

Brief Report: The Vineland Adaptive Behavior Scales in Young Children with Autism Spectrum Disorders at Different Cognitive Levels

Adrienne Perry · Helen E. Flanagan ·
Jennifer Dunn Geier · Nancy L. Freeman

Published online: 21 February 2009
© Springer Science+Business Media, LLC 2009

Abstract Vineland Adaptive Behavior Scales (VABS) data were examined in a large sample of young children with ASD ($n = 290$) of varying cognitive levels. IQ was higher than VABS composite score among high functioning children only; the opposite pattern was found in lower IQ subgroups. Profile analysis of VABS domains across cognitive levels demonstrated different profiles in different subgroups. A characteristic “autism profile” was found for most subgroups for Age Equivalents but not Standard Scores. In a small set of matched pairs ($n = 28$) of children with autism versus MR, significantly different profiles were found, with Socialization and Communication lower in autism, but no differences were found between matched pairs of children with autism and PDD-NOS ($n = 48$). Correlations between age, cognitive level, and adaptive level were also reported, and regression analyses indicated that autism severity accounts for a modest amount of unique variance in Socialization and Daily Living Skills.

Keywords Adaptive Behavior · Vineland · Autism · MR · PDD-NOS · Profiles

Autistic Disorder (hereafter “autism”) is one of a spectrum of disorders characterized by impairments in communication and socialization and the presence of repetitive or restrictive behaviors (American Psychiatric Association [APA] 2000). Other autism spectrum disorders (ASDs) include Pervasive Developmental Disorder- Not Otherwise Specified (PDD-NOS) and Asperger’s Disorder. Autism often co-exists with other disabilities, and up to 75% of people with autism also meet criteria for an Intellectual Disability or Mental Retardation (MR; APA 1994), although other individuals on the autism spectrum exhibit a range of intellectual functioning (Fombonne 2005).

An evaluation of adaptive functioning is recommended as best practice in assessments of autism to assist with diagnostic classification and treatment planning (Filipek et al. 1999; Perry et al. 2002). The assessment of adaptive functioning, typically based on caregiver report, is intended to determine how well the individual functions in everyday life in terms of functional communication skills, getting along with people, self-help and life skills, and independence. A better understanding of adaptive behavior profiles in autism is important for diagnostic, program planning, and research purposes. Information about adaptive functioning in young children with autism and related disorders may be especially important, as diagnostic assessments are most frequent during the preschool years (e.g., Mandell et al. 2005).

The Vineland Adaptive Behavior Scales (VABS; Sparrow et al. 1984) have been used very commonly over the past two decades to assess adaptive behavior in individuals

A. Perry · H. E. Flanagan
TRE-ADD (Treatment, Research, and Education for Autism
and Developmental Disorders), Thistleton Regional Centre,
Toronto, ON, Canada

A. Perry (✉) · H. E. Flanagan · N. L. Freeman
Department of Psychology, York University, 4700 Keele Street,
Toronto, ON M3J 1P3, Canada
e-mail: perry@yorku.ca

J. Dunn Geier
Autism Intervention Program of Eastern Ontario, Children’s
Hospital of Eastern Ontario, Ottawa, ON, Canada

N. L. Freeman
Toronto Partnership for Autism Services, Surrey Place Centre,
Toronto, ON, Canada

with ASD as well as other populations (Gillham et al. 2000). The VABS evaluates adaptive functioning in four domains: Communication, Daily Living Skills, Socialization, and Motor Skills (Motor Skills norms are only available for children under 6). Age Equivalent scores and Standard Scores ($M = 100$; $SD = 15$) are provided for each domain, and scores across domains can be combined to create an overall Adaptive Behavior Composite score (ABC). There are several forms of the VABS; the Survey Form, frequently used in clinical practice, was used in the present study. Based on the standardization sample, the internal consistency and test–retest reliability of the VABS Survey Form is good and inter-rater reliability is adequate (Sparrow et al. 1984). Additional research involving samples with autism and other developmental disabilities supports its internal consistency (De Bildt et al. 2005) and convergent validity (De Bildt et al. 2005; Perry and Factor 1989). A second edition of the VABS was published in 2005 (the Vineland-II; Sparrow et al. 2005). It measures adaptive functioning in the same domains as the VABS, but was not available during the time period in which the current data were collected.

