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ORIGINAL PAPER

Predicting the Academic Achievement of Gifted Students with Autism Spectrum Disorder

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Abstract We are not well informed regarding the ability-achievement relationship for twice-exceptional individuals (very high cognitive ability and a diagnosed disability, e.g., autism spectrum disorder [ASD]). The research question for this investigation ($N = 59$) focused on the predictability of achievement among variables related to ability and education in a twice-exceptional sample of students (cognitive ability of 120 [91st percentile], or above, and diagnosed with ASD). We determined that WISC-IV Working Memory and Processing Speed Indices were both significantly positively correlated with achievement in math, reading, and written language. WISC Perceptual Reasoning Index was uniquely predictive of Oral Language test scores. Unexpected findings were that ASD diagnosis, Verbal Comprehension Index, and forms of academic acceleration were not related to the dependent variables.

Keywords Autism · Cognitive ability · Academic achievement · Gifted

Introduction

The dearth of empirical research about twice-exceptional students, including gifted students with autism spectrum disorder (ASD), has been documented and the call to action issued (Foley Nicpon et al. 2011). Complexities related to vagaries of definitions of giftedness among educators, coupled with the fact that educators are not familiar with diagnosis, intervention, and advocacy of twice-exceptional students (Assouline and Foley Nicpon 2007), are among the reasons for an absence of empirical research in the area of twice-exceptionality. Descriptive studies of a sample are a common first step in empirical research aimed at better understanding a research sample. Descriptive research can yield profiles of psychological characteristics, which can lead to better understanding of a sample's unique characteristics relative to the general population. Toward that end, Foley Nicpon et al. (2012) examined the cognitive and academic performance profiles of twice-exceptional students and discovered interesting patterns. Specifically, students diagnosed with Asperger Syndrome (AS) had significantly higher verbal comprehension index scores than did students diagnosed with autism (Foley Nicpon et al.). Refinement of our understanding of this interaction among diagnosis, achievement, and ability will allow researchers to gain insight into the relationship between and among variables associated with twice-exceptionality. The impetus for the current study is to examine cognitive and educational variables that are related to achievement in gifted students with ASD (twice-exceptional students).

Cognitive Ability and ASD

Severe cognitive impairment is not among the diagnostic criteria for any of the ASDs, including autism (American Psychiatric Association 2000; Sansosti et al. 2010); however, that does not eliminate the confusion about the effect of cognitive ability. Experts in the field are equivocal about the role of cognitive ability on diagnosis, especially as it relates to differential diagnosis between autism and Asperger Syndrome (American Psychiatric Association 2000). Volkmar and Klin's (2000) review of the historical relationship between autism and Asperger syndrome

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succinctly summarizes that Kanner and Asperger were essentially describing two similar, yet different populations, which resulted in the "subsequent tendency to equate Kanner's syndrome with the 'classically' lower-functioning autistic child and Asperger's description with the nonretarded and verbal child with autism" (p. 33).

The evolution of the ASD diagnostic categories, coupled with shifts in the relationship of the categories to cognitive functioning, offer insight into the complexities in understanding the nature of ASD as a disability and its effect on achievement, especially in individuals with high cognitive ability (e.g., IQ of one standard deviation, or higher, above the mean). Woo and Keatinge's (2008) historical summary reveals the parallel nature of the seminal work on two of the major ASD disorders: autism (Kanner 1943) and Asperger Syndrome (Asperger 1991). Prior to 1980, individuals who presented with the now-classic characteristics of autism were diagnosed with childhood schizophrenia. Woo and Keatinge (2008, p. 199) write that Wing was able to combine observations and research and conclude that "autism is a spectrum disorder that was more closely linked to mental retardation than to Schizophrenia". This description, which simultaneously associated autism with behavioral impairments and cognitive ability with mental retardation, mirrored Kanner's reports.

Likely because not all individuals with autism had mental retardation, the term high functioning autism (HFA) emerged as the descriptor for individuals with IQ in the borderline range or above. Unfortunately, the descriptor of "high functioning" does not refer to autism characteristics, rather high functioning refers to cognitive ability, which has resulted in confusion and over-generalization.

