MEMORY ABILITIES IN CHILDREN WITH HIGH FUNCTIONING AUTISM SPECTRUM DISORDERS

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Mary Ann Thamaravelil Gansle entitled "Memory Abilities in Children with High Functioning Autism Spectrum Disorders." I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in School Psychology.

Kathy DeOrnellas, Ph.D., Major Professor

We have read this dissertation and recommend its acceptance:

Department Chair

Accepted:

Dean of the Graduate School

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DEDICATION

This dissertation is dedicated to my two precious boys, Joshua and Jacob, and my wonderful and supportive parents. I could not have done it without you.

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I would like to thank my parents for their endless encouragement and support. I could not have done any of this without you. Thank you for being there for me through everything. Thank you to my two brothers, Matt and Michael, for always encouraging me and being there any time without question or hesitation when I needed you. Thank you to Dr. Kathy DeOrnellas for supporting me through this process and chairing my dissertation committee. Thank you to all of my graduate professors and colleagues at Texas Woman's University.

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ABSTRACT

MARY ANN THAMARAVELIL GANSLE

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In the present study, demographic and intellectual performance data previously collected on groups of children with Asperger Syndrome (AS) and high functioning autism (HFA) were analyzed. It was hypothesized that children and adolescents with HFA or AS would exhibit lower scores on measures of visual memory as compared to auditory memory. It was also hypothesized that participants would display lower scores on visual memory tasks that contain a social component as compared to visual memory tasks without a social component. It was also hypothesized that this group would have difficulty with the Memory for Faces task on the NEPSY as compared to other visual tasks. Another hypothesis stated that the Symbolic Memory task on the UNIT may yield lower mean scores when compared to the other visual tasks. Additionally, it was hypothesized that these children and adolescents would demonstrate lower mean scores on tasks involving auditory working memory as compared to auditory memory tasks alone. Instruments used included the NEPSY, the Universal Nonverbal Intelligence Test (UNIT), and the Woodcock Johnson Test of Cognitive Abilities, Third Edition (WJ-III Cog).

Participants included child and adolescent volunteers (47 males and 7 females) ranging in age from 8 years to 17 years with a mean age of 11 years. All participants had a full scale IQ of 85 or above. Repeated measures ANOVAs were performed using diagnosis (HFA, AS) as a between subjects effect on the dependent variables. The results failed to reveal significant differences for diagnosis on any of the dependent measures; therefore, the between subjects factor diagnosis (HFA, AS) was collapsed across groups to create one sample of children with autism for subsequent analyses.

Repeated measures analysis of variance, pairwise multiple comparisons using Fisher's Least Significant Difference (LSD), and correlations were performed to analyze performance of the sample group across the various subtests included in the hypotheses. With regard to hypothesis one, results revealed that children's standardized mean responses on visual memory measures were not significantly different from each other. With respect to hypothesis two, scores on the Symbolic Memory Subtest were not significantly lower than other visual tasks.

Results for hypothesis three indicated the standardized mean scores on auditory measures and visual memory measures were not significantly different from each other. Hypothesis four analysis indicated that the standardized mean scores on the auditory memory measures and auditory working memory measures were not significantly different from each other. Overall, four hypotheses failed to show significance. There was some suggested overlap in skills measured by the various subtests. The implications

of these results for the development of effective classroom interventions for use with students with AS or HFA were discussed.

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CHAPTER I

INTRODUCTION

Delays in a child's development are always of concern and often present a quandary for many parents and professionals. Often these delays are labeled Pervasive Developmental Disorders or PDD, which include a number of disorders such as Asperger's Syndrome (AS), Autism, Rett's Syndrome, Childhood Disintegrative Disorder, and PDD-Not Otherwise Specified (PDD-NOS). These disorders are neurologically-based, with the severity of symptoms varying across individuals, ranging from low to high functioning. According to the Autism Society of America (2006), autism affects approximately 1 in 166 children, and is the fastest growing developmental disability, affecting over one million individuals across the United States. Autism affects a child's world at home and school and currently has no cure. The etiology of autism spectrum disorders is unknown and may result from different factors, including heredity, environment, and brain functioning (Ruble, 2004). Associated brain changes have been suggested to occur either before birth or shortly after. Given the impact of this epidemic on children and families across the country, it becomes important to take a closer look at this condition and seek out new research to inform effective interventions.

Descriptions

Autism spectrum disorders are diagnosed based on observable behaviors rather than medical tests and AS and high-functioning autism (HFA) are difficult to differentiate due to their similar characteristics. To complicate the diagnostic process, these disorders affect children differently; therefore, two children can meet different combinations of the diagnostic criteria (Ruble, 2004). In general, children with autism display difficulties in three areas: socialization, communication, and restricted patterns of behaviors and interests. General characteristics include: uneven development of cognitive skills, difficulty understanding social rules, problems reading emotions of others, difficulty responding to verbal information presented at a fast pace, difficulty with organization, and problems with self-direction (Ruble). Autism is often diagnosed prior to age three due to the developmental delays associated with speech, social interaction, emotional development, sensory development, toilet training, and/or play. Symptoms vary with degree of severity of the diagnosis (Yale Child Study Center, 2008).

AS is considered controversial in its definition, but is distinguishable from autism by the lack of significant delay in language development, according to the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision* published by the American Psychiatric Association *(DSM-IV-TR,* 2000). Often AS is not diagnosed until middle or high school years. As a result of late diagnosis, these individuals often experience low self-esteem due to numerous failures they have experienced. Additional psychiatric diagnoses may accompany AS such as anxiety or depression, due to a lack of emotional coping resources. Attention-Deficit/Hyperactivity Disorder (ADHD) may also be present. Social and communication deficits are often less severe, and special interests are more apparent in AS than in autism. Speech is often grammatical, but peculiar due to abnormalities of inflection and repetitive pattern. Clumsiness is prominent both in articulation and gross motor behavior. Also, there is typically a circumscribed area of interest which often leaves little room for more age appropriate, common interests (Barnhill, 2004). There are also a number of learning strengths associated with AS, including intelligence, grammar and vocabulary skills, rote memory, absorption of facts, interest in the social world, and blunt honesty (Barnhill). Given the fact that learning variations, including both strengths and weaknesses, have been shown in those with AS and/or HFA, it follows that memory skills may be affected as well.

Memory

Memory is a complex function consisting of auditory, visual, tactile, olfactory, and gustatory components. Memory has been explained using various theories; among the most widely known is the model by Baddeley and Hitch (Baddeley, 2001). In this model, four components of memory and information processing are indicated, among them being a visual and auditory component. Memory for information obtained through visual and auditory routes are critical to our daily functioning, and variations in memory have been found in those individuals with HFA and/or AS. Sanders (2007) found significantly lower performance on various verbal and nonverbal memory tasks and an overall general memory dysfunction in individuals with autism. Studies by Minshew et al. (1992, 1994) cited significant differences between the AS group and control group on memory tasks that require recall of complex visual and auditory material (as cited in Bowler, Matthews, & Gardiner, 2004).

Memory skills are measured in the current study using three instruments: the NEPSY (Korkman, Kirk, & Kemp,1998), Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998), and the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III; Woodcock, McGrew, & Mather, 2001). These three test batteries were chosen because they are frequently used by school psychologists and because there is a limited amount of literature examining these instruments and memory.

The NEPSY (Korkman et al., 1998) is a comprehensive instrument designed to assess neuropsychological development in children ages 3 to 12 across five functional domains: Attention/Executive Functions, Language, Sensorimotor Functions, Visuospatial Processing, and Memory and Learning. The focus of this study is the Memory and Learning domain which includes the subtests: Memory for Faces, Sentence Repetition, and Narrative Memory. The Memory for Faces subtest is a test of immediate and delayed facial recognition. Narrative Memory measures auditory free recall and cued recall skills. The child listens to a story then retells it, and for the cued recall portion, they must elicit details that were not reported in free recall. Sentence Repetition is a measure of auditory short term memory in which the child is asked to recall sentences read to them.

The Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998) is a norm referenced, individually and nonverbally administered intelligence test. The UNIT yields six subtest scores and four quotient scores, including a Memory Quotient, Reasoning Quotient, Symbolic Quotient, and Nonsymbolic Quotient, as well as a Full Scale IQ score. It is designed to measure two components of intelligence, memory and reasoning. The following subtests are included in the analysis: Object Memory, Spatial Memory, and Symbolic Memory. In each subtest, the participant is asked to look at a picture for five seconds then reproduce it without looking. Spatial Memory involves the placement of tokens on a grid; Symbolic Memory utilizes small tiles with representations of people lined up in varying order, and Object Memory requires individuals to correctly place plastic chips on specific pictures in an array.

The Woodcock-Johnson III Tests of Cognitive Abilities is a norm-referenced instrument that measures general and specific cognitive abilities and provides a general intellectual measure (the GIA) for those ages 2 to 90 (Woodcock et al., 2001). In addition to the full scale measure of IQ, the WJ-III Cog provides broad ability clusters such as verbal ability, thinking ability, and cognitive efficiency. For purposes of this study the following subtests were examined: Numbers Reversed, Auditory Working Memory, Working Memory, and Memory for Words. Numbers Reversed measures working memory, cognitive efficiency, broad attention, and short term memory. Memory for Words measures cognitive efficiency and short term memory. Auditory Working memory is a task that measures working memory and broad attention. There is limited research on the UNIT, WJ-III, and NEPSY in relation to their assessment of memory in children with AS or HFA. The purpose of this study is to add to the body of literature related to memory skills and HFA/AS.

Implications for the School Setting

Based on the characteristics of AS and HFA and the purpose of this study, critical implications can be easily identified. A child carrying this diagnosis is faced with many challenges on a daily basis. Often, additional supports and modifications are necessary for a student to experience success in the classroom environment. A school classroom is not consistently set up to foster success in a student with developmental differences. Often this necessitates support through special education, as general education teachers are often not given the tools and resources to help these students in a large classroom. Additional training for teachers may be necessitated to further inform educators regarding pervasive developmental disorders and the associated behavioral manifestations. Potential ramifications of AS and/or HFA diagnoses include low self-esteem, decreased academic motivation, and behavioral issues. Identifying a student's strengths regarding memory type and/or modality can foster development of academic weaknesses. Additionally, research has provided evidence for techniques such as applied behavior analysis and discrete trial training for use in teaching specific skills and behaviors in those with autism. These along with classwide behavioral interventions may serve to further facilitate success in students with autism.

'Research Question

Given the research by Lockyer and Rutter (1970), indicating hyper-developed rote memory skills (as cited in Bowler, Matthews, & Gardiner, 1997) in children with AS, this study hypothesizes that auditory memory may be more highly developed than visual memory abilities in children with AS or HFA. Difficulty with interpretation of social cues and facial expressions, inherent in the AS and HFA diagnosis, leads to a hypothesis that children carrying these diagnoses may display lower scores on visual memory tasks that contain a social component as compared to visual memory tasks without a social component. It is also expected that holding the information in memory and performing cognitive manipulations with it is more difficult than just holding the information in memory alone. As a result, it is predicted that the participants in this study will demonstrate lower mean scores on tasks involving auditory working memory as compared to auditory short term memory tasks alone.

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this chapter is to provide, through a review of the literature, definitions and descriptions of autism and Asperger's syndrome (AS) in relation to cognition, development, physiology, and memory. This chapter will also discuss types and modalities of memory and characteristics of each, including their relationship to autism and AS. Concluding this chapter is a brief summary of the instruments used in this study, the purpose, and hypotheses of the current study.

Prevalence

Information from the National Institute of Mental Health and the Center for Disease Control and Prevention (CDC) indicates that between 2 to 6 per 1,000 children (from 1 in 500 to 1 in 150) have a form of autism or Pervasive Developmental Disorder (PDD; NICHCY, 2007). Given the complexity of autism and the broad spectrum of related disorders, current prevalence rates, and the possibility of increasing rates, are highly debated topics. However, little is known about the prevalence of autism in the U.S. because only four U.S. population studies have been carried out, and results have not been conclusive. A study by Yeargin-Allsopp, Rice, Karapurkar, Doernberg, Boyle, and Murphy (2003) examined the prevalence of autism among children aged 3 to 10 years in the five counties of metropolitan Atlanta, Georgia in 1996 and concluded that in several counties of a major metropolitan area, the rate of autism was 10 times higher than published rates from studies conducted in the U.S. in the 1980s and early 1990s (Yeargin-Allsopp et al.).

Diagnostic Criteria

In a discussion of autism and AS, it is important to include a discussion of definition and general characteristics, with the understanding that the two syndromes are similar in many ways and often difficult to differentiate. The etiology of autism or PDD is unknown. Currently, researchers are investigating areas such as brain development, brain structure, genetic factors, and biochemical imbalance in the brain as possible causes. The two syndromes are classified as pervasive developmental disorders that often become apparent during infancy and last for the duration of the lifespan.

