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Academic Abilities in Children and Adolescents with a History of Autism Spectrum Disorders Who Have Achieved Optimal Outcomes

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Academic Abilities in Children and Adolescents with a History of Autism Spectrum Disorders Who Have Achieved Optimal Outcomes

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Autism Spectrum Disorders (ASDs) are a group of neurodevelopmental disorders that affect as many as 1 in 150 children (Centers for Disease Control [CDC], 2006; Fombonne, Zakarian, Bennett, Meng, & McLean-Heywood, 2006), and are characterized by deficits in communication and socialization, as well as by the presence of repetitive and stereotyped behaviors (American Psychiatric Association [APA], 2000). Although ASDs are considered by many to be life-long conditions, several studies have indicated that a small percentage of individuals who are diagnosed with an ASD early in childhood respond particularly well to early intensive intervention and experience a reduction in autism symptomatology to such a degree that they no longer meet diagnostic criteria for any ASD as they get older.

"Recovery" From Autism Spectrum Disorders

Lovaas (1987) initially introduced the phenomenon of "recovery" when reporting the results of a study investigating an early, intensive, behavioral intervention program for ASDs. Lovaas described the outcomes of 19 children who received his intervention program and found that the cognitive functioning of nine of these children fell in the average range after receiving the intervention and described their outcome as "recovered." The term "recovery" in this context suggests not only a loss of the behavioral characteristics of ASDs, but also a complete return to normal functioning (Helt et al., 2008; Mundy, 1993; Sallows & Graupner, 2005). However, the lack of research examining the functioning of children who lost their ASD diagnosis as they grew older is far too limited to allow for any conclusions to be drawn about whether residual social, cognitive or linguistic deficits exist in this group. As it is somewhat premature to use the term "recovery" at this point, the term "OO (OO)" will be used instead to refer to individuals who achieve such an outcome.

A number of recent studies investigating the effect of an early intensive behavioral treatment for ASDs have provided support for Lovaas' (1987) initial report. These studies reported that a small number of participants responded particularly well to treatment and performed in the average range on some outcome measures by the conclusion of the study (Cohen, Amerine-Dickens, & Smith, 2007; Harris & Handleman, 2007; Sallows & Graupner, 2005; Weiss, 1999; Zachor, Ben-Itzchak, Rabinovich, & Lahat, 2007). The percentage of children reportedly achieving OO at follow-up varied considerably across studies, as did the measures used to assess outcomes. These ranged from almost half of the sample being included in regular education classrooms, speaking fluently and exhibiting average cognitive, adaptive and academic skills (Sallows & Graupner, 2005), to 21 percent of the sample not meeting diagnostic criteria for any ASD (Zachor et al., 2007).

Reports of OO have also been confirmed by several longitudinal studies that have followed children diagnosed with ASDs to examine outcome in middle childhood and adolescence. These studies have reported that a small percentage of the participants with ASDs within their cohort lost their ASD diagnoses by the conclusion of the study (Fein, Dixon, Paul & Levin, 1999; Sigman & Ruskin, 1999; Stevens et al., 2000; Venter, Lord, & Schopler, 1992). Sigman and Ruskin (1999) reported that 10 percent of their sample lost their ASD diagnosis approximately nine years after receiving the diagnosis. Fein and colleagues (1999) and Stevens and colleagues (2000) followed a group of preschool children with an ASD diagnosis for 8 years and found that 25 percent of their sample exhibited few symptoms of autism and performed in the average range on measures of verbal and nonverbal reasoning. Similarly, Venter and colleagues (1992) followed high-functioning children, adolescents and young adults with autism

over 8 years and reported that 22 percent of the sample was included in regular education classrooms with limited or no supports.

Adult outcome studies of high-functioning individuals with a history of ASDs have also provided documentation of OO (Howlin, Goode, Hutton, & Rutter, 2004; Rutter, 1970; Seltzer et al., 2004; Szatmari, Bartolucci, Bremner, Bond, & Rich, 1989; Venter et al., 1992). In 1970, Rutter reported that 1.5% of his original adult sample was functioning "normally" at the time of follow-up. Szatmari and colleagues (1989) provided another compelling documentation of OO in a follow-up study of adults. In this sample 50 percent of the sample scored in the average range on measures of adaptive functioning, 25 percent of the sample no longer met diagnostic criteria for ASDs when reassessed between 11-27 years after initially being diagnosed with an ASD.

Several important criticisms have been voiced in response to the OO reports described above. The core symptoms of ASD generally tend to improve by the time that an individual reaches adulthood and because the definition used to categorize participants as having achieved "good" outcomes has been inconsistent across studies, it has been argued that reports of OO are not compelling enough to suggest that children could grow out of an ASD diagnosis (Seltzer et al., 2004). Additionally, because standardized diagnostic measures were not used regularly to ensure the accuracy of the early diagnosis in many of the studies mentioned above, it remains unclear whether individuals who were correctly diagnosed with an ASD truly lost that diagnosis as they grew older. Furthermore, many of the studies described above have used average IQ scores and placement in regular-education classrooms as indicators of OO. Some argue that these criteria do not rule out the possibility that these children continue to exhibit symptoms of

ASDs and exhibit social and communicative problems (Charman & Howlin, 2003; Mundy, 1993).

In response to these criticisms, Helt and colleagues (2008) provided a thorough review of reports of OO and indicated that between 3 and 25 percent of children diagnosed with ASDs lose their diagnoses and exhibit average abilities within the cognitive, adaptive and social range. The authors argued that misdiagnosis of ASD is unlikely to be a factor in OO because of the extensive similarity in the presentation of ASD symptoms between children who later lose their ASD diagnosis and those who retain the diagnosis. Instead, Helt and colleagues (2008) suggested that OO may be limited to some forms of ASDs in which symptoms diminish as the individual matures or to cases in which successful early intensive treatment is combined with some pre-existing characteristics of the child.

Residual Deficits in Children with OO

In an effort to address questions raised about individuals who achieve OO and to examine the current functioning of these children, researchers have begun to design studies to focus on this group of children. A study by Fein and colleagues (2005) described several children diagnosed with Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS) in early childhood, who lost their ASD diagnoses by middle childhood, instead meeting diagnostic criteria for ADHD at re-evaluation. While these children no longer met diagnostic criteria for ASD, some of them continued to exhibit perseverative interests and occasional repetitive motor movements, as well as mild social difficulties. The authors suggested that attention difficulties may be a core feature of ASDs that is more difficult to address with early behavioral intervention.

In addition, several studies conducted at the University of Connecticut have used standardized assessment measures to examine a group of children who achieved OO and confirmed that these children did not exhibit behavioral symptoms necessary for an ASD diagnosis (Kelley, Paul, Fein, & Naigles, 2006; Kelley et al., 2010; Sutera et al., 2007). Sutera and colleagues (2007) presented the results of a longitudinal study describing the outcomes of 13 preschoolers who were diagnosed with an ASD at the age of 2 years but did not meet diagnostic criteria for any ASD when they were re-evaluated approximately two years later. Sutera and colleagues (2007) reported that the children who achieved an OO were more likely to have received an initial diagnosis of PDD-NOS, rather than Autistic Disorder, and exhibited significantly better developed motor abilities at age 2 than did children who retained their ASD diagnosis. The authors speculated that in this young sample, motor skills may have reflected underlying cognitive abilities or the extent of neurological impairment. Aside from these differences, at the age of 2 years, children who went on to achieve OO performed similarly to children who retained their ASD on measures of cognitive functioning, adaptive skills, expressive or receptive language ability, socialization ability or severity of ASD symptomatology.

In a series of studies, Kelley and colleagues (2006, 2010) sought to uncover the presence of any residual deficits among children who achieved OO by evaluating cognitive, adaptive, social and communicative functioning among children who were initially diagnosed with ASDs by professionals specializing in ASDs. In the first of these studies, Kelley and colleagues (2006) evaluated the language abilities of 14 children between the ages of 5 and 9 years, with a history of ASDs who achieved OO. All of the children were diagnosed with ASDs as toddlers and at the time of the study exhibited average IQ scores, were mainstreamed into age-appropriate

classrooms, were functioning at age-appropriate levels according to the report of the children's parents and teachers, and no longer met diagnostic criteria for any ASD. The OO group demonstrated residual difficulties on measures of pragmatic and semantic language, particularly in understanding second order theory of mind, using of mental state verbs, producing a narrative and using of inductive reasoning about animate objects.

In the second study, Kelley and colleagues (2010) described the functioning of 11 children included in her first study and two additional participants, all of whom were aged 8-13 years, had average IQs, were mainstreamed in regular classrooms without any extra assistance, did not meet diagnostic criteria for an ASD and were not classified as having an ASD according to the school system. As part of this study, the authors compared the performance of the OO group on measures of ASD symptomatology, cognitive, adaptive, social and communicative functioning, as well as expressive and receptive language, to typically developing peers and high-functioning peers with a current ASD diagnosis. The OO group exhibited more difficulties with attention than typically developing peers, but otherwise did not differ on any other measure included in the study, including pragmatic language ability.

The inconsistency in the results regarding pragmatic language ability between the two studies conducted by Kelley and colleagues (2006, 2010) may be attributed to different measures used to assess these skills. Specifically, the earlier study used a series of tasks to examine comprehension of second order theory of mind, use of mental state verbs, production of a spoken narrative and the use of inductive reasoning. The later study assessed pragmatic language by including a standardized measure evaluating the ability to make inferences and comprehend figurative language, as well as a more global standardized measure of pragmatic language ability. It is also possible that the inconsistencies in the findings related to the older sample of

children who achieved OO included in the later study, which would suggest that pragmatic language abilities may improve among children who achieve OO as they age.

Academic Functioning of Children who Achieve OO

The research conducted thus far suggests that there is a small group of children who achieve OO, who are fully included in a regular education classroom, some receiving minimal, if any, special education supports (Cohen et al., 2005; Fein et al., 2005; Granpeesheh et al., 2009; Harris & Handleman, 2000; Howlin et al., 2004; Kelley et al., 2006, 2010; Lovaas, 1987; Sallows & Graupner, 2005; Seltzer et al., 2004; Weiss, 1999). Given the tendency for some school districts to attempt to include all children in regular education classrooms unless they are severely impaired, it is possible that children and adolescents who achieved OO may be exhibiting mild or moderate impairments in academic skills that may warrant specialized intervention. These impairments may interfere with these individuals' abilities to meet academic requirements set forth by the No Child Left Behind Act of 2001 and to eventually succeed in the work force.