This paper reports on four sets of analyses focused on the VABS. The analyses build upon existing research that has reported on the relationship between cognitive and adaptive levels (e.g., Bolte and Poustka 2002), examined profiles on the VABS within samples with autism (e.g., Carter et al. 1998), compared VABS scores for individuals with autism to those of other diagnostic groups (e.g., Volkmar et al. 1987), and reported on the relationship among adaptive functioning, developmental level, and severity of autism symptomatology in individuals with ASD (e.g., Liss et al. 2001).

It has generally been found that cognitive and adaptive composite scores are highly correlated (e.g., Liss et al. 2001; Vig and Jedrysek 1995) but also that overall adaptive functioning is lower than cognitive level, at least for higher functioning people with ASD (e.g. Bolte and Poustka 2002; Freeman et al. 1991; Klin et al. 2007). However, this finding has not consistently been reported in other studies with lower functioning groups (e.g., Bolte and Poustka 2002; Fenton et al. 2003) and requires further investigation as to whether this is a function of cognitive level or other sampling differences across studies.

A body of research involving the VABS has focused on profiles of relative strengths and weaknesses within samples of individuals with autism. Examining scores on individual domains of the VABS, it has been suggested that individuals with autism have a distinct profile on the VABS, with highest scores in Motor (if administered) and Daily Living, lowest scores in Socialization, and intermediate scores in Communication (Kraijer 2000; Sparrow et al. 2005). In the largest study of its kind, Carter et al.

(1998) examined adaptive behavior profiles in a sample of 684 children and adults with autism, breaking their sample into four groups based on age (under 10 vs. 10 years and older) and language ability (verbal and nonverbal). Most groups demonstrated the expected “autism profile” of higher Daily Living Skills, lower Socialization scores, and intermediate Communication scores when age equivalent scores were used. However, inconsistent and unexpected results were obtained when standard scores were examined. Similarly, Fenton et al. (2003) did not uncover the expected “autism profile” in a small study of younger children who had autism and moderate to severe MR when using standard scores. Carter and colleagues hypothesized that unexpected results based on standard scores may be due in part to floor effects on the VABS.

The presence of a clear and consistent “autism profile” on the VABS could inform diagnostic decision-making and we know, anecdotally, that it is often used in this way in clinical practice. In fact, the Vineland-II manual includes a section suggesting that an uneven profile is characteristic of children with autism and concomitant MR, versus a flat profile being shown in individuals with MR only (this information is based largely on research using the original VABS and does not specify whether profiles are based on standard scores or age equivalent scores). However, it is noteworthy that few studies have systematically examined profiles on the VABS in cognitively delayed individuals without autism or carefully compared profiles for children with autism to other groups.

Mervis and Klein-Tasman (2004) have speculated that the supposed “autism profile” of age equivalent scores on the VABS may be present in many individuals with delayed adaptive functioning, regardless of diagnosis, due to the psychometric properties of age equivalents on the measure. Indeed, we have previously demonstrated that the “autism profile” of age equivalent scores appears using the norms tables for hypothetical children with equal standard scores across domains, as soon as the standard scores get to the moderate range (Perry et al. 2006). Additional research is needed to clarify whether individuals with autism possess a reliable profile of scores on the VABS that is unique to autism as opposed to cognitive level.

A number of studies have addressed this issue slightly differently, by comparing VABS scores (standard scores typically) of individuals with autism to those of other diagnostic groups, producing inconsistent results. Most studies have found that people with autism have lower Socialization scores than age- and mental-age matched controls with MR or learning disabilities (e.g., Carpentieri and Morgan 1996; Loveland and Kelley 1991; Volkmar et al. 1987), consistent with the assumption that social difficulties are the core deficit in autism. Several studies have also reported lower Communication scores for people

with autism (Carpentieri and Morgan 1996; Stone et al. 1999; VanMeter et al. 1997; Vig and Jedrysek 1995), and some have reported lower Daily Living Skills as well (e.g., VanMeter et al. 1997; Volkmar et al. 1993). However, some studies have reported equivalent Communication, Daily Living Skills, and Motor Skills across groups (e.g., Fenton et al. 2003; Loveland and Kelley 1991; Schatz and Hamdan-Allen 1995). Several authors have suggested these diagnostic comparisons need to be considered within the context of the cognitive level of the study participants (e.g., Fenton et al. 2003; Liss et al. 2001; Schatz and Hamdan-Allen 1995).