According to the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision* (*DSM-IV-TR*; American Psychiatric Association, 2000, p. 75, 84), autism and AS are characterized by a number of similar criteria including the following:

1. Qualitative impairment in social interaction, as manifested by at least two of the following: (a) marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction; (b) failure to develop peer relationships appropriate to developmental level; (c) a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people; and (d) a lack of social or emotional reciprocity (such as: communication problems (e.g., using and understanding language) and difficulty relating to people, objects, and events [NICHCY, 2007]).

2. Restricted repetitive and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following: (a) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus; (b) apparently inflexible adherence to specific, nonfunctional routines or rituals; (c) stereotyped and repetitive motor mannerisms; and (d) persistent preoccupation with parts of objects (unusual play with objects or toys [NICHCY])

Criteria specific to autism but not AS include (see *DSM-IV-TR*, 2000, pp. 75, 84).

1. Qualitative impairments in communication as manifested by at least one of the following: (a) delay in, or total lack of, the development of spoken language; (b) in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others; (c) stereotyped and repetitive use of language or idiosyncratic language; and (d) lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level.
2. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (a) social interaction, (b) language as used in social communication, or (c) symbolic or imaginative play.
3. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder.

There are criteria specific to AS but not to autism including the following (Note: seriation added by author).

The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning:

1. There is no clinically significant general delay in language.
2. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behavior, and curiosity about the environment in childhood.
3. Criteria are not met for another specific pervasive developmental disorder or schizophrenia (*DSM-IV-TR*, 2000, pp. 75, 84).

The distinguishing features of AS include problems with social interaction, particularly reciprocating and empathizing with the feelings of others; difficulties with nonverbal communication (such as facial expressions); peculiar speech habits that include repeated words or phrases and a flat, emotionless vocal tone; an apparent lack of "common sense" a fascination with obscure or limited subjects (for example, the parts of a clock or small machine, railroad schedules, astronomical data, etc.) often to the exclusion of other interests; clumsy and awkward physical movements; and odd or eccentric behaviors (hand wringing or finger flapping); swaying or other repetitious whole-body movements; watching spinning objects for long periods of time (Ozbayrak, n.d.). Children with AS often learn to talk at the usual age and often have above-average verbal skills (Klin & Volkmar, 1995). In young children, the symptoms of AS typically include problems picking up social cues and understanding the basics of interacting with other children.

Other common descriptions of AS include a precociousness in learning to talk, a fascination with letters and numbers, and the establishment of attachment patterns to family members but inappropriate approaches to peers and other persons, rather than withdrawal or aloofness as in autism. Again, these behaviors are described for those with high functioning autism (HFA) as well, albeit not as frequently. Individuals with AS are often socially isolated but are not unaware of the presence of others, even though their approaches may be inappropriate and peculiar. For example, they may engage an individual, usually an adult, in one-sided conversation characterized by long-winded, pedantic speech, about a favorite and often unusual and narrow topic. Also, although individuals with AS are often self-described as "loners," they often express a great interest in making friendships and meeting people (Klin & Volkmar, 1995).

Speech may be marked by poor prosody. For example, there may a constricted range of intonation patterns that is used with little regard to the communicative functioning of the utterance (assertions of fact, humorous remarks, etc.). Second, speech may often be tangential and circumstantial, conveying a sense of looseness of associations and incoherence (Klin & Volkmar). Also, the child or adult may talk incessantly, usually about their favorite subject, often in complete disregard to whether the listener might be interested, engaged, or attempting to interject a comment, or change the subject of conversation. Additionally, often one learns extraordinary amounts of factual information about very circumscribed topics (e.g., snakes, names of stars, maps, TV guides, or railway schedules; Klin & Volkmar, 1995).

Although not a diagnostic criteria, individuals with AS may present with motor clumsiness. They may have a history of delayed acquisition of motor skills such as pedaling a bike, catching a ball, opening jars, climbing on playground equipment, and so on. They are often visibly awkward, exhibiting rigid gait patterns, odd posture, poor manipulative skills, and significant deficits in visual-motor coordination (Klin & Volkmar, 1995). Lawson, Baron-Cohen, and Wheelwright (2004) described AS as a neurodevelopmental disorder in which young males often show a lack of empathy, have difficulty in forming relationships, engage in one-sided conversations, and have intense interests in specific topics.

It has been suggested that AS is a form of autism without the delays in language or cognitive development associated with autism. Freeman, Cronin, and Candela (2002) compared autism and AS for diagnostic criteria differences. The differences included a lack of communication and imagination impairments, lack of significant language delay, and a lack of significant delay in cognitive development or self-help skills in AS. There were additional delays in social interaction and curiosity about the environment in those with AS. These authors found few clinical differences between HFA and AS with the exception of prevalence of co-morbid ADHD in those with AS. The authors suggested a continuum of severity with regard to autism and AS (Freeman et al.). A study by Howlin

(2003) was consistent with findings that there are no reliable differences in social skills, communication skills, and repetitive/stereotyped behaviors between individuals with HFA and AS, and showed that the two groups were comparable. Howlin showed similar scores in language comprehension and expression as well. It was noted that parents of children with autism reported symptoms at an earlier age in development than those in the AS group. This same study also reported similar ratings for social functioning, communication, and stereotyped behaviors. These results support the view that HFA and AS exist on a continuum of severity rather than two separate disorders.

Brain Differences

Studies have detailed a number of physiological differences in those diagnosed with autism. In 1943, Kanner noted large head size in those with autism (as cited in Lainhart et al., 1997). Courchesne, Carper, and Akshoomoff (2003) suggested that brain increases may occur early, perhaps before the first clinically noticeable behavioral symptoms, and these changes may be related to outcomes in early childhood. Compared with typically developing children, infants with autism had smaller head circumference at birth, but after birth growth accelerated in the autism group, and significant differences in head circumference were found by 6-14 months. Courchesne et al. attributed this increase to greater cerebral cortex volume.

Lainhart et al. (1997) examined a group of children and adults diagnosed with autism to determine whether head circumference was associated with clinical features. They found that 14% of the participants had macrocephaly-11% of males and 24% of females. In most cases it was a result of increased rate of head growth rather than present at birth. They found that a large but normal head size was often present. Lainhart et al. found a small negative correlation ($r = -.21$) between the total score on the Autism Diagnostic Interview (ADI) and head circumference, suggesting no relationship between autism severity and head size.

Davidovitch, Patterson, and Gartside (1996) examined 148 charts of those diagnosed with autism. Results indicated that 18% of those with autism had a head circumference above the 98th percentile, which is consistent with Bailey et al.'s (1993) finding that 37% of children with autism had a head circumference above the 97th percentile (as cited in Davidovitch et al.). Herbert et al. (2004) suggested that most volume increase noted is in white matter underlying the prefrontal cerebral cortex, and this may contribute to pervasive core processing deficits such as impaired information processing.

Several brain structure variations have been implicated in autism. The cerebellum, amygdala, and hippocampus are involved, but there have been no clear results showing how. The cerebellum is the lower back part of the brain responsible for functions such as maintaining balance and coordinating and controlling voluntary muscle movement. The amygdala is an almond-shaped part the brain structure involved in regulating emotion, and it may also play a role in the association of memories. Finally, the hippocampus is involved in spatial orientation and plays an important role in establishing memories. A study was completed by Schumann, Hamstra, Goodlin-Jones, Lotspeich, Kwon, and

Buonocore (2004) using magnetic resonance imaging (MRI) to measure the size of these structures in children with autism compared with controls. There were no differences between groups in total cerebral volume, but children with autism (7-12 years of age) had larger right and left amygdala volumes than the control group. There were no differences in amygdala volume between the adolescent groups (12-18 years of age). The amygdala in typically developing children increased substantially in volume from 7 to 18 years of age. Thus, the amygdala in children with autism was initially larger, but did not show the age-related increase seen in typically developing children (Schumann et al.).

Schumann et al. (2004) found children with autism—with and without mental retardation—also had a larger right hippocampal volume than typically developing controls. Children with autism without mental retardation also had a larger left hippocampal volume compared with controls. The findings of this cross-sectional study indicate abnormal early amygdala development in autism and a divergent pattern of hippocampal development that persists through adolescence. The lack of the age-related increase in size of the amygdala in children with autism may reflect the abnormal development in social behavior, memory and emotion, and other cognitive processes such as recognition of faces. The enlarged hippocampus may be related to memory function—some evidence suggests that children with autism may have enhanced memory, a function of the hippocampus. The cause of amygdala and hippocampal abnormalities in autism seen in this study is not known (Schumann et al.).

Processing Facial Stimuli

Children with autism have difficulties reading the emotions expressed by others through their faces and find it difficult to share emotions with others. A study by Dawson et al. (2005) focused on face processing ability as a potential neural marker for autism susceptibility. Many of the social impairments of autism such as eye contact, joint attention, and face recognition rely upon the ability to attend to and process faces, so it is not surprising that individuals with autism have been shown to have impairments in face processing. For this study, verbal, visual-spatial, and face processing abilities of 143 parents of children with autism were measured. The parents exhibited significant difficulty in face recognition ability compared to their verbal and visual-spatial abilities. A subset of 21 parents of children with autism from the original study and 21 parents from a control group also participated in an experiment to measure their response to face and non-face stimuli. Parents of children with autism showed an atypical response to face stimuli which was similar to that shown by individuals with autism, (i.e., slower than expected processing of faces and abnormal cortical specialization of face processing). The authors suggest that abnormal face processing ability is a functional neural trait marker for autism. They note the importance of identifying and defining neural trait markers for susceptibility to autism so that autism risk can be identified early, and interventions that target the specific areas of the brain can be initiated while they are developing and most easily molded (Dawson et al.).

Deficits in processing social context in facial expressions have also been detailed by Herbert et al. (2002). They compared 16 boys with autism with a performance IQ greater than eighty to 16 control participants. They found abnormal asymmetry in the language asymmetry cortex in those with autism. The boys with autism had significant asymmetry reversal in the frontal language-related cortex. These inferior temporal regions are implicated in visual face processing. The language and face processing regions displayed abnormal asymmetry in the group with autism, which has been implicated with the language and social differences present in autism (Herbert et al.).

Recent studies suggest abnormalities in the functioning of specific brain areas of children with autism in reading facial expressions. Ogai et al. (2003) examined abnormalities in brain functioning when processing emotions from faces. Five adults (average age 21 years) with autism and nine typical participants (average age 23 years) were studied with functional MRI scanning while viewing different faces. Each participant was asked to identify whether the face appeared happy, disgusted, fearful, or neutral (no emotion). During presentation of fearful face expressions, the control adults showed more activation than adults with autism in the brain area called the left middle frontal gyrus, suggesting this area is involved in interpreting information on fear or disgust in facial expression. In those with autism, this brain region does not function as well so that during presentation of faces showing disgust or fear, individuals with autism showed less activation than controls in brain regions of left insula, left inferior frontal gyrus, and left putamen. Findings show that unlike typically developing persons, those with autism may have impairment in brain circuits that process emotions from faces. Subjects with autism may have difficulty in grasping facially expressed emotions from others, and therefore cannot behave in an effective and emotionally appropriate way (Ogai et al.).

Results of a study by Joseph and Tanaka (2003) indicated that in typically developing children, when faces are turned upside down, recognition is disrupted, much more than after inversion of non-face objects. This has been taken as evidence that faces are recognized holistically. Some researchers suggest that children with autism cannot easily recognize a person's whole face at once and instead rely on face parts to put them into the context of the whole face. Joseph and Tanaka studied face recognition in two studies. Study 1 studied typically developing children: twenty-seven typical 9-year-olds and thirty typical 11-year-olds. Children were asked to look at whole faces and match them to the same face or a similar face with one varied feature (eyes, nose, or mouth). As expected, typically developing children in Study 1 were better at recognizing face parts represented in the whole face than in parts in all of the upright faces but not in the inverted faces. These children were most accurate in identifying faces based on differences in eyes (Joseph & Tanaka).

In Study 2 (Joseph & Tanaka), children with autism showed an advantage over typical children in recognizing differences in the mouth, but were far less efficient than typically developing children at distinguishing differences in faces from the eyes. The performance of the children with language delay who did not have autism was commensurate with the performance of the typically developing children. The children with autism processed faces holistically, and this was mainly evident when recognition depended on the mouth. The authors suggest that face recognition abnormalities in autism are not fully explained by an impairment of whole face processing, and that there is an unusual significance of the mouth region when children with autism process information from people's faces. The authors indicate this may be a result of the specific impairment in processing information from the eyes, or because of an aversion to looking at eyes, so that the mouth takes on greater significance as a primary medium of communication for the child with autism. This is consistent with studies that show children with autism are delayed (by several years) in spontaneously following shifts of gaze from others, and they depend on vocal cues to establish attention. Another possibility for these findings is that autistic impairments in language functioning foster an early and enduring tendency to attend to mouths so they can make sense of speech via lip reading, especially when other communicative cues from the eyes are inaccessible (Joseph & Tanaka). Given the observed differences in facial processing and subsequently memory for faces, it is apparent that other areas of memory may be affected as well in individuals with autism.

