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Longitudinal Follow-up of Academic Achievement in Children with Autism from Age 2 to 18

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Abstract

Objective—This study examined early predictors of and changes in school-age academic achievement and class placement in children referred for autism spectrum disorder (ASD) at age 2.

Method—Of 111 ASD referrals, 74 were diagnosed with ASD at age 18. Regression analyses were performed to identify age 3 predictors of achievement in arithmetic, passage comprehension, word reading, and spelling at ages 9 and 18. Linear Mixed Models were used to examine predictors of academic growth between ages 9 and 18.

Results—Academic skills varied widely at 9 and 18, but were mostly commensurate with or higher than expected given cognitive levels. However, 22% (age 9) and 32% (age 18) of children with average/above average IQ showed below/low average achievement in at least one academic domain. Children who remained in general education/inclusion classrooms had higher achievement than those who moved to special education classrooms. Stronger cognitive skills at age 3 and 9 predicted better academic achievement and faster academic growth from 9 to 18. Parent participation in intervention by age 3 predicted better achievement at 9 and 18.

Conclusion—Many children with ASD achieve basic academic skills commensurate with or higher than their cognitive ability. However, more rigorous screening for learning difficulties may be important for those with average cognitive skills because a significant minority show relative academic delays. Interventions targeting cognitive skills and parent participation in early treatment may have cascading effects on long-term academic development.

Keywords

Autism Spectrum Disorders; Academic Achievement; Early Predictors

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Introduction

There is a growing worldwide demand for special educational resources for children with Autism Spectrum Disorder (ASD). In 2012-2013, 512,000 children in the U.S. received educational services under the Individuals with Disabilities Education Act classification of "autism," a significant increase from the 370,000 receiving services under the same classification in 2010 (Kena et al., 2015). In the UK, ASD is the most common primary need among students who receive special education (Department of Education, 2016). Although it is clear that the number of children requiring supports under the ASD classification is increasing, we know little about the academic profiles of these children nor about how other behavioral features such as cognitive and language skills are related to academic development.

Although limited, a few studies suggest that some children with ASD display notable gaps between achievement and cognitive levels. In an American study of 30 9-year-olds with nonverbal IQs over 70, children showed significant discrepancies between achievement in spelling, word reading or math and intellectual abilities (Estes, Rivera, Bryan, Cali, & Dawson, 2010). While 60% of children exhibited achievement<IQ profiles (approximately 14 standard score points difference) in one of the three domains measured, an equal number of children demonstrated achievement>IQ profiles. A British study of 100 adolescents with ASD (mean IQ=84.3, *SD*=18.0) also reported that 70% of children demonstrated discrepant achievement-IQ profiles, with children excelling in some academic areas, but exhibiting delays in others (Jones, et al., 2009). In a study of 130 6-to-9-year-olds with ASD, 9% excelled in reading and 20% excelled in math compared to national norms published in 2005 (Wei et al., 2015). In contrast, Mayes & Calhoun (2003) reported that 17% of 54 6-to-14-year-olds showed arithmetic achievement lower than predicted based on FSIQ using the norms of standardized IQ testing (Wechsler, 2007). These findings suggest that subsets of children with ASD may not exhibit achievement commensurate with cognitive abilities.

Past studies focused on early predictors of later academic outcomes with typically developing (TD) children revealed that early language skills provide a foundation for the development of word reading and passage comprehension (NICHD, 2005). Studies showed that early nonverbal problem solving skills in TD children predict later development of more complex mathematical concepts (Baroody, Dowker, & Dowker, 2013). Attention and hyperactivity was found to predict academic outcomes (Smith-Donald, Raver, Hayes, & Richardson, 2007). Furthermore, in TD children, early educational interventions including efforts to increase parent involvement were found to result in long-term increases in educational attainment (Campbell et al., 2012), reductions in special education needs and grade retentions (Reynolds, 2000).

Consistent with the literature on TD children, cross sectional studies reported that cognitive and language abilities are associated with concurrent academic outcomes in children with ASD (Assouline, Nicpon, & Dockery, 2011; Jones, et al., 2009; Mayes & Calhoun, 2003). In one longitudinal study of 58 children assessed in preschool or early school-age years (Venter, Lord, & Schopler, 1992), IQ at initial assessment and presence of speech before age 5 were the strongest predictors of academic achievement assessed 8 years later. These studies suggest that, as expected, academic skill development of children with ASD is associated with developmental characteristics such as IQ and language level. A closer look at these associations in a longer-term cohort study would be useful to inform the extent to which early developmental characteristics during preschool age predict academic outcomes in later elementary or high school. Given the high proportions of children with ASD showing delays in early cognitive and language skills, this may have important implications for early intervention efforts and mental health policy for service provision. In fact, evidence for the effects of early intervention on cognitive and language outcomes is promising for children with ASD (Dawson et al., 2010). Moreover, parent involvement in early treatment for ASD (e.g., parent mediated interventions) has shown significant short-term (Green et al., 2010; Kasari et al., 2014; Wetherby et al., 2014) as well as long-term effects (Pickles et al., 2016) on the child's autism symptom severity and/or language and cognitive development. However, the potential benefits of early intervention (clinician delivered or parent-mediated) on longer-term *academic* outcomes have not yet been explored.