Our knowledge of the academic abilities of this group remains rather limited. Of all of the studies investigating OO among children and adolescents with ASD described above, only two included any standardized measures of academic functioning (Butter et al., 2006; Sallows & Graupner, 2005). These studies reported performance in the low average to average range on standardized measures of achievement, but both include noteworthy limitations (Butter et al., 2006; Sallows & Graupner, 2005). Sallows and Graupner (2005) reported average performance on a standardized measure of academic achievement assessing reading, arithmetic and spelling among a group of 7-year-old children who achieved OO. The authors did not include measures of written expression. Butter and colleagues (2006) used retrospective methods to describe

outcomes of eight preschool to elementary school aged children who previously met diagnostic criteria for an ASD and mental retardation, but no longer met diagnostic criteria for either disorder. These eight children scored in the low average to average range on an academic achievement composite. However, the authors did not report which academic abilities were assessed; consequently, it remains unclear whether any residual difficulties were noted within any single academic domain. Furthermore, both studies focused on preschool to elementary school ages, an age at which academic tasks tend to rely on rote abilities, which are typically a relative strength among children with ASDs (Minshew, Goldstein, Muenz, & Payton, 1992; Wing, 1981). Therefore, these results may provide limited insight on how children who achieve OO would perform on academic tasks as these children age and the tasks become more complex and less concrete.

While Kelley and colleagues (2006) did not include any standardized measures of academic functioning in their study of OO, measures assessing spoken narrative ability were included and provide some insight into the ability of this group to produce written narratives. Children who achieved OO and were between the ages of 5 and 9 were asked to narrate the events of a wordless picture book. The results indicated that children who achieved OO performed similarly to typically developing peers on general lexical variables and grammatical variables, but were significantly less likely to provide causal explanations for the events in the story. Additionally, children in the OO group were less likely to include the goals and motivations of the characters and were more likely to misinterpret the story and include erroneous information in the narrative. Again, this study focuses on elementary to middle school aged children; however, these results suggest that older children and adolescents who achieve OO may continue to exhibit difficulty in producing narratives in written form.

Given the limited research investigating difficulties in the academic domain among children and adolescents who achieve OO, it is important to examine academic functioning in this group in more detail. We would expect that if any residual deficits in academic functioning are present, they are most likely to affect the domains that are known to be weak in similarly aged children and adolescents who are also included in regular education classrooms and exhibit average cognitive abilities, but continue to exhibit symptoms of ASD and retain their ASD diagnosis.

Academic Abilities of High-Functioning, School-Aged Children with ASDs

Some adolescents with ASDs perform at or above grade level academically, are included in regular education classrooms and are referred to as having high-functioning autism (HFA) or Asperger's Syndrome (AS). Currently there is no clear distinction between HFA and AS in the literature (Mayes & Calhoun, 2001; Eisenmajer et al., 1998; Klin, McPartland, & Volkmar, 2005; Manjiviona & Prior, 1999; Mayes, Calhoun, & Crites, 2001; Schopler, 1998; Szatmari, 1991, 1992; Volkmar & Klin, 1998). In fact, partially as a result of this lack of distinction, the editors of the fifth revision of the DSM have proposed to include AS and HFA within a single ASD diagnostic category (Lord, 2009). Therefore, for the purpose of this paper the term HFA will be used to refer to individuals with any ASD, including AS, who perform at or above grade level academically and are included in regular education classrooms.

Studies investigating deficits in academic abilities among school-aged children with HFA have found that these abilities generally fall in the average range (Mayes et al., 2000; Mayes & Calhoun, 2003a, 2003b). However, some studies have indicated relative weaknesses in the areas of reading comprehension, written expression and ability to solve mathematical problems (Griswold, Barnhill, Myles, Hagiwara, & Simpson, 2002; Mayes & Calhoun, 2003a, 2003b;

Myles, Barnhill, Hagiwara, Griswold, & Simpson, 2001; Wahlberg & Magliano, 2004). Many researchers have suggested that these weaknesses reflect previously identified deficits associated with ASDs, including social and communication deficits, circumscribed interests, difficulties with inferring meaning, comprehension of ambiguity and abstract concepts, as well as the ability to discern relevant from irrelevant information (Attwood, 1998; Dennis, Lazenby, & Lockyer, 2001; Griswold et al., 2002; Happe, 1994, 1995, 1997; Jolliffe & Baron-Cohen, 1999; Jones et al., 2009; Kaland, et al., 2002; Myles & Southwick, 1999; Tager-Flusberg, 1981; Wahlberg & Magliano, 2004).

Studies examining reading ability in high-functioning children and adolescents with ASDs have found proficient reading accuracy, but have identified reading comprehension as an area of relative weakness (Church et al., 2000; Dennis et al., 2001; Goldstein, Minshew, & Siegel, 1994; Happe, 1994, 1995, 1997; Jolliffe & Baron-Cohen, 1999; Jones et al., 2009; Mayes & Calhoun, 2003a; Minshew, Goldstein, & Siegel, 1995, 1997; Myles et al., 2001; Myles et al., 2002; Nation, Clarke, Wright, & Williams, 2006; Snowling & Frith, 1986; Venter et al., 1992; Wahlberg & Magliano, 2004). A multitude of studies indicate that individuals with HFA are more likely to interpret language too literally, have trouble understanding idioms, figures of speech and metaphors, have difficulty inferring intentions of characters in a narrative and are often unable to construct causal inferences between story events (Attwood, 1998; Happe, 1994, 1995, 1997; Jolliffe & Baron-Cohen, 1999; Kaland et al., 2002; Myles & Southwick, 1999; Tager-Flusberg, 1981).

Several studies have examined deficits in written expression among high-functioning children with ASDs (Eigsti & Bennetto, 2009; Griswold et al., 2002; Mayes & Calhoun, 2003a, 2003b, 2006, 2008; Myles et al., 2001). Studies examining academic achievement in a group of

school-aged, high-functioning children with ASDs have reported significantly lower scores on measures of written expression than would be expected given the participants' IQ and other academic scores (Mayes & Calhoun, 2003a, 2003b, 2008). Differences in the ability to detect grammatical errors have been found when comparing high-functioning school-aged children with ASD to typically developing peers, particularly among children aged 9 to 13 years (Eigsti & Bennetto, 2009). Furthermore, the prevalence of a specific learning disability in written expression appears to be more than four times higher among high-functioning children with ASD than in the general population (Mayes & Calhoun, 2003a, 2003b, 2006, 2008).

Several explanations have been proposed to explain difficulties with written expression among children and adolescents with HFA. It is possible that the impairments in social cognition that are commonly exhibited by individuals with HFA, interfere with the writer's ability to have a sense of the audience (Jones et al., 2009; Lindstrom, 2007; Mayes & Calhoun, 2003a). Individuals with HFA tend to exhibit fine motor deficits and motoric clumsiness throughout their lifespan (Eisenmajer et al., 1996; Hardan, Kilkpatrick, Keshavan, & Minshew, 2003; Mayes & Calhoun, 2008; Minshew, Goldstein, & Siegel, 1997; Noterdaeme, Mildenberger, Minow, & Amerosa, 2002). Fine motor skills and motor sequencing play an essential role in the ability to compose a written passage and any deficit or delay in these abilities are likely to make writing more difficult. Additionally, students with HFA often exhibit impairments in a group of frontally-mediated abilities referred to as executive functions. These skills include attention, inhibition, monitoring, strategy, planning and organization (Dawson, Meltzoff, Osterling & Rinaldi, 1998; Pennington & Ozonoff, 1996) and are imperative for producing well-developed compositions. Consequently, impaired executive functioning is also likely to contribute to deficits in written expression.

Few studies have employed standardized measures to examine mathematical abilities among high-functioning children with ASD (Chiang & Lin, 2007; Griswold et al., 2002). The studies that have included standardized measures have reported that mathematical ability generally falls in the average range among children with high-functioning ASD (Chiang & Lin, 2007; Church et al., 2000; Griswold et al., 2002; Mayes & Calhoun, 2003a, 2003b). However, some reports have suggested the presence of a significant, but clinically modest relative weakness in mathematical achievement (Chiang & Lin, 2007; Griswold et al., 2002; Mayes & Calhoun, 2006). According to some measures, the rate of dyscalculia may be more than three times higher among children with HFA than in the general population (Mayes & Calhoun, 2003a, 2003b, 2006; Shalev & Gross-Tsur, 2001). Problem-solving ability in this population may be a specific area of relative weakness (Myles et al., 2001; Myles & Simpson, 2003; Griswold et al., 2002). These relative weaknesses in problem-solving ability may result from inattention, impaired ability to understand abstract concepts and difficulty processing auditory information; all are common deficits seen in children with HFA (Attwood, 1998; Fein et al., 2005; Schuler, 1995; Wing, 1981).

Current Study

The current study aims to examine the academic abilities of a group of children and adolescents who have a history of ASDs, but who no longer meet diagnostic for these disorders. Specifically, this study will investigate reading, writing, and arithmetic problem solving abilities of individuals who achieve OO in an effort to identify residual difficulties and outline needs for continued intervention. In order to accomplish this goal, performance of children who achieve OO on measures of academic ability will be compared to children of similar ages and cognitive functioning who have retained their ASD diagnosis, as well as typically developing peers.

The authors predict that individuals who achieve OO will exhibit residual deficits in reading comprehension, written expression and mathematical problem solving that are not evident among typically developing peers. Additionally, it is predicted that children who achieve OO will perform better than children who have retained their ASD diagnosis on measures of these academic domains. Previous research has consistently identified these domains as areas in which high-functioning, school-aged children and adolescents with ASDs exhibit relative weaknesses. Therefore, these difficulties may continue to persist to some degree despite the gains made by the individuals who achieve OO.

