J Autism Dev Disord (2011) 41:1007–1018
DOI 10.1007/s10803-010-1126-4

ORIGINAL PAPER

The Role of Adaptive Behavior in Autism Spectrum Disorders: Implications for Functional Outcome

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Published online: 2 November 2010

Abstract The relationship between adaptive functioning and autism symptomatology was examined in 1,089 verbal youths with ASD examining results on Vineland-II, IQ, and measures of ASD severity. Strong positive relationships were found between Vineland subscales and IQ. Vineland Composite was negatively associated with age. IQ accounted a significant amount of the variance in overall adaptive skills (55%) beyond age and ASD severity. Individuals with ASD demonstrated significant adaptive deficits and negligible associations were found between the level of autism symptomatology and adaptive behavior. The results indicate that IQ is a strong predictor of adaptive behavior, the gap between IQ and adaptive impairments decreases in lower functioning individuals with ASD, and older individuals have a greater gap between IQ and adaptive skills.

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Keywords Autism · Autism spectrum disorder · Adaptive functioning · Vineland

Introduction

Autism is a pervasive neurodevelopmental disorder characterized by lifelong impairments in communication, social reciprocity and the presence of repetitive or restrictive behaviors and/or interests. Individuals with autism spectrum disorders (ASD) represent a heterogeneous group, with wide variability in symptom severity, cognitive ability, and adaptive behavior. Less clear are the relationships between these three areas of functioning and to what extent they contribute to a positive functional outcome for individuals with ASD.

Outcome Studies in ASD

Research has shown that an increasing number of individuals with ASD are achieving levels of independence in adulthood, which is promising; yet, the majority endure a host of vulnerabilities throughout life, with at least half failing to achieve a good outcome (Billstedt et al. 2005; Eaves and Ho 2008; Howlin et al. 2004; Tsatsanis 2005). Language and intellectual functioning have consistently been associated with positive outcome in ASD. Moreso, if an individual with ASD has functional language by age 5 and the absence of cognitive impairment, outcomes are more promising (Billstedt et al. 2005; Howlin et al. 2004; Paul and Cohen 1984). However, a recent sobering finding from a 20-year longitudinal outcome study of adults that had baseline IQs in the non-impaired range showed little evidence to support any cognitive factors associated with adult success (Farley et al. 2009). Instead, they found

adaptive skills, as measured by the Vineland Adaptive Behavior Scales, Survey Edition (Sparrow et al. 1984), to be more highly associated with outcome. For instance, there were cases of adults with high IQ scores but limited adaptive skills, whereas there were also adults with borderline IQ scores who were fairly independent and obtained "good" or "very good" outcome ratings. Adaptive skills instruction was more likely to be an explicit component of intervention for the latter group (Farley et al. 2009).

Although the factors that contribute to positive outcome in ASD may be ambiguous, the definition of positive outcome tends to be more clear—self-sufficiency (irrespective of levels of symptomatology or cognitive ability). *Adaptive behavior* is defined by the extent to which a person is capable of being self-sufficient in real-life situations, including the functional use of communication, socialization, daily living and motor skills (Sparrow et al. 1984, 2005). Therefore, it is reasonable that adaptive skills be used as outcome measures.

Profiles of Adaptive Behavior in ASD

There is a host of research showing that individuals with ASD exhibit significant deficits in their adaptive skills, as measured by the Vineland (e.g., Fenton et al. 2003; Paul et al. 2004; Tomanik et al. 2007), with the typical "autism profile" being marked by the most substantial delays in socialization, lesser delays in adaptive communication, and relative strengths in daily living skills (Bolte and Poustka 2002; Carter et al. 1998; Volkmar et al. 1987). This profile may be impacted by the level of cognitive ability. For instance, the "autism profile" has been documented in higher functioning samples of individuals with ASD, such as Asperger Syndrome and autism/PDD-NOS without cognitive impairment (e.g., Klin et al. 2007; Perry et al. 2009; Saulnier and Klin 2007). Yet, in lower functioning individuals with autism and cognitive delays, adaptive behavior has been found to be on par with or above mental age in some cases (e.g., Fenton et al. 2003; Perry et al. 2009). That is, perhaps the "autism profile" is less likely to manifest as the gap increases between chronological and mental age (Fenton et al. 2003). Gabriels et al. (2007), however, examined a group of 14 children with ASD in a 5-year follow up study and found that children with both normative and impaired nonverbal IQ scores demonstrated considerably delayed adaptive skills. The group with normal IQs demonstrated higher overall adaptive skills and increases in adaptive behavior over time, whereas the group with cognitive impairments did not demonstrate increases in adaptive behavior (Gabriels et al. 2007). Clearly, more research is needed to fully understand these profile differences.

Relationship Between Age and Adaptive Behavior

In addition to the discrepancy between adaptive skills and IQ in higher functioning individuals, there is evidence to suggest that this gap widens with age (Klin et al. 2007; Szatmari et al. 2003). This implies that individuals are failing to acquire skills commensurate with their chronological and cognitive growth. Although the Klin et al. (2007) study was a cohort sample, the Szatmari et al. (2003) study was longitudinal. Furthermore, an early detection study wherein children were initially evaluated at age 2 and followed up at age 4, demonstrated that the gap between developmental skills and adaptive behavior widened over time despite progress in both developmental and adaptive skills (Klin et al. 2008). Moreover, the minimal gains evidenced in adaptive socialization skills were independent of symptom severity.

Few studies have investigated specific treatments that may improve adaptive skills in children with autism. Williams et al. (2006) examined the effects of Risperidone medication in both decreasing behavior problems and improving adaptive skills in 48 children with autism between the ages of 5 and 16. Results indicated that over a period of 6–8 months, children gained an average of about 7 age-equivalent months in the area of socialization, which denotes more than a 6% improvement beyond developmental expectations (Williams et al. 2006). Thus, an important consideration of adaptive behavior profiles is the extent to which treatment services have impacted actual skill levels.