The current study aims to examine patterns of academic achievement and class placement in elementary and high school for children who were referred for a possible ASD and followed from age 2 to 18 years. Interpreting the results for inclusion is complicated because class placement determines whether children with ASD have access to TD peers or not. Therefore, class placement can be a potential moderator as well as an indicator of academic success in children with ASD. These factors may also change as children advance through elementary to high school. Therefore, we address class placement descriptively in the present study. In addition, this study explores whether early developmental characteristics (e.g., cognitive abilities, expressive language, activity level, ASD diagnosis) and parent participation in structured teaching interventions prior to age 3 predict later academic outcomes at ages 9 and 18 while controlling for demographic factors (e.g., gender, race, maternal education). We also aim to examine age 9 predictors of academic skill growth from age 9 to 18.

Methods

Sample

Participants were drawn from a longitudinal study of 213 children referred to agencies in North Carolina and Chicago for possible autism at 2 years, approved by the Weill Cornell Medicine and the University of Michigan Institutional Review Boards. Of 213 children, 165 completed in-person assessments at ages 2, 3 and 9. Children with verbal mental ages less than 21 months (n=54; 90% with ASD diagnosis) at age 9 who could not complete achievement testing were excluded. All children included in the present study had valid basal scores on achievement testing. The final sample included 111 children (71% male; 79% Caucasian; 78% of mothers had some college or more advanced degrees). Maternal education did not vary significantly by race or recruitment site although African American mothers compared to Caucasian mothers tended to have lower education levels.

Seventy-four children received a diagnosis of ASD at their final visit. The remaining 37 received non-spectrum (NS) diagnoses (n=26; language disorder, intellectual disability) and no diagnosis (n=11). At age 3, 9 and/or 18, the ASD and NS groups showed significant group differences in FSIQ, expressive language levels, autism symptom severity, and/or overactivity ratings (Table 1). The male:female ratio was significantly greater for the ASD than the NS cases. All developmental and demographic characteristics were treated as covariates in analyses.

Measures

Age 9 and 18 Measures

Academic Achievement: The Wide Range Achievement Test-3 (WRAT-3; Wilkinson, 1993) is designed to provide a general screening of academic skills in arithmetic, word reading and spelling for individuals aged 5-75. Arithmetic tasks measure an individual's ability to count, solve simple oral problems, and calculate written mathematics computations. Word reading tasks measure letter and word decoding through letter identification and word recognition. Spelling tasks measure an individual's ability to write letters and words in response to a dictated list. Standard scores (M=100; SD=15) and grade-equivalents were used for analyses. The Neale Analysis of Reading Ability (Neale; Neale, 1999) is a measure of reading achievement initially validated in the UK and Australia. The Neale was only administered at age 9 to measure passage comprehension; grade equivalents were converted based on the U.S. grading system for analyses.

Class Placement: Placement in a general education classroom or part-time inclusion was used as a proxy for “access to TD peers.” Children in a full-time autism-specific or self-contained special education classroom or special school were considered to have “no access” to TD peers. Proportions of children in general education or inclusion classrooms are reported in Table 2**.**

Cognitive and Language Skills: Cognitive assessments at ages 9 and 18 were chosen from the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1991) and Differential Abilities Scale (DAS; Elliott, Murray, & Pearson, 1990) Expressive language was assessed using the age equivalents (AEs) on the Vineland Adaptive Behavior Scale (Sparrow, Balla, & Cicchetti, 2005; Sparrow, Balla, Cicchetti, Harrison, & Doll, 1984), a semi-structured parent interview of adaptive functioning.

Early Predictors from Age 3

Cognitive and Language Skills: Cognitive scores were assessed with the Mullen Scales of Early Learning (Mullen, 1995) for all but two children who received the DAS Preschool (Elliott et al., 1990) at age 3 because they did not receive a ceiling on the Mullen scales when tested. Expressive language was assessed based on the VABS (Sparrow et al., 2005, 1984). Standard scores from age 2 evaluations were substituted for 16 children who did not complete cognitive assessments at age 3. When analyses were conducted while excluding the two children whose cognitive scores were computed from the DAS rather than the Mullen and also those 16 children whose age 2 scores were used instead of age 3 scores, all results were similar to when the full sample was included.

Activity level: The ‘Overactivity at home and elsewhere’ item on the Toddler version of the Autism Diagnostic Interview-Revised (Le Couteur, Lord, & Rutter, 2003) that was developed for research use in children under 4 years was used as a measure of early childhood activity level at age 3 (coded as 0=none and 1 to 3=some).

Mentored, parent-implemented structured teaching (MPST) intervention: Based on parent diaries and interviews completed, the hours of mentored, parent structured teaching (MPST; a home program modeled after the TEACCH extended diagnostic services (Mesibov, Shea, & Schopler, 2005) from age 2-3 were computed. Consistent with analyses from previous studies (Anderson, Liang, & Lord, 2014; Bal, Kim, Cheong, & Lord, 2015) based on the median number of MPST hours (not including children with 0h), hours of intervention were collapsed into two categories: (a) ‘Minimal to None’ i.e., less than 20 hrs; and (b) ‘Some’ i.e., 20 hrs or more between the 2 and 3 year-old assessments.