Memory

Memory is a large area of research with many facets, only a few of which are discussed in this paper. This study examines short term memory (STM) and working memory (WM), as measured by subtests on the Universal Nonverbal Intelligence Test (Bracken & McCallum, 1998), NEPSY (Korkman, Kirk, & Kemp, 1998), and the

Woodcock Johnson Test of Cognitive Abilities, 3rd edition (WJ-III Cog; Woodcock, McGrew, & Mather, 2001). The memory terms, STM and WM have a history of being used interchangeably, but in much of the literature, STM is considered a lower order process of the WM type of memory (Leffard, Miller, Bernstein, DeMann, Mingis, & McCoy, 2006). The two are measured as distinct types of memory in the WJ-III Cog. It is clear that both STM and WM utilize either the visual or auditory modality in processing information. Working memory skills are measured by Numbers Reversed (WJ-III Cog) and Auditory Working Memory (WJ-III Cog). Short term memory tasks include Memory for Words (WJ-III Cog), Sentence Repetition (NEPSY), Narrative Memory (NEPSY), Object Memory (UNIT), Spatial Memory (UNIT), Symbolic Memory (UNIT) and Memory for Faces (NEPSY). Each type of memory can be compared across the visual and auditory modality, which is the case in the current study.

Auditory Modality of Memory

Both working memory and short term memory skills are measured through the auditory modality in this study. A study by Leffard et al. (2006) compared memory processes measured by various assessment instruments, including the WJ-III Cog. It was reiterated in the study that the WJ-III Cog based its memory measures on the facet that short term memory and working memory are separate factors. Despite this, two of the memory tasks, Numbers Reversed and Auditory Working Memory are purported to measure both auditory short term memory and working memory. Memory for Words measures solely auditory short term memory. The overlap supports the idea that short term memory and working memory are not independent factors, but rather working memory is a similar but higher process. Kail and Hall (2001) indicate that working memory is short term memory plus additional resources necessary in completing more complex tasks.

Many studies in the literature focus on the free recall skill when examining memory in the auditory modality. Free recall is used when one attempts to recall information without a prior filled delay. In those with HFA, auditory verbal memory is often poor if there is a delay between presentation and recall (Boucher & Warrington, 1976). Results from Boucher (1978) indicated that the auditory memory modality was normal in children with autism, specifically a normal digit span. It was concluded that with autism, memory span for words differs from memory span for digits.

Bowler, Matthews, and Gardiner (1997) conducted a study with adults diagnosed with autism that used word lists. Words were presented, and participants were asked to repeat as many words as they could recall. The second experiment in this study used a list of words but half of the words were generated and half read aloud. With the generated words, the participants were asked to provide the target word from a semantic clue and the initial letter of the word. The Mill Hill Vocabulary Test and half of the Digit Symbol test from the Wechsler Adult Intelligence Scale were used as filler tasks for the memory portion of the experiment. Bowler et al. found that adults with AS were impaired in free recall of categorized word lists but not in free recall of unrelated word lists.

Boucher and Lewis (1989) also investigated components of the auditory memory modality in those with autism. They found that the ability to recall heard speech (tested using a short story recall task) after a short delay, and the ability to act immediately on that speech, was impaired in those with this diagnosis. This contradicts other evidence that immediate recall of words is not impaired. Literature presents numerous conflicting conclusions such as normal immediate memory span for unrelated items, normal recognition memory, normal cued recall, as well as evidence that supports inconsistencies. Bowler, Gardiner, and Berthollier (2004) suggested that deficits in free recall were related to problems with retrieval rather than encoding. Bowler et al. found supporting evidence for an impaired episodic memory system, as well as a difference in overall recognition memory between the group with AS and the control group.

Boucher and Warrington (1976) conducted three studies to examine retention abilities in a group of children, ages 9-13, with autism as well as a control group. In one study, they asked participants to name objects on cards followed by a color naming task, after which they were asked to recall the objects. The mean performance of the group with autism was significantly lower than the matched control group. The second study required participants to learn pairs of unrelated words. A group with autism was compared to a control group matched in non-verbal ability and a normal control group. It was found that the group with autism learned significantly faster than the ability matched group, despite the lower verbal ability of the autistic group. A third study was conducted to test whether the retention impairment could be explained by differing language abilities in the autistic and control groups. In this experiment, cued recall using acoustic cues, and a forced recognition task was used. Here, the child was asked to name pictures immediately after the experimenter named the picture. The child was given a 30-second interval, and then asked to recall them while the experimenter listed them, and in the forced recognition task, the child was asked to choose the correct picture after a 40-second interval. Results showed the group with autism performed lower on the recognition task but there was no difference in the cued recall task, leading to the conclusion that the retention deficit in the autistic group was not related to poor language ability. Scores were varied in these studies, which suggested that some, but perhaps, not all children with autism have recognition deficits (Boucher & Warrington, 1976).

Studies by Minshew et al. (1992, 1994) cited in Bowler, Gardiner, and Berthollier (2004) indicated that those with autism show less evident memory impairment with cues as compared to free recall tasks. There were no differences between HFA and the control group on rote and associative memory but significant differences on memory tasks that required comprehending and recalling complex visual and auditory stimuli. They concluded from this data that the impairment may not be as much of a memory deficit as a deficit in organizing information into categories (Minshew et al.,1992, 1994, as cited in Bowler et al., 2004).

In 1981, Boucher conducted a review of the literature, and concluded that immediate memory span is unimpaired in HFA, as well as the cued recall of verbal material after a delay. Boucher, found that those with autism performed similarly on free recall tasks as language matched controls. When variables such as age, verbal ability, and non-verbal ability were controlled, the group with autism had significantly poorer recall of all except the last three words of a list (Boucher).

Visual Modality of Memory

The visual memory modality encompasses skills examined in the current study, such as facial recognition and facial processing. There is a suggested link between the lack of social interest in autism and abnormalities in face processing. Boucher and Lewis (1989) investigated the role of memory through the visual modality in communication impairments in those with HFA. Boucher and Lewis point out that memory deficits using the visual modality could impair spoken communication and the ability to use nonverbal gestures in communication. They were examining the hypothesis that "eliminating the need to use memory skills should improve an autistic person's communication" (Boucher & Lewis, p. 100). Boucher and Lewis found that children with autism have difficulty accessing related groups of memories, but not recalling memories from within the same group. Results also showed impairment in the ability to imitate observed actions.

Jemel, Mottron, and Dawson (2006) examined face processing and how it presents in those with autism by reviewing the existing literature on the subject. Volkmar, Chawarska, and Klin (2005) cite characteristics of autism associated with social abilities, including poor eye contact, delayed onset or lack of gaze following, decreased orienting to faces, lack of social smile, lack of facial expression, lack of responsiveness to parents voices, and lack of spontaneous imitation. Tantum et al. (1989) found that those with autism had difficulty finding the odd facial expression out and labeling facial emotions (as cited in Jemel et al. 2006). There is also evidence that those with autism attend more to the lower parts of the face rather than the eyes (Jemel et al.). Grandin (2000) compared an autistic individual's mind to a web browser. She stated that those with autism "think in pictures," and the mind looks for picture memories that are associated with a word (p. 15). The language part of the brain uses simple non-descriptive language to tell the rest of the brain what to do. She added that the emotion center in the amygdala is not activated when solving social situations, for instance, when judging expressions in another's eyes (Grandin).

Barton, et al. (2004) compared a group of adults with a social developmental disorder (such as autism and AS), a group diagnosed with prosopagnosia, and a control group in their ability to discriminate changes in internal facial configuration and their imagery for famous faces. Barton et al. theorized that perceptual deficits may lead to social deficits. The authors used a face recognition test to assess face processing and a line orientation test to assess perceptual discrimination not involving faces. Famous face recognition was assessed using a series of 20 familiar and 20 unfamiliar faces, and perception of internal facial configuration was tested using target faces presented on a computer screen. The results of the Barton et al. study indicated that a certain group of those with a social developmental disorder had normal famous face recognition along with normal perception of facial configuration, normal imagery for famous faces, and good performance on tests of face perception and memory. This led Barton et al. to conclude that a social developmental disorder does not always lead to impaired face recognition. It was also found, however, that 66% of those with a social developmental disorder displayed impairments in face recognition, the specific diagnosis did not matter, and the face recognition and perception deficits were not as significant as in those with prosopagnosia. This was observed on tasks that measured perceptual matching in which participants were asked to identify which two of three faces were identical. It was also suggested that face perception deficits are not a result of delayed maturation, but instead a disability continuing into adulthood (Barton et al.).

Bar-Haim, Shulman, Lami, and Reuveni (2006) conducted a study and cited earlier research by Klin, Jones, Schultz, Volkmar, and Cohen (2000) that found those with autism looked longer at the mouth region while typical individuals focused twice as long on the eyes. This was observed using both films and photographs (Bar-Haim et al.). Viewing a movie involves a number of cognitive processes including attention, processing features, and integrating perceptual information with contextual cues. Bar-Haim et al. examined differences in initial attention allocation in a control group of children and a group with autism when presented with facial stimuli. The examiners presented face stimuli with a neutral emotion expression presented either upright or inverted and asked participants to respond as quickly as possible. They found that with upright faces, both groups attended more to the eye region than the mouth region. The authors suggested that atypical face processing, therefore, may not be a result of abnormal allocation of attention to different parts of the face. Bar-Haim et al. used neutral facial expressions, and therefore, did not examine the theory that face processing is related to social and emotional cues in the face.

A study by Pierce, Muller, Ambrose, Allen, and Courchesne (2001) included a physiological component in their study of facial perception by measuring haemodynamic responses during a face perception task in a group of adults with autism and a control group. Both groups performed similarly with regard to reaction time and accuracy when performing a face perception task in which participants were asked to press a button in response to female faces alternating with pressing a button in response to a circle shape. None of the typical face processing regions of the brain were active in those with autism when they performed these tasks. Instead, individual-specific neural sites were activated in the autism group as compared to 100% activation of the fusiform face area in the control group. This led to the conclusion that those with autism process faces using different areas of the brain, individual to each person.

Related specifically to performance on the NEPSY, an instrument utilized in the current study, a study was conducted by Hooper, Poon, Marcus, and Fine (2006), which examined performance on the NEPSY by a group of children diagnosed with HFA and a control group. Korkman, Kirk, and Kemp (1998), in their original NEPSY manual, reported lower performance from an HFA group on several subtests, including Memory for Faces, Narrative Memory, Comprehension of Instructions, Arrows, Imitating Hand Positions, and Visuomotor Precision. Hooper et al. cited early data from Hauck et al. (1998) suggesting a deficit in Memory for Faces in the HFA group also. Results from

Hooper et al.'s study found conclusions consistent with the manual. The subtests of Imitative Hand Positions, Arrows, Visuomotor Precision, and Memory for Faces were significantly lower in the HFA group.

In summarizing, it is apparent that the literature indicates variations in memory functions in those with a developmental disorder such as autism or AS. These variations include physiological aspects, memory skills in both the auditory and visual modalities, and social communication skills specifically related to facial processing. Based on these differences it becomes necessary to address methods of assessment in order to foster effective interventions for these individuals. This discussion can be found in the following chapter. The discussion of assessment methods remains specific to instruments used in this study, which include the NEPSY (Korkman et al., 1998), the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III Cog; Woodcock, McGrew, & Mather, 2001), and the Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998). The three instruments above have various differences as well as similarities in constructs, scoring, and interpretation. They each can provide a piece of the picture with regard to assessing a child's intellectual abilities, executive functioning, and memory abilities. The utility of each instrument and psychometric properties, which are addressed in chapter three, provide support for their use in the current study.

The purpose of the current study is to examine the performance of a group of children diagnosed with HFA or AS on the UNIT, the WJ-III Cog, and the NEPSY. Hypotheses include the following.