Relationship Between Symptom Severity and Adaptive Behavior

Studies examining the relationship between adaptive skills and autistic symptomatology as measured by the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002) have found varying trends. In addition to corroborating the vast discrepancy between cognitive ability and adaptive skills in higher functioning individuals with ASD ages 8–18, Klin et al. (2007) were among the first to document a weak relationship between autism symptomatology and adaptive behavior (using the ADOS and the Vineland, respectively), suggesting that neither normative cognitive skills nor lower levels of symptomatology are necessarily protective factors in outcome. However, in a sample of children with ASD under the age of 6, Perry et al. (2009) found autism severity to be moderately to strongly negatively associated with adaptive behavior, though the authors cautioned that much more variance in adaptive skills scores was accounted for by age and developmental level. The disparity in findings between the Klin et al. (2007) and Perry et al. (2009) studies may derive from the differences in age

and functional level of the samples, again emphasizing the need for additional research in this regard.

Research using the Social Responsiveness Scale (SRS; Constantino et al. 2003b), which is a quantitative measure of autistic traits in the general population, yields even more variable results. In a recent study by Bolte et al. (2008), the SRS was found to correlate both with the Vineland Communication and Socialization domains ($r = -0.43$ & -0.41, respectively) and with the ADOS ($r = 0.35$), although all correlations had only moderate effect sizes (Bolte et al. 2008; McCarthy et al. 1991).

Current Study

Past research has identified language and intellectual functioning as strong predictors of positive outcome. The present study is extending this previous research examining the relationship between adaptive skills, cognitive abilities, and levels of autistic symptomatology in a large and rigorously characterized cohort of verbal individuals with ASD; *the Simons Simplex Collection* (SSC). The SSC is a North American, multi-site, university-based research project investigating genetic features in simplex families of individuals with ASD, ages 4–17. With a greater sample that includes a wide range of cognitive functioning, this study proposes the following: (a) Examine the "autism profile" of adaptive behavior across the range of ASD severity, with the hypothesis that overall adaptive skills will be impaired and adaptive social skills will be the most impacted; (b) confirm the minimal relationship between ASD symptom severity and adaptive behavior regardless of age or cognitive level. (c) examine the discrepancies between adaptive behavior and age across ASD severity levels, with the hypothesis that older individuals with ASD will have larger gaps between their cognitive potential and adaptive skill level; and (d) examine the discrepancies between adaptive behavior and cognitive skills while controlling for age and ASD severity levels, with the hypothesis that as cognitive potential increases, the gap between IQ and adaptive skill level will also increase. Clarifying the role that adaptive behavior plays in ASD is essential not only for outcome research, but also for developing appropriate intervention strategies that aim to optimize self-sufficiency for individuals of all levels of functioning throughout development.

Methods

Participants

The sample included 1,089 children between the ages of 4 and 17 (mean age = 9.2 years, SD = *3.5)* who participated in the Simons Simplex Collection (SSC), a North American multiple-site, university-based research study that includes families with only one child with an ASD. Given the research indicating the role of language as a predictor of outcome, only children considered "verbal" by ADI criteria were included to avoid possible confounds including a nonverbal contingent. Demographic information is presented in Table 1, which includes the total group as well as presenting the information separated by age (ages 4–8 and 9–17). The majority of the sample was male (86.3%). Full Scale IQ scores ranged from 19 to 167, with a mean of 88.4 (SD = 23.6; Median = 89.0).

Participants in the SSC study were administered a variety of phenotypic measures and genetic information was collected from both probands and family members. With regard to the IQ measure, the *Differential Ability Scales, 2nd Edition* was the primary scale administered to 90.6% of the participants (Elliot 2007). In a small subset, either the *Mullen Scales of Early Learning* (2.4%), *Wechsler Intelligence Scale for Children, 4th Edition* (2.8%), or *Wechsler Abbreviated Scale of Intelligence* (4.2%) was used (Mullen 1995; Wechsler 1999, 2003) depending on the child's age or ability to complete the other measures. A standard, deviation IQ was computed for all of the measures when appropriate normative data was available; however, in a small number of cases wherein raw scores were outside of standard ranges for deviation scores (11.7%), a ratio IQ was computed by taking the average of the age equivalents across the subtest scales and dividing by chronological age in months, and then multiplying by 100. For the purposes of the current study, the following measures were examined: Autism Diagnostic Interview-Revised (ADI-R; Rutter et al. 2003a), Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002), Vineland Adaptive Behaviors Scales, 2nd Edition (Vineland-II; S. S. Sparrow et al. 2005), and Social Responsiveness Scale (SRS; Constantino et al. 2000).

Measures

Autism Diagnostic Interview—Revised (ADI-R)

The *ADI-R* (Rutter et al. 2003b) is a 93 item semi-structured diagnostic interview that was administered to all parents. The *ADI-R* yields scores in the areas of reciprocal social interaction, language/communication, and restricted, repetitive, and stereotyped patterns of behavior. Specific coding conventions include "0" (Behavior of type specified in the coding is/was not present) through "3" (Definite abnormality of the type specified, and a more severe manifestation of "2") with additional categories for "abnormality in the general areas of the coding, but not of the type specified, not applicable, and not known". The