Best Estimate Clinical Diagnosis: Based on all available information, clinicians made best-estimate diagnoses of ASD, other non-spectrum psychiatric or developmental disorder, or no diagnosis at each in-person assessment. Most diagnoses were stable over the course of development, but there was some variability over time (Lord et al., 2006). The most recent diagnoses were used in all analyses (mean age = 18.8 years, SD= 6.9).

Analyses

Participants were assessed at ages 9 and 18. Out of 194 assessments, missing data for 49 assessments (mostly WRAT scores at age 18 due to attrition) were computed based on a regression analysis with multiple imputation using a Markov chain Monte Carlo (MCMC) method (Raghunathan, Lepkowski, Van Hoewyk, & Solenberger, 2001; Rubin, 1987) allowing prediction from age 3 variables (FSIQ, binary MPST intervention hours, VABS Expressive Language age equivalents [LAEs], and ADI Overactivity), age 9 variables (WRAT arithmetic, word reading and spelling scores, FSIQ, VABS ELAEs) and demographic factors (ASD diagnosis, gender, race, maternal education). We generated 100 imputed datasets using 30 iterations, each with different imputed values to reflect our uncertainty in their true value. Estimates of means and other parameters of interest were obtained by averaging results from each dataset and standard errors calculated that accounted for between- and within-imputation variation (Donald, 1987). Similarly, age 9 Neale scores were inferred based on multiple imputation for 50 children allowing prediction from age 3 FSIQ, binary MPST intervention hours, VABS ELAEs, ADI Overactivity and age 9 WRAT reading scores, FSIQ, VABS ELAEs and demographic factors with 100 datasets and 30 iterations. At Age 9, children who were followed up through age 18 vs. those who were not did not show any statistically significant differences in the proportions of children with ASD or the proportion of males, different races, and levels of maternal education. These groups also did not differ in FSIQ, language level (VABS ELAE), and ADOS symptom severity. Results were highly similar when analyses were conducted on the subset of children with data at both time points (results available upon request), therefore findings reported below include imputed data to maximize sample size and increase power.

We examined patterns of academic achievement (WRAT, Neale) at ages 9 and 18. Given the close association between IQ and achievement, academic scores were examined separately for children with average or Higher-IQ (IQ≥85; “Higher-IQ”) and those with below average IQ scores (IQ<85; “Lower-IQ”) at age 9. The cutoff of IQ at 85 was used because we were specifically interested in the differences in the academic outcomes and achievement-IQ gaps for those with average to above average IQ (>85) vs. those with below average IQ (<85), as opposed to differences between children with Intellectual Disability (ID) and non-ID (i.e., a cutoff of 70) which may be even more pronounced and somewhat more predictable. Group differences in the distributions of grade equivalents (variance) were compared using a nonparametric test, the Kolmogorov-Smirnov Z test. Proportions of children showing discrepant achievement-IQ profiles were compared between IQ groups using Chi-square analyses. Discrepant achievement- IQ profiles were based on the IQ-achievement discrepancy model that suggests that a difference of 15 or more standard score points between cognitive and academic measures reflect a clinically significant gap between intelligence and academic achievement (Fletcher, Francis, Morris, & Lyon, 2005).

To investigate the early predictors (at age 3) of academic scores at ages 9 and 18, we performed stepwise regression analyses. The WRAT standard scores and the IQ scores met assumptions of normality at all ages. Continuous variables, FSIQ and expressive language (VABS ELAEs) as well as binary variables, parent- mediated early intervention (MPST; 0=minimal or none, 1=some) and activity level (ADI item; 0=no activity, 1=some activity) were entered as predictors while covarying other binary variables, ASD diagnosis (0=non-ASD, 1=ASD), gender (0=female, 1=male), race (0=non-Caucasian, 1=Caucasian), and maternal education (0=high school degree or lower, 1=Bachelor's degree or higher). FSIQ was selected because it is the most widely recommended metric for identifying learning disabilities (Jones, et al., 2009) and has previously been suggested to predict reading and arithmetical achievement (Mayes & Calhoun, 2007). We also examined the patterns and age 3 predictors of class placement at ages 9 and 18 using chi-square (to examine the difference in the proportions of children in certain classroom types) and stepwise regression analyses described above (to examine age 3 predictors of later class placement at ages 9 and 18). The proportions of children with different class placements between ages 9 and 18 were compared based on a McNemar Test.

Linear mixed models were used to examine how child characteristics (cognitive and language skills at age 9; ASD diagnosis, gender, race, maternal education) predicted changes in academic scores between ages 9 and 18. Age, FSIQ, and expressive language (VABS ELAEs) were all entered as continuous variables. Main effects of age, FSIQ and language were examined as predictors of WRAT scores from age 9 to 18, and age by FSIQ and age by language interactions were added to examine the effects of FSIQ and language on changes in WRAT scores over time. Grade equivalents (GEs) from the WRAT were used as dependent variables because they are more sensitive to change than standard scores, which may remain stable or decrease over time for children who do not gain skills at the same pace as TD children.