Even though cognitive functioning is not a part of the autism diagnostic criteria, cognitive functioning remains an important descriptor for researchers and clinicians alike. Recent reviews (Witwer and Lecavalier 2008) propose that intellectual differences between groups, rather than the differences in diagnostic criteria, are better able to separate autism and Asperger Syndrome. Although this may appear to be helpful diagnostically, it is problematic from a research perspective, especially when the cognitive profile range is large (e.g., four or more standard deviations) and analyses are conducted on group means (Joseph et al. 2002). There are also issues relative to recommended interventions (Sansosti et al. 2010).

Although intraindividual differences are common in overall cognitive functioning, even among students with very high cognitive ability (Rowe et al. 2010), students with ASD typically display general deficits in higher-order thinking and problem-solving skills, as well as stronger rote than recognition memory skills (Meyer 2001). As well, they commonly have lower processing speed scores than verbal, nonverbal, and working memory (Calhoun and Mayes 2005; Mayes and Calhoun 2007), executive functioning, theory of mind, and abstract reasoning scores (Ozonoff and Griffith 2000). Among average or above IQ students with autism, researchers found that verbal and nonverbal abilities were better than working memory and processing speed abilities (Mayes and Calhoun 2003).

Cognitive Ability, Academic Achievement, and ASD

Despite debates about diagnostic differentiation among experts and researchers, both can agree that students with ASD experience social and academic challenges in the school settings and throughout their school careers. Therefore, a better understanding of the relationship between cognitive abilities and achievement in individuals with ASD who have very high cognitive abilities will contribute substantially to the research and assist in developing evidence-based practices for intervention, especially in academic settings. In particular, individuals with very high IQ and ASD characteristics are at risk for not being referred and/or assessed (Assouline et al. 2009), which may jeopardize the fidelity of the diagnostic process and consequently delay intervention.

Studies investigating the relationship between the achievement and academic profiles of students with ASD are limited and conclusions are equivocal. In one investigation (Eaves and Ho 1997) researchers looked at a group of students with a wide range of IQ and a diagnosis of ASD and determined that students generally achieve at a level commensurate with their IQ, especially in reading. Results from a recent analysis of 30 children with high functioning autism indicated that 90% had intellectual and achievement discrepancies, and that social skills may positively influence academic achievement (Estes et al. 2011).

Meyer (2001) determined that students with ASD obtained higher rote word reading and spelling scores than reading comprehension and written expression scores. However, fine-motor skills are commonly impaired independent of ability (Fuentes et al. 2009), and oral and written language skill impairments have been identified among those with AS (Myles et al. 2001). Researchers determined that students diagnosed with ASD who have IQs of 80 or higher obtained reading, math, and spelling scores in the average range; however, their written language scores were below expectations based on IQ (Mayes and Calhoun 2003). To date, only one empirical study (Foley Nicpon et al. 2012) has reviewed the cognitive and academic profiles of individuals with very high cognitive ability (an ability index score of 120 or higher) and ASD. This study yielded information that gives a fuller understanding of the very broad cognitive range of individuals with ASD, specifically addressing cognitive strengths and weaknesses relative to the different ASD diagnoses.

Research Questions

To address the purpose of the current study, which was to examine the predictability of achievement among high ability youth with ASD (twice-exceptional), we asked three questions. First, what is the relationship among achievement in reading, math, written language, and oral language and ASD diagnosis, measures of ability, and educational interventions including participation in talented and gifted programs, subject acceleration, and whole-grade acceleration? Second, what aspects of student ability predict achievement among gifted students with ASD? Third, what impact do educational interventions (participation in talented and gifted programming [TAG] and whole grade or single-subject acceleration) have on the achievement of gifted students with ASD?

Methods

Participants

Data for the study were gathered from 59 cognitively gifted students with ASD who were referred for an evaluation in a psychology clinic housed in a university center for gifted and talented students. Recruitment occurred in one of two ways: a US department of education grant-funded project that evaluated high-ability students with a specific learning disability or an autism spectrum disorder; or through a pool of clients evaluated by the clinic's licensed psychologists.