Table 1 Sample characteristics

	Total group ($n = 1,089$)		4–8 Age group ($n = 581$)		9–17 Age group ($n = 508$)	
% Male	86.3		87.1		85.4	
% AD/Asp/PDD	66/11/23		68/6/26		64/16/20	
	Mean	SD	Mean	SD	Mean	SD
Age	9.2	3.5	**6.5**	**1.4**	**12.3**	**2.5**
Full Scale IQ*	88.4	23.5	89.2	20.7	87.5	26.5
Verbal IQ*	85.6	26.5	86.4	21.6	84.6	31.3
Nonverbal IQ*	91.0	22.5	92.3	20.4	89.5	24.6
Vineland Composite*	76.0	10.8	**79.6**	**10.3**	**71.9**	**9.8**
Vineland communication*	80.2	12.6	**84.8**	**11.9**	**75.0**	**11.2**
Receptive**	11.1	2.3	**11.7**	**2.2**	**10.4**	**2.3**
Expressive**	10.8	2.6	**11.3**	**2.3**	**10.1**	**2.8**
Written**	13.0	3.4	**14.5**	**3.2**	**11.2**	**2.6**
Vineland socialization*	73.7	11.8	**77.4**	**11.2**	**69.4**	**10.9**
Interpersonal relationships**	9.7	2.5	**10.7**	**2.3**	**8.7**	**2.4**
Play and leisure time**	10.3	2.9	**11.2**	**2.8**	**9.3**	**2.7**
Coping skills**	10.7	2.3	**11.1**	**2.2**	**10.2**	**2.4**
Vineland daily living skills*	79.6	12.9	**82.3**	**12.2**	**76.5**	**12.9**
Personal**	10.9	2.7	11.0	2.4	10.7	3.0
Domestic**	12.1	2.8	**13.0**	**2.5**	**11.1**	**2.8**
Community**	11.9	3.0	**12.6**	**2.9**	**11.1**	**3.0**
ADOS CSS	7.4	1.8	7.4	1.8	7.3	1.8
ADI-R social	19.5	5.7	**18.5**	**5.7**	**20.6**	**5.5**
ADI-R communication	16.4	4.3	**16.1**	**4.3**	**16.8**	**4.2**
ADI-R repetitive Bx	6.5	2.6	6.5	2.7	6.4	2.5
SRS total score	95.3	26.3	**91.5**	**26.8**	**99.9**	**25.0**

Bold values indicate significant difference between mean group scores, $p < 0.001$

AD autistic disorder, *ASP* Asperger Syndrome, *PDD* pervasive developmental disorder—not otherwise specified

* Scale has mean of 100 and standard deviation of 15

** Scale has a mean of 15 and standard deviation of 3

ADI-R is scored via an algorithm with identified cutoff values for the diagnosis of ASD. The *ADI-R* manual reports several studies of interrater reliability. In a related study (Lord and Rutter 1994), weighted kappa values for individual items were 0.70 or higher with intraclass correlations ranging from 0.93 to 0.97.

Autism Diagnostic Observation Schedule (ADOS)

The *ADOS* (Lord et al. 2002) is a semi-structured, standardized assessment which assesses an individual's behavior in the areas of communication, reciprocal social interaction, imagination/creativity, and stereotyped behaviors and restricted interests. It includes four modules: Module 1 (Pre-Verbal/Single Words), Module 2 (Phrase Speech—Non fluent), Module 3 (Fluent Speech—Child/Adolescent) and Module 4 (Fluent Speech—Adolescent/Adult). Only individuals completing Modules 1–3 were included in the current study. The *ADOS* is scored via a diagnostic algorithm that provides cutoff values for diagnoses of Autistic Disorder and Autism Spectrum Disorders. The *ADOS* manual reports interrater reliability studies for Modules 1 through 4 in which "all items exceeded 80% agreement" and the mean percent agreement ranged from 88.2 to 91.5%.

Because the number and nature of items differ across modules, as does the diagnostic algorithm, a calibrated severity score (CSS) was computed for each participant's ADOS result (Gotham et al. 2009). The CSS transforms a participant's ADOS results into a metric used to gauge autism severity. Gotham and colleagues based the CSS on a sample of 1,118 individual's ADOS assessments. The CSS

attempts to account for age and language variables and was found to be less influenced by the participant's demographics when compared to the use of the raw ADOS total scores.

Differential Ability Scales, 2nd Edition (DAS-II)

The *DAS-II* (Elliot 2007) has 20 cognitive subtests that assess conceptual and reasoning abilities with both preschool and a school age versions, for ages 30 months to 17 years of age. The Preschool version includes indices for General Conceptual, Verbal, and Nonverbal Ability, with a Lower Preschool Battery made up of four core subtests and the Upper Preschool battery made up of six core subtests. The school age version includes indices for Verbal, Nonverbal Reasoning, and Spatial Ability made up of six core subtests. All versions also have Diagnostic subtests that can be administered to aid in interpreting strengths and weaknesses. A Special Nonverbal score may also be obtained. Test–retest coefficients for the *DAS-II* reportedly ranged from 0.85 to 0.94 for the major indices, and interrater reliability was also very high (0.98–0.99). The *DAS-II* was highly correlated with the *DAS, WISC-IV, WPPSI-III, Bayley-III*, and *Bracken School Readiness Assessment*.

Social Responsiveness Scale (SRS)

The *SRS* (Constantino and Todd 2000) is a 65 item parent and teacher report measure assessing autistic traits. Only parent report measures were used in the current study. The questionnaire targets several aspects relating to an individual's ability to engage in reciprocal social interactions. The *SRS* includes items related to all three autism symptom domains of social impairment, communication impairment, and stereotyped/repetitive behaviors. Psychometric studies of the *SRS* indicate that scores are continuously distributed across the general population and that the *SRS* shows good test–retest reliability (Constantino et al. 2000, 2003a; Constantino and Todd 2000, 2003), inter-rater reliability (Pine et al. 2006), discriminant validity (Constantino et al. 2000; Constantino and Todd 2003), and concurrent validity (Constantino et al. 2003a).