Results

Academic achievement at Ages 9 and 18

As shown in Table 2, when children were divided by IQ (≥85 vs. <85), the Lower-IQ group showed consistently lower achievement scores than the Higher-IQ group for both ASD and NS cases at ages 9 and 18 (all $p<0.001$). When distributions in grade equivalents (GEs) on WRAT and Neale were compared between the two IQ groups, at age 9, the Lower and Higher-IQ groups showed comparable variability in all academic domains with GEs ranging widely from the kindergarten to the 12th grade level. However, the distribution was more skewed downward for the Lower-IQ group; at age 9 when children are typically in the 2nd or 3rd grade, many children in the Lower-IQ group (50-80%) were performing below the 2nd level on the WRAT and Neale (Figure 1), whereas a majority of children (80-95%) in the Higher-IQ group were performing at or above the 2nd grade level. At age 18, when adolescents are typically in the 12th grade, the Lower-IQ group showed significantly greater variation in all three domains on the WRAT than the Higher-IQ group with scores ranging from the kindergarten to the 12th grade ($p<0.001$). In contrast, a majority of children (65-75%) of the Higher-IQ group performed at the 12th grade level. Within IQ groups, ASD and NS groups did not differ in their academic scores. The mean Neale passage comprehension score was significantly lower than the mean WRAT word reading score for children with ASD in the Higher-IQ group ($p<0.05$), but not for the NS cases.

Discrepancies between achievement and IQ

A large proportion of children (66% at age 9; 77% at age 18) showed a notable discrepancy between IQ and achievement (15 or more points). Out of the children showing discrepancies, a significant minority of children (13-25%) in the Higher-IQ group showed WRAT scores that were 15 or more points below their IQ ("LowAch" profile; Figure 2). At ages 9 and 18, the Higher-IQ group was more likely than the Lower-IQ group to exhibit a LowAch profile for both word reading and spelling ($p<0.05$). In contrast, the Lower-IQ group was more likely than the Higher-IQ group to demonstrate a "HighAch" profile (i.e., academic scores 15 or more points higher than IQ) across all three WRAT domains ($p<0.05$; except for the arithmetic domain at age 9); 44-69% of the Lower-IQ group showed a HighAch profile across the three WRAT domains. This was partly due to a floor effect because a few children (7% of sample) with Lower-IQ-HighAch profile had FSIQ<40. While many children with achievement-IQ discrepancy in word reading (80-85% at ages 9 and 18) showed the same profile in spelling, fewer children (30-60%) who showed achievement-IQ discrepancy in arithmetic showed the same discrepancy profiles in word reading or spelling.

Similarly, within the ASD group only, most children (74% at age 9; 92% at age 18) showed discrepancy in at least one academic domain (Figure S1). We also found small subsets of children with ASD showing the Higher-IQ-LowAch profile (16% at age 9; 10% at age 18) and larger subsets of children showing the Lower-IQ-HighAch profile (41% at age 9; 50% at age 18). The largest subset of children showed the LowerIQ-HighAch profile (n=24) in word reading/spelling at age 9. Most of these children also showed the HighAch profile in arithmetic (in addition to word reading/spelling) by age 18 (n=22). Figure S2 further illustrates the academic and IQ scores of these children with ASD. The difference scores between IQ and achievement were large, ranging from 18 to 29 point in average by domain. Despite Lower-IQ scores, achievement in the Lower-IQ-HighAch group was fairly intact; achievement scores across all domains were moderately delayed (2-3 SDs below the mean) at age 18 or in the average ranges at age 9. On the other hand, despite average to above average IQ scores, the Higher-IQ-LowAch group showed below average arithmetic and average word reading/spelling at age 9. This group also showed average achievement in all domains at age 18 despite above average IQ scores.

Preschool Predictors of Academic Achievement Profiles at Age 9 and 18

Higher FSIQ at age 3 significantly predicted higher WRAT arithmetic (age 9: β=1.13, *SE*=.17; age 18: β=.79, *SE*=.30), word reading (age 9: β=.76, *SE*=.13; age 18: β=.56, *SE*=.17), and spelling scores (age 9: β=.80, *SE*=.14; age 18: β=.755, *SE*=.26) as well as passage comprehension (β=.04, *SE*=.02; all $p<0.01$). Children whose mothers received more than 20 hours of early parent teaching intervention between ages 2-3 showed significantly higher arithmetic scores at age 9 (β=16.65, *SE*=8.10) and higher word reading scores at age 18 (β=15.075, SE=7.28) compared to those who received less intensive or no intervention while controlling for FSIQ, diagnosis, language and demographic factors (*p's*<0.05). Diagnostic group differences were significant only for word reading skills at age 9 (β=−3.584, *SE*=.1.79; ASD>NS). When the analyses were repeated with the sample without missing data, the results for the three WRAT domains remained the same compared to the results based on the complete data except for the effect of parent teaching intervention on age 9 arithmetic scores, which became marginally significant (p=0.08).

Elementary School Predictors of *Changes* in Academic Skills from Age 9 to 18

Grade equivalents (GEs) for all WRAT domains improved significantly over time ($p<0.001$; Table 3). However, changes were moderated by FSIQ; not surprisingly, children with higher FSIQs showed larger improvements compared to those with lower FSIQs ($p<0.001$). Age 9 FSIQ significantly predicted academic scores across age 9 and 18 ($p<0.05$). Children with ASD also showed higher word reading scores at both age 9 and 18 compared to the NS group ($p<0.05$) while controlling for all other factors.