Inclusion criteria were an IQ standard score of 120 or higher on at least one of the Index scores from the Wechsler Intelligence Scales for Children—4th Edition (WISC-IV; Wechsler 2003) or the Wechsler Adult Intelligence Scale—3rd Edition (WAIS-III; Wechsler 1997), and a diagnosis of ASD, including autism, AS, or PDD-NOS. ASD diagnoses were made through administration of the Autism Diagnostic Interview—Revised (ADI-R; Rutter et al. 2003) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2003). Both instruments were administered as a part of a larger diagnostic battery, which included a clinical interview, review of records, behavioral observations, as well as ability, achievement, executive functioning, and psychosocial assessment. Students were not required to be enrolled in their school's gifted and talented program. Forty-one participants were part of the grant-funded sample and met both inclusion criteria. The remaining 18 were from parent- or self-referred clinic evaluations. In the total sample, 40.7% (n = 24) were diagnosed with autism, 39% (n = 23) with AS, and 20.3% (n = 12) with PDD-NOS.

Procedures

Licensed psychologists administered the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2003) to each participant, and the Autism Diagnostic Interview—Revised (ADI-R; Rutter et al. 2003) to all parents. Parents also completed a behavior measure, which was scored by advanced doctoral students under the supervision of a licensed psychologist. In addition to the ADOS, students younger than 16-years-old were administered the WISC-IV, and students sixteen or older were administered the WAIS-III.

The assessment protocol for all participants included administration by a licensed psychologist, or by advanced doctoral students under the supervision of the licensed psychologists, of an individualized achievement test, a measure of visual-motor integration, and measure of behavior and social adaptability. Information about academic interventions, including academic acceleration and/or participation in gifted and talented programming, was obtained during the pre-assessment intake interview with parents. The interview was conducted by a licensed psychologist.

Measures

Intellectual Ability, Academic Achievement, and Visual-Motor Skills

Subjects younger than 16-years-old were administered the *Wechsler Intelligence Scales for Children* (WISC-IV; Wechsler 2003), an individually administered ability test developed for use with students between the age of 6 and 16. The WISC-IV subtest scores are presented as scaled scores with a mean of 10 and a standard deviation of three. The subtest scale scores are combined to yield a Full Scale IQ, which is presented as a standard score with a mean of 100 and a standard deviation of 15. The subtests are also used to generate four Index Scores, which also are presented as standard scores with a mean of 100 and a standard deviation of 15. The four Index scores are: Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI). The VCI includes three core subtests: Similarities (a measure of verbal reasoning), Vocabulary (a measure of word knowledge), and Comprehension (a measure of word knowledge and understanding of social rules and norms), all of which are used as an indicator of verbally-based reasoning skills. The PRI includes three core subtests: Block Design (a measure of visual-spatial skills), Matrix Reasoning (a measure of nonverbal and spatial reasoning), and Picture Concepts (a measure of nonverbal concept formation), all of which are used as an indicator of nonverbal reasoning and visual-motor skills. The WMI has two core subtests: Digit Span (a measure of rote and manipulative memory) and Letter-Number Sequencing (a measure of short term and manipulative memory), which are designed to measure sustained attention and the ability to recall and mentally manipulate auditorily presented information. The fourth index, the PSI has two core subtests: Coding (a measure of visual processing and fine motor skills) and Symbol Search (a measure of visual scanning and cognitive processing), both of which are used to assesses visual acuity, perceptual discrimination, and speed of mental processing.

Subjects who were 16-years-old or older were administered the Wechsler Adult Intelligence Test (WAIS-III; Wechsler 1997). Similar to the WISC-IV, the WAIS is comprised of individually administered subtests that yield scaled scores with a mean of 10 and a standard deviation of three. The subtest scale scores are combined to comprise a Full Scale IQ, which is presented as a standard score with a mean of 100 and a standard deviation of 15. The subtests are also used to generate a Verbal Scale IQ and a Performance Scale IQ, as well as four Index Scores, all of which also are presented as standard scores with a mean of 100 and a standard deviation of 15. The four Index scores are: Verbal Comprehension Index (VCI), Perceptual Organization Index (POI), Working Memory Index (WMI), and Processing Speed Index (PSI). Similar to the WISC-IV, the WAIS has extremely high reliability.

The *Woodcock-Johnson III Tests of Achievement* (WJIII ACH; Woodcock et al. 2001) were used to measure achievement. The WJIII ACH is an individually administered achievement test that assesses the areas of reading, mathematics, written language, and oral language. All scores are reported as Standard Scores with a mean of 100 and a standard deviation of 15. School and clinical psychologist use the WJIII to determine a student's individual academic strengths and weaknesses.