Vineland Adaptive Behaviors Scales, 2nd Edition (Vineland-II)

The *Vineland-II* (Sparrow et al. 2005) assesses individuals from birth to adulthood in their functional personal and social abilities. The Vineland-II produces standard scores in four domains: Communication, Daily Living Skills, Socialization, and Motor Skills. In addition to age equivalent scores for domain raw scores, the measure also produces an overall Adaptive Behavior Composite Standard score. Split-half and test–retest reliability coefficients for the Composite scores range from median values of 0.83 f to 0.94. Interrater coefficients reportedly ranged from 0.62 to 0.78. For the purposes of the current study, only the Communication, Daily Living, and Socializations subscales were used. Each subscale is made up of subdomains with a mean of 15 and standard deviation of 3.

Wechsler Abbreviated Scale of Intelligence (WASI)

The *WASI* produces indices for overall level of intellectual functioning (FSIQ), as well as Verbal and Performance. Subtests include Vocabulary, Similarities, Block Design, and Matrix Reasoning (Psychological Corporation 1999). The *WASI* manual reported average reliability coefficient for the 4-subtest FSIQ to be high (0.98), as was test–retest reliability (0.92) and subtest inter-rater reliability (0.98—Vocabulary; 0.99—Similarities).

Wechsler Intelligence Scale for Children—Fourth Edition (WISC-IV)

The *WISC-IV* produces indices for overall level of intellectual functioning (FSIQ), as well as Verbal, Perceptual Reasoning, Processing Speed, and Working Memory. The 15 subtests include Vocabulary, Comprehension, Information, Similarities, Word Reasoning, Picture Concepts, Picture Completion, Digit Span, Letter-Number Sequencing, Cancellation, Arithmetic, Block Design, Coding, Symbol Search, and Matrix Reasoning (Wechsler 2003). The *WISC-IV* manual reported average reliability coefficient for the FSIQ to be high (0.97), as was test–retest reliability (0.89).

Mullen Scales of Early Learning

The *Mullen* (Mullen 1995) produces five indices of cognitive and motor development for individuals from birth to 68 months. The scales include Gross Motor, Visual Reception, Fine Motor, Expressive Language, and Receptive Language. The *Mullen* manual reports median split half internal consistency as exceeding 0.75 for composites and subscales. Test–retest reliability exceeded 0.80 for 1–24 months of age, and 0.70 for 25–56 months of age.

Results

Due to the number of correlations that were conducted and the large sample size, only associations between variables with a medium effect size, meaning a conservative absolute correlation of 0.300, were regarded as significant (see Table 2 for correlations).

Table 2 Age, Vineland, CSS, ADI-R, SRS, and IQ correlations

	1	2	3	4	5	6	7	8	9	10	11
1. Age	–										
2. Vineland Composite	**−0.39***	–									
3. Vineland communication	**−0.43***	**0.88***	–								
4. Vineland socialization	**−0.36***	**0.85***	**0.67***	–							
5. Vineland daily living	−0.25*	**0.86***	**0.67***	**0.66***	–						
6. ADOS CSS	0.02	−0.17	−0.15*	−0.16*	−0.15*	–					
7. ADI-R socialization	0.22*	**−0.40***	**−0.36***	**−0.43***	−0.29*	0.21*	–				
8. ADI-R communication	0.11*	**−0.32***	−0.28*	**−0.31***	−0.27*	0.21*	0.65*	–			
9. ADI-R repetitive Bx	0.01	−0.09	−0.06	−0.16*	−0.04	0.14*	0.25*	0.28*	–		
10. SRS total	0.15*	**−0.40***	**−0.33***	**−0.46***	−0.28*	0.09	**0.33***	0.28*	0.26*	–	
11. IQ	−0.01	**0.54***	**0.57***	**0.38***	**0.50***	−0.26*	−0.25*	−0.24*	−0.08	−0.12*	–

Bold indicates $r > 0.30$; * $p < 0.001$

Hypothesis 1: Adaptive Profiles

Mean overall adaptive rating (i.e., Vineland-II Adaptive Behavior Composite) was 76.0 (SD = 10.8). Mean standard scores for Vineland-II Socialization, Communication, and Daily Living Skills were 73.7, 80.2, and 79.6, respectively. Note that the mean Communication standard score may be inflated due to the impact of the Written subdomain, especially in the 4–8 year age range (see Table 1). Of the three subscales, the Socialization subscale was the lowest and significantly different from the others $t(1087) = 21.8$ and $t(1087) = 19.0$, $p < 0.001$, and represented a nearly two standard deviation discrepancy from an average IQ of 100. Within the Socialization domain, the Interpersonal Relationships subdomain was significantly lower than both Play and Leisure Time, $t(1083) = 8.9$ and Coping Skills, $t(1082) = 13.5$, $p < 0.001$ in both cases, and nearly two standard deviations below the mean for these subdomains of 15 (*SD* of 3).

Hypothesis 2: Adaptive Behavior and Autism Symptomatology

Clinician Assessment of Autism Symptoms

The mean clinical level of ASD severity based on the CSS was 7.4 (SD = 1.8). The CSS did not associate strongly with either parent report of ASD symptoms (ADI-R domains all $r = 0.22$; SRS, $r = 0.09$), or with level of intellectual functioning ($r = -0.26$). CSS was not associated with age (CSS $r = -0.02$). There was also not a significant association between CSS and the Vineland Composite ($r = -0.17$), nor were there significant associations between the CSS and the Vineland subscales (all $r < -0.17$). Note, however, that the negative trend indicated that with increasing ASD severity, adaptive skills decreased, which is also indicated by an examination of the Vineland Composite mean scores over ASD severity level (e.g., CSS severity of 4, Vineland Composite = 79.9 vs. CSS severity of 10, Vineland Composite = 73.4). An examination of the scatter plots clarifies why the correlations were low despite this decreasing trend (see Fig. 1).