Class Placement at Ages 9 and 18

The proportions of children in general education or inclusion classrooms at each time point are indicated in Table 2. A higher proportion of children in the Higher-IQ group were placed in general education or inclusion classrooms compared to the Lower-IQ group (χ^2=15.5 at age 9, χ^2=21.9 at age 18, both $p<0.05$); the proportion of children in general education or inclusion classrooms in both groups decreased significantly by age 18 (McNemar χ^2=42.6, $p<0.001$). Higher FSIQ also predicted general education or inclusion classroom placement (vs. full time special education placement) at age 9 (β=.01, *SE*=.01, $p<0.05$) and marginally at 18 (p=0.06). Children with ASD in the Higher-IQ group were less likely to be placed in general education or inclusion classrooms at age 18 than the NS group ($p<0.05$), even though IQ and achievement levels were comparable between the groups. Children with ASD and NS diagnoses who remained in general education or inclusion classroom from age 9 to 18 (n=26) had significantly higher academic, cognitive and language skills and lower autism severity scores compared to those who moved from general education or inclusion to special education classrooms (*n*=30; $p<0.05$; Table S1). The rest of the children (n=21 out of 87) remained in special education classrooms from age 9 to 18. Similar patterns emerged when the analysis was performed with children with ASD only. Children with ASD were also more likely to move from general education or inclusion to special education classrooms from age 9 to 18 compared to the NS group ($p<0.05$).

Discussion

This is the first longitudinal study examining preschool and school-age predictors of basic academic skills in elementary and high school children referred for possible ASD as toddlers. Although we excluded children with verbal mental ages less than 21 months at age 9 because they could not complete achievement testing (*n*=54), children included in our sample still showed a wide range of cognitive and language functioning and autism symptom severity. Reflecting this, we found similar variability in academic skills at ages 9 and 18. However, achievement in basic academic domains for many children was found to be either commensurate with or above what would be expected given their cognitive levels. Consistent with previous cross-sectional or short-term longitudinal studies of children with ASD, achievement scores ranged widely from very low to average ranges across arithmetic, word reading, passage comprehension and spelling (Estes et al., 2010; Jones et al., 2009; Nation et al., 2006; Wei et al., 2015). Variable academic achievement has also been reported in general population studies (Kena et al., 2015).

Consistent with TD children (Duncan et al., 2007), one of the most robust early predictors of elementary and high school academic achievement for this ASD referral sample was preschool cognitive skills. While all children's grade equivalents and raw scores suggested improvements across academic domains from ages 9 to 18, rates of gains were moderated by school-age IQ levels; children with higher cognitive skills showed more rapid gains compared to those with lower cognitive skills. While previous studies have reported IQ as a concurrent predictor of academic outcome in children with ASD (Assouline et al., 2011; Jones, et al., 2009; Mayes & Calhoun, 2003), this is the first study to show that preschool cognitive levels predict elementary and high school academic achievement and that school-age cognitive levels moderate *changes* in academic development from elementary to high school.

Participation in a structured parent teaching program prior to age 3 was also associated with higher arithmetic and word reading skills at ages 9 and 18. Notably, this study was not designed to assess effects of early intervention. Because there are many child and family characteristics such as parent knowledge, parent and child motivation, family's access to resources and other environmental factors that could not be measured and controlled in our study, results may reflect the long-term benefits of such environmental factors on academic outcomes in ASD. Since past studies were limited to short-term follow-ups or cross-sectional investigations, replications with other longitudinal samples will help elucidate the link between the participation of parents in early intervention programming and longer-term academic outcomes while considering other confounding factors that may moderate this relationship in individuals with ASD.

Similar to past studies (Estes et al., 2010; Jones, et al., 2009; Nation et al., 2006; Wei et al., 2015), many children referred for possible ASD at age 2 in our study showed notable discrepancies between achievement and IQ (either higher or lower achievement vs. IQ in 15 points or more; 70% at 9; 80% at 18) on the WRAT arithmetic, word reading or spelling. This could suggest that there may be other underlying neuropsychological factors that mediate relationships between achievement and IQ scores in children with ASD. A significant minority of children with ASD in the Higher-IQ group showed a LowAch profile in at least one academic domain (16% at 9; 10% at age 18). These profiles may reflect additional learning difficulties, suggesting a need to ensure that children with ASD are carefully screened for potential learning problems. In contrast, a larger number of children with ASD in the Lower-IQ group showed a HighAch profile in at least one academic domain (41% at 9; 50% at 18), with an increasing number of children showing higher achievement in all academic domains over time. For these children, achievement scores were either in the average range (age 9) or slightly delayed (age 18) despite the mild to moderate range of intellectual disability. These results highlight the importance of continued support for basic academic instruction throughout high school in adolescents with cognitive impairments to ensure that they achieve their full academic potential.

Although many children with ASD performed at or above expectations on the WRAT word reading, which targets basic letter and word recognition, passage comprehension based on the Neale was significantly more impaired. Similar to past studies (Huemer & Mann, 2009; Nation et al., 2006), the gap between word reading and passage comprehension found in our sample of children with Higher-IQ scores suggests that the ability to infer information from passages may often be impaired in many children with ASD even though they may have relatively intact letter and word recognition. Future studies aimed at identifying which skills (e.g., inattention, working memory) are driving this discrepancy are necessary to inform intervention development.