1. Participants will have difficulty with the Memory for Faces task on the NEPSY as compared to other visual tasks.
2. Symbolic Memory task on the UNIT may yield lower mean scores when compared to the other visual tasks
3. Measures of visual memory from the UNIT will yield lower scores than the auditory memory measures from the WJ-III Cog and the NEPSY.
4. Individuals will demonstrate a lower mean score on the Auditory Working Memory (WJ-III Cog) and Numbers Reversed (WJ-III Cog) tasks as compared to the Memory for Words (WJ-III Cog), Narrative Memory (NEPSY), and Sentence Repetition (NEPSY) tasks

CHAPTER III

METHODOLOGY

This study was a review of archival data obtained from a research study on Asperger syndrome and high functioning autism at Texas Woman's University (TWU) in Denton, Texas. The original study was conducted by members of a research team in the Department of Psychology and Philosophy and was sponsored by grants from the Woodcock Munoz Foundation and the TWU Office of Research and Sponsored Programs. The author of this paper was a member of the research team and participated in the assessments.

Participants

The participants in the TWU study were recruited through advertisement in the North Texas area. Participants were between the ages of 8 and 17, had a Full Scale IQ of 85 or above, and were diagnosed with Asperger's syndrome (AS), autism, or Pervasive Developmental Disorder, Not Otherwise Specified (PDD NOS) by a Licensed Psychologist or physician. This study examined data from 55 participants, 45 of which were diagnosed with AS, and 10 with high functioning autism (HFA). Those with PDD NOS were not included in this study due to the nebulous nature of this diagnosis.

Assessment Measures

The measures in this study were chosen based on their ability to measure language ability, visual-motor skills, nonverbal IQ, and executive functioning. Nonverbal IQ was measured using the Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998). The Woodcock-Johnson III Tests of Cognitive Abilities were used to measure verbal and language abilities (WJ-III Cog; Woodcock, McGrew, & Mather, 2001), as well as the NEPSY (Korkman, Kirk, & Kemp, 1998). The NEPSY and WJ-III Cog also measured aspects of executive functioning.

Woodcock-Johnson III Tests of Cognitive Abilities

The Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III Cog) is a norm-referenced instrument that measures general and specific cognitive abilities and provides a general intellectual measure (the GIA) for those ages 2 to 90 (Woodcock et al., 2001). In addition to the full scale measure of IQ, the WJ-III Cog provides broad ability clusters such as, verbal ability, thinking ability, and cognitive efficiency. Standard scores are based on a mean of 100 and a standard deviation of 15. The norm sample for the WJ-III Cog consisted of 1,143 preschool children, 4,783 students ranging from kindergarten to 12th grade, and 1,843 adults (Cizek, 2003). The sample was representative of the U.S. Census data from 1996 to 1999. The WJ-III Cog consists of 10 subtests in the standard battery and 10 additional subtests in the extended battery. Internal consistency reliability estimates were in the .80 to .90 range for individual subtests and .90 range for broad clusters. Median reliabilities mostly ranged from the .70s to the .90s. Support for the internal structure of the WJ-III Cog was obtained via fundamental correlational analysis and confirmatory factory analyses. The technical manual presents a considerable amount of evidence supporting the validity of scores from the test, noting that the earlier versions of the battery have also been shown to have validity (Sandoval, 2003). Cizek (2003) and Sandoval report reasonably high correlations between cognitive scores and other popular individual tests of intellectual ability obtained from several studies.

The subtests administered in this study include the eight subtests from the standard battery (Verbal Comprehension, Visual-Auditory Learning, Spatial Relations, Sound Blending, Concept Formation, Visual Matching, Numbers Reversed, and Auditory Working Memory), and subtests 11 through 17 on the extended battery (General Information, Retrieval Fluency, Picture Recognition, Auditory Attention, Analysis-Synthesis, Decision Speed, and Memory for Words). Further explanation is provided for Numbers Reversed, Auditory Working Memory, and Memory for Words, as these are the subtests that were examined in the current study.

Numbers Reversed is a task in which the child is read a set of numbers and asked to repeat them in reversed order. This task measures working memory, cognitive efficiency, broad attention, and short-term memory. Memory for Words is a task in which the child is asked to recall words read aloud to him/her. This task measures cognitive efficiency and short-term memory. Auditory Working memory is a task that requires a child to remember information and manipulate it before repeating it back. It measures working memory and broad attention.

Universal Nonverbal Intelligence Test

The UNIT (Bracken & McCallum, 1998) is a norm referenced, individually, and nonverbally administered intelligence test. The nonverbal methods of administration are considered advantageous when evaluating children with language or verbal limitations. It was intended to provide an accurate assessment of intellectual functioning for those with language deficits due to speech, language, or hearing impairments, differences in cultural background, or specific psychiatric disorders (Bandalos, 2003).

The UNIT yields six subtest scores and four quotient scores, including a Memory Quotient, Reasoning Quotient, Symbolic Quotient, and Nonsymbolic Quotient, as well as a Full Scale IQ score. It was designed to measure two components of intelligence: memory and reasoning. Despite its nonverbal nature, the authors indicate that three of the subtests (i.e., Symbolic Memory, Analogic Reasoning, and Object Memory) are verbally mediated due to their concrete representations of objects that can be labeled and organized. Parts of the test are also considered to be symbolic in nature, which include the Cube Design, Symbolic Memory, and Mazes subtests (Bandalos, 2003).

The UNIT was standardized on a nationally representative sample of 2,100 children between the ages of 5 and 17 (Bandalos, 2001). The sample was similar to the 1995 U.S. Census data on gender, race, Hispanic origin, region, and parental educational level. Internal consistency estimates for the subtests range from .89 to .95 for the standard battery and .91 to .94 for the extended battery. Reliabilities for the younger children are slightly lower than for the older children. Coefficients for the scaled scores were in the

.80 and .90 range. Validity estimates were provided using factor analyses, which indicated a memory and a reasoning factor, as hypothesized by the authors (Bandalos, 2003).

The UNIT was correlated with other IQ measures, and the UNIT was shown to share a significant amount of variance with other measures, providing evidence of concurrent validity (Bandalos, 2001). The Memory domain, which included the Spatial Memory, Symbolic Memory, and Object Memory subtests, will be more closely analyzed for purposes of this study. UNIT scores are reported using a mean of 100 and a standard deviation of 15. According to an article by Fives and Flanagan (2002), the test is based on an intelligence model that includes a general "g" factor with a memory and reasoning factor. Participants in the current study were administered all of the subtests.

NEPSY

The NEPSY (Korkman et al., 1998) is a norm referenced neuropsychological assessment instrument that is individually administered. It has two forms for use with ages 3 to 4 and ages 5 to 12. It provides a comparison between functional domains, which is consistent with Luria's theory that emphasizes the interrelatedness of brain operations (Haynes, 2001). It assesses five domains including Attention/Executive Functions, Language, Sensorimotor Functions, Visuospatial Processing, and Memory and Learning, using a total of 27 subtests. In addition to the 27 subtest scores, 5 domain scores are provided. A set of subtests from each domain can be administered as the Core assessment or additional subtests can be administered for the expanded assessment. Supplemental scores and qualitative analyses are also provided (Korkman et al.).

The NEPSY was originally developed in Finland and later revised for use in the United States (Korkman et al., 1998). The standardization sample was completed using 1995 U.S. Census data. The reliability and validity prove to be moderate to high with core domain coefficients ranging from .69 to .91. Moderate stability coefficients range from .67 to .76 across the five domains for the 5 to 12 age group (Miller, 2003). Support for construct validity is provided in the manual, as well as evidence for the convergent and divergent validity.

Korkman et al. (1998) originally developed the test with five domains, including attention/executive function, language, sensorimotor, visuospatial processing, and memory and learning. The NEPSY was developed with four purposes (Stinnett, Oehler-Stinnett, Fuqua, & Palmer, 2002). The first was

> to detect subtle deficiencies in neuropsychological functioning of children that can interfere with learning. Second, it provides a method to contribute to the understanding of the effects of brain damage in children. It can be used for long term follow up of children. Finally, it can study typical and atypical neuropsychological development of children. (Stinnett et al., p. 68)

A review by Ahmad and Warriner (2001) reiterated that the test assesses five complex domains including attention/executive functions, language, sensorimotor functions, visuospatial processing, and memory and learning. NEPSY subtests scores are reported using a mean of 10 and a standard deviation of 3. For purposes of this paper, the Memory and Learning domain of the NEPSY are examined in detail in order to report on the working memory skills measured by this instrument. The Memory for Faces, Sentence Repetition, and Narrative Memory are explained in further detail, as these are the subtests examined in the current study.

Memory for Faces is a test of immediate and delayed facial recognition after a brief exposure. It involves faces in photographs that the child is asked to sort into piles by gender. A deficit in facial recognition, poor social perception, and /or inattention tend to lead to lower scores on this task (Kemp, Korkman, & Kirk, 2001). Narrative Memory measures auditory free recall and cued recall skills. The child listens to a story then retells it, and for the cued recall portion, they must elicit details that were not reported in free recall. Deficits that may lead to lower scores on this task include verbal memory deficit, and/or any global, receptive, or expressive language deficit, inattention, anxiety, slow processing, difficulties in organizing and sequencing, and/or poor memory span (Kemp et al.). Sentence Repetition is a measure of auditory short term memory in which the child is asked to recall sentences read to them. Poor performance on this task could be attributed to verbal memory deficits, language deficits, inattention, poor memory span, and/or difficulties with organizing and sequencing (Kemp et al.).

Design and Procedure

Following approval of the university's Institutional Review Board, parents of potential participants were screened over the telephone and information was gathered to determine if their child met criteria for participation in the study. After this initial discussion, an appointment for assessment was made and the location of testing was at one of four locations in the Dallas/Fort Worth area: a local university, administration building of a local school district, and two private offices. Prior to testing, informed consent was obtained including an explanation of the purpose of the study and information regarding confidentiality. Testing methods were standardized, and all instruments were individually administered in quiet, small, well-lit rooms. The majority of participants completed testing in one day with a one-hour lunch break included in the day. Breaks were scheduled throughout the day and participants were allowed to take breaks as needed. There were a few participants who returned for a second day of testing in order to complete the battery.

The participants were administered the following instruments in randomized order: W-J III Cog (tests 1-7, 9, and 11-17), the UNIT, the Wide Range Assessment of Visual Motor Ability, the Murphy-Meisgeier Type Indicator for Children-Revised, the Student Styles Questionnaire, the Social Skills Rating System-Student Form, the Kinetic House-Tree-Person Drawing, and a structured clinical interview. In addition, children ages 8-12 were administered selected subtests from the NEPSY. In the meantime, parents were asked to complete a developmental history form, the Parenting Stress Index-Short Form or the Stress Index for Parents of Adolescents (depending on the age of their child), the Marital Satisfaction Inventory-Revised, the Behavior Assessment System for Children-Parent Rating Scale, the Krug Asperger's Disorder Index, and the Behavior

Assessment Scale for Children, Second Edition-Parent Rating Scale in addition to a structured clinical interview. Several weeks after testing was completed, a summary form of testing results was mailed to parents.

Hypotheses and Analysis

For purposes of the current study, the following hypotheses are examined. Methods of data analysis are briefly described along with each hypothesis.

1. It is predicted that the participants in the study will demonstrate lower mean scores on the visual memory subtests that have a social component as compared to the other visual memory subtests administered. Mean scores for Memory for Faces (NEPSY) will be significantly lower than mean scores for Object Memory (UNIT) and Spatial Memory (UNIT). This is examined statistically using a repeated measures ANOVA.
2. It is predicted that Symbolic Memory (UNIT) will yield a lower mean score as compared to Object Memory (UNIT) and Spatial Memory (UNIT).
3. A significant difference is predicted between the two modalities of memory, specifically, mean scores on subtests measuring visual memory and subtests measuring auditory memory. Specifically, mean scores will be higher for Numbers Reversed (WJ-III Cog), Auditory Working Memory (WJ-III Cog), Memory for Words (WJ-III Cog), Sentence Repetition (NEPSY), and Narrative Memory (NEPSY) as compared to the mean scores for Memory for Faces (NEPSY), Spatial Memory (UNIT), Symbolic Memory (UNIT), and Object

Memory (UNIT). This is examined statistically using repeated measures ANOVAs. A correlation matrix is used to examine the means across all of the subtests being examined. Using this matrix, the mean of one subtest can be compared to the means of other subtests to check for significance.

4. The fourth hypothesis focuses on the auditory modality, predicting a significant difference between mean scores for auditory memory tasks and auditory working memory tasks. Specifically, the mean scores for subtests involving auditory working memory, Auditory Working Memory (WJ-III Cog) and Numbers Reversed (WJ-III Cog) will be lower than other subtests involving auditory memory including Memory for Words (WJ-III Cog), Narrative Memory (NEPSY), and Sentence Repetition (NEPSY). Data analysis includes the same methods as stated for hypothesis number two. A correlation matrix is included to compare the means across all of the subtests being examined. Using this matrix, the mean of one subtest can be compared to the means of other subtests to check for significance.