The VABS scores of individuals with autism have also been compared to those of individuals with PDD-NOS, matched for IQ range, also with inconsistent results. Paul et al. (2004) found that children with autism had lower Socialization and Communication skills than children with PDD-NOS. Gillham et al. (2000) reported deficits in Daily Living Skills as well as Socialization and Communication (after controlling for differences in MA) suggesting that adaptive behaviour was generally lower in autism versus PDD-NOS. However, Vig and Jedrysek (1995) found no differences between autism and PDD-NOS children on any VABS domain after IQ was controlled. In addition, Njardvik et al. (1999) found no significant differences in VABS scores across two groups of adults with profound MR and either autism or PDD-NOS.

Previous research comparing diagnostic groups is difficult to interpret due to substantial differences in chronological age and level of cognitive functioning of participants across studies (both of which are correlated with adaptive behavior). In addition, the composition of control groups has varied (i.e., Down Syndrome, idiopathic MR, learning disabilities, mixed), sample sizes have often been small and, in some cases, sample differences have not been controlled either statistically or by individual matching. Additional research involving well-matched and well-specified samples is necessary to clarify previous findings.

Another body of research has reported on correlations between the VABS and other measures in an effort to understand variables affecting adaptive functioning in autism. Most studies suggest that adaptive functioning is positively correlated with cognitive level (sometimes measured by Verbal IQ, Performance IQ, Full Scale IQ, or Mental Age) across domains (Freeman et al. 1999; Klin et al. 2007; Liss et al. 2001; Perry et al. 2005; Schatz and Hamdan-Allen 1995), with the strongest correlations for the Communication domain (Klin et al. 2007).

In addition, age has been reported to be positive correlated with VABS age equivalent scores (e.g., Carter et al. 1998; Klin et al. 2007) and standard scores (Liss et al. 2001). However, some research suggests that age is

negatively correlated with VABS standard scores, at least in some domains (e.g., Carter et al. 1998; Fenton et al. 2003; Klin et al. 2007; Szatmari et al. 2003). Negative correlations between age and VABS standard scores may indicate several things. It could be that adaptive functioning decreases as children with ASD age. More likely, it is that adaptive behavior increases at a much slower rate than children age and, thus, the gap between their actual scores and the scores expected for their age progressively widens over time. However, these negative correlations may also reflect floor effects, especially in lower functioning samples (the floor of the VABS domains decreases with age, down to “below 20” in older individuals, but the lowest possible standard scores are as high as 53 when children are 24 months old). A negative correlation between VABS standard scores and age has also been reported for individuals who have severe MR without autism (e.g., Chadwick et al. 2005). Further examination of these relationships among a large and diverse sample could help clarify these previous findings.

Although many studies have examined adaptive behavior in individuals with autism, only a few have examined the relationship between adaptive behavior scores and autism symptomatology (using various measures) with results suggesting that autism symptom severity is somewhat negatively correlated with adaptive behavior (De Bildt et al. 2005; Klin et al. 2007; Liss et al. 2001). However, correlations may vary across age and functioning level of the individuals. Recently, Klin et al. (2007) examined the relationship between social and communicative abilities (on the VABS) and social and communicative disabilities (on the ADOS) in two high functioning samples and found surprisingly small (sometimes nonsignificant) negative correlations. Little research has examined correlations between adaptive functioning and autism severity in preschool children within a range of cognitive levels. Stronger correlations might be expected in children with lower developmental levels.

Clearer understanding of the relationships between adaptive functioning and all of these other variables (age, cognitive level, and symptom severity) could allow for better predictions regarding future functioning and inform decisions about goals to target during intervention programs.

Research Questions

Based on the above literature, we set out to answer several research questions. Throughout our analyses, both VABS standard scores and age equivalents were examined. Although age equivalent scores have definite psychometric limitations (they do not have equivalent meaning at

different ages, are not normally distributed, and so on; see Sattler 2001), we included them as they are often used clinically, especially with “lower functioning” children who may be at the floor of the test (or off the scale) on standard scores, and due to their ease of interpretation by parents and teachers. Although many studies only report standard scores, several of the key studies on the VABS have reported both (e.g., Carter et al. 1998; Klin et al. 2007).