During the elementary school period, many children in this study were included in general education or part-time inclusion classrooms. This is encouraging given that TD peers can serve as role models for both acquisition and generalization of academic and social skill development for children with ASD (Justice et al., 2014). However, in our study, children with ASD, including those with average or above average IQ and achievement scores were more likely to move from general education or inclusion classrooms to full-time special education classrooms from ages 9 to 18 compared to those with non-ASD diagnoses, despite the fact that both groups showed similar academic achievement levels. Additionally, children who remained in general education or inclusion classrooms, thus who maintained access to typical peers, had better academic, cognitive and language skills and lower symptom severity at both age 9 and 18 compared to those who lost their access to typical peers. It is important to note that we cannot infer causality between changes in class placement and academic development in adolescents with ASD from these results; thus, further investigation is needed in this area.

Limitations and Future Direction

This study includes a relatively large sample of participants assessed across multiple points, at ages 3, 9 and 18, which allowed us to examine early predictors of later academic achievement as well as changes in academic skills throughout elementary and high school years. Participants were children with a wide range of cognitive and language functioning as well as with variable diagnostic outcomes (e.g., ASD, language impairments, and intellectual disability), although a majority of children retained ASD diagnoses.

From age 3 to 18 years, not all children were assessed at every time point. A large sample size and a comprehensive set of clinical and demographic variables allowed us to perform multiple imputation methods to obtain the equivalent of the full data at age 9 and 18; results were highly similar when analyses were limited to the subset of children with full data at both time points. Nonetheless, replications of results are needed with large, independent datasets. Although we found a link between parent participation in early intervention and later academic achievement, the effects of other factors on academic outcomes (e.g., parent motivation, access to educational resources) should be further explored.

Finally, future research is needed to consider the extent to which academic achievement predicts longer-term adult outcomes, such as independence and other markers for "real-world" function. In an analysis of the cohort described in this paper, Anderson and colleagues (2014) reported no differences in academic achievement scores on the WRAT between young adults with ASD and VIQ above 70 and those designated as having "Very Positive Outcomes" (i.e., no longer meeting criteria for a clinical ASD diagnosis although they were diagnosed with ASD earlier). This might suggest that academic achievement is not a good predictor of "real world" functioning. Nonetheless, it will be important for other studies and future analyses to systematically investigate the relationship between achievement and adult outcomes.

Conclusion

Many children referred for ASD early on achieve basic academic skills commensurate with or higher than their cognitive ability during elementary and high school years. Some children with ASD with intact cognitive skills showed delayed achievement, suggesting a need for more rigorous screening for additional learning difficulties. Interventions targeting cognitive skills and parent participation in early treatment may be crucial for later academic development in ASD.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points

- Elementary and high school academic outcomes in children referred for possible ASD at age 2 varied widely, but were mostly compatible with or higher than those predicted by cognitive skills.
- Small subsets of children with ASD who had average to above average cognitive skills showed lower achievement scores (15 points or more). On the other hand, a few children with ASD with mild to moderate cognitive delays showed average to moderately delayed achievement scores that were higher than their cognitive skills (15 points or more).
- Children who stayed in general education or inclusion classrooms showed significantly higher achievement and IQ scores at both age 9 and 18 compared to those who moved from general education or inclusion classrooms to special education classrooms.
- Early cognitive abilities and the provision of parent-mediated intervention by age 3 emerged as the predictors of long-term academic outcomes at age 9 and 18.
- All children showed continuous growth in academic skill development throughout high school, but those with higher cognitive skills at age 9 showed more rapid improvements from age 9 to 18 compared to those with lower cognitive and language skills.