CHAPTER IV

RESULTS

The purpose of the current study is to examine the performance of a group of children diagnosed with High Functioning Autism (HFA) or Asperger's Syndrome (AS) on the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III Cog; Woodcock, McGrew, & Mather, 2001), the Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998), and the NEPSY (Korkman, Kirk, & Kemp, 1998). Both AS and HFA are grouped together for purposes of the present study and the term autism will be used from this point forward to refer to the group of participants. Specifically, the study examines scores on memory domains and/or subtests across these instruments.

Demographics

The initial sample for the current study involved 64 children with a prior diagnosis of Autism or Pervasive Development Delay (PDD). Ten of the children were diagnosed with PDD and were not included in the following analyses, leaving a final sample of 54 children diagnosed with high functioning autism (HFA) or Asperger syndrome (AS) to be included in analyses. As shown in Table 1, there were more males (87.0%) than females (13.0%) in the final sample of children diagnosed with Autism (HFA or AS). The average age for children diagnosed with HFA or AS was 11 years (M = 11.65, SD = 2.93; see Table 2).

Table 1

Frequencies and Percentages for Demographic Variables

	Frequency	%
Gender		
Male	47	87.0
Female	7	13.0
Age Category		
Nine years or younger	15	27.8
10 – 11 years	15	27.8
12 years or older	24	44.4
Ethnicity		
Caucasian	50	92.6
African-American	2	3.7
Hispanic	2	3.7
Diagnosis		
High Functioning Autism	14	25.9
Asperger's Syndrome	40	74.1

Table 2

Means and Standard Deviations for Child Age

	N	Mean	*SD*	Min	Max
Age	54	11.65	2.93	8	18

A grouping variable was created for child age in order to classify the children into one of three age groups. As shown in Table 1, slightly over one fourth of the children were nine years or younger (27.8%), slightly over one fourth of the children were between the ages of ten and eleven (27.8%) and nearly half of the children were twelve years or older (44.4%). The groups were divided according to this criteria to facilitate statistical comparison of test means, despite the larger number in the older age grouping (The NEPSY was administered to participants age 12 and under). The majority of the children were of Caucasian ethnicity (92.6%), less than 5% were African American (3.7%) and less than 5% were Hispanic (3.7%). Finally, approximately one fourth of the children included in the analyses had a prior diagnosis of High Functioning Autism (25.9%) and the remaining 74.1% had a prior diagnosis of Asperger's Syndrome.

Frequencies and percentages for child diagnosis by child gender are displayed in Table 3. The relationship between child gender and child diagnosis was not significant, $\chi^2(1) = .57, p = .45$, Cramer's $V = .10$.

Table 3

Frequencies and Percentages for Diagnosis by Gender

	Male		Female			
	N	%	*N*	%	χ^2	*p*
Diagnosis					.57	.451
High Functioning Autism	13	27.7	1	14.3		
Asperger's Syndrome	34	72.3	6	85.7		

Note. Percentages not adding to 100% reflect missing data

An independent samples *t* test was conducted in order to examine the data for gender differences in age (see Table 4). The results showed that male children (M = 11.66, SD = 3.08) did not significantly differ from female children (M = 11.57, SD = 1.72) in age, t (52) = .07, p = .94.

An independent samples *t* test was also conducted to uncover potential differences between the two diagnosis groups (HFA vs. AS) and child age (see Table 5). The results failed to reveal significant differences for diagnosis on age, t (52) = -.01, p = .99. Children diagnosed with HFA (M = 11.64, SD = 3.10) were approximately the same age as children diagnosed with AS(M = 11.65, SD = 2.90).

Table 4

Means and Standard Deviations for Age by Gender

	N	Mean	*SD*	*t*	*p*
Age				.07	.942
Male	47	11.66	3.08		
Female	7	11.57	1.72		

Table 5

Means and Standard Deviations for Age by Diagnosis

	N	Mean	*SD*	*t*	*P*
Age				-.01	.994
High Functioning Autism	14	11.64	3.10		
Asperger's Syndrome	40	11.65	2.90		

Woodcock-Johnson III Tests of Cognitive Abilities

The WJ-III Cog was used to measure verbal and language abilities (Woodcock, McGrew, & Mather, 2001). The WJ-III Cog is a norm-referenced instrument that measures general and specific cognitive abilities and provides a general intellectual measure (the GIA; Woodcock et al.). In addition to the full scale measure of IQ, the WJ-III Cog provides broad ability clusters such as verbal ability, thinking ability, and cognitive efficiency.

The variables for the WJ III Cog measures were scaled so that the lower end of the measure reflected lesser general intellectual ability and the upper end of the measure reflected higher general intellectual ability. In addition, quotient and subtest measures were scaled so that the lower end of the measures reflected lesser verbal and language abilities and the upper end of the measures reflected higher verbal and language abilities. The primary measure assessed general intellectual ability. Quotients included measures for short-term memory and working memory. Subtests included measures for numbers reversal, auditory working memory, and memory for words. Standard scores are based on a mean of 100 and a standard deviation of 15.

Table 6

Means and Standard Deviations for Woodcock-Johnson III Cog Scores

	N	Mean	*SD*	Min	Max
WJ-III Cog - General Intellectual Ability	53	104.32	17.35	72	146
WJ-III Cog - Short Term Memory	53	99.77	15.18	68	135
WJ-III Cog - Working Memory Quotient	53	100.11	17.17	60	152
WJ-III Cog - Numbers Reversed Subset	53	99.60	17.16	55	154
WJ-III Cog - Auditory Working Memory Subtest	53	101.32	15.33	71	133
WJ-III Cog - Memory for Words Subset	53	100.40	14.21	74	130

Means and standard deviations for children's scores on the WJ-III Cog General Intellectual Ability measure and subtests are shown in Table 6. On average, children scored slightly above the standard score of 100 for General Intellectual Ability (M = 104.32, SD = 17.35). Scores ranged from 72 to 146. The average score for the Short Term Memory Quotient was 99.77 (SD = 15.18) and ranged from 68 to 135. The mean score for the Working Memory Quotient was 100.11 (SD = 17.17) and ranged from 60 to 152. The average score of the Numbers Reversed Subtest was 99.60 (SD = 17.16) and ranged from 55 to 154. The mean score for the Auditory Working Memory Subtest was 101.32 (*SD* = 15.33) and ranged from 71 to 133. Finally, the average score for the Memory for Words Subtest was 100.40 (*SD* = 14.21) and ranged from 74 to 130 (see Table 6).

Universal Nonverbal Intelligence Test

The Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998) was administered to the children in the present study. It was intended to provide an accurate assessment of intellectual functioning for children with language or verbal limitations. The UNIT was also intended to measure two components of intelligence, memory and reasoning. The UNIT yielded four subtest scores, four quotient scores, and a Full Scale IQ score (see Table 7).

Standard scores are based on a mean of 100 and a standard deviation of 15. Means and standard deviations for children's scores on the UNIT memory and reasoning quotient measures, Full Scale IQ score, and memory and reasoning subtest measures are shown in Table 7. The average score for the Memory Quotient was 95.56 (*SD* = 16.97) and ranged from 62 to 135. The mean score for the Reasoning Quotient was 108.42 (*SD* = 14.32) and ranged from 73 to 135. The average score of the Symbolic Quotient was 100.85 (*SD* = 14.18) and ranged from 68 to 132. The mean score for the Non-Symbolic Quotient was 103.90 (*SD* = 16.67) and ranged from 71 to 137. The average score for the Full Scale IQ Score was 102.48 (*SD* = 15.92). Scores ranged from 70 to 135. The average score for the Symbolic Memory Subtest was 10.29 (*SD* = 3.22) and ranged from 6 to 19. The mean score for the Spatial Memory Subtest was 9.71 (*SD* = 3.63) and ranged from 3 to 17. Finally, the average score for the Object Memory Subtest was 8.54 (*SD* = 3.08), ranging from 1 to 15.

Table 7

Means and Standard Deviations for Universal Nonverbal Intelligence Test

	N	Mean	*SD*	Min	Max
UNIT - Memory Quotient	52	96.56	16.97	62	135
UNIT- Reasoning Quotient	52	108.42	14.32	73	135
UNIT - Symbolic Quotient	52	100.85	14.18	68	132
UNIT - NonSymbolic Quotient	52	103.90	16.67	71	137
UNIT - Full Scale IQ Score	52	102.48	15.92	70	135
UNIT - Symbolic Memory Subtest	52	10.29	3.22	2	19
UNIT - Cube Design Subtest	52	11.98	3.53	6	19
UNIT - Spatial Memory Subtest	52	9.71	3.63	3	17
UNIT - Object Memory Subtest	52	8.54	3.08	1	15

NEPSY

The NEPSY (Korkman et al., 1998) is a norm referenced neuropsychological assessment instrument that is individually administered. It has two forms for use with ages 3 to 4 and ages 5 to 12. Thirty-five children were administered the NEPSY since it is appropriate for children ages twelve and under. Standard NEPSY subtests scores are based on a mean of 10 and a standard deviation of 3. The Memory and Learning domain of the NEPSY measures working memory skills and consists of three subtests scores, Memory for Faces Subtest, Narrative Memory Subtest, and Sentence Repetition Subtest.

Means and standard deviations for children's scores on the NEPSY Memory and Learning domain subtests are shown in Table 8. The average score for the Memory for Faces Subtest was 10.41 (*SD* = 2.46) and ranged from 6 to 15. The mean score for the Narrative Memory Subtest was 9.37 (*SD* = 3.89) and ranged from 2 to 17. Finally, the average score of the Symbolic Quotient was 8.76 (*SD* = 3.33) and ranged from 2 to 16.

Table 8

Means and Standard Deviations for NEPSY

	N	Mean	*SD*	Min	Max
NEPSY Memory for Faces Subtest	34	10.41	2.46	6	15
NEPSY Narrative Memory Subtest	35	9.37	3.89	2	17
NEPSY Sentence Repetition Subtest	34	8.76	3.33	2	16

Relationships Between the WJ-III Cog and the UNIT

Pearson's product moment correlations were conducted to examine the relationships between the UNIT measures Memory Quotient, Reasoning Quotient, Symbolic Quotient, NonSymbolic Quotient, Full Scale IQ Score, Symbolic Memory Subtest, Cube Design Subtest, Spatial Memory Subtest and Object Memory Subtest and the WJ-III Cog measures General Intellectual Ability, Short Term Memory, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest and Memory for Words Subtest (see Table 9). The results revealed significant positive correlations between UNIT Memory Quotient scores and scores for all of the Woodcock Johnson III Cog measures, $p < .05$. Specifically, there were significant positive correlations between UNIT Memory Quotient Scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .67, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .49, p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .54, p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .48, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .51, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(51) = .38, p < .05$. Children who scored higher on UNIT Memory Quotient scored higher on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest and Memory for Words Subtest (see Table 9).

Table 9

Pearson's Product Moment Correlations between WJ-III Cog Scores and UNIT Scores

	UNIT MQ	UNIT RQ	UNIT SQ	UNIT NSQ	UNIT FSIQS	UNIT SymMS	UNIT CDS	UNIT SpaMS	UNIT OMS
WJ-III Cog – GIA	.673**	.690**	.758**	.655**	.759**	.696**	.676**	.532**	.432**
WJ-III Cog - STMQ	.489**	.435**	.540**	.430**	.517**	.509**	.362**	.423**	.268
WJ-III Cog – WMQ	.539**	.450**	.582**	.465**	.555**	.550**	.432**	.466**	.309*
WJ-III Cog – NRS	.475**	.393**	.495**	.427**	.489**	.517**	.371**	.458**	.184
WJ-III Cog – AWM	.512**	.423**	.570**	.415**	.523**	.461**	.417**	.387**	.423**
WJ-III Cog – MWS	.337*	.332*	.404**	.286*	.371**	.330*	.226	.239	.264

Note. ** $p < .001$, * $p < .05$. WJ-III Cog (GIA=General Intellectual Ability, STMQ=Short Term Memory Quotient, WMQ=Working Memory Quotient, NRS=Numbers Reversed, AWM=Auditory Working Memory, MWS=Memory for Words), UNIT=Universal Nonverbal Intelligence Test (MQ=Memory Quotient, RQ=Reasoning Quotient, SQ=Symbolic Quotient, NSQ=Non-Symbolic Quotient, FSIQS=Full Scale IQ Score, SymMS=Symbolic Memory, CDS=Cube Design, SpaMS=Spatial Memory, OMS=Object Memory)

Further, results revealed significant positive correlations between UNIT Reasoning Quotient scores and scores for all of the Woodcock Johnson III Cog measures, $p < .05$. Specifically, there were significant positive correlations between UNIT Reasoning Quotient Scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .69, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .44, p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .45, p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .39, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .42, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(51) = .33, p < .05$). Children who scored higher on UNIT Reasoning Quotient had higher scores on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest and Memory for Words Subtest (see Table 9).