The current study will also examine relationships between academic domains in which significant group differences are identified and performance on measures of cognitive ability, and, when justified by previous literature, ASD symptomatology, comprehension of metaphorical language and inference making skills. Exploring their relationships will assist in clarifying the skill areas that contribute to group differences and outline potential areas in need of intervention. The authors predict that a positive relationship will be found between academic skills and cognitive ability, such that increases in verbal ability will be associated with higher reading comprehension and written expression scores, while increases in nonverbal ability will be associated with higher mathematical problem solving scores. Previous research suggests that deficits in the core features of ASD, specifically communication and socialization skills, may interfere with the participants' ability to comprehend social processes in reading and appreciate the audience when writing. Consequently, the authors predict that increases in ASD symptomatology will be associated with lower scores on reading comprehension and written expression tasks. Finally, because understanding metaphorical language and inference making are essential in reading comprehension and written expression, the authors predict finding a

positive relationship between scores on metaphorical language and inference making, and reading comprehension and writing.

Methods

Sample and Participant Selection

Performance of 30 children and adolescents who achieved OO (OO), 30 high functioning individuals with a current ASD diagnosis (HFA), and 23 typically-developing peers (TD) were compared on standardized measures of reading and mathematical problem solving (See Table 1 for characteristics of this sample). The individuals included in the study were between the ages of 8 years, 5 months and 21 years, 7 months. The participants were predominantly Caucasian, with the exception of only three participants in the TD group, three participants in the OO group and one participant in the HFA group. The groups were matched on age ($F(2,80) = 1.21$, $p = .30$), sex ($\chi^2(2, N = 82) = 3.30$, $p = .19$) and nonverbal IQ ($F(2,80) = 0.23$, $p = .80$). However, the groups differed significantly on verbal IQ ($F(2,80) = 4.08$, $p = .02$), with the HFA group scoring significantly lower than the OO and TD groups (Tukey: $p = .03$, $p = .04$, respectively), while performance of the OO and TD groups did not differ significantly from each other. Additionally, the groups differed significantly on measures of adaptive communication ($F(2,77) = 8.01$, $p < .001$) and socialization skills ($F(2,77) = 44.7$, $p < .001$), as well as activities of daily living ($F(2,77) = 8.71$, $p < .001$). The Tukey test revealed that the HFA group scored significantly lower that the OO group on all three subtests (all p's $< .001$) and scored significantly lower than the TD group on the subtests measuring adaptive socialization ($p < .001$) and activities of daily living ($p = .01$). Scores of received by the participants in the TD and OO groups did not differ significantly from each other.

Finally, the groups differed significantly on both the Communication and Socialization score of the Autism Diagnostic Observation Schedule (ADOS; Communication: $F(2,80) = 78.86$, $p < .001$; Socialization: $F(2,80) = 125.32$, $p < .001$). Post-hoc analyses using the Tukey test revealed that the HFA group exhibited significantly more behaviors consistent with the ASD diagnosis than the OO and HFA groups (both *p's* <.001). Post-hoc analyses also indicated that the OO group scored similarly to the TD group on the Communication score ($p = .94$), but exhibited significantly higher scores within the socialization domain than the TD group ($p = .04$). It is important to note that the average score received on the Socialization score by the OO group was 1.43, which does not meet the cutoff for ASD on this measure (scores at or above 4 fall in the autism spectrum range, while scores at or above 6 fall in the Autistic Disorder range).

Additionally, 24 of the individuals who achieved OO described above completed a standardized measure of written expression. Their performance was compared to 21 individuals with HFA and 19 TD peers who completed the same measure (See Table 2 for characteristics describing this subsample). The standardized measure used to assess writing ability for this study was developed for use in individuals younger than 17 years, 11 months of age; consequently, six participants who were older than 17 years, 11 months were excluded from these analyses. As with the larger sample, the groups included in this subsample were also matched on age ($F(2,61) = 0.83$, $p = .44$), sex ($\chi^2(2, N = 64) = 1.88$, $p = .39$) and nonverbal IQ ($F(2,61)=0.83$, $p = .44$). The groups differed significantly on verbal IQ ($F(2,61)=4.20$, $p = .02$), with the HFA group scoring significantly lower than the OO (Tukey: $p = .04$) and TD groups (Tukey: $p = .03$). The groups received significantly different scores on measures of adaptive communication ($F(2,61) = 5.76$, $p = .01$) and socialization skills ($F(2,61) = 28.38$, $p < .001$), as well as activities of daily living ($F(2,61) = 4.78$, $p = .01$). The Tukey test revealed that the HFA

group scored significantly lower that the OO group on all three subtests (Communication: p =.01; Socialization: p =.02; Daily Living: p <.001) and scored significantly lower than the TD group on the adaptive socialization (p <.001) and activities of daily living subtests (p =.03). According to the Tukey test, scores received by the participants in the TD and OO groups did not differ significantly from each other. Similarly to the larger sample, the three groups differed significantly on the Communication and Socialization scores of the ADOS (Communication: $F(2,80) = 55.64$, p <.001; Socialization: $F(2,80) = 79.55$, p <.001), with HFA group exhibiting significantly more behaviors consistent with the ASD diagnosis than the OO and HFA groups (both p's <.001). Post-hoc analyses also indicated that the OO group scored similarly to the TD group on the Communication score (p = .98), while the difference in the Socialization score between the OO and TD groups approach significance (p = .05).

All participants were enrolled as part of the "Language Functioning in OO Children with a History of Autism" study at the University of Connecticut, approved by the university's Institutional Review Board. Participants were recruited through advertisements posted in schools, newspapers, online forums, and at conferences. The principal and co-investigators also referred children from their private practices, as did a prominent ABA therapist in Massachusetts. Additionally, children were referred from the University of Connecticut's Psychological Services Clinic and from other ongoing studies at the University of Connecticut and Hartford Hospital's Institute of Living.

Enrollment criteria

To be included in the OO group:

(1) Participants had to be between the ages of 8 years and 21 years, 7 months.

(2) Participants had to establish a history of an ASD diagnosis. Parents of the

participants had to provide a written report that described an ASD diagnosis made before the age of 5 by a specialist in the field of ASDs (i.e. psychologist, neurologist or psychiatrist who evaluated and diagnosed at least 100 children with ASD prior to the evaluation of the participant.

(3) To confirm the child's early diagnosis, the written report was then edited to remove all references to the child's diagnosis and to recommendations for further testing and services, and was reviewed by an expert in the field of ASDs who was blind to group membership. The description of behavior and history were left in the report, and the blinded expert confirmed or disconfirmed the appropriateness of the behavior and history for a diagnosis of ASD. Reports from the OO group were interspersed with foil reports of children with non-ASD diagnoses of the same age. The reviewer was given a total of 35 reports of participants who appeared appropriate for the OO group after the phone screening. In addition, the reviewer was provided with 18 reports of children who did not have an ASD diagnosis. Of these, the reviewer rejected four potential participants for the OO group and all 18 children who did not have an ASD diagnosis.

(4) An evaluation of the participants' current functioning had to confirm the absence of ASD symptoms. Specifically, participants were included if they did not meet criteria for any Pervasive Developmental Disorder according to the Autism Diagnostic Observation Schedule (ADOS; did not meet the cutoff on the Socialization + Communication Total Score) and clinical judgment. Three participants who received the evaluation were excluded from the study because clinical judgment suggested the presence of residual ASD symptoms.

(5) Participants had to perform in the average range on standardized measures of

cognitive and adaptive functioning. Specifically, the verbal, performance and full scale IQs could not fall lower than 1.5 standard deviations from the mean (i.e. score of 78 or above on the Wechsler Abbreviated Intelligence Scales). Likewise, scores on socialization and communication subtests of an adaptive functioning measure could not fall more than 1.5 standard deviations below the mean (i.e. 78 or above on the Vineland Adaptive Behavior Scales). Two additional participants were excluded from this study because their cognitive functioning or adaptive skills did not fall in the average range.

(6) Participants had to be included in a regular education classroom with very limited support or special education services to address impairments not specific to ASDs, including learning disorders (e.g., no more than one hour weekly). Children in this group were allowed to receive speech and language therapy for no more than one hour each week, but could not receive and other services to address deficits specific to ASDs.

To be included in the HFA group:

(1) Participants had to between the ages of 8 years and 21 years, 7 months of age.

(2) Participants' behavioral presentation and parent reports of ASD symptomatology had to be consistent with ASD diagnoses at the time of the assessments. Specifically, participants had to meet criteria for ASD on the ADOS Socialization + Communication Total Score and according to clinical judgment. Two participants were excluded from the study because their scores on this measure did not meet criteria for ASD.

(3) Participants had to perform in the average range on standardized measures of cognitive and adaptive functioning. Specifically, the verbal, performance and full scale IQs could not fall lower than 1.5 standard deviations from the mean (i.e. score of 78 or above on the Wechsler Abbreviated Intelligence Scales). Four additional participants

were excluded from this study because their cognitive functioning or adaptive skills did not fall in the average range.

To be included in the TD group:

(1) Participants had to between the ages of 8 years and 21 years, 7 months of age.

(2) Participants could not meet diagnostic criteria for any ASD at any point of their development. Specifically, children could not meet diagnostic criteria according to the ADOS Socialization + Communication Total Score or according to clinical judgment, nor could participants exhibit any clinical features of an ASD at present or in the past, as noted during the evaluation or according to an interview with the parent. Two participants were excluded from the study because they exhibited some features of ASD.

(3) Participants had to perform in the average range on standardized measures of cognitive and adaptive functioning. Specifically, the verbal, performance and full scale IQs could not fall lower than 1.5 standard deviations from the mean (i.e. score of 78 or above on the Wechsler Abbreviated Intelligence Scales). Scores on socialization and communication subtests of an adaptive functioning measure also could not fall more than 1.5 standard deviations below the mean (i.e. 78 or above on the Vineland Adaptive Behavior Scales). Two participants were excluded from the study because their adaptive skills did not fall in the average range.

Exclusion criteria

Potential participants were excluded from the study if (1) at the time of the telephone screening they exhibited symptoms of a psychotic disorder that would impede their full participation in the study; (2) they had a visual disorder that could not be corrected using corrective lenses to a level of 20-40; or (3) they had a history of a seizure disorder, Fragile X

syndrome, hearing impairments or a head injury that involved a loss of consciousness. Two participants were excluded from the study because both had histories of seizure disorders.