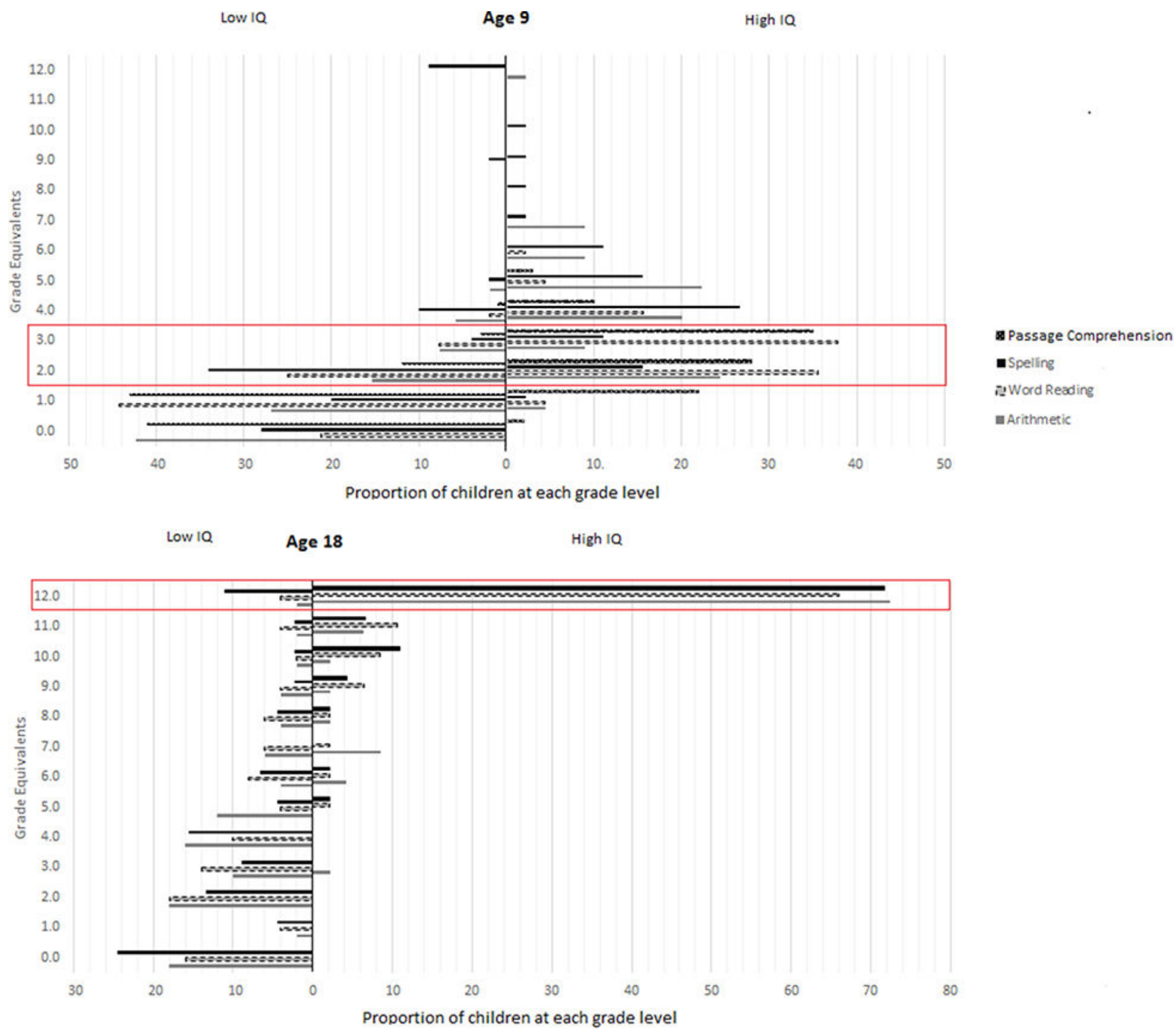

Figure 1.
Proportions of children at different grade levels of achievement at age 9 and 18 for Lower-(IQ<85) vs. Higher-IQ (IQ≥85) groups. Redbox indicates the grades at which children were placed at age 9 and 18.

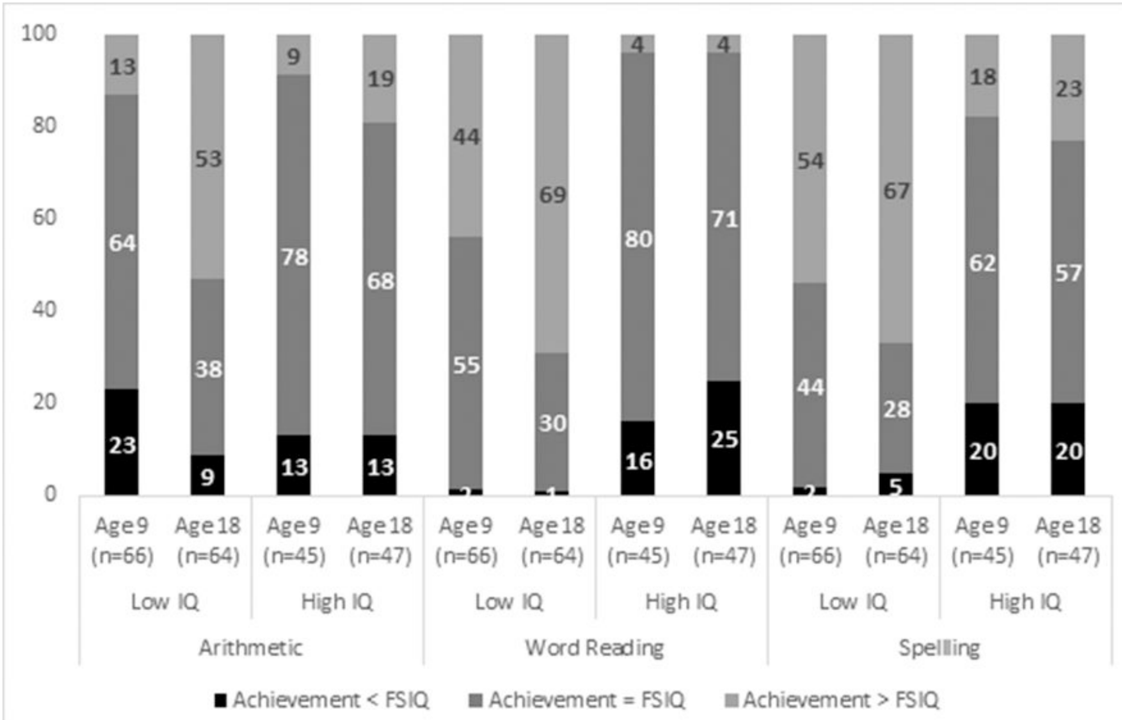

Figure 2. Proportions of children with discrepancies between achievement and cognitive scores (15 points or more)