Parent Report of Autism Symptoms

The mean ADI-R Social domain score was 19.5 (SD = 5.7), the mean ADI-R Communication domain score was 16.4 (SD = 4.3), and the mean ADI-R Restricted and Repetitive Behavior score was 6.5 (SD = 2.6). All ADI-R mean scores fell far above cut-off criteria for an ASD diagnosis (Social cut-off = 8; Communication

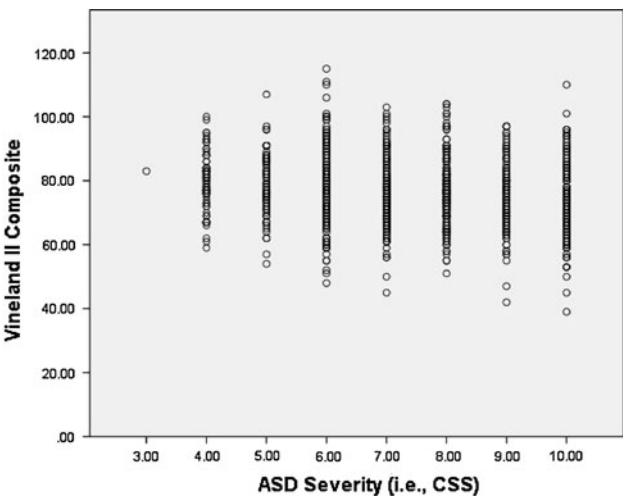

Fig. 1 Scatter plot of ASD severity (i.e., CSS) by overall adaptive skills (i.e., Vineland Composite)

cut-off = 10; Restricted and Repetitive Behavior cut-off = 3). There were no significant correlations between ADI-R domains and age (ADI-R Social $r = 0.22$; Communication $r = 0.11$; Restricted and Repetitive Behaviors $r = 0.01$). There was a significant negative association between the ADI-R Social domain and the Vineland-II Composite ($r = -0.40$, $p < 0.001$), meaning that lower adaptive skills overall were associated with parent report of greater ASD-related social difficulties early in development. ADI-R Social domain had a significant negative correlation with both Vineland-II Communication and Socialization subscales ($r = -0.36$ and $r = -0.43$, $p < 0.001$, respectively). ADI-R Communication was also significantly associated with Vineland-II Composite ($r = -0.32$) and Vineland-II Socialization subscales ($r = -0.31$, $p < 0.001$). Thus, weaker adaptive socialization skills were related to greater parent report of ASD-related communication difficulties. There were no significant associations between ADI-R restricted and repetitive behaviors and Vineland-II adaptive indices.

The mean SRS Total score was 95.4 (SD = 26.3). The SRS uses a similar ascertainment method as the ADI-R (i.e., parent report of ASD symptoms) and demonstrated a significant negative association with the ADI-R Socialization domain ($r = -0.33$, $p < 0.001$). The SRS demonstrated a pattern of associations with the Vineland-II indices very similar to the ADI-R socialization domain.

Hypothesis 3: Adaptive Behavior and Age

The Vineland-II Composite was significantly negatively associated with age (see Fig. 2; $r = -0.39$, $p < 0.001$). That is, the overall level of adaptive skills decreased relative to increases in age with older children having relatively worse adaptive skills in comparison to their mental age. Age demonstrated similar significant negative associations with the Vineland-II Communication and Socialization subscales ($r = -0.43$, $p < 0.001$ and $r = -0.36$, $p < 0.001$, respectively), but not with the Daily Living subscale ($r = -0.25$).

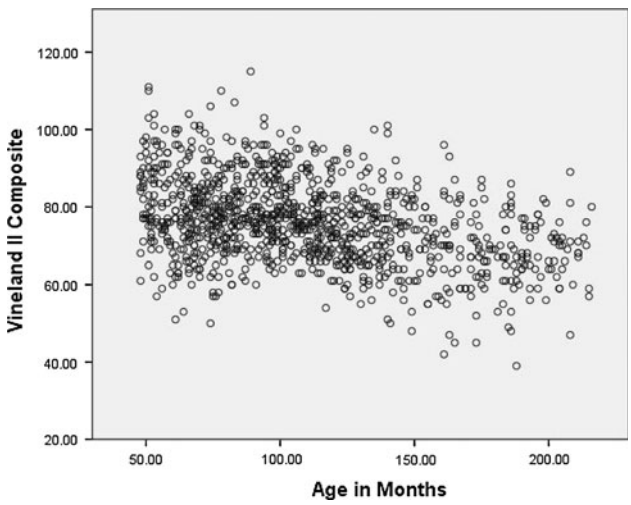

Fig. 2 Scatter plot of age in months by overall adaptive skills (i.e., Vineland Composite)

For purposes of further elucidating the differences in adaptive skills as these verbal individuals with ASD become older, an analysis was conducted comparing the younger aged participants ($M = 6.5$, range 4–8 years) to the older participants ($M = 12.3$, range 9–18). See Table 1 for a summary of the results. Only differences at $p < 0.001$ were considered significant due to the number of comparisons performed. The groups did not differ significantly in full scale, verbal, or nonverbal IQ. Moreover, the groups did not differ significantly with respect to severity of clinician rated symptomatology (i.e., CSS), repetitive or restricted behaviors from the ADI-R, or the subdomain of Personal from the Vineland-II Daily Living Skills domain.

However, the older age group demonstrated significantly lower overall adaptive skills (i.e., Vineland-II Composite; $M = 71.9$ vs. 79.6), as well as lower Vineland-II Communication ($M = 75.0$ vs. 84.8), Socialization ($M = 69.4$ vs. 77.4), and Daily Living Skills ($M = 76.5$ vs. 82.3). Parents rated the older group as having more significant ASD-related social and communication difficulties via the ADI-R ($M = 20.6$ vs. 18.5 and $M = 16.8$ vs. 16.1, respectively), and more ASD-related traits on the SRS ($M = 71.9$ vs. 80.3).