The WJIII ACH produces four broad scores: Broad Reading, Broad Mathematics, Broad Written Language, and Oral Language. Three subtests, Letter-Word Identification (single word reading), Reading Fluency (speed and understanding), and Passage Comprehension (reading understanding) comprise the Broad Reading Index. Likewise, three subtests comprise the Broad Mathematics Index: Computation (math calculation), Math Fluency (computation speed), and Applied Problems (math problem-solving ability). The three subtests that comprise Broad Written Language are Spelling, Writing Fluency (how quickly a student writes simple sentences) and Writing Samples (written expression based on a student's ability to compose sentences). The final achievement index, Oral Language is comprised of two subtests: Story Recall (short-term, auditory memory and expressive language) and Understanding Directions (receptive language where students are asked to follow increasingly complex auditory directions.

The Beery-Buktanica Test of Visual Motor Integration (VMI; Beery et al. 2004) is an individually administered test designed to measure eye-hand and fine motor coordination. The VMI evaluates fine-motor coordination through a paper-and-pencil task in which the student is asked to copy increasingly complex geometric figures. Results from the VMI are reported on a standard scale with a mean of 100 and a standard deviation of 15 (Beery and Beery 2004).

Results

Descriptive Statistics

The sample of 59 individuals ranged in age from 5 years, 6 months to 17 years, 11 months; the average age was 10 years, 7 months, with a standard deviation of 3.19 years. Nine participants were girls and 50 were boys. The majority of the students (86.5%, n = 51) were White. Participants also self-identified as Hispanic (5.1%, n = 3), Asian (1.7%, n = 1), and Mixed Race (1.7%, n = 1) participants. There were 14 students in grades K-2, 22 in grades 3–5, 14 in grades 6–8, and nine in grades 9–12.

From the study sample (N = 59), a subsample (n = 28) reported one or more forms of academic acceleration as an educational intervention. One student was whole grade accelerated only; 16 were single-subject accelerated only, and 11 were both single and whole-grade accelerated. The means, standard deviations, and ranges from the remaining independent variables and the dependent variables are reported in Table 1.

Correlations

The first research question concerned the relationship among reading, math, written language, and oral language achievement scores and diagnosis, measures of ability, participation in talented and gifted programs, subject acceleration, and whole-grade acceleration. The correlations among these variables are presented in Table 2. Both reading and math achievement scores were significantly positively correlated with three variables: participation in talented and gifted programs, and students' scores on the Working Memory Index (WMI) and the Processing Speed Index (PSI) of the WISC-IV. The strongest correlation was found between WJ-III Broad Reading and the WISC-IV PSI. Written Language achievement was significantly

Table 1 Means and standard deviations

	N	Minimum	Maximum	Mean	SD
WISC VCI	48	95	155	125.08	15.102
WISC PRI	48	90	149	123.73	13.321
WISC WMI	48	86	141	111.33	13.734
WISC PSI	47	68	126	96.57	15.706
VMI	40	71	138	96.12	16.721
WJ broad reading	39	86	174	124.67	18.347
WJ broad math	38	86	153	119.26	13.582
WJ broad written language	35	78	166	117.60	19.959
WJ broad oral language	39	94	137	114.67	10.621

Table 2 Correlations between achievement scores and independent variables

	Written language	Reading	Math	Oral language
Aspergers	−0.018	0.009	−0.084	0.126
Autism	0.235	0.050	0.193	−0.075
PDD	−0.245	−0.071	−0.131	−0.063
Grade acceleration	−0.212	0.016	−0.045	0.051
Subject acceleration	0.034	0.139	0.213	0.02
TAG	0.264	0.346*	0.357*	0.353*
VMI	0.237	0.104	0.421*	0.273
WISC VCI	−0.034	0.224	0.02	0.297
WISC PRI	0.209	0.239	0.333	0.440**
WISC WMI	0.496**	0.401*	0.495**	0.331
WISC PSI	0.374*	0.713**	0.475**	0.170

* $p \leq 0.05$; ** $p \leq 0.01$

positively correlated with students' scores on the Working Memory Index and Processing Speed Index. Oral Language achievement scores were significantly positively correlated with participation in talented and gifted programs and scores on the Perceptual Reasoning Index. Only Math achievement was positively correlated with performance on the VMI.