Table 1

Sample Characteristics

	ASD (n=74)			NS (n=37)		
	Mean	SD	Range	Mean	SD	Range
Age 3-FSIQ(M, SD) *	62.9	20.5	24-108	75.4	18.7	33-113
Age 9-FSIQ(M, SD)	72.7	27.2	29-126	78.8	31.1	25-136
Age 18-FSIQ(M, SD)#	69.0	38.2	1-142	74.7	38.2	13-144
Age 3-VABS-ELAE(M, SD) *	18.3	9.3	0-44	22.7	7.5	10-38
Age 9-VABS-ELAE(M, SD)	74.3	37.5	11-186	85.7	37.3	17-186
Age 18-VABS-ELAE(M, SD)	116.4	92.5	20-264	134.4	92.4	24-264
Age 3-ADOS-CSS-symptom severity(M, SD) *	6.6	2.4	1-10	3.0	2.4	1-8
Age 9-ADOS-CSS-symptom severity(M, SD) *	7.3	2.2	1-10	3.3	2.3	1-9
Age 18-ADOS-CSS-symptom severity(M, SD) *	6.5	1.8	2-10	3.7	2.4	1-8
Age 3-ADI-Activity level(M, SD)	0.5	0.5	0-1	0.3	0.5	0-1
Males(n,%)	66, 89%			25, 68%		
Caucasian(n,%)	54, 72%			29, 78%		
Maternal education; BA+(n,%)	65, 88%			22, 59%		
MPST-Intervention from 2-3 years(n,%)						
>=20h	9, 12%			1, 3%		

FSIQ Full-scale IQ, ADOS Autism Diagnostic Observation Schedule, *CSS* Calibrated Severity Scores, *VABS* Vineland Adaptive Behavioral Scale, *ELAE* Expressive Language Age Equivalents; *ADI* Autism Diagnostic Interview, *BA+* Bachelor's degree or higher, *MPST* Mentored Parent Structured Teaching.

* Significant group differences emerged ($p<0.05$).

\# Age 18 FSIQ computed based on a complete dataset with imputed scores. The range for FSIQ for ASD at age 18 was from 20-125 for children without imputed data.

Table 2

Age 9 and 18 Academic Outcomes

	Age 9				Age 18			
	ASD(n=74)		NS(n=37)		ASD(n=74)		NS(n=37)	
	Lower-IQ (<85)	Higher-IQ (≥85)	Lower-IQ (<85)	Higher-IQ (≥85)	Lower-IQ (<85)	Higher-IQ (≥85)	Lower-IQ (<85)	Higher-IQ (≥85)
n	47	27	19	18	44	30	20	17
FSIQ(M, SD)	55.0(14.9)	103.3(11.9)	53.3(17.2)	105.8(15.6)	41.1(19.1)	110.1(13.7)	43.0(19.5)	110.3(14.8)
WRAT-Standard Scores(M, SD)								
Arithmetic	53.3(22.1)	101.3(17.1)	47.1(22.0)	102.0(16.5)	59.3(25.3)	115.3(21.9)	56.7(25.4)	110.8(20.5)
Word Reading	68.5(16.9)	100.9(14.8)	65.4(15.6)	100.9(13.4)	64.1(17.9)	104.4(14.0)	66.0(15.8)	102.5(14.5)
Spelling	70.7(17.1)	102.6(18.9)	69.8(17.9)	104.4(19.3)	69.1(23.6)	110.7(21.7)	64.2(23.9)	109.6(17.6)
WRAT-Grade Equivalents(M, SD)*								
Arithmetic	0.9(1.3)	4.1(2.4)	0.8(1.2)	3.8(1.8)	3.2(3.6)	12.7(3.4)	2.2(3.8)	11.6(2.9)
Word Reading	1.2(0.9)	3.0(1.1)	1.0(0.8)	2.8(0.9)	3.6(3.8)	12.1(2.9)	3.7(3.6)	11.5(2.8)
Spelling	1.3(1.8)	4.9(3.0)	1.5(1.4)	5.1(3.1)	4.1(4.4)	11.9(3.5)	3.9(4.4)	12.7(2.2)
Neale PC Grade Equivalents(M, SD[#])	0.6(1.2)	2.1(1.3)	0.5(0.9)	2.4(1.2)	-	-	-	-
Class Placement (% in GenEd/Inc)[a]	60%	93%	82%	100%	14%	47%	31%	100%

Neale PC Neale Passage Comprehension, *GenEd/Inc* General Education or Inclusion Classrooms.

[a]Information of Class Placement was not available for 1 child at age 9 and 24 at age 18. Means and Standard Deviations were computed based on a complete dataset with imputed scores.

Table 3

Results of linear mixed model predicting academic skills from age 9 to 18

		Estimates	Standard Error
Arithmetic GE	Age**	−7.288	773
	FSIQ at age 9**	.158	.025
	Age x FSIQ**	−.117	.025
Word Reading GE	Age**	−8.650	.619
	FSIQ at age 9**	.124	.020
	VABS-ELAE*	.033	.015
	ASD diagnosis*	−.313	.153
	Age x FSIQ**	−.099	.021
Spelling GE	Age**	−5.930	.878
	FSIQ at age 9**	.702	.156
	Age × FSIQ*	−.084	.030

** $p<0.01$,

* $p<0.05$, *GE* Grade Equivalents; *FSIQ* Full-Scale IQ, *VABS-ELAE* Vineland Adaptive Behavioral Scale Expressive Language Age Equivalents. All variables except for the VABS-ELAE for Word Reading ($p=0.06$) were still significant when analyses were performed based on the sample without missing data. FSIQ and VABS-ELAE were centered at 100 and 9 years respectively.