Hypothesis 4: Adaptive Behavior and Intellectual Functioning

IQ correlated strongly with the Vineland-II Composite (see Fig. 3), $r = 0.54$, $p < 0.001$, and demonstrated a significant association with the Vineland-II Communication ($r = 0.57$), Socialization ($r = 0.38$), and Daily Living subscales ($r = 0.50$). Looking at specific Vineland-II subdomains, within the area of Communication, Expressive and Written Communication ($r = 0.54$, respectively) correlated more strongly with IQ than Receptive Language ($r = 0.32$). Within Socialization, Interpersonal Skills were not as strongly correlated with IQ ($r = 0.29$) as Play & Leisure skills ($r = 0.44$). This indicates that with increasing intellectual functioning, most areas of adaptive skills also increased, but with less predictive strength in the areas of responsivity to language and interpersonal relationships.

To further examine the impact of IQ on adaptive skills in individuals with ASD, a series of hierarchical regression analyses were conducted, with the Vineland-II Composite score serving as the dependent variable. Age and level of ASD severity (i.e., CSS) were entered in the first two steps of the model, followed by IQ in the third step. By utilizing

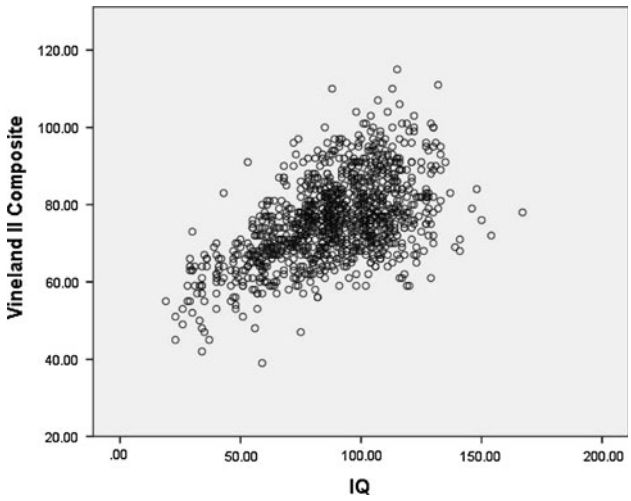

Fig. 3 Scatter plot of IQ by overall adaptive skills (i.e., Vineland Composite)

this approach, we were able to partial out variability in adaptive skills related to ASD symptomatology and age. The portion of remaining variance attributable to solely IQ could then be identified (i.e., partial correlation; pr^2).

In the model, using criteria suggested by Cohen (1988) and expanded by others (Cicchetti 2007, 2008; Cohen 1988; McCarthy et al. 1991), CSS alone has a small effect ($R = 0.16$), whereas CSS and age together demonstrate a medium effect ($R = 0.41$) and CSS, age, and IQ together demonstrate a large effect ($R = 0.66$). As can be seen in Table 3, CSS accounted for a significant portion of individual variability in adaptive skills; $R^2 = 0.03$; $F(1,1009) = 27.8$, $p < 0.001$. Age accounted for a unique and significant degree of variability in adaptive scores, accounting for 37% of the variance over and above ASD severity; $\Delta R^2 = 0.14$, $F(1,1008) = 165.0$, $p < 0.001$. However, IQ demonstrated the greatest effect size, accounted for 54.6% of the variance above and beyond that associated with age and ASD severity; $\Delta R^2 = 0.28$, $F(1,1007) = 496.0$, $p < 0.001$. Thus, consistent with the correlations reported between CSS and adaptive behaviors, though significant, CSS only accounts for 3% of the variance in adaptive behaviors. In contrast, after controlling for the variance attributable to age and ASD severity, IQ accounts for a much greater degree, nearly 55% of the variance.

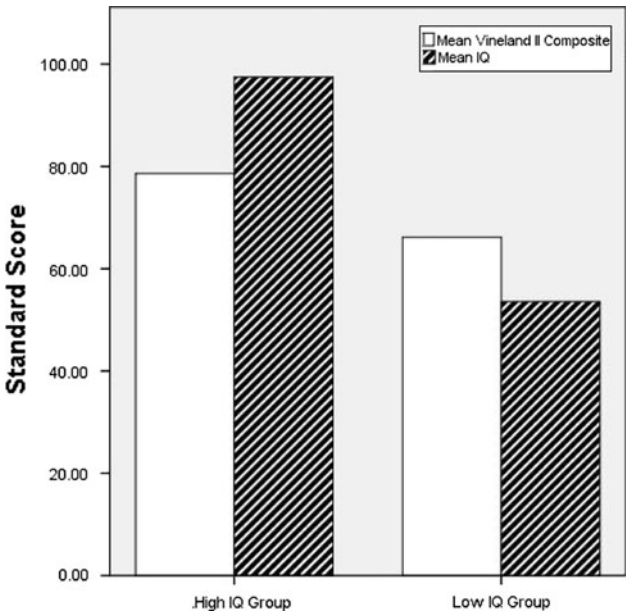

Fig. 4 Graph of mean high and low IQ and Vineland Composite scores

Given past research indicating that in IQ-adaptive discrepancies may vary depending on level of cognitive functioning, descriptive analyses were conducted to better understand this relationship. We compared a group with Full Scale IQ below 70 ($N = 223$; $M = 53.6$) to those with IQs 70 or above ($N = 855$; $M = 97.6$). Average adaptive behavior scores in the low IQ group were *above* their IQ score (mean Vineland-II Composite = 66.2 vs. mean IQ = 53.6), whereas adaptive behavior scores in the high IQ group were *below* the standard IQ score (mean Vineland-II Composite = 79.2 vs. mean IQ = 97.6). Therefore, even though adaptive skills increase with IQ, the relative difference between those scores changes as a function IQ level (see Fig. 4).