There were significant positive correlations between UNIT Symbolic Quotient scores and scores for all of the WJ-III Cog measures, $p < .001$. Specifically, there were significant positive correlations between UNIT Symbolic Quotient Scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .76, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .54, p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .58, p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .50, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .57, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(51) = .40, p < .001$). These results indicate that children who scored high on the UNIT Symbolic Quotient also scored high on the

WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest and Memory for Words Subtest (see Table 9).

Results showed significant positive correlations between UNIT Non-Symbolic Quotient scores and scores for all of the Woodcock Johnson III Cog measures, $p < .05$. Specifically, there were significant positive correlations between UNIT Non-Symbolic Quotient Scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .66, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .43, p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .47, p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .43, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .42, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(51) = .29, p < .05$). Children who scored higher on the UNIT Non-Symbolic Quotient had higher scores on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest, and Memory for Words Subtest (see Table 9).

Further, there were significant positive correlations between UNIT Full Scale IQ Scores and scores for all of the Woodcock Johnson III Cog measures, $p < .001$. Specifically, there results revealed positive correlations between UNIT Full Scale IQ Scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .76, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .52, p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .56, p < .001$), the WJ-III Cog Numbers Reversed

Subtest ($r(51) = .49, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .52, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(51) = .37, p < .001$). Children who had higher UNIT Full Scale IQ scores also had higher scores on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest and Memory for Words Subtest (see Table 9).

Results revealed significant positive correlations between UNIT Symbolic Memory Subtest scores and scores for all of the WJ-III Cog measures, $p < .05$. Specifically, there were significant positive correlations between UNIT Symbolic Memory Subtest scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .70, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .51, p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .55$ $p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .52, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .46, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(51) = .33, p < .05$). Children who had higher UNIT Symbolic Memory Subtest scores also scored high on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest, and Memory for Words Subtest (see Table 9).

Results also revealed significant positive correlations between UNIT Cube Design Subtest scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .68, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .36, p < .001$), the WJ-III Cog

Working Memory Quotient ($r(51) = .43$ $p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .37$, $p < .001$), and the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .42$, $p < .001$). The relationship between UNIT Cube Design Subtest scores and the WJ-III Cog Memory for Words Subtest was not significant ($r(51) = .23$, $p = .11$). These results indicate that children who had high UNIT Cube Design Subtest scores also scored high on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, and Auditory Working Memory Subtest (see Table 9).

There were significant positive correlations between UNIT Spatial Memory Subtest scores and scores on the WJ-III Cog General Intellectual Ability ($r(51) = .53$, $p < .001$), WJ-III Cog Short Term Memory Quotient ($r(51) = .42$, $p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .47$ $p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .46$, $p < .001$), and the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .39$, $p < .001$). The relationship between UNIT Spatial Memory Subtest scores and the WJ-III Cog Memory for Words Subtest, however, was not significant ($r(51) = .24$, $p = .09$). Children who had higher UNIT Spatial Memory Subtest scores also scored high on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, and Auditory Working Memory Subtest (see Table 9).

Further, results revealed significant positive correlations between UNIT Object Memory Subtest scores and scores on the WJ-III Cog General Intellectual Ability ($r(51)$

= .43, $p < .001$), the WJ-III Cog Working Memory Quotient ($r(51) = .31$ $p < .05$), the WJ-III Cog Numbers Reversed Subtest ($r(51) = .46$, $p < .001$), and the WJ-III Cog Auditory Working Memory Subtest ($r(51) = .42$, $p < .001$). Children who had higher UNIT Object Memory Subtest scores also scored high on the WJ-III Cog measures for General Intellectual Ability, Working Memory Quotient, and Auditory Working Memory Subtest (See Table 12). The relationships between UNIT Object Memory Subtest scores and the WJ-III Cog measures for Short Term Memory Quotient ($r(51) = .27$, $p = .06$), Numbers Reversed Subtest ($r(51) = .18$, $p = .20$), and Memory for Words Subtest ($r(51) = .26$, $p = .06$) were not significant.

Relationships Between the UNIT and the NEPSY

Pearson's product moment correlations were conducted to examine the relationships between the NEPSY measures Memory for Faces Subtest, Narrative Memory Subtest, and Sentence Repetition Subtest and the UNIT measures Memory Quotient, Reasoning Quotient, Symbolic Quotient, Non-Symbolic Quotient, Full Scale IQ Score, Symbolic Memory Subtest, Cube Design Subtest, Spatial Memory Subtest and Object Memory Subtest (see Table 10). The results revealed significant positive correlations between NEPSY Narrative Memory Subtest scores and scores for the UNIT measures, $p < .05$. Specifically, there were significant positive correlations between scores on the NEPSY Narrative Memory Subtest and scores for the UNIT Memory Quotient ($r(35) = .62$, $p < .001$), UNIT Reasoning Quotient ($r(35) = .59$, $p < .001$), the UNIT Symbolic Quotient ($r(35) = .63$, $p < .001$), the UNIT Non-Symbolic Quotient

($r(35) = .62$, $p < .001$), the UNIT Full Scale IQ Score ($r(35) = .67$, $p < .001$), the UNIT Symbolic Memory Subtest ($r(35) = .57$, $p < .001$), the UNIT Cube Design Subtest ($r(35) = .48$, $p < .001$), the UNIT Spatial Memory Subtest ($r(35) = .56$, $p < .001$) and the UNIT Object Memory Subtest ($r(35) = .39$, $p < .05$).

Children who scored higher on the NEPSY Narrative Memory Subtest also scored higher on the UNIT Memory Quotient, the UNIT Reasoning Quotient, the UNIT Symbolic Quotient, the UNIT Non-Symbolic Quotient, the UNIT Full Scale IQ Score, the UNIT Symbolic Memory Subtest, the UNIT Cube Design Subtest, the UNIT Spatial Memory Subtest and the UNIT Object Memory Subtest (see Table 10).

Further, results revealed significant positive correlations between NEPSY Sentence Repetition Subtest scores and scores for the UNIT Reasoning Quotient ($r(34) = .45$, $p < .001$), the UNIT Symbolic Quotient ($r(34) = .37$, $p < .05$), and the UNIT Full Scale IQ Score ($r(34) = .37$, $p < .05$), indicating that children who scored high on the NEPSY Sentence Repetition Subtest also scored high on the UNIT Reasoning Quotient, the UNIT Symbolic Quotient, and the UNIT Full Scale IQ Score. In addition, the relationships between the NEPSY Memory for Faces Subtest and the UNIT measures were not significant (see Table 10).

Table 10

Pearson's Product Moment Correlations Between Universal Nonverbal Intelligence and NEPSY

		NEPSY	NEPSY
	MFS	NMS	SRS
UNIT - Memory Quotient	.321	.616**	.243
UNIT- Reasoning Quotient	.140	.594**	.453**
UNIT - Symbolic Quotient	.171	.629**	.368*
UNIT – Non Symbolic Quotient	.302	.615**	.321
UNIT - Full Scale IQ Score	.251	.668**	.369*
UNIT - Symbolic Memory Subtest	.305	.572**	.238
UNIT - Cube Design Subtest	.213	.484**	.317
UNIT - Spatial Memory Subtest	.321	.555**	.298
UNIT - Object Memory Subtest	.155	.388*	.062

Note. ** $p < .001$, * $p < .05$, NEPSY Scores: MFS = Memory for Faces Subtest, NMS = Narrative Memory Subtest, SRS = Sentence Repetition Subtest

Relationships Between the WJ-III Cog and the NEPSY

Pearson's product moment correlations were conducted to examine the relationships between the NEPSY measures Memory for Faces Subtest, Narrative Memory Subtest, and Sentence Repetition Subtest and the WJ-III Cog measures General Intellectual Ability, Short Term Memory, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest and Memory for Words Subtest (see Table 11).

The results revealed significant positive correlations between NEPSY Narrative Memory Subtest scores and scores for all of the Woodcock Johnson III Cog measures, $p < .001$. Specifically, there were significant positive correlations between NEPSY Narrative Memory Subtest scores and scores on the WJ-III Cog General Intellectual Ability ($r(35) = .70, p < .001$), WJ-III Cog Short Term Memory Quotient ($r(35) = .64, p < .001$), the WJ-III Cog Working Memory Quotient ($r(35) = .59, p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(35) = .51, p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(35) = .57, p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(35) = .56, p < .001$). Children who scored high on the NEPSY Narrative Memory Subtest also scored high on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest, and Memory for Words Subtest (see Table 11).

The results revealed significant positive correlations between NEPSY Sentence Repetition Subtest scores and scores for all of the WJ-III Cog measures, $p < .001$. Specifically, there were significant positive correlations between NEPSY Sentence Repetition Subtest scores and scores on the WJ-III Cog General Intellectual Ability ($r(34) = .48$, $p < .001$), WJ-III Cog Short Term Memory Quotient ($r(34) = .59$, $p < .001$), the WJ-III Cog Working Memory Quotient ($r(34) = .54$, $p < .001$), the WJ-III Cog Numbers Reversed Subtest ($r(34) = .45$, $p < .001$), the WJ-III Cog Auditory Working Memory Subtest ($r(34) = .55$, $p < .001$), and the WJ-III Cog Memory for Words Subtest ($r(34) = .55$, $p < .001$).

Children who scored high on the NEPSY Sentence Repetition Subtest also scored high on the WJ-III Cog measures for General Intellectual Ability, Short Term Memory Quotient, Working Memory Quotient, Numbers Reversed Subtest, Auditory Working Memory Subtest, and Memory for Words Subtest (see Table 11). Finally, relationships between the NEPSY Memory for Faces Subtest and WJ-III Cog measures were not significant (see Table 11).

Table 11

Pearson's Product Moment Correlations Between NEPSY and Woodcock-Johnson III Cog

	NEPSY MFS	NEPSY NMS	NEPSY SRS
WJ-III Cog - General Intellectual Ability	.296	.703**	.483**
WJ-III Cog - Short Term Memory Quotient	.216	.641**	.585**
WJ-III Cog - Working Memory Quotient	.242	.587**	.536**
WJ-III Cog - Numbers Reversed Subtest	.240	.507**	.445**
WJ-III Cog - Auditory Work Memory Subset	.202	.569**	.546**
WJ-III Cog - Memory for Words Subtest	.119	.561**	.549**

Note. **$p < .001$, NEPSY Scores: MFS = Memory for Faces Subtest, NMS = Narrative Memory Subtest, SRS = Sentence Repetition Subtest.

Repeated Measures ANOVAs

Each of the remaining analyses were performed using diagnosis (HFA, AS) as a between subjects effect. The results failed to reveal significant differences for diagnosis on any of the dependent measures and did not alter the results for the remaining effects in the analyses. Due to these results, the between subjects factor diagnosis (HFA, AS) was collapsed across groups to create one sample of children with autism (HFA or AS) and will not be mentioned further.

Woodcock-Johnson III Tests of Cognitive Abilities

A repeated measures ANOVA was conducted on the WJ-III Cog using measure as the within subjects effect (see Table 12). Results revealed that the effect for measure was significant, $F(5, 260) = 2.40, p < .05$, indicating that there were differences in responses on the WJ-III Cog measures (see Table 12). Pairwise multiple comparisons using Fisher's Least Significant Difference (LSD) were conducted to determine which WJ-III Cog scores differed from each other. As Table 12 shows, mean scores on the General Intellectual Ability (GIA) measure were significantly greater ($M = 104.32$, $SD = 17.35$) than mean scores for the Short Term Memory Quotient ($M = 99.77$, $SD = 15.18$, $p < .01$), the Working Memory Quotient ($M = 100.11$, $SD = 17.17$, $p < .05$), the Numbers Reversed Subtest ($M = 99.60$, $SD = 17.16$, $p < .05$), and the Memory for Words Subtest ($M = 100.40$, $SD = 14.21$, $p < .05$).

Universal Nonverbal Intelligence Test

A repeated measures ANOVA was conducted on the UNIT Quotients and Full Scale IQ Score using measure as the within subjects effect (see Table 13). Results revealed that the effect for measure was significant, $F(4, 204) = 22.65, p < .001$, indicating that there were differences in scores on the UNIT Quotients and Full Scale IQ. Pairwise multiple comparisons using Fisher's Least Significant Difference (LSD) were conducted to determine which mean scores differed from each other.

Table 12

Means and Standard Deviations for Woodcock-Johnson III Cog Scores

	N	Mean	*SD*	*F*	*p*
Woodcock Johnson III Cog Scores				2.40	.038
General Intellectual Ability	53	104.32[a]	17.35		
Short Term Memory Quotient	53	99.77[b]	15.18		
Working Memory Quotient	53	100.11[b]	17.17		
Numbers Reversed Subset	53	99.60[b]	17.16		
Auditory Working Memory Subset	53	101.32[ab]	15.33		
Memory for Words Subset	53	100.40[b]	14.21		

Note. Columns with differing superscripts differed significantly, Fisher's Least Significant Difference (LSD) test for pairwise multiple comparisons, $p < .05$.

