1105.

Ozonoff, S., Rogers, S. J. & Pennington, B. F. (1991b). Asperger's syndrome: Evidence of an empirical distinction from high-functioning autism. *Journal of Child Psychology & Psychiatry*, 32(7), 1107-1122.

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

Reader, M. J., Harris, E. L., Schuerholz, L. J. & Denckla M.S. (1994). Attention deficit hyperactivity disorder and executive dysfunction. *Developmental Neuropsychology*, 10, 493-512.

Rickaby, G; Carruthers, A. & Mitchell, M. (1991). Brief report: Biological factors associated with asperger syndrome. *Journal of Autism and Developmental Disorders*, 21(3), 341-348.

Rimland, B. (1964). *Infantile autism: The syndrome and its implications for a neural theory of behavior*. San Diego, CA; Meredith Publishing Company.

Rinehart, N. J., Bradshaw, J. L., Brereton, A. V. & Tonge, B. J. (2002a). A clinical and neurobehavioral review of high-functioning autism and asperger's disorder.

Australian and New Zealand Journal of Psychiatry, 36, 762-770.

Rinehart, N. J., Bradshaw, J. L., Brereton, A. V. & Tonge, B. J. (2002b). Lateralization in individuals with high-functioning autism and asperger's disorder: A

frontostriatal model. *Journal of Autism and Developmental Disorders*, 32(4), 321-332.

Rinehart, N. J., Bradshaw, J. L., Moss, S. A., Brereton, A. V. & Tonge, B. J. (2000). Atypical interference of local detail on global processing in high-functioning autism and asperger's disorder. *Journal of Child Psychology & Psychiatry and Allied Disciplines*, 41(6), 769-778.

Samanago-Sprouse, C. (1999). Frontal subcortical circuits: Anatomy and function. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders* (pp. 584-603). Baltimore: Paul H. Brookes Publishing Co.

Siegel, D., Minshew, N. & Goldstein, G. (1996). Weschler IQ profiles in diagnosis of high functioning autism. *Journal of Autism and Developmental Disorders*, 26, 389-406.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18(6), 643-661.

Stuss, D.T. & Benson, D.E. (1986). *The Frontal Lobes*. New York: Raven Press.

Szatmari, P., Tuff, L., Finlayson, A. J. & Bartolucci, G. (1990). Asperger's syndrome and autism: Neurocognitive aspects. *Journal of the American Academy of Child & Adolescent Psychiatry*, 29(1), 130-136.

Tantam, D. (1991). *Asperger's Syndrome in adulthood*. In U. Frith (ed.), *Autism and Asperger's Syndrome*. Cambridge: Cambridge University Press.

Thatcher, R. W. (1991). "Maturation of the frontal lobes: Physiological evidence for aging." *Developmental Neuropsychology*, 7, 397-419.

Tranel D., Anderson S.W., Benton A.L. (1994). Development of the concept of "executive function" and its relationship to the frontal lobes. In: *Handbook of neuropsychology* (Boller F, Grafman J, eds), pp 125-148. Amsterdam: Elsevier.

Tsai, L. (2000). Children with autism spectrum disorder: Medicine today and in the new millennium. *Journal of Positive Behavior Interventions*, 15(3), 138-148.

Voeller, K. K., & Heilman, K. M. (1988). Attention deficit disorder in children: A neglect syndrome? *Neurology*, 38(5), 806-808.

Welsh, M. C., Pennington, B. R. & Grossier, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology*, 7(2), 131-149.

Willcutt, E.G., Doyle, A.E., Nigg, J.T., Faraone, S.T., & Pennington, B.F. [2005]. Validity of the Executive Function Theory of Attention-Deficit/Hyperactivity Disorder: A Meta-Analytic Review. *Biological Psychiatry*, 570 (11),1336-1346.

Wing, L. (1981). Asperger's syndrome: A clinical account. *Psychological Medicine*, 11, 115-129.

Wing, L. (1988). The continuum of autistic characteristics. In E. Schopler & G. B. Mesibov (Eds.), *Diagnosis and assessment in autism* (pp. 91-110). New York: Plenum Press.

Wing, L. (1998). The history of asperger syndrome. In E. Schloper, G. B. Mesibov & L. J. Kunce (Eds.), *Asperger syndrome of high functioning autism?* (pp. 11-28), New York: Plenum Press.

Wing, L. (2000). Past and future research on Asperger Syndrome. In A. Klin, F. R. Volkmar & S.S. Sparrow eds.), *Asperger Syndrome* (pp.418-432). New York: Guilford Press.

Wing, L & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. *Journal of Autism and Developmental Disorders*, 9(1), 11-29.

APPENDIX A

Research Intake

Please fill this out completely for your child/adolescent.

Child's Name: _____

Date of Birth: _____ Age: _____ Grade: _____

Home Address: _____

Child's Primary Diagnosis: _____

Is your child currently in Special Education Classes? Yes No

If yes, what type of services does your child receive?

- Resource Classroom Some Special Ed Classes/ Some Mainstream Classes
- All Classes are Special Education

If no, is your child on a 504 plan and receiving academic accommodations?