Discussion

This study investigated adaptive behavior profiles in ASD using one of the largest samples (i.e., over 1,000) of the most rigorously characterized individuals with ASD, ages 4–17, across North America. Given the equivocal findings

Table 3 Hierarchical regression analysis predicting adaptive scores from ASD severity (i.e., CSS), age, and IQ

Dependent variable	Step 1		Step 2				Step 3			
	CSS		Age				IQ			
	R^2	$\Delta F_{(1,1009)}$	R^2	ΔR^2	pr^2	$\Delta F_{(1,1008)}$	R^2	ΔR^2	pr^2	$\Delta F_{(1,1007)}$
Vineland Composite	0.03	27.8*	0.16	0.14	−0.37	165.0*	0.44	0.28	0.55	496.0*

* $p < 0.001$

in the literature on smaller samples, we wished to examine and clarify how adaptive behavior profiles in ASD are associated with IQ, age, and symptom severity, with the ultimate goal of investigating what factors could contribute to stronger adaptive behavior in these individuals.

Overall Profiles of Adaptive Behavior

As outlined in the methodology, the sample of verbal individuals derived from this genetics consortium was, overall, "high functioning," with verbal and nonverbal cognitive abilities falling solidly within the average range—despite the majority of individuals carrying a classic or prototypical autism diagnosis. In fact, mean ADI-R and ADOS algorithm scores met cut-off criteria for autism compared to the broader spectrum, highlighting the severity of symptomatology in these individuals in the context of their often intact IQ. There are several possible explanations for the cognitive prowess of this sample. First, the exclusionary criteria for the study are extremely stringent, ruling out psychiatric, medical, and developmental comorbidities, all of which could be more prevalent in lower-functioning individuals. Second, more recent studies are showing a decrease in the percentage of individuals with ASD who also have intellectual disability in the general population, with rates ranging from 29 to 51% (Centers for Disease Control 2009), and these data could be reflecting this trend. Finally, this consortium is specifically investigating simplex families where there can be no known ASD in immediate family members or 1st degree relatives. Thus, the higher IQs observed in this sample could be a manifestation of an underlying genetic phenotype of ASD that is qualitatively different than that of multiplex families.

Despite the absence of cognitive impairment in the majority of subjects from this sample, significant adaptive delays were evidenced across all Vineland-II domains. The greatest impairments were observed in Socialization skills, where the domain standard score of 73.7 fell almost two standard deviations below the population mean of 100, and this pattern was observed across all ASD severity levels. Communication and Daily Living skills were moderately delayed, falling more than one and a half standard deviations below the mean in both domains. These results are consistent with those obtained in smaller studies (e.g., Klin et al. 2007; Perry et al. 2009; Saulnier and Klin 2007; Tomanik et al. 2007) and re-affirm the notion that adaptive deficits are not only present, but also substantially deficient in intellectually-able individuals with ASD.

Adaptive Behavior and Autism Symptomatology

Consistent with findings by Klin et al. (2007) and Saulnier and Klin (2007), this study confirmed the poor association between adaptive behavior (i.e., Vineland-II) and level of current autism symptomatology by clinician observation (i.e., ADOS CSS), reiterating the notion that these are relatively independent constructs. That is, an individual's level of symptom severity has little bearing on that same individual's ability to function independently in the world. Current research is revealing that even "high functioning" individuals with ASD are not achieving levels of independence in adulthood; rather, many become prompt-dependent, are unable to self-manage, and fail to hold down jobs or live on their own (Farley et al. 2009; Hume et al. 2009). This consistent trend, now confirmed in the current study in a sample of over 1,000 individuals with "high functioning" ASD, needs greater emphasis and priority in therapeutic and educational programming where adaptive skills instruction is often overlooked.

Stronger associations were observed between adaptive behavior and autism symptomatology as reported by parents (i.e., ADI-R and SRS), particularly between adaptive socialization skills and social communication impairments. It should be noted that the ADI-R scores analyzed in the algorithm consist of the time period between the individual's 4^{th} and 5^{th} birthday, which is considered "most abnormal" in development. Therefore, one explanation for this trend is that the strong correlations obtained in this study are not a reflection of the individual's current level of symptomatology (as measured, for example, by the ADOS), but more characteristic of their early development. Thus, the strong associations with the Vineland-II suggest that those individuals with more severe *early social deficits* present with more severe *current adaptive impairments*. Yet, these data can also imply that early in development, there is a stronger relationship between autism symptomatology and adaptive behavior, and that this association weakens with age—as preliminary findings suggest (Saulnier et al. 2008).Additional longitudinal studies continue to be merited in this area for these findings to be fully understood.

A final possible explanation for the stronger relationship between the ADI-R and Vineland-II compared to the ADOS is that both the ADI-R and Vineland-II share a common ascertainment method (both are parent-report measures) and that these findings are more the product of the informant rather than individual's characteristics. This hypothesis seems to be corroborated by the similar strong association found between the Vineland and SRS, which is also a parent-report measure. In this regard, parents who report higher symptomatology are similarly reporting more deficits in adaptive behavior. However, one must also consider the overlap in the behaviors that the items on both the SRS and Vineland-II aim to measure. That is, in addition to surveying ASD symptomatology, the SRS may be tapping into "adaptive" or "maladaptive" social/communication skills. This raises the need for future item

analyses on these measures and, unfortunately, data is not available at the item level through the consortium.

Age Trends

Age was not associated with ASD severity or IQ; however, significant negative correlations were observed between age and Vineland-II Communication and Socialization domains, suggesting that individuals with ASD are not acquiring adaptive skills in these areas at a pace consistent with their chronological development or intellectual growth. Certainly, since the current study used cohort samples, these findings need to be examined using longitudinal data, as it is difficult to discern if this is truly an age effect or, for example, the result of better intervention for the younger sample. Nevertheless, the trends are worrisome and pose important implications for intervention, as older school-age and adolescent individuals with ASD are presenting with greater deficits in their functional independence compared to younger school-age individuals, despite no difference in presenting autistic symptomatology or intellectual ability.