As Table 13 shows, scores were significantly lower for the Memory Quotient ($M = 96.56$, $SD = 16.97$) compared to scores for the Reasoning Quotient ($M = 108.42$, $SD = 14.32$, $p < .001$), the Symbolic Quotient ($M = 100.85$, $SD = 14.18$, $p < .001$), the Non-Symbolic Quotient ($M = 103.90$, $SD = 16.67$, $p < .001$) and the Full Scale IQ Score ($M = 102.48$, $SD = 15.92$, $p < .001$). In addition, children's average scores for the Reasoning Quotient ($M = 108.42$, $SD = 14.32$) were significantly higher than their average scores for the Memory Quotient (*M* = 96.56, *SD* = 16.97, *p* < .001), the Symbolic Quotient (*M* = 100.85, *SD* = 14.18, *p* < .001), the Non-Symbolic Quotient (*M* = 100.85, *SD* = 14.18, *p* < .001), and the Full Scale IQ Score (*M* = 102.48, *SD* = 15.92, *p* < .001).

Table 13

Means and Standard Deviations for Universal Nonverbal Intelligence Test Quotient Scores and Full Scale IQ Score

	N	Mean	*SD*	*F*	*p*
UNIT Scores				22.65	.001
Memory Quotient	52	96.56[a]	16.97		
Reasoning Quotient	52	108.42[b]	14.32		
Symbolic Quotient	52	100.85[c]	14.18		
Non-Symbolic Quotient	52	103.90[c]	16.67		
Full Scale IQ Score	52	102.48[c]	15.92		

Note. Columns with differing superscripts differed significantly, Fisher's Least Significant Difference (LSD) test for pairwise multiple comparisons, *p* < .05.

A repeated measures ANOVA was conducted on the UNIT Subtest measures using measure as the within subjects effect (see Table 14). Results revealed that the effect for measure was significant, $F(3, 153) = 19.01$, $p < .001$, indicating that there were differences in scores on the UNIT subtests. Pairwise multiple comparisons using Fisher's Least Significant Difference (LSD) were conducted to determine which mean scores differed from each other.

Table 14

Means and Standard Deviations for Universal Nonverbal Intelligence Test

	N	Mean	*SD*	*F*	*p*
UNIT Scores				19.01	.001
Symbolic Memory Subtest	52	10.29[a]	3.22		
Cube Design Subtest	52	11.98[b]	3.53		
Spatial Memory Subtest	52	9.71[a]	3.63		
Object Memory Subtest	52	8.54[c]	3.08		

Note. Columns with differing superscripts differed significantly, Fisher's Least Significant Difference (LSD) test for pairwise multiple comparisons, $p < .05$.

NEPSY

A repeated measures ANOVA was conducted on the NEPSY measures using measure as the within subjects effect (see Table 15). Results revealed that the effect for measure was marginally significant, $F(2, 66) = 2.90$, $p = .06$, indicating that some mean responses on NEPSY measures differed with marginal significance. Fisher's Least Significant Difference (LSD) pairwise multiple comparisons were conducted to determine which mean scores differed from each other. As Table 15 shows, children's scores were significantly higher on the Memory for Faces measure (*M* = 10.41, *SD* = 2.46) than the Sentence Repetition Measure (*M* = 8.76, *SD* = 3.33, $p < .05$).

Table 15

Means and Standard Deviations for NEPSY

	N	Mean	*SD*	*F*	*p*
NEPSY Scores				2.90	.062
Memory for Faces Subtest	34	10.41[a]	2.46		
Narrative Memory Subtest	34	9.59[ab]	3.73		
Sentence Repetition Subtest	34	8.76[b]	3.33		

Note. Column means with differing superscripts differed significantly, Fisher's Least Significant Difference (LSD) test for pairwise multiple comparisons, $p < .05$

Primary Analyses

Hypothesis 1

The first hypothesis examined the mean scores on the visual memory subtests with a social component compared to the remaining visual memory subtests that were administered. In order to evaluate these scores for differences, a repeated measures ANOVA was conducted on the standardized scores for visual memory measures, including the NEPSY Memory for Faces Subtest, the UNIT Object Memory Subtest, and the UNIT Spatial Memory Subtest, using measure as the within subjects effect (see Table 16).

Table 16

Means and Standard Deviations of Standardized Scores for NEPSY Memory for Faces, UNIT Object Memory, and UNIT Spatial Memory

	N	Mean	*SD*	*F*	*p*
Visual Memory Subtests				.36	.701
NEPSY Memory for Faces Subtest	34	10.41	2.46		
UNIT - Object Memory Subtest	34	8.54	3.08		
UNIT - Spatial Memory Subtest	34	9.71	3.63		

The results revealed that the effect for measure was not significant, $F\,(2, 66) = .36, p = .70$. Children's standardized mean responses on visual memory measures the NEPSY Memory for Faces Subtest, the UNIT Object Memory Subtest and the UNIT Spatial Memory Subtest were not significantly different from each other.

Hypothesis 2

The second hypothesis predicted Symbolic Memory (UNIT) to have lower mean scores than Object Memory (UNIT) and Spatial Memory (UNIT) scores. A repeated measures ANOVA was conducted to examine these measures (UNIT Symbolic Memory, UNIT Object Memory, UNIT Spatial Memory), using measure as the within subjects effect (see Table 17).

Table 17

Means and Standard Deviations for UNIT Symbolic Memory, UNIT Object Memory, and UNIT Spatial Memory

	N	Mean	*SD*	*F*	*p*
UNIT Subtests Scores				7.38	.001
Symbolic Memory Subtest	52	10.29[a]	3.22		
Object Memory Subtest	52	8.54[b]	3.08		
Spatial Memory Subtest	52	9.71[a]	3.63		

Note. Column means with differing superscripts differed significantly, Fisher's Least Signficant Difference (LSD) test for pairwise multiple comparisons, $p < .05$.

Results revealed that the effect for the measure was significant, F (2, 102) = 7.38, $p < .001$, indicating that there were differences among the mean responses on the UNIT subtests. Pairwise multiple comparisons using Fisher's Least Significant Difference (LSD) were performed to determine which mean scores differed from each other. As displayed in Table 17, scores on the Symbolic Memory Subtest (M = 10.29, SD = 3.22) were significantly greater than scores on the Object Memory Subtest (M = 8.54, SD = 3.08, $p < .001$). Scores for the Symbolic Memory Subtest (M = 10.29, SD = 3.22), however, were not significantly different from mean scores for the Spatial Memory Subtest (M = 9.71, SD = 3.63, p = .17).

Hypothesis 3

The third hypothesis examined differences between the visual and auditory modalities, specifically, subtests measuring visual memory and subtests measuring auditory memory. In order to compare these scores, a repeated measures ANOVA was conducted on the standardized scores for the visual memory subtest scores and the auditory memory subtest scores, using measure as the within subjects effect (see Table 18). The results failed to reveal a significant effect for measure, F (8, 264) = .40, p = .92. As shown in Table 18, the standardized mean scores on auditory measures WJ-III Cog Numbers Reversed, WJ-III Cog Auditory Working Memory, WJ-III Cog Memory for Words, NEPSY Sentence Repetition, NEPSY Narrative Memory and mean responses on visual memory measures NEPSY Memory for Faces, UNIT Spatial Memory Subtest, UNIT Symbolic Memory, and UNIT Object Memory were not significantly different from each other.

Table 18

Means and Standard Deviations of Standardized Scores for Auditory Memory Subtests and Visual Memory Subtests

	N	Mean	*SD*	*F*	*p*
Auditory and Visual Memory Subtests				.40	.920
Auditory Memory					
WJ-III Cog - Numbers Reversed Subtest	34	99.6	17.16		
WJ-III Cog - Auditory Working Memory	34	101.32	15.33		
WJ-III Cog - Memory for Word Subset	34	100.40	14.21		
NEPSY Sentence Repetition Subtest	34	8.76	3.33		
NEPSY Narrative Memory Subtest	34	9.37	3.89		
Visual Memory					
NEPSY Memory for Faces Subtest	34	10.41	2.46		
UNIT - Spatial Memory Subtest	34	9.71	3.63		
UNIT- Symbolic Memory Subtest	34	10.29	3.22		
UNIT - Object Memory Subtest	34	8.54	3.08		

Hypothesis 4

The fourth hypothesis predicted a significant difference between mean scores for auditory memory tasks and auditory working memory tasks. Therefore, a repeated measures ANOVA was conducted using the standardized scores for the auditory memory subtest measures and the auditory working memory subtest measures, using measure as the within subjects effect (see Table 19). The results indicated that the effect for measure was not significant, $F(4, 132) = .70, p = .59$.

Table 19

Means and Standard Deviations of Standardized Scores for Auditory Memory Tasks and Auditory Working Memory Tasks

	N	Mean	*SD*	*F*	*p*
Cognitive Auditory Measures				.70	.593
Auditory Memory					
WJIII Cog - Memory for Words Subset	34	100.40	14.21		
NEPSY Narrative Memory Subtest	34	9.37	3.89		
NEPSY Sentence Repetition Subtest	34	8.76	3.33		
Auditory Working Memory					
WJIII Cog - Auditory Working Memory	34	101.32	15.33		
WJIII Cog- Numbers Reversed Subset	34	99.60	17.16		

As displayed in Table 19, the standardized mean scores on the auditory memory measures (WJ-III Cog Memory for Words, NEPSY Narrative Memory, NEPSY Sentence Repetition) and standardized mean responses on auditory working memory measures (WJ-III Cog Auditory Working Memory, WJ-III Cog Numbers Reversed) were not significantly different from each other.

Summary

In summary, results yielded no significant relationships between diagnosis, child gender, and age. Results failed to reveal significant differences between diagnosis (HFA vs. AS) on any of the dependent measures. All composite and subtest scores on the three measures fell within the average range. Scores ranged from 96 to 108 in standard scores. Scores within each measure were positively correlated. Children scoring high on each subtest had higher scores on the subsequent subtests and higher scores for the GIA. Working memory and auditory working memory subtests correlated positively with each other, as did the visual tasks on the UNIT. There were significant positive correlations between UNIT Symbolic Quotient scores and scores for all of the WJ-III Cog scores. The same was true for the Reasoning Quotient on the UNIT, the UNIT Full Scale IQ score, and all WJ-III Cog scores. Memory for Faces on the NEPSY did not significantly correlate with any of the scores on the UNIT or the WJ-III Cog measures.

With regard to hypothesis 1, results revealed that children's standardized mean responses on visual memory measures the NEPSY Memory for Faces Subtest, the UNIT Object Memory Subtest and the UNIT Spatial Memory Subtest were not significantly different from each other. With respect to hypothesis 2, scores on the Symbolic Memory Subtest were significantly greater than scores on the Object Memory Subtest. Scores for the Symbolic Memory Subtest, however, were not significantly different from mean scores for the Spatial Memory. Results for hypothesis 3 indicated the standardized mean scores on auditory measures WJ-III Cog Numbers Reversed, WJ-III Cog Auditory Working Memory, WJ-III Cog Memory for Words, NEPSY Sentence Repetition, NEPSY Narrative Memory and mean responses on visual memory measures NEPSY Memory for Faces, UNIT Spatial Memory Subtest, UNIT Symbolic Memory, and UNIT Object Memory were not significantly different from each other. Hypothesis 4 analysis indicated that the standardized mean scores on the auditory memory measures (WJ-III Cog Memory for Words, NEPSY Narrative Memory, NEPSY Sentence Repetition) and standardized mean responses on auditory working memory measures (WJ-III Cog Auditory Working Memory, WJ-III Cog Numbers Reversed) were not significantly different from each other. Overall, three out of four hypotheses failed to show significance.

CHAPTER V

DISCUSSION

In education, students with developmental differences face challenges that may not be fully appreciated or realized. Those with an autism spectrum disorder face these challenges on a daily basis, and a full appreciation of these challenges may lead to greater success for these students. Memory abilities are included in those potential challenges individuals with autism may face. This study examined performance on memory tasks utilizing the visual and auditory modalities of memory in an effort to further inform new research and interventions for those with autism. Instruments examined in this study included the Universal Nonverbal Intelligence Test (UNIT, Bracken & McCallum, 1998), NEPSY (NEPSY, Korkman, Kirk, & Kemp, 1998), and the Woodcock Johnson Test of Cognitive Abilities, 3rd edition (WJ-III Cog; Woodcock, McGrew, & Mather, 2001). Results, outlined below, indicated marginal to no significance for the stated hypotheses.