- Yes No

Ethnicity: African-American Asian/Pacific Islander Caucasian

- Hispanic Native American Other

Medical History (please check any that apply to your child):

Head Trauma (if yes, please explain):

Brain Tumor Stroke Meningitis Encephalitis

HIV Infection Seizure Epilepsy Diabetes

Cancer

Brain Injury (if yes, please explain):

None of the Above

Psychiatric History (please check any that currently apply to your child):

Differential Performance on Tasks of Executive Function

- Depressive Disorder
- Primary Secondary
- Bipolar Disorder
- Primary Secondary
- Anxiety Disorder
- Learning Disability: If yes, please describe:
- Nonverbal Learning Disorder
- Substance Abuse/Substance Dependence Disorder
- Other: If yes, please describe:
- No Psychiatric History

APPENDIX B

Differential Performance on Tasks of Executive Function between Asperger's Syndrome and Attention Deficit Hyperactivity Disorder in Middle School Children

Parent Consent

Description:

You have been asked to give permission for your child to participate in a research study to learn about how children with Attention Deficit Hyperactivity Disorder (ADHD) and children with Asperger's Syndrome (AS) process abstract and complex information (executive skills). Kathryn Drinkwater MS, CAGS who is a School Psychologist in the Marblehead Public Schools and a PhD student at Northeastern University is conducting this study. The following information applies to your child.

Procedures:

If you agree to have your child participate in this study the following will occur:

1. Your child will be asked to complete a series of tasks. Each task will require them to use different types of skills including: verbal reasoning, nonverbal/spatial reasoning, memory and executive skills. Each of these tasks takes approximately ten to fifteen minutes to complete, or at most 1 hr. overall to complete.
2. If you have not already done so, you will be asked to complete a background questionnaire and behavior checklist. These forms will take approximately 10 to 15 minutes to complete.

Total participation in this study will take your child a total of 30 to 45 minutes to complete. All procedures will be done at your child's school without disruption of important classroom activities such as, tests.

Risk/Discomforts:

1. Confidentiality: Your child's results will be handled as confidentiality as possible within the law. Special precautions will be taken to protect the identities of all participants in the study and the confidentiality of all information provided. All records will be coded and kept in locked files so that only the study investigators have access to them. No individual identities will be used in any reports or publications resulting from this study.

2. Your child may be concerned over his/her performance in this study. These tasks are designed like games, which decreases anxiety over test performance and makes the activity more fun and challenging for most children.

Benefits:

1. The information gathered may help educators and psychologists further understand how children with ADHD and AS process complex information and utilize executive functioning skills. This can lead to more effective intervention strategies in the classroom and home environments for these children.
2. Effective intervention will also help improve educational policies and practices within the Marblehead Public Schools where the primary investigator provides psychological consultation.

Costs:

There will be no cost to you.

Decision to participate:

Your participation is voluntary. You and your child have the right to withdraw your consent or discontinue participation at any time without penalty. You and your child have the right to refuse to answer particular questions. This study has been approved by the Marblehead Public Schools.

Questions:

If you have any questions about this consent form you can call and discuss them with Kathryn Drinkwater (617) 216-7159 or Dr. Carmen Armengol, PhD, faculty supervisor at: (617) 373-5917. If you any comments or concerns about participation in this study, you should first talk with the study investigator.

The extra copy of this consent form is for you to keep.

The signature of a parent or guardian on this document indicates approval for the child to participate and that the child is willing to participate. If you wish to have your child participate in this study, please sign on the line provided below.

Name: _____

Differential Performance on Tasks of Executive Function

Appendix C

Aspergers	AGE	FSIQ	Verbal Fluency Scaled Score	Design Fluency Scaled Score	C-W Inhibition Scaled Score	Sorting Scaled Score
DM #1	10	94	12	8	8	7
GW#2	11	100	11	13	12	10
ML#3	14	116	15	13	13	10
JC#4	16	115	14	9	8	8
Fo#5	14	102	11	8	8	6
MC#6	16	130	15	12	10	7
MS#7	16	124	13	5	11	11
JS#8	14	115	14	10	10	11
JB#9	16	105	13	8	10	12
BN#10	16	110	19	9	16	6
MS#11	12	107	13	11	12	9
PS#12	14	130	13	9	11	7
DF#13	12	105	12	12	13	8
SO#14	13	124	13	10	12	8
BD#15	14	115	14	10	11	8
PI#16	12	108	13	9	12	7
AR#17	14	115	14	8	11	8
KR#18	13	120	15	9	13	7
GR#19	11	113	13	8	10	8
DC#20	13	115	14	9	13	9

ADHD	AGE	FSIQ	Verbal Fluency Scaled Score	Design Fluency Scaled Score	C-W Inhibition Scaled Score	Sorting Scaled Score
GW#1	12	104	11	13	8	12
ZD#2	12	115	11	14	10	13
MS#3	14	117	11	9	7	11
DM#4	12	116	12	15	10	13
JL#5	10	99	11	11	11	9
FM#6	11	105	7	14	8	11
AK#7	13	115	7	11	7	12
MF#8	16	113	9	10	8	11
DM#9	16	110	6	15	5	12
DW#10	16	110	8	12	8	12
GL#11	10	134	11	12	7	12
BN#12	14	110	10	11	9	11
PT#13	14	105	9	12	10	12
SS#14	13	112	11	12	9	11
BC#15	15	108	9	14	11	13
KD#16	14	120	9	13	9	13
JD#17	13	115	9	12	8	12
PT#18	12	110	8	13	7	12
RD#19	14	106	10	11	8	11
PC#10	13	111	9	12	8	11