Procedure

Phone screenings were conducted with the parents of each child to ensure that the participant's history was consistent with the eligibility requirements for the study and that the participant was high-functioning. Participants who met these criteria, and were suspected of meeting enrollment criteria for the OO group, were asked to provide an early report documenting an ASD diagnosis made before the age of 5 years, which were reviewed as described above. Participants whose history was determined by the reviewer to be consistent with an ASD diagnosis were scheduled for an evaluation. The evaluation was administered over the course of two testing sessions either at the University of Connecticut, the Institute of Living, or in the child's home and lasted approximately 5.5 hours. Testing was conducted in a quiet room, at a table with one examiner. Occasionally, one or two students observed the testing session and portions of the evaluation were videotaped in order to calculate inter-rater reliability for some of the measures used. In most cases, parent interviews were conducted concurrently by a second examiner and lasted approximately 3 hours.

Measures

Autism Symptomatology:

The *Autism Diagnostic Observation Schedule* (ADOS; Lord et al., 2000) is a structured play and interview session for the diagnosis of ASDs. The instrument consists of a series of activities designed to interest young children and encourage communication, social interaction and imaginative use of materials. In addition, it provides opportunities to observe social

interactions including affect sharing, checking adults' reactions, and symbolic play. The instrument includes four modules each of which is appropriate for individuals of different language levels. For this study, Modules 3 and 4 were used to determine whether the child met criteria for ASD at the time of the study. Higher scores on this measure are indicative of more severe behaviors. Published inter-rater reliability of this instrument is 0.82 or above on all domains, and test-retest reliability is 0.73 or above, except for restricted interests (r = 0.59; Lord et al., 2000).

Cognitive Functioning:

Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) is a brief measure of intelligence that consists of two subtests that measure nonverbal reasoning (Block Design and Matrix Reasoning) and two subtests that measure verbal ability (Vocabulary and Similarities). The measure was standardized on a sample of children and adults between 6 and 89 years of age. The raw scores from each subtest yield Full Scale, Verbal and Performance IQs that have a mean of 100 and standard deviations of 15. In the present study this measure was used to assess cognitive abilities of the participants and to match the groups on IQ. Wechsler (1999) measured internal consistency using corrected split-half reliability for all subtests, which ranged between 0.81 and 0.98. Published test-retest coefficients ranged between 0.83 and 0.95, depending on the age of the sample (Wechsler, 1999). Wechsler (1999) demonstrated criterion validity by evaluating the correlation between the WASI with other measures of cognitive ability. Correlations between the IQ scales on the WASI and the Wechsler Scale of Adult Intelligence, III (WAIS-III) ranged between 0.76 and 0.92 (Wechsler, 1999).

Adaptive Functioning

Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984) is a parent report measure that evaluates adaptive functioning across the domains of Communication, Daily Living Skills and Socialization. The interview assesses developmental milestones in adaptive behavior by asking for concrete examples of observable behavior. The raw scores are converted into standard scores with a mean of 100 and a standard deviation of 15. Sparrow and colleagues (1984) reported internal consistency using split-half reliability as ranging between 0.69 and 0.84 for all subdomains. According to Sparrow and colleagues (1984) the majority of test-retest coefficients ranged between 0.80 and 0.90 for domain scores. A previous study using the Vineland to measure adaptive behaviors of children and adolescents with ASD revealed a moderate correlation between the Vineland and other measures of adaptive functioning, indicating that the instrument has good concurrent validity (Perry & Factor, 1989).

Academic Functioning

Woodcock-Johnson III, Test of Achievement (WJ-III; McGrew & Woodcock, 2001) is an assessment of an individual's academic strengths and weaknesses that consists of 22 subtests designed to measure an individual's reading, writing and arithmetic skills. Three subtests were selected for this study: Passage Comprehension, Applied Problems and Word Attack. The Passage Comprehension subtest asks the examinee to identify a key word that is missing from a written passage. The Applied Problems subtest requires the examinee to solve mathematical problems presented orally. The median test-retest reliability of the Applied Problems subtest is 0.82. The Word Attack subtest requires the participant to read phonically regular non-words aloud. According to McGrew and Woodcock (2001), the median test-retest reliability of these subtests are 0.80, 0.82, and 0.83, for the Passage Comprehension, Applied Problems and Word Attack subtests respectively. The WJ-III content is similar to that of other achievement tests and

scores on the WJ-III correlate in the range of 0.50 to 0.80 with the corresponding scores on the WIAT and the Kaufman Test of Educational Achievement (McGrew & Woodcock, 2001).

Test of Written Language, Third Edition (TOWL-3; Hammill & Hresko, 1994) is a comprehensive measure of written language that could be used with students between the ages of 7 years and 17 years and 11 months of age. This study included subtests evaluating a spontaneous writing sample, which asks each participant to generate a story about a picture of a space scene that included astronauts and space ships. The narrative is used to assess three writing components: Contextual Conventions (e.g., punctuation, spelling), Contextual Language (e.g., sentence structure, vocabulary), and Story Construction (e.g., use of prose, action of the story). Raw scores for each writing component are converted to scaled scores that have a mean of 10 and a standard deviation of 3. As evidence for content validity, the examiner's manual provides a clear theoretical rationale for the inclusion of each subtest. The measure also moderately correlates with other measures of writing ability. Finally, the measure is able to discriminate well between children with disabilities and those without, as well as between high and low achievers (Hammill & Hresko, 1994).

A second rater, who was blind to group membership, viewed fifteen percent of the narratives produced by the participants in this study, and calculated inter-rater reliability for each item and each of the subtest scores. Moderate inter-rater agreement was found for all of the items, with Cohen's kappa coefficients ranging from 0.44 to 1.0. Intraclass correlation coefficients were used to examine inter-rater reliability for the three subtests of the TOWL and the coefficients were all above 0.95, indicating excellent agreement.

The written narratives produced by each child were also coded for a number of lexical and pragmatic variables (see Table 4 for a complete list and explanation of all of the variables

used to examine the written narratives). Passages were coded for variables examining the length of the narratives, including the number of words in each passage, the number of sentences, the number of words per sentence and the length of each word. Additionally, each passage was also coded for the presence of a series of pragmatic variables, including social words, emotion words, cognitive words and causal attributions. The passages were coded using the Linguistic Inquiry and Word Count (LIWC) text analysis software program (Pennebaker, Chung, Ireland, Gonzales & Booth, 2007). This software uses an extensive dictionary for each classification category and provides users with percentages that represent the frequency of words included in the dictionary for each of the classification category relative to the number of words in the passage. The authors reported high correlation coefficients between the scores on the LIWC scales for 72 passages with ratings made by three trained judges (coefficients ranged from 0.31 to 0.70 for the classification categories used for this study; Pennebaker, Chung, Ireland, Gonzales & Booth, 2007).

Inference Making and Comprehension of Figurative Language

The *Test of Language Competence – Expanded Edition* (TLC-E; Wiig & Secord, 1989) is a measure of the development of metalinguistic abilities, including syntax, semantics and pragmatics, in children aged 5 years to 18 years, 11 months. The TLC-E is comprised of four subtests, two of which were selected for this study. The Listening Comprehension: Making Inferences subtest measures the inference-making skill by presenting the individual with a lead-in and a conclusion of a causal event, and asking the participant to make two possible inferences that would describe how the sentences are related. The Figurative Language subtest assesses the child's ability to understand metaphorical language by asking the participant to read a series of sentences that have metaphorical meanings and interpret the meaning. Test results provide

subtest scores for each subtest, as well as an Interpreting Intents composite score for the two subtests. The authors reported high correlations between TLC-E Composite and the Wechsler Intelligence Scales for Children-Revised, verbal scale (r = .78) and the Test of Adolescent Language (r = .74). Internal consistency for the TLC-E was moderately high, ranging from .75 to .82 for the subtest scores and the composite scores. The authors reported high inter-rater reliability (98%) for the Figurative Language subtest, which required examiner judgment.

Results

To address the primary question of study and determine whether any residual deficits in academic domains are evident among children and adolescents who achieve OO, a series of one-way multivariate analyses of variance (MANOVAs) were run to examine subtests of reading and writing abilities. When overall tests were significant, univariate main effects were examined to isolate a specific skill area within an academic domain. Because the mathematics domain was measured by a single task, a one-way univariate analysis of variance (ANOVA) was conducted to examine group differences. Finally, effect sizes were calculated to determine the magnitude of group differences and post-hoc analyses (Tukey's) were used to examine group differences when significant univariate main effects were found.

A secondary set of analyses was conducted to address the study's secondary question of exploring potential contributors to any academic domains in which significant group differences were detected. Pearson correlations were examined within each group to explore the strength of the relationship between scores on academic tasks and scores on measures of abilities previously identified in the literature as contributors to the weaker performance of individuals with ASD. Specifically, if a significant group difference was identified in scores on the Passage

Comprehension subtest, then correlations were examined between the Passage Comprehension score and performance on measures of cognitive ability, ASD symptomatology, comprehension of metaphorical language and inference making skills. If significant group differences were found in performance on the variables measuring written expression, then correlations were examined between scores on the writing variables and measures of cognitive functioning, ASD symptomatology, comprehension of metaphorical language and inference making skills. Finally, if a significant group difference was detected on the Applied Problems subtest, then correlations were examined between performance on the Applied Problems subtest and scores on measures of cognitive ability.

Group Differences in Academic Domains

Reading

Reading ability was assessed using the Passage Comprehension and Word Attack subtests of the WJ-III, and participants in all three groups performed in the average range on these subtests (see Table 3 for scores on subtests measuring reading ability). A one-way MANOVA revealed a significant multivariate main effect for group membership (Wilks' λ = 0.78, $F(4, 158) = 5.34$, $p < .001$). According to a measure of effect size using Partial Eta-Squared, 11.9 percent of the total variance in reading ability is accounted for by the variance in group membership. Given the significance of the overall test, the univariate main effects were examined. Significant univariate main effects were obtained for the Passage Comprehension subtest of the WJ-III ($F(2, 80) = 11.38$, $p = <.001$). Partial Eta-Squared indicated that 22.2 percent of the variance in performance on the Passage Comprehension subtest is accounted for by group membership. Tukey's post-hoc analyses revealed that the HFA group scored significantly lower on the Passage Comprehension subtest than the OO and TD groups (both *p*'s

< .001), while the performance of the OO and TD groups did not differ significantly from each other (p = .44). Performance on the Word Attack subtests did not differ significantly among the three groups ($F(2, 80) = 0.32$, p = .73).