Between Subjects Analysis

The majority of participants in the study were Caucasian males with an average intellectual ability. A sample of 54 children diagnosed with a high-functioning autism spectrum disorder was included in the analyses. There were more males (87.0%) than females (13.0%), and the average age of participants was 11 years. The majority of the children were of Caucasian ethnicity (92.6%), less than 5% were African American (3.7%) and less than 5% were Hispanic (3.7%). Finally, approximately one fourth of the children included in the analyses had a prior diagnosis of High Functioning Autism (HFA; 25.9%) and the remaining 74.1% had a prior diagnosis of Asperger's Syndrome (AS). Repeated Measures ANOVAs were conducted on dependent cognitive measures. All the following analyses were initially conducted with Diagnosis (HFA vs. AS) as a between subjects factor. The results of these preliminary analyses yielded no significant differences between mean scores on the dependent measures for children with HFA vs. AS. Therefore, the primary analyses were conducted after collapsing diagnoses into one group: children with autism.

Analyses of Hypotheses

Difficulties with facial recognition, facial memory, and social communication have been noted in individuals with autism. As a result, the first hypothesis predicted lower mean scores on the visual memory subtests containing a social component as compared to the other visual memory subtests administered. Mean scores for Memory for Faces (NEPSY) were predicted to be significantly lower than mean scores for Object Memory (UNIT) and Spatial Memory (UNIT). Results yielded no significant differences between the mean standardized scores on the visual memory subtests that were theorized to have a social component as compared to the other visual memory subtests administered. Mean scores on the NEPSY Memory for Faces Subtest were not significantly different from mean scores on the UNIT Object Memory Subtest or the UNIT Spatial Memory Subtest. This is contradictory to information stated in the original NEPSY manual (Korkman, Kirk, & Kemp 1998), demonstrating lower performance from the HFA group on several subtests, including Memory for Faces, Narrative Memory, Comprehension of Instructions, Arrows, Imitating Hand Positions, and Visuomotor Precision. It also contradicts similar findings by Hooper, Poon, Marcus, and Fine (2006), Joseph and Tanaka (2006), and Schumann et al. (2004), whose findings suggested a deficit in Memory for Faces in an HFA group. Schumann et al. and Grandin (2000) suggested differences in the functioning of the amygdala, thereby causing impairments in facial recognition.

Results of the current study supported findings by Barton, et al. (2004), who found normal famous face recognition, normal perception of facial configuration, normal imagery for famous faces, and good performance on tests of face perception and memory in those with autism. Pierce, Muller, Ambrose, Allen, and Courchesne, (2001) found that those with autism see faces using different areas of the brain, individual to each person. Based on this data, these researchers suggested that experiential factors play a role in normal development of the fusiform face area (Pierce et al.). This suggested that greater exposure and experience with facial recognition would lead to better performance on these tasks.

In keeping with the hypothesis that individuals with autism have difficulties with social tasks, it was predicted that the Symbolic Memory subtest, as a social task, would demonstrate lower mean scores. The Symbolic Memory task is composed of tiles with visual representations of people on each tile. Specifically, the second hypothesis predicted a lower mean score for Symbolic Memory (UNIT) as compared to Object

Memory (UNIT) and Spatial Memory (UNIT). There were significant differences in mean scores on the UNIT Symbolic Memory, UNIT Object Memory, and UNIT Spatial Memory Subtests. Contrary to the prediction, however, mean scores on the UNIT Symbolic Memory Subtest were significantly higher than mean scores on the UNIT Object Memory Subtest. In addition, mean scores on the UNIT Spatial Memory Subtest were significantly higher than mean scores on the UNIT Object Memory Subtest. Mean scores on the UNIT Symbolic Memory Subtest were not significantly different from mean scores on the UNIT Spatial Memory Subtest. The results found here suggest that Symbolic Memory was not a more difficult task for the individuals with HFA or AS in this study.

Results of this study, in keeping with the literature, suggest a possible compensatory mechanism which those with autism utilize to recognize and process faces. This skill may be well developed in some individuals and not in others, therefore, creating variation in facial processing and recognition skills.

The fact that individuals with autism have difficulty maintaining visual attention leads to the prediction of stronger memory skills using the auditory modality as compared to the visual modality. The third hypothesis predicted a significant difference between mean scores on subtests utilizing the visual modality of memory and subtests utilizing the auditory modality. Specifically, higher mean scores were predicted for Numbers Reversed (WJ-III Cog), Auditory Working Memory (WJ-III Cog), Memory for Words (WJ-III Cog), Sentence Repetition (NEPSY), and Narrative Memory (NEPSY) as compared to the mean scores for Memory for Faces (NEPSY), Spatial Memory (UNIT), Symbolic Memory (UNIT), and Object Memory (UNIT). No significant differences were found between mean scores on the various tasks comparing the visual and auditory modality.

Results were aligned with findings by Sanders (2007), which showed that, although a general memory dysfunction was present in participants with autism, those with autism performed similarly to a control group on tasks of object recall, location memory, delayed selective reminding of words, and delayed facial memory. The results failed to support findings by Boucher (1981) and Bowler et al. (1997), which showed those with a general autism diagnosis performed lower on various aspects of an auditory memory recognition task. Boucher and Lewis (1989) also found that the ability to recall heard speech (tested using a short story recall task) after a short delay, and the ability to act immediately on that speech, was impaired in those with autism. Given the results of the current study, it can be proposed that one modality of memory is not more challenging than the other for those with an HFA or AS diagnosis.

Resulting from the theory that auditory working memory requires more mental manipulation of material than short term memory and is therefore more difficult, the fourth hypothesis predicted a significant difference between mean scores for auditory short term memory tasks and auditory working memory tasks. Specifically, mean scores for the subtests, Auditory Working Memory (WJ-III Cog) and Numbers Reversed (WJ-III Cog) were predicted to be lower than the subtests of Memory for Words (WJ-III Cog), Narrative Memory (NEPSY), and Sentence Repetition (NEPSY). Results indicated that mean scores for auditory short term memory tasks and auditory working memory tasks as defined in this study were not significantly different. In other words, mean standardized scores for the WJ-III Cog Memory for Words Subtest, WJ-III Cog Narrative Memory Subset, NEPSY Sentence Repetition Subtest, WJ-III Cog Auditory Working Memory Subset and WJ-III Cog Numbers Reversed Subset were not significantly different from each other. Given the similarity of these scores, it can be suggested that working memory and short term auditory memory do not appear to be distinct skills but rather similar or overlapping constructs. More research is needed in this area.

Limitations

In addressing the limitations of this study, the first factor to consider is the definition of terms used in this study. Short-term memory and working memory were examined and divided into auditory and visual modalities. Various subtests require a higher degree of mental manipulation of material and may involve more working memory than other tasks that are pure recall. Some tasks appear to involve both skills. Memory is a large area of study that is still being conceptualized. It affects every area of learning and performance and continued study in this field is needed.

Another issue with definitions exists in the literature on HFA and AS, which may have influenced these results. There is a controversy regarding diagnosis of HFA and AS and whether they are on the autism spectrum or separate disorders. Ruble (2004) reiterates that autism spectrum disorders are diagnosed based on behaviors rather than medical tests and that these disorders affect children differently, often resulting in two children meeting different combinations of the diagnostic criteria. This contributes to the nebulous distinction between the two disorders.

Another limitation is the vast amount of literature focusing on autism. Thousands of articles have been written over the past ten years and much of the evidence is conflicting, making it difficult to arrive at logical definitive conclusions. For example, impaired facial processing is attributed to autism, but in some studies it is also connected to Asperger's syndrome. The definition of each disorder, having slight variations across studies, influences those findings.

Characteristics related to the participants serve as additional limiting factors in this study. Although the sample size used is considered fairly large for studies involving autism, the number presented limitations in statistical analysis and the diagnoses had to be collapsed into one. The sample loaded heavily on a larger number of Caucasian males diagnosed with AS as compared to HFA, thereby influencing results. Autism is found across cultures around the world, however, the sample size was limited to Caucasian males; therefore results of this study cannot be generalized to cultures or ethnicities not included in this study. Additionally, certain information about the participants was not obtained, such as level of social skills training and age of diagnosis, which may have provided information as to the amount of therapy or coping skills the child has been taught. The longer a child has carried the diagnosis increases the possibility that they have been taught coping or compensatory skills. The current study depended on others' definitions and diagnoses of the participants as a starting point for analysis. Participants were screened for inclusion in the study by having parents submit documentation that their child had been diagnosed with a high functioning autism spectrum disorder by a psychiatrist, physician, or licensed psychologist. However, a closer look at the documentation later revealed a significant difference in the diagnostic tools used by the various professionals, thus leaving in question the accuracy of the participants' diagnoses.

Future Research

In pursuing new directions with this research, inclusion of additional variables in the study such as level of social skills training may be beneficial. Additionally, comparing performance on these memory tasks to classroom performance on tasks that are similar may provide valuable information. For example, comparing the Memory for Faces task and the ability to recognize emotion in a group of individuals and appropriately respond in a communicative fashion may contribute to new curriculum ideas for social skills instruction. Measuring facial recognition and memory using photographs as compared to line drawings may provide information as well. Finally, further research may benefit from larger and broader samples including a wider range of gender and ethnicities.

Implications for School Psychologists

Results of this study emphasize the importance of considering each student on an individual basis when conducting any assessment. One measure cannot be used as a sole diagnostic tool in making any diagnosis, but rather as part of a full battery of tests specifically geared toward the specific student's concerns. For example, participants with autism in this study performed in the average range with respect to memory measures and did not display deficits. Assumptions cannot be made however, that all students with autism perform in the average range with respect to memory. Additionally, average scores may be obtained, but this may not necessarily indicate average skills in every case. Other means of gathering information must be utilized to confirm any findings.

Results of this study can also be used to further inform interventions for students with autism. Interventions currently used in the school setting include visual strategies such as visual schedules, picture communication methods, and use of computers, among many. Strategies to enhance visual facial and emotion recognition include social skills training, use of stories and scripts to address social situations (Gray, 2000), direct instruction in emotion recognition, and video modeling (Bellini & Akullian, 2007).

Various interventions have been utilized to address memory difficulties using the auditory modality. Mnemonic strategies, visual tools, verbal repetition, and use of multisensory learning strategies have been utilized in the school setting to address memory issues as well. Training in social skills is a widely used intervention for students with autism that addresses deficits in the verbal and nonverbal realm, using visual and auditory modalities. Bellini (2006) advocates the use of pictures and videos to read emotions, "if-then" statements (p. 130), reciprocal interaction activities, and the use of role play and behavioral rehearsal strategies.

Recommendations for memory improvement include increasing a student's attention using visual aids and activities, and reinforcing positive behavior. Encouraging the use of external tools such as a portable handheld devices, assignment notebooks, or calendars can facilitate memory improvement. Enhancing meaningfulness of the material and using pictures, photographs, or videos can assist in learning and memory. Additional strategies such as avoiding extraneous information, encouraging active manipulation of materials, encouraging active thinking and reasoning, and increasing practice time can assist in compensating for memory impairments (Mather & Jaffe, 2002).

Additional accommodations suggested by Mather and Jaffe (2002) include limiting complexity of information presented, writing steps of instructions on the chalkboard, using visual illustrations, encouraging student to write steps on paper and check off as completed, and using a peer to assist the student in completing steps of an assignment. Frequent repetition, review of material, and emphasis on comprehension are also suggested (Mather & Jaffe).

Summary

Memory and learning are intertwined to the point that it is difficult to isolate areas of the brain based on each separate function. Both abilities are attributed to permanent changes in neuronal synapses (Matlin, 1998). Given that these physiological differences have been shown in those with AS and HFA, it is important to examine whether the corresponding memory functions are also impaired or different. Results from this study appear to fall into the mixed literature, presenting conflicting evidence of memory impairment in some areas, but typical memory functioning in other areas. As compared to the other memory tasks in the study, memory for faces (as it is measured and defined in this study) does not appear to be impaired, which contradicts the majority of literature cited. Also, visual and auditory modalities of memory, as they are measured in this study, do not appear to differ.

Given the results of this study, despite a failure to confirm the stated hypotheses, it is important to work with a student's strengths, whether it be visual or auditory memory, as it has been shown that some individuals are impaired in one modality or another. Memory and learning are so closely related that memory function is vital to assess, and intervention or training may be necessary. This is especially true in the areas of social skills and facial processing ability in those with an autism spectrum disorder. Teaching facial recognition skills and how they are related to social communication is important in order to encourage generalization to situations in the school, home, and community.

Another important piece to consider in working with students with an ASD is the nebulous nature of the diagnosis. School psychologists are encouraged to monitor the progress of research in this area so as to be informed of evolving definitions and new interventions for these students.

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