The older individuals were reported to have more social and communication difficulties early in development as measured by the ADI-R. This finding could be a manifestation of the field's focus on early detection and subsequent intensive intervention in that the younger cohort would have been more likely to benefit from services by the ages of 4–5 years. However, this question can only be answered with treatment data, which is beyond the scope of this study.

Adaptive Behavior and Intellectual Functioning

The overall sample of individuals in this study not only evidenced adaptive impairments in relation to national IQ norms, but also in relation to the group's overall IQ. Again, the greatest discrepancy was observed between the Vineland-II Socialization standard score and Full Scale IQ, with a gap of one full standard deviation. This indicates that despite having a solid repertoire of verbal and nonverbal processing skills, these individuals are having difficulty functionally applying their own strengths to daily contexts, particularly in the areas of Receptive and Expressive Communication, Personal Daily Living skills, and all three Socialization subdomains (i.e., Interpersonal, Play/Leisure, and Coping). That is, these individuals do not use their cognitive abilities appropriately in the service of improving their adaptive skills, especially their social skills.

IQ was strongly associated with adaptive behavior. Even after controlling for ASD severity and age, both of which are associated to some degree with adaptive behavior, IQ remained a strong predictor of adaptive skills (i.e., 55% of the variability). Looking more closely, overall IQ was most strongly correlated with adaptive Communication skills; specifically, Expressive and Written Communication ($r = 0.54$, respectively). The items involved in these subdomains include, for example, an individual's repertoire of words, basic speech skills, and affinity for numbers and letters. These rote skills are often strengths in ASD and though "adaptive," do not often translate into functional independence the way responsivity to language, ability to follow instructions, and social interaction skills might. These adaptive areas were less associated with IQ (Receptive Communication $r = 0.32$; Interpersonal Skills $r = 0.29$).

Within the Vineland-II Socialization domain, the Play and Leisure subdomain was strongly associated with IQ ($r = 0.44$), suggesting that the more cognitively able individuals might be better equipped to organize their leisure time with activities. Yet, this does not necessarily indicate that these individuals are engaging in more "social" activities—an item analysis of Vineland-II data would again be needed to flush out this finding. Such an analysis may demonstrate, for example, that the items in these areas require more cognitive skills to perform successfully. Nevertheless, this finding could have important implications for intervention, particularly in the area of interactive play for younger children and self-management and organizational skills for older individuals. Thus, exploring adaptive skills at the item level (i.e., skill by skill) is an essential future goal.

Interestingly, the gap between IQ and adaptive ability was observed to decrease in the more cognitively impaired but still verbal individuals. In fact, those with IQ scores falling in the range of intellectual disability (i.e., a Full Scale IQ score below 70), exhibited relative strengths in adaptive skills relative to their IQ, although still falling significantly below age expectations. These findings are consistent with more recent studies that have compared both low and high functioning subjects (e.g., Perry et al. 2009), but inconsistent with older research that showed significant deficits in adaptive skills even in the severely afflicted individuals (e.g., Carter et al., 1998).

Summary

The current study confirms and extends past research exploring adaptive behavior in a very large and well characterized sample of individuals with ASD. In addition to negligible associations found between the level of autism symptomatology and adaptive behavior, significant adaptive deficits were found in the individuals with ASD, particularly in comparison to IQ and otherwise "high functioning" individuals. Consistent with more recent research, the current results found IQ to be a strong predictor of adaptive behavior, even after taking into account

age and severity of ASD. Also, the gap between IQ and adaptive impairments decreases in lower functioning (yet verbal) individuals with ASD. Although these individuals still have significant adaptive deficits, their adaptive skills are more on par with their intellectual level—or even relative strengths in some areas. Other parent report measures that survey ASD related symptoms, such as the SRS and ADI-R, show a stronger association with the Vineland-II compared to the clinician rated ADOS. Finally, the current study also suggests that older individuals have a greater gap between IQ and adaptive skills than younger individuals, though this needs corroboration using a longitudinal approach.

The current study has several limitations, and suggests many areas for future direction. First, though the study uses one of the largest and meticulously phenotyped groups of individuals with ASD, there may be biases associated with the sample that limit the generalization of results. For example, the individuals in the sample come from a simplex family, and thus may not represent the same phenotypic expression as a multiplex family. They are also relatively "high functioning" with the mean IQ in the average range. Extending these findings to multiplex families will be an important next step. Moreover, exploring adaptive behaviors in individuals with ASD who are nonverbal will be an important extension. Exploring adaptive skills and IQ at an item level will help elucidate some of the current findings at a much deeper level, looking more closely at which specific adaptive behaviors are related to cognitive or ASD related traits. However, the current study highlights the level of functional impairment that individuals with ASD experience regardless of level of IQ or ASD severity, allowing a richer understanding of the disorder with implications for treatment focus.

Acknowledgments This work was supported by a grant from the Simons Foundation (SFARI award #26021565-08C000066 to J.M.). We are grateful to all of the families at the participating Simons Simplex Collection (SSC) sites, as well as the principal investigators (A. Beaudet, A. Klin, B. Peterson, C. Lord, C. Martin, C. Saulnier, C. Walsh, D. Geschwind, D. Grice, D. Ledbetter, D. Martin, E. Cook, E. Fombonne, E. Wijsman, J. Miles, J. Constantino, J. Piggot, J. Sutcliffe, M. State, O. Ousley, R. Bernier, R. Maxim, W. Stone). We appreciate obtaining access to phenotypic data on SFARI Base, https://ordering.base.sfari.org/~browse_collection/archive[sfari_collection_v6]/ui:view().

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