To examine the significant group difference in Passage Comprehension further, the ranges of these scores within each group were examined to determine how many participants in each group performed below the average range or more than one standard deviation below the mean on this task (see Table 3). All of the participants in the TD group scored in the average range on the Passage Comprehension subtest, while two of the 30 participants (7%) in each the OO and HFA groups received scores that were lower than one standard deviation below the mean.

Written Expression

To assess residual deficits in writing ability, performance of the three groups was compared on the subtests measuring the spontaneous writing sample of the TOWL-3, as well as a series of lexical and pragmatic variables examining the spontaneous writing sample (see Table 4 for a list of additional variables examining the writing sample and Table 5 for group performance on variables assessing written expression). Participants in all three groups performed in the average range on the three subtests of the TOWL-3. A one-way MANOVA was conducted to detect group differences on writing as measured by the subtests of the TOWL-3 and revealed no significant multivariate main effect for group membership (Wilks' $\lambda = 0.85$, $F(6, 118) = 1.70$, p = .13, η_p^2 = .08). A secondary one-way MANOVA was conducted to detect group differences on the lexical variables examining the number of words and sentences included in the writing samples, as well as the length of the sentences and the words used. No significant group differences were detected (Wilks' $\lambda = 0.84$, $F(8, 108) = 1.24$, p = .27, η_p^2 = .09). Finally, a one-

way MANOVA was conducted to detect group differences in the pragmatic variables assessed, which revealed no significant group differences (Wilks' $\lambda = 0.817$, $F(10, 106) = 1.13$, $p = .35$, $\eta_p^2 = .096$).

Individual variation within groups was examined on the subtest scores of the TOWL-III, with the goal of determining how many participants in each group scored below the average range (i.e., more than one standard deviation below the mean). These analyses indicated that only 4.2 percent (1/24) of the OO group received scores lower than one standard deviation below the mean on the Contextual Conventions subtest, while 10.5 percent (2/19) of the participants in the TD group and 14.3 percent (3/21) of the HFA group received scores that fell below the average range. On the Contextual Language subtest, all of the participants in the OO group scored in the average range, while one participant (4.2%) in the TD group and two participants (9.5%) in the HFA group scored below the average range. Lastly, on the Story Construction subtest, one of 24 (4.2%) participants in the OO group scored below the average range and all of the participants in the TD group scored in the average range. Scores of three of 21 (14.3%) participants in the HFA fell below the average range on the Story Construction subtest.

Mathematical Problem Solving

The ability to solve problems using arithmetic was evaluated using the Applied Problems subtest of the WJ-III. Participants in all three groups scored solidly in the average range on this subtest (see Table 6). A one-way univariate ANOVA revealed a group difference that approaches significance on this subtest ($F(2, 80) = 2.98$, $p = .06$), with 6.9 percent of the total variance in scores on the Applied Problems subtest being accounted for by variance in group membership ($\eta_p^2 = .069$). Tukey's post-hoc test revealed that the HFA group scored significantly lower than the OO group on this measure ($p = .045$), while the OO and TD groups

performed similarly (p = .59). An examination of the scores of the individual participants indicated that all 30 participants in the OO group scored in the average range on this subtest, while one of the 23 participants (4%) in the TD group and 2 of 30 participants (6.7%) in the HFA group received scores in the below average range or lower than one standard deviation below the mean.

Potential Contributors to Group Differences in Academics

To examine factors that may explain the group differences identified in reading comprehension and mathematical problem solving, Pearson correlations were conducted. Specifically, Pearson correlations were performed to examine the associations between scores on the Passage Comprehension subtest and performance on measures of cognitive ability, ASD symptomatology, comprehension of metaphorical language and inference making skills. Additionally, Pearson correlations were examined between performance on the Applied Problems subtest and scores on measures of cognitive ability.

Passage Comprehension and Cognitive Functioning

To examine the relationship between reading comprehension and cognitive functioning, Pearson correlations were examined between performance on the Passage Comprehension subtest, and verbal and nonverbal IQ for each group (see Table 7). These analyses revealed significant positive associations between scores on the Passage Comprehension subtest and verbal IQ for the HFA and OO groups (r(28)=0.52, p=.003; r(28)=0.48, p=.01), but not for the TD group (r(21) = 2.97, p =.17) . Additionally, a significant correlation was found between performance on the Passage Comprehension subtest and nonverbal IQ for the OO group (r(28)=0.52, p=.003), while the magnitude of the correlation between these variables for the HFA group approached significance (r(28) = 0.35, p = .07). No significant correlation was

found between these variables for the TD group ($r(21) = -0.26$, $p = .91$). Converting these correlation coefficients into observed values of z indicated that the relationship between Passage Comprehension scores and verbal reasoning ability for the three groups did not differ significantly among the three groups. This analysis did reveal a significant difference between the magnitude of the correlation between the Passage Comprehension score and nonverbal IQ for the OO and TD groups ($z_{obs} = -2.22$). The magnitude of the correlation between Passage Comprehension and nonverbal reasoning for the HFA group did not differ significantly from the TD or OO groups.

To determine whether the differences in performance on the Passage Comprehension subtest may have resulted from the significant group difference in verbal IQ, a one-way multivariate analysis of covariance (MANCOVA) was run with verbal IQ included as a covariate. This analysis revealed that group differences remained significant on the measure of reading comprehension even after controlling for verbal reasoning ability ($F(2, 80) = 26.72$, $p < .001$). Furthermore, the group difference in performance on the Passage Comprehension subtest remained significant when a similar analysis was used to control for nonverbal reasoning ability ($F(2, 80) = 11.95$, $p < .001$).

Passage Comprehension and Autism Symptomatology

A case has been made in previous studies that relative weaknesses in reading comprehension among school-aged children and adolescents with ASDs may also relate to core ASD symptomatology, and specifically to deficits in the socialization and communication domain (Jones et al., 2009; Lindstrom, 2007; Mayes & Calhoun, 2003a). In an effort to determine whether performance on the Passage Comprehension subtest appears to be related to impairments in the socialization or communication domain, Pearson correlations were examined

for each group between scores on the Passage Comprehension subtest and scores on the ADOS Socialization + Communication Total Score (See Table 8). These analyses revealed a significant negative correlation between the Passage Comprehension subtest and the ADOS Socialization + Communication Total Score for the OO and TD groups ($r(28) = -0.42$, $p = .02$; $r(21) = -0.54$, $p = .01$). A higher score on the ADOS suggests that more ASD symptoms are present. Therefore, a negative correlation means that higher Passage Comprehension scores were associated with fewer symptoms of ASD. Performance of the HFA group did not correlate significantly with the ADOS Socialization + Communication Total Score ($r(28) = -0.19$, $p = .92$). According to an observed z value, the correlation coefficients of the HFA and TD groups are significantly different ($z_{obs} = 1.96$).

Partial correlation was used to determine whether the relationship between the ADOS Socialization + Communication Total Score and performance on the Passage Comprehension subtest would remain significant for the OO and TD groups while controlling for verbal reasoning ability. The results indicated that a moderate, negative, partial correlation between Passage Comprehension and ADOS scores remained for the TD group when controlling for verbal reasoning ability ($r(21) = -0.48$, $p = .02$). The strength of the partial correlation between these variables for the OO group continued to be moderate, but reduced such that it was approaching significance ($r(28) = -0.36$, $p = .06$) when verbal reasoning ability was held constant.

Passage Comprehension and Interpreting Intent

To explore the possibility that difficulties in interpreting figurative language and inferring meaning may be contributing to group differences in reading comprehension, participants were asked to complete the TLC-E's Listening Comprehension: Making Inferences and Figurative

Language subtests and the Interpreting Intents Composite score was calculated. Performance of the three groups on both subtests of the TLC-E was examined using a one-way MANOVA (see Table 9). This analysis revealed a significant main effect for group membership (Wilks' λ = 0.68, $F(4, 154) = 8.35$, $p < .001$, $\eta_p^2 = 0.18$), and significant univariate main effects were obtained for both the Listening Comprehension: Making Inferences subtest ($F(2, 78) = 8.77$, $p < .001$, $\eta_p^2 = 0.18$) and the Figurative Language subtest ($F(2, 78) = 17.52$, $p < .001$, $\eta_p^2 = 0.31$). Tukey's post-hoc test revealed that the HFA group scored significantly lower than the TD (both *p's* < .001) and OO groups on both subtests of the TLC-E (Listening Comprehension: Making Inferences: $p = .04$; Figurative Language: $p = .01$). Performance of the OO group did not differ significantly from the TD group on the inference-making task ($p = .16$), but the OO group scored significantly lower on the Figurative Language subtest than the TD group ($p = .01$). A one-way univariate ANOVA also indicated a significant group difference on the Interpreting Intents Composite ($F(2, 78) = 15.43$, $p = < .001$). Tukey's post-hoc test showed that the HFA group scored significantly lower than the OO ($p = .01$) and TD ($p < .001$) groups on the composite score, while difference between the OO and TD groups on this measure approached significance ($p = .05$).

Pearson correlations were used to examine associations between each group's performance on the Passage Comprehension subtest and scores of the TLC-E (see Table 10). Performance on the Passage Comprehension subtest was significantly correlated with scores on the Listening Comprehension: Making Inferences subtest and the Interpretive Intents Composite for the OO and HFA groups (OO: Listening Comprehension: Making Inferences: $r(28) = 0.41$, $p = .02$; Interpreting Intents: $r(28) = 0.42$, $p = .02$; HFA: Listening Comprehension: Making Inferences: $r(28) = 0.51$, $p < .001$; Interpreting Intents: $r(28) = 0.38$, $p = .046$). Additionally,

performance of the HFA group on the Passage Comprehension subtest was significantly correlated with the Figurative Language subtest score ($r(28) = 0.37$, $p = .048$), while the magnitude of the correlation between these variables for the OO group approached significance ($r(28) = .035$, $p = .06$). No significant relationships were found between the TD group's scores on the subtests and composite of the TLC-E and performance on the Passage Comprehension subtest. Observed values of *z* were calculated and revealed that none of these correlation coefficients differed significantly from one another.

A one-way univariate ANCOVA revealed that group differences in reading comprehension remained significant even after controlling for the ability to make inferences and comprehend figurative language as measured by the Interpreting Intent composite ($F(1, 75) = 10.13$, $p = .002$, $\eta_p^2 = .08$), with the HFA group continuing to score significantly lower than the TD and OO groups.