Unexpectedly, there were no significant correlations between VCI and any of the four dependent variables. Likewise, there were no significant correlations between ASD diagnosis, subject acceleration, or grade acceleration and the four dependent variables. There was no significant correlation between WISC-IV PRI and Broad Reading, Broad Math, or Broad Written Language. As indicated, among the ability measures, only the correlation between Oral Language and WISC PRI was significant and positive; Oral Language was not correlated with the other three WISC indices.

Regression Analyses

Regression analyses were performed to answer the second and third research questions: What aspects of student ability predict achievement among gifted students with ASD, and what impact do educational interventions (participation in talented and gifted programming and whole grade or single-subject acceleration) have on the achievement of gifted students with ASD? Initially, all of the potential independent variables (all WISC Index Scores: VCI, PSI, PRI, WMI, diagnosis, VMI, both single-subject and whole-grade acceleration, and participation in TAG) were included. This model accounted for 76.5% of the variance in Broad Reading, 70.6% of the variance in Broad Math, 66.2% of the variance in Broad Written Language, and 39.1% of the variance in Broad Oral Language.

Stepwise regression methods were performed to find a parsimonious model for each content area that would be as good at predicting the achievement score as the initial model used with all independent variables and no interaction terms. The results of these analyses are presented in Table 3. Not surprisingly, the variables for diagnosis, acceleration, and WISC Verbal Comprehension Index, which were not significantly correlated with the dependent variables, dropped out of all four equations as being not significantly useful in predicting the achievement scores when other variables were present. The variables that remain in the models are all positively related to the achievement score they are predicting. The Working

Table 3 Regression analysis results

	β value	Partial p value	R^2	p value for final model	F change from initial model
Reading			0.613	0.000	0.687
WMI	0.454	0.010			
PSI	0.758	0.000			
Math			0.597	0.000	0.467
PSI	0.404	0.001			
TAG	14.428	0.001			
VMI	0.375	0.002			
Oral Language			0.218	0.007	0.591
PRI	0.367	0.007			
Written Language			0.254	0.006	1.269
WMI	0.839	0.006			

Memory and Processing Speed Indices accounted for 61% of the variance in reading achievement. Combined, the Processing Speed Index, participation in talented and gifted programming, and the VMI predicted 60% of the variance in math achievement. The Working Memory Index predicted 25% of the variance in written language achievement, and the Perceptual Reasoning Index predicted 22% of the variance in oral language achievement.

To respond to the research question about the impact of participation in TAG and acceleration on achievement, interaction terms between the two types of acceleration and TAG, and the other independent variables were added to the regression. Comparing the model with the interaction terms to the original model with all independent variables, there was no significant benefit to including the interaction terms in a model for any of the four content areas ($p = 0.679$ for Reading; $p = 0.887$ for Written Language; $p = 0.477$ for Math; $p = 0.798$ for Oral Language).

Discussion

The results of this study shed light on the academic experiences of gifted students with ASD, an under-investigated area. Specifically, when one thinks of school achievement prediction, a common assumption, based in research, is that ability predicts achievement. In fact, over 50% of the variance in achievement is accounted for by ability (Harackiewicz et al. 2002; Jensen 1998; Rohde and Thompson 2007). Therefore, this assumption is not inaccurate; however, the complexity that underlies this finding reveals the degree to which psychologists and educators must use caution in generating recommendations for intervention, especially when working with twice-exceptional individuals. Furthermore, models relating ability to achievement indicate that there is unexplained variance, or reasons other than verbal and nonverbal ability, that influence how one performs in school (Rohde and Thompson 2007). Our study examined some of the cognitive and educational factors that may be a part of this unexplained variance among a specific group of learners: gifted students with ASD.