Applied Problems and Cognitive Functioning

In order to examine the relationships between the ability to solve mathematical problems and cognitive functioning, Pearson correlations were used to measure the strength of the relationship between scores on the Applied Problems subtest, and verbal and nonverbal IQ for each group (see Table 11). These correlational analyses revealed the presence of a significant positive relationship between scores on the Applied Problems subtest and nonverbal IQ for all three groups (TD: $r(21) = 0.59$, $p = .003$; OO: $r(28) = .0.56$, $p = .001$; HFA: $r(28) = 0.54$, $p = .003$). Verbal IQ was also significantly associated with performance on the Applied Problems subtest for the OO and HFA groups (OO: $r(28) = 0.43$, $p = .02$; HFA: $r(28) = 0.45$, $p = .01$), but not for the TD group ($r(21) = 0.16$, $p = .11$). An examination of the observed z value indicated

that the correlations between scores on the Applied Problems subtest and verbal reasoning ability did not differ significantly between the three groups.

The significant association between performance on the Applied Problems subtest and nonverbal IQ across all three groups raises the question of whether group differences in performance on the Applied Problems subtest would remain if nonverbal IQ of the groups was held constant. To answer this question, a one-way MANCOVA was run with nonverbal IQ included as a covariate. The results of this analysis revealed the presence of significant group differences in performance on the Applied Problems subtest when controlling for nonverbal reasoning ability ($F(2, 78) = 3.27$, $p = .04$; $\eta_p^2 = 0.08$). No significant group difference was found in Applied Problems subtest scores when a similar procedure was used to control for verbal reasoning abilities ($F(2, 78) = 0.99$, $p = .38$; $\eta_p^2 = 0.03$).

Discussion

This study investigated the academic abilities of individuals who were diagnosed with an ASD before the age of 5 years, but who currently do not meet diagnostic criteria for any ASD. All of the children who achieved OO and were included in this study were high-functioning and included with no support in a regular-education classroom and minimal special education services. The goal of this study was to uncover the presence of any residual difficulties and outline needs for intervention or academic support for this group. Participants who achieved OO were compared to similarly aged, high-functioning children who have retained their ASD diagnosis and to TD peers.

The authors predicted that participants in the OO group would exhibit residual deficits on tasks of reading comprehension, written expression and mathematical problem solving that were not evident among typically developing peers. The authors also predicted that children and

adolescents in the OO group would not exhibit as much difficulty on measures of academic functioning as do similarly aged individuals with HFA.

In accordance with previous research on academic functioning among high-functioning children and adolescents with ASDs, the findings of this study indicated that the academic performance of participants in all three groups fell solidly in the average range (Chiang & Lin, 2007; Myles et al., 2002; Nation et al., 2006). Contrary to the predictions of the authors, the findings of this study suggest that the academic abilities of individuals who achieved OO are similar to those of their TD peers, even in areas where participants who have retained their ASD diagnoses exhibit difficulty.

The results of this study revealed no group differences on measures of decoding and written expression. Additionally, the findings suggested that the OO sample performed similarly to TD peers on measures of reading comprehension and mathematical problem solving. It is particularly noteworthy that individuals in the OO group performed similarly to the TD group in areas in which the participant in the HFA group continued to exhibit weaknesses, specifically on a reading comprehension task and mathematical problem solving task. Again, it is important to note that the performance of the HFA group was in the average range even on academic tasks in which they received lower scores than the OO and TD groups.

An examination of reading comprehension scores indicated no significant differences between the OO and TD groups, suggesting that children and adolescents who achieve OO do not exhibit weaknesses in this academic domain. As predicted by the authors, participants who achieved OO received higher scores on measures of reading comprehension than did children and adolescents with HFA. However, it is important to note that the HFA group also reached average levels on this measure. These results are consistent with multiple previous findings

suggesting that despite average scores on measures of reading comprehension, children and adolescents with ASDs perform lower on these tasks than would be expected given their cognitive functioning levels and other academic skills (Church et al., 2000; Dennis et al., 2001; Goldstein, Minshew, & Siegel, 1994; Happe, 1994, 1995, 1997; Jolliffe & Baron-Cohen, 1999; Jones et al., 2009; Mayes & Calhoun, 2003a; Minshew et al., 1995, 1997; Myles et al., 2001; Myles et al., 2002; Nation et al., 2006; Snowling & Frith, 1986; Venter et al., 1992; Wahlberg & Magliano, 2004). A lack of group difference in decoding is also consistent with prior studies (Goldstein et al., 1994; Happe, 1997; Mayes & Calhoun, 2003a; Nation et al., 2006; Snowling & Frith, 1986), and suggests that lower scores of the HFA group on reading comprehension are unlikely to be the result of decoding ability.

Again contrary to the predictions of the authors, the writing abilities of children and adolescents who achieved OO did not differ from the performance of TD peers. Specifically, individuals in the OO and TD groups demonstrated a similarly developed level of mastery of the arbitrary conventions of written language, language use in writing, and the ability to construct a story. As has been reported in the literature, the written narratives produced by the OO and TD groups did not differ significantly on length, as measured by the number of words and sentences used, as well as the average length of the sentences and words (Kelley et al., 2006). Participants in the OO and TD groups also included a similar number of words describing social, emotional, cognitive and causal processes in their written passages. Unlike the findings of the current study, Kelley and colleagues (2006) found that the OO group's spoken narratives included significantly fewer references to causal processes than did TD peers. This inconsistency may be the result of the older sample included in this study (sample of the Kelley et al. (2006) study was aged 5-9 years), as well as the difference in task used by the researchers. Kelley and colleagues (2006)

used a spoken narrative task and asked children to tell a story depicted in a picture book. The current study asked participants to write a story based on a single picture.

The performance of the HFA group on the measures used to evaluate the writing sample was also not consistent with the predictions of the authors. Individuals in the HFA group scored similarly to the OO and TD groups on all of variables used to assess written expression. These results indicate that the OO and HFA groups are not exhibiting residual deficits in writing skills that have previously been identified among high-functioning, school-aged individuals with ASDs (Griswold et al, 2002; Mayes & Calhoun, 2003a; Myles et al., 2001). The findings of this study did show that the HFA group contained more participants who scored in the below average range on a measure of written expression than did the OO and TD groups. The inconsistency between the current findings relating to performance of the HFA group as a whole and the results reported by previous research which identified weaknesses in the area of written expression may be the consequence of the HFA group in this sample being older and having higher verbal and nonverbal IQs than the samples included in prior studies.

Similarly to the performance of the OO group measures of reading and writing, performance of the OO group on a measure of mathematical problem solving also revealed no residual deficits in this domain. The results of this study revealed that the HFA group received significantly lower scores on this task than did the participants in the OO and TD groups. Despite the significantly lower score, participants in the HFA group scored solidly in the average range on this measure, with only two of 30 participants receiving scores that lower than one standard deviation below the mean. These results are consistent with the findings presented by Griswold and colleagues (2002), who also reported average, but lower scores on a measure of mathematical problem solving than would be predicted by cognitive functioning abilities.

An examination of factors that may explain group differences in reading comprehension revealed, as predicted, a moderate, positive relationship between scores on the Passage Comprehension subtest and verbal reasoning ability for the OO and HFA groups. Although this relationship was not significant for the TD group, the magnitude of the relationship for the TD group was not significantly different from the magnitude of the relationship between these variables in the OO and HFA groups. Consequently, it is possible that the group difference in reading comprehension simply reflects inequalities among the three groups in verbal ability. The difference in group performance on the measure of reading comprehension remains significant even after controlling for verbal reasoning abilities, suggesting that the relative weakness in reading comprehension exists above and beyond the difference in verbal reasoning abilities.

However, it is important to note that given the nature of the three groups included in this study, using verbal reasoning ability as a covariate is considered by some to be a controversial procedure. When a covariate is included in an analysis of variance, an assumption is made that the groups differ on the variable of interest only by chance. However, when group differences in the variable of interest are nonrandom and may be attributed to the nature of the groups being studied, it is not appropriate to statistically adjust the results for the differences in the covariate (Dennis et al, 2009). In this case, verbal IQ is likely to differ because of the composition of the groups, with the HFA group performing lower than the other two groups. Consequently, an argument could be made that statistically adjusting verbal IQ is not appropriate in this case, and will not help determine the causal mechanisms of the relationship between verbal reasoning ability and performance on the Passage Comprehension subtest of the WJ-III. According to Dennis and colleagues (2009), researchers should include differences in IQ as a potential explanation of group differences regardless of the result of the statistical adjustment and they

would argue that, the results of these analyses cannot rule out the possibility that group differences in reading comprehension are the result of group differences in verbal reasoning ability.

Interestingly, performance on the reading comprehension task also shared a strong, positive relationship with a measure of nonverbal reasoning ability for the OO group. This relationship approached significance for the HFA group, but was not found for the TD group. In fact, the size of the correlation coefficient between these two variables for TD group was significantly different from the size of the correlation coefficient in the OO group. One possible explanation for this finding is that the OO and HFA groups may be using compensatory strategies that incorporate both verbal and nonverbal reasoning abilities to succeed in passage comprehension task, while TD peers rely more exclusively on verbal reasoning abilities. The HFA group continued scoring significantly lower than the OO and TD groups on the reading comprehension task even when nonverbal reasoning abilities were controlled for, suggesting that the group difference in reading comprehension is not due exclusively to the influence of nonverbal reasoning.

The authors also predicted that deficits in the core features of ASD, specifically communication and socialization skills, would interfere with the participants ability to comprehend social processes in reading. As expected, significant negative relationships were found between reading comprehension and the extent of ASD symptomatology in the domains of socialization and communication for the OO and TD groups. These relationships suggested that fewer symptoms of ASD in the OO and TD groups were associated with a higher reading comprehension score. However, this relationship was not found for the HFA group and the magnitude of the relationship between these scores was significantly different between the HFA

and TD groups. These findings argue against the possibility raised by previous research that the relative weakness in reading comprehension exhibited by the HFA group results from broader deficits in the understanding of social processes and communicative abilities.

The moderate, negative relationship found between the reading comprehension score and ASD symptom severity found for the OO and TD groups, raised the question of whether this relationship was driven by verbal reasoning ability. In other words, the authors wanted to determine whether individuals who have more developed social savvy or social relatedness were receiving higher scores on reading comprehension, or whether participants who had more developed verbal reasoning abilities were also exhibiting few symptoms of ASD and scoring higher on the reading comprehension task. The relationship between ASD symptom severity and reading comprehension score remained significant even after controlling for verbal reasoning ability for the TD group and approached significance for the OO group. These results suggest that participants who were more socially aware scored higher on the reading comprehension task.

The authors also predicted that a positive relationship would be found between reading comprehension and measures of inference making and comprehension of metaphorical language. In order to answer this question, appropriate subtests of the TLC-E were administered and a composite score was calculated. A significant group difference was found in performance on both subtests and composite score of the TLC-E, such that the HFA group scored significantly lower than both the OO and TD groups. Additionally, the OO group scored significantly lower than the TD group on a subtest measuring the comprehension of figurative language, suggesting that pragmatic reasoning is one area in which individuals with OO are scoring lower compared to TD peers who are matched on verbal reasoning abilities. It is important to note that comprehension of figurative language should not be considered a residual deficit of the OO

group as they scored solidly in the average range on this measure. Instead, it appears that the OO group has not yet reached the above average level that would be expected given their verbal reasoning ability.

As predicted by the authors, performance on the Passage Comprehension subtest was positively associated with performance on subtests measuring the ability to infer meaning and comprehend figurative language for the HFA and OO groups. While correlational analyses cannot determine the causal relationship between the variables of interest, they do suggest that the ability to infer meaning and comprehend figurative language was related to reading comprehension in the HFA and OO groups. These skill areas did not appear to cluster together within the TD group. Given these findings, it is possible that weaknesses in these abilities may have contributed to weaknesses in reading comprehension exhibited by the HFA group. However, the HFA group continued to score significantly lower than the TD and OO groups when their abilities to make inferences and comprehend figurative language were held constant. This suggests that the relative weakness in reading comprehension exhibited by the HFA group is not due merely to the influence of the ability to make inferences or comprehension of figurative language.

Finally, the authors examined whether cognitive functioning contributed to the significantly lower score that the HFA group received on mathematical problem solving. As expected, the results of this study indicated that performance on the mathematical problem solving task shared a significant positive relationship with nonverbal reasoning ability for all three groups. However, the HFA group continued to score significantly lower than the other two groups even when nonverbal IQ was controlled for, suggesting that differences in nonverbal IQ do not sufficiently account for group differences on this measure.

In addition to nonverbal reasoning, verbal reasoning abilities were also associated with scores on the mathematical problem-solving task for the OO and HFA groups. Specifically, participants with higher verbal IQs received higher scores on the problem-solving task. While the TD group did not exhibit a significant relationship between these variables, the magnitude of the correlation coefficient relating these variables for the TD group did not differ significantly from the correlation coefficients relating the same variables for the OO and HFA groups. When verbal reasoning abilities were controlled for, group differences in problem solving were no longer significant. Consequently, the lower performance of the HFA group on this task may reflect group differences in verbal reasoning abilities. In other words, it is possible that because of their lower verbal reasoning abilities, participants in the HFA group had more difficulty solving verbally presented mathematical problems. However, as mentioned above, these results should be interpreted with caution because it is problematic to statistically adjust for verbal IQ given the compositions of the groups included in this study. Therefore, it is possible that in addition to differences in verbal reasoning abilities, the HFA group's significantly lower score on mathematical problem solving may reflect other areas of weaknesses previously identified among individuals with HFA, including difficulty with the comprehension of abstract concepts and the ability to discern relevant from irrelevant information.

Taken together, these findings suggest that children with a history of ASD have reached high average to superior levels on tasks of decoding, reading comprehension, writing and mathematical problem solving. Overall, these results indicate that children and adolescents who achieve OO are rightfully included in regular-education classroom without supports and with minimal special education services. From the results of this study it does not appear that this group exhibits any residual academic difficulties that would require intervention or academic

support. In fact, the comprehension of figurative language was the only area in which participants of the OO group scored significantly lower than TD peers and the OO group scored solidly in the average range on this measure. These results also suggest that high-functioning children and adolescents with ASD also generally perform in the average range on measures of academic achievement. However, this group does exhibit significant relative weaknesses in the area of reading comprehension and mathematical problem solving that may require academic support. Additionally, It is worth noting that given the average verbal reasoning abilities of high-functioning children and adolescents with ASDs, it is possible that educators will find it challenging to accurately determine the appropriate level of support needed by these individuals.

Limitations and Future Directions

These results should be generalized with caution for a number of reasons. The sample included in this study was relatively small and homogeneous. Consequently, it is difficult to determine how the results of this sample would generalize to a broader ASD community. A hypothetical power analysis revealed that with the size of the samples used in this study, a medium to large sized effect could be detected by this study. Any effects smaller than this would require a larger sample to be detected. In order to detect a medium effect, 43 participants would be needed within each group and 261 participants would be needed within each group to detect a small effect. While it would be difficult to collect a larger sample of children and adolescents who achieved such positive outcomes, doing so would allow researchers to detect subtle differences between the groups and draw conclusions that are less tentative and more generalizable.

Another limitation to the current study is that retrospective methods were used to confirm a history of ASD. Research suggests that as few as 3 percent of children diagnosed with an ASD

may achieve such outcomes (Helt et al., 2008). Examining a group of children who achieve OO longitudinally would require following a very large sample of children diagnosed with an ASD and would be very time consuming and costly. However, doing so and conducting research diagnoses with children who go on to achieve OOs would ensure that early diagnoses were consistently made using similar gold-standard measures used in the diagnosis of ASD and would increase the likelihood that early diagnoses were accurately made. Additionally, having access to standardized measures of early abilities for participants who go on to achieve OO would allow researchers to draw conclusions about early factors that have contributed to this outcome. For the current study, this limitation was addressed by requiring that the initial ASD diagnosis was made by a specialist in the field of autism and by having a specialist in the field of autism that was blind to group membership confirm that early records were consistent with an ASD diagnosis.

The results of this study are also limited in that the participants with ASDs that were used as a comparison group were very high-functioning, with all of the participants in the HFA group demonstrating average cognitive functioning. The goal of this study was to find a group of comparable individuals who continue to exhibit behaviors that are consistent with an ASD diagnosis, so that comparisons could be made between the ability levels of these individuals and individuals who achieve OO. However, choosing to design the study in this way limited the extent to which these findings could apply to a broader range of individuals with HFA or lower functioning individuals with ASD.

Measures of academic functioning included in this study were collected in an environment in which distractions were limited and an adult was present to monitor the activities of the participant and encourage the participant to remain on task. These results measure the

academic abilities in an optimal environment. From these results, it is difficult to speculate about whether group differences would exist if these measures of academic abilities were collected in a classroom environment with only one adult and a classroom full of other students. Given the findings that individuals who achieve OO exhibit significantly more symptoms of attentional difficulties than TD peers (Fein et al., 2005; Tyson et al., 2011), it is possible that this group would exhibit residual weaknesses in academic abilities if these were measured in less ideal environment. Future studies are needed to determine whether residual deficits would be found between the OO and TD groups if academic measures are collected in an environment that more closely simulates the distractions found in regular classrooms.

It is possible that the measures selected to examine academic functioning for this study were not sensitive enough to detect subtle differences in writing, mathematics or decoding abilities that exist between the TD and OO groups. In order to limit the length of the extensive testing battery included in this study, the measures selected to assess academic abilities were limited to the academic weaknesses of children and adolescents with HFA previously identified in the literature. It is possible that subtle residual deficits would be found if more extensive measures of academic abilities were included.

Future studies are needed to examine residual deficits between the OO and TD groups using more extensive and complex academic tasks, including persuasive writing assignments and reading comprehension tasks that require reading longer passages and answering more complex questions about the reading. If residual deficits are uncovered, more extensive measures of academic ability will enable researchers to examine aspects necessary for each academic domain. This will allow for the identification of specific skills that are difficult for the OO group to master and will allow for more targeted, and likely more effective intervention.

Tables:

Table 1: Characteristics of participants who completed the *Woodcock-Johnson III, Test of Achievement*

	HFA	OO	TD	*F/χ2*	*p*	Tukey
N	30	30	23			
Sex	27 M; 3 F	22 M; 8 F	20 M; 3 F	3.30	0.19	
Age	13.29 (2.48) (8.6 – 18.4)	12.97 (3.39) (8.5 – 21.2)	14.20 (2.80) (9.9 – 21.7)	1.21	0.30	
Verbal IQ	103.83 (12.72) (81 – 133)	112.57 (14.23) (80 – 137)	112.35 (11.97) (93 – 136)	4.08	0.02	HFA < OO, TD
Nonverbal IQ	111.59 (14.32) (78 – 147)	112.50 (14.68) (87 – 142)	114.22 (12.75) (89 – 139)	0.23	0.80	
Vineland – Communication	85.93 (11.82) (51 – 108)	97.87 (12.03) (79 – 122)	92.48 (9.12) (77 – 115)	8.10	0.001	HFA < OO
Vineland – Socialization	77.96 (14.80) (54 – 109)	102.34 (8.15) (80 – 118)	102.35 (8.38) (86 – 119)	44.70	< .001	HFA < OO, TD
Vineland – Daily Living	76.10 (14.70) (46 – 110)	90.69 (15.50) (65 – 120)	88.00 (10.20) (74 – 115)	8.71	< .001	HFA < OO, TD
ADOS – Communication	3.40 (1.45) (2 – 7)	0.53 (0.68) (0 – 2)	0.44 (0.60) (0 – 2)	78.86	< .001	HFA > OO, TD
ADOS – Socialization	6.63 (1.98) (4 – 11)	1.43 (1.65) (0 – 5)	0.35 (0.65) (0 – 2)	125.32	< .001	HFA > OO > TD

Note. This table reports means, with standard deviations followed by ranges in parentheses.