Overall interpretation of our findings suggests that lower order thinking skills, such as working memory and processing speed, are important factors to the academic success of high ability youth with ASD. Specifically, the WISC-IV Working Memory and Processing Speed Indices were significantly correlated with reading, mathematics, and written language scores and both scores were significant predictors in reading achievement, and independently predictive of math (PSI) and written language (WMI) achievement. This is an important finding for many reasons. First, despite their relatively high verbal and nonverbal abilities (see Table 1), the students in our sample struggled with working memory and processing speed tasks, which is a common finding among students with ASD (Calhoun and Mayes 2005; Foley Nicpon et al. 2012; Mayes and Calhoun 2003, 2007). Therefore, there may be a negative impact on academic performance of students diagnosed with ASD and with high verbal and nonverbal abilities who struggle to keep information in auditory working memory and process information quickly. These findings also suggest that the contribution of the IQ profiles to achievement among twice-exceptional youth is different than it is for gifted youth without disabilities. Findings from a recent study of students referred for gifted and talented programming (Rowe et al. 2010) suggested that higher order thinking skills (VCI and PRI scores), as well as working memory skills (WMI scores) were predictive of math and reading achievement, but not processing speed (PSI scores). The current findings indicate that it is possible that the IQ profiles of gifted students with ASD should be interpreted differently than those of gifted students without a disability because of the differing extent to which index scores relate to performance on academic assessments.

The second reason this finding is striking is because previous research has found that academic achievement is typically commensurate with ability among individuals with ASD (Eaves and Ho 1997), but this may not be the case among high ability youth. In fact, a more recent study (Estes et al. 2011) corroborates our findings because high ability students in their sample had lower than expected achievement scores based on their IQ. Why might this be the case? One hypothesis is that the deficits in lower order thinking among high ability students with ASD impact academic performance to a greater extent than previously thought. For example, the reading subtests of the WJIII Broad Reading composite measure word recognition, reading speed, and reading comprehension, which mirrors the focus in schools—reading speed and phonics—especially in the younger years. One's verbal reasoning skills are not as crucial to success in these areas. Therefore, even if students obtain high verbal reasoning scores, they may not read to a commensurate level when the focus is as much on speed and accuracy as it is on understanding.

The strongest regression model found was that working memory and processing speed contributed 61% of the variance in reading achievement. The relationship between reading and working memory has been previously documented among gifted students (Rowe et al. 2010) but not independent of verbal and nonverbal reasoning skills' contributions. And it has been documented that reading difficulties are related to deficits in short-term memory (Carretti et al. 2009; Swanson 2011; Swanson et al. 2009) and speed of processing (Catts et al. 2002). These factors clearly are important among high ability youth with ASD, and deficits in these areas seemingly impact reading performance.

Another key finding was the role of fine motor skills in predicting math achievement. Specifically, scores on the VMI and WISC PSI (which has a large fine-motor component) predicted math achievement, along with participation in TAG. Other studies (Rohde and Thompson 2007) examining gifted students mathematics ability support the contribution of speed to math achievement as well as visual spatial skills (Lubinski et al. 2001; Rohde and Thompson 2007) and the importance of these factors appears to extend to high ability youth with ASD. Thus, fine-motor skills, which are commonly impaired in students with ASD (Fuentes et al. 2009), seem to play a key role in math achievement. The WJIII Math Composite is comprised of three subtests measuring knowledge of math equations, speed of completing simple math facts, and math problem-solving skills. It may be that a student's math achievement is impacted negatively if handwriting is poor, or if one completes math slowly, even if one has sound nonverbal reasoning skills.

Lower order reasoning skills were also related to written language achievement, and working memory specifically predicted 25% of the variance in written language achievement. The WJIII Written Language Composite is comprised of three tests assessing spelling, the ability to construct simple sentences quickly, and the ability to compose increasingly complex sentences based on various prompts. Working memory, especially as measured by tests such as digit span, reveals the role of cognitive processes, e.g., immediate auditory memory, concentration, ability to use encoding strategies (Sattler 2008), which may be considered central to achievement measures, e.g., spelling. Scholars examining written language performance in children emphasize the demand writing places on working memory (Bourdin and Fayol 1994; Raulerson et al. 2010). That is, children and adolescents need to allocate cognitive resources to the technical aspects of generating written language, which impacts the availability of higher-order thinking skills necessary to select and order complex ideas in writing. Bourlin and Fayol found in their sample of 16 third graders that written language abilities were lower than oral language abilities, presumably because of the greater working memory requirements for the written language activities. In our sample, Written Language performance was slightly higher (Standard Score mean of 117.60) than Oral Language performance (Standard Score mean of 114.67). However, the standard deviation for Written Language was nearly twice the standard deviation for Oral Language, which makes it difficult to draw conclusions other than that consideration of the higher working memory demands of the writing tasks are important when evaluating skills of high ability students with ASD (Foley Nicpon et al. 2012).