Table 2: Characteristics of participants who completed the *Test of Written Language, Third Edition*:

	HFA	OO	TD	*F/χ2*	*p*	Tukey
N	21	24	19			
Sex	18 M; 3 F	17 M; 7 F	16 M; 3 F	1.87	0.39	
Age	13.26 (2.33) (8.6 – 17.87)	12.49 (2.73) (8.5 – 17.55)	13.26 (1.58) (9.9 – 16.6)	0.83	0.44	
Verbal IQ	102.20 (11.50) (81 – 122)	112.08 (15.00) (80 – 136)	113.26 (12.87) (93 – 136)	4.20	0.02	HFA < OO, TD
Nonverbal IQ	110.20 (13.76) (78 – 133)	112.50 (14.68) (87 – 142)	114.22 (12.75) (89 – 139)	0.83	0.44	
Vineland - Communication	85.90 (12.44) (51 – 108)	96.91 (12.11) (79 – 122)	94.00 (7.41) (85 – 115)	5.76	0.01	HFA < OO
Vineland - Socialization	80.38 (15.13) (54 – 109)	100.39 (7.56) (80 – 113)	103.79 (8.03) (91 – 119)	28.38	< .001	HFA < OO, TD
Vineland – Daily Living	77.57 (15.00) (46 – 110)	88.04 (13.75) (65 – 117)	88.26 (8.11) (74 – 102)	4.78	0.01	HFA < OO, TD
ADOS – Communication	3.43 (1.57) (2 – 7)	0.54 (0.66) (0 – 2)	0.47 (0.61) (0 – 2)	55.64	< .001	HFA > OO, TD
ADOS – Socialization	6.48 (2.09) (4 – 11)	1.58 (1.74) (0 – 5)	0.37 (0.68) (0 – 2)	79.55	< .001	HFA > OO, TD

Note. This table reports means, with standard deviations followed by ranges in parentheses.

Table 3: Group performance on the Passage Comprehension and Word Attack of the *Woodcock-Johnson III, Test of Achievement*

	HFA	OO	TD	*F/χ2*	*p*	η_p^2	Tukey
N	30	30	23				
Passage Comprehension	99.87 (9.70) (82 – 117)	109.97 (13.83) (74 – 133)	113.74 (8.66) (101–137)	11.38	< 0.001	0.22	HFA < OO, TD
Word Attack	103.30 (10.33) (82 – 127)	104.30 (8.33) (83 – 121)	105.35 (8.85) (86 – 124)	0.32	0.73	0.01	

Note. This table reports means, with standard deviations followed by ranges in parentheses. The mean for each subtest of the *Woodcock-Johnson III, Test of Achievement* is 100 and the standard deviation is 15.

Table 4: Writing narrative variables

Name	Description
Number of words	Number of overall words used in the narrative.
Number of sentences	Number of sentences using in the narrative.
Length of sentences	Average number of words used in one sentence.
Length of each word	Average number of characters in each word.
Social words	Percentage of words used to describe social processes relative to the number of words used in the narrative.
Positive emotion words	Percentage of words describing positive emotional states relative to the number of words used in the narrative.
Negative emotion words	Percentage of words describing negative emotional states relative to the number of words used in the narrative.
Cognitive words	Percentage of words describing cognitive processes relative to the number of words used in the narrative.
Causal attributions	Description of the cause of an action or event (e.g., the Earth's atmosphere became too hot to live in because of global warming).

Table 5: Group performance on variables assessing written expression:

	HFA	OO	TD	$F/\chi 2$	p	η_p^2	Tukey
N	21	24	19				
Subtests of the TOWL-3:							
Contextual Conventions	10.19 (3.34) (5 – 18)	11.87 (3.39) (6 – 18)	10.47 (3.04) (6 – 16)	1.72	0.19	0.05	
Contextual Language	10.48 (3.44) (5 – 17)	12.38 (2.99) (8 – 18)	12.47 (3.50) (4 – 20)	2.45	0.10	0.07	
Story Construction	9.48 (2.50) (5 – 14)	10.96 (2.16) (6 – 16)	11.32 (2.96) (7 – 17)	3.07	0.54	0.09	
Lexical Variables:							
Number of words	136.05 (76.47) (42 – 302)	200.19 (128.38) (61 – 619)	203.47 (91.99) (47 – 385)	2.66	0.08	0.09	
Number of sentences	8.84 (5.90) (2 – 26)	16.67 (12.16) (3 – 48)	14.79 (7.66) (1 – 29)	3.95	0.03	0.12	HFA < OO
Length of sentences	15.68 (7.52) (6.6 – 39.5)	13.82 (4.84) (6.4 – 23.3)	16.07 (8.10) (8.8 – 47)	0.61	0.55	0.02	
Length of each word	4.29 (0.38) (3.5 – 4.9)	4.24 (0.32) (3.5 – 4.8)	4.18 (0.28) (3.6 – 5.1)	0.48	0.62	0.02	
Pragmatic Variables:							
Social words	8.68 (3.73) (2.4 – 17.4)	8.68 (3.73) (2.5 – 14.4)	7.73 (3.94) (1.9 – 13.8)	0.94	0.40	0.03	
Positive emotion words	0.85 (0.96) (0 – 2.9)	1.01 (1.01) (0 – 3.3)	1.44 (1.29) (0 – 6.1)	1.52	0.23	0.05	
Negative emotion words	0.93 (1.09) (0 – 4.3)	1.00 (1.13) (0 – 4.4)	1.01 (1.10) (0 – 3.8)	0.03	0.97	0.001	
Cognitive words	5.92 (3.01) (1.2 – 11.2)	5.65 (2.70) (1.9 – 13.7)	5.08 (2.49) (1.3 – 11.3)	0.48	0.62	0.02	
Causal attributions	1.00 (1.03) (0 – 3)	0.88 (1.19) (0 – 5)	1.68 (1.53) (0 – 5)	2.40	0.10	0.08	

Note. This table reports means, with standard deviations followed by ranges in parentheses. The mean for each subtest of *Test of Written Language, Third Edition* is 10 and the standard deviation is 3.

Table 6: Group performance on Applied Problems subtest of the Woodcock-Johnson III, Test of Achievement

	HFA	OO	TD	$F/\chi 2$	p	η_p^2
N	30	30	23			
Applied Problems	105.60 (13.33) (82 – 129)	113.27 (11.32) (86 – 133)	109.96 (11.77) (76 – 133)	2.98	0.057	0.07

Note. This table reports means, with standard deviations followed by ranges in parentheses. The mean for each subtest of the *Woodcock-Johnson III, Test of Achievement* is 100 and the standard deviation is 15.

Table 7: Correlations between verbal and nonverbal reasoning abilities and the Passage Comprehension subtest of the *Woodcock-Johnson III, Test of Achievement*

	TD Group (N=23)	
	Passage Comprehension	Verbal IQ
Verbal IQ	*r* = 0.30	
Nonverbal IQ	*r* = -0.03	*r* = 0.28
	OO Group (N=30)	
	Passage Comprehension	Verbal IQ
Verbal IQ	*r* = 0.52**	
Nonverbal IQ	*r* = 0.59 **	*r* = 0.48**
	HFA Group (N=30)	
	Passage Comprehension	Verbal IQ
Verbal IQ	*r* = 0.48**	
Nonverbal IQ	*r* = 0.35	*r* = 0.28

Note. * $p < .05$; ** $p < .01$

Table 8: Correlations between Socialization + Communication Total Score on the *Autism Diagnostic Observation Schedule* and the Passage Comprehension subtest of the *Woodcock-Johnson III, Test of Achievement*

TD Group (N=23)	
	Passage Comprehension
ADOS Total	r = -0.54**
OO Group (N=30)	
	Passage Comprehension
ADOS Total	r = -0.42**
HFA Group (N=30)	
	Passage Comprehension
ADOS Total	r = -0.02

Note. * p < .05; ** p < .01

Table 9: Group performance on the *Test of Language Competence – Expanded Edition*

	HFA	OO	TD	F/χ^2	p	η_p^2	Tukey
N	29	30	22				
Listening Comprehension: Making Inferences	8.17 (2.75) (3 – 16)	10.00 (2.79) (4 – 15)	11.45 (2.89) (6 – 15)	8.77	< 0.001	0.18	HFA < OO, TD
Figurative Language	7.41 (2.57) (3 – 11)	9.53 (2.91) (3 – 16)	11.72 (2.07) (7 – 16)	17.52	< 0.001	0.31	HFA < OO < TD
Interpreting Intents Composite	84.04 (18.86) (16 – 121)	98.53 (15.74) (69 – 127)	109.52 (12.25) (82 – 135)	15.43	<0.001	0.29	HFA < OO, TD

Note. This table reports means with standard deviations in parentheses. The mean for each subtest of the *Test of Language Competence – Expanded Edition* is 10 and the standard deviation is 3. The mean for the Composite score is 100 and the standard deviation is 15.

Table 10: Correlations between scores on the *Test of Language Competence – Expanded Edition* and the Passage Comprehension subtest of the *Woodcock-Johnson III, Test of Achievement*

TD Group (N=22)			
	Passage Comprehension	Listening Comprehension: Making Inferences	Figurative Language
Listening Comprehension: Making Inferences	$r = 0.01$		
Figurative Language	$r = 0.19$	$r = 0.23$	
Interpreting Intents Composite	$r = 0.11$	$r = 0.86$**	$r = 0.70$**
OO Group (N=30)			
	Passage Comprehension	Listening Comprehension: Making Inferences	Figurative Language
Listening Comprehension: Making Inferences	$r = 0.41$*		
Figurative Language	$r = 0.35$	$r = 0.67$**	
Interpreting Intents Composite	$r = 0.42$*	$r = 0.91$**	$r = 0.92$**
HFA Group (N=29)			
	Passage Comprehension	Listening Comprehension: Making Inferences	Figurative Language
Listening Comprehension: Making Inferences	$r = 0.51$**		
Figurative Language	$r = 0.37$*	$r = 0.44$*	
Interpreting Intents Composite	$r = 0.38$*	$r = 0.68$**	$r = 0.47$*

Note. * $p < .05$; ** $p < .01$

Table 11: Correlations between verbal and nonverbal reasoning abilities and the Applied Problems subtest of the *Woodcock-Johnson III, Test of Achievement*

	TD Group (N=23)	
	Applied Problems	Verbal IQ
Verbal IQ	$r = 0.16$	
Nonverbal IQ	$r = 0.59$**	$r = 0.28$
	OO Group (N=30)	
	Applied Problems	Verbal IQ
Verbal IQ	$r = 0.43$**	
Nonverbal IQ	$r = 0.56$ **	$r = 0.48$**
	HFA Group (N=30)	
	Applied Problems	Verbal IQ
Verbal IQ	$r = 0.49$**	
Nonverbal IQ	$r = 0.54$**	$r = 0.28$

Note. * $p < .05$; ** $p < .01$

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