An encouraging finding was the positive relationship between involvement in talented and gifted (TAG) programming and academic achievement in math, reading, and oral language; TAG participation was predictive of achievement in math. To know that this educational intervention has a positive relationship with the achievement performance of gifted students with ASD is central to policy development. Anecdotally, it has been reported during the clinical intake, that students may be excluded from talented and gifted programs due to problem behavior, which may in turn have an even greater negative impact than might have been assumed. However, other acceleration as an educational intervention was not related to achievement. This too is surprising given the known positive impact of acceleration as an educational intervention in the talented and gifted population (Colangelo et al. 2004).

The most unexpected finding was that performance on the Perceptual Reasoning Index of the WISC-IV and the Perceptual Organization Index of the WAIS-III contributed to 22% of the variance in Oral Language achievement. The WJIII Oral Language composite is comprised of two subtests, one measuring recall of increasingly complex stories (a measure of auditory memory) and the other measuring the ability to listen to directions. This latter subtest requires that students point to parts of pictures corresponding to directions given auditorally. It may be that one's visual-spatial ability helps performance on this measure, rather than one's verbal and memory abilities (as might be assumed). Further investigation and replication of this finding is warranted.

Implications

Findings from the present study have implications about the achievement of high ability students with ASD. Because working memory and processing speed skills are commonly considered to be of lower cognitive order than verbal and nonverbal reasoning skills, educators may observe unexpected educational difficulties. As well, if students are not administered a full cognitive assessment, the potential causes of the educational difficulties will be unknown. As a result, gifted students with ASD who have discrepancies between their educational performance and ability potential will simply look like they are getting by in school, instead of displaying educational underachievement. Knowledge of the ability profile highlights strengths as well as areas that may negatively impact educational performance. For students with complex neuropsychological profiles, such as those with ASD, response to intervention and curriculum-based assessments may not be enough.

Our findings also suggest that what predicts achievement in high ability adolescents with ASD is different than for high ability students without a diagnosis. Rowe et al.'s (2010) findings with gifted and talented students imply that higher order thinking skills and working memory are important factors in predicting achievement—not processing speed. Among our sample, students' lower-order thinking skills were much more central to predicting student academic success. Interpretation of these differing findings suggests that selection of cognitive batteries, and interpretation of findings, should be made on an individual basis in light of strengths and identified (or unidentified) disabilities.

A final notable implication is the value of participation in talented and gifted programming. In times when the economic viability of gifted and talented education is questioned (Stephens 2011), these findings highlight the importance of talented and gifted programs, particularly in mathematics, for high ability youth with ASD. This type of educational intervention can be implemented with limited expense but seemingly large personal and economic implications that should not be ignored.

Limitations of the Study

The largest limitation to our study is the generalizability of the findings. Although relatively large, the fact remains that our sample of gifted students with ASD is a small subsample of all students diagnosed with ASD and cannot be generalized to students with other levels of cognitive ability. However, given the large IQ range of samples in other studies (e.g., Eaves and Ho 1997; Joseph et al. 2002) we contend that it is important for scholars and educators to understand how results vary according to ability. Additionally, our study examined students from grades K-12, and the relationship between ability and achievement may vary over time. In reading, for example, it is likely that working memory demands change as reading becomes more automatic. A cross-sectional or longitudinal study design would give us more information about how ability predicts achievement within various cohorts of students, rather than students across the elementary, middle, and secondary school ages. A final limitation to our study is that we did not employ a comparison group. Our findings would be enriched if we could examine what predicts achievement among students with ASD and other ability profiles, as well as among students identified as high ability without a disability.

Conclusions

Our goal in the current study was to examine the relationship between ability, achievement, and talented and gifted educational interventions in a group of high ability youth with ASD. We discovered that lower order thinking skills (working memory and processing speed) are important factors in this group of students' achievement. We also found that talented and gifted programming is a valuable, predictive educational intervention, particularly in mathematics. Despite limitations, we believe that these results have implications for those who work with high ability students with ASD in educational and clinical settings. Our findings highlight the need for a comprehensive assessment to identify cognitive strengths and areas for growth, as well as participation in school services for the gifted.

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