Research Question #1: What is the relationship between cognitive and general adaptive levels in children with ASD and does this vary across levels of cognitive functioning?

We expected adaptive skill level to vary across different cognitive levels. Based on the literature, we hypothesized that adaptive scores would be lower than cognitive skills, for higher functioning children but, based on our clinical experience and some research, we anticipated the opposite pattern (higher adaptive than cognitive skills) in lower functioning groups.

Research Question #2: Is there a characteristic “autism profile” on the VABS?

We expected to detect the previously described “autism profile” (highest scores in Motor Skills, followed by Daily Living Skills, Communication and then Socialization) for age equivalent scores but not standard scores.

Research Question #3: Are VABS profiles unique to autism? Does the adaptive behavior of children with autism differ from (a) individually matched children with MR (without autism), and (b) individually matched children with PDD-NOS?

We hypothesized that young children with autism would have lower Socialization and Communication scores than children with MR, as social and communication deficits are closely related to diagnostic criteria for autism and deficits in these domains have been reported most consistently in previous studies. Similarly, we expected children with autism to have lower Socialization and Communication scores than children with PDD-NOS who, by definition, are likely to meet fewer DSM criteria and/or to be milder than children with Autistic Disorder.

Research Question #4: How are VABS scores in young children with ASD related to age, cognitive skills, and autism severity?

We hypothesized that chronological age would be positive correlated with age equivalent scores and negatively correlated with standard scores. In addition, we expected cognitive level to be positively correlated with adaptive functioning in all domains. Furthermore, we predicted significant negative correlations between autism

severity and adaptive functioning in all domains. In terms of the predictions, we expected autism severity to contribute unique variance (beyond developmental level) in adaptive functioning, especially in the Socialization domain, as social deficits are central to the conceptualization of autism.

Participants and Procedures

Data were obtained through retrospective file review from routine clinical practice at three sites specializing in the assessment of children with autism and other developmental disabilities. Ethical approval was obtained from all sites. One site was a comprehensive specialized autism service for children and adolescents (14% of the total sample), the second was a bilingual children’s hospital with a diagnostic clinic for developmental disabilities and a preschool autism intervention program (52% of the total sample), and the third was a treatment center with an assessment clinic for developmental disabilities and a preschool autism intervention program (34% of the total sample). All sites were located in urban centers in Ontario, Canada and all services were publicly funded. Although demographic information was not systematically collected, as per agency policies, all three agencies served families from highly diverse cultural and economic backgrounds. Since families did not volunteer for a research study, the sample may be assumed to be more diverse than is often the case.

A database was created that included information for all children at the three sites who were under the age of 6 years, met diagnostic criteria for an autism spectrum disorder (Autistic Disorder or PDD-NOS) and/or MR, and for whom there was complete cognitive and adaptive information available. Assessments were carried out between 1997 and 2006, most often to determine eligibility for autism treatment or for intervention planning within autism programs. However, a small number of assessments were carried out in the diagnostic clinics at sites 2 and 3 that assessed children with a range of developmental disabilities (not just autism), which provided a small sample of children with MR for whom autism had been ruled out.

Diagnoses resulted from routine clinical practice, based on combined information from diagnostic tools, observations of the child, and parent report. Most diagnoses were determined by one of three of the authors, all licensed psychologists with many years of experience in the field (as of 2006, AP had 17 years post-PhD experience, JDG had 21 years, and NF had 10 years) and established inter-rater reliability from other projects (Perry et al. 2005). For each child, DSM-IV criteria were systematically applied relative to developmental level, and the algorithm of at least two social criteria, one communication criterion, and one

repetitive behavior criterion, with a total of at least six criteria, was strictly adhered to. Children with social deficits and some (but not enough) symptoms of autism were diagnosed with PDD-NOS. Although no inter-rater reliability was conducted on this difficult diagnostic distinction, some validity is provided by the fact that autism severity, as measured on the Childhood Autism Rating Scale (CARS; Schopler et al. 1988) was significantly higher in the Autistic Disorder subgroup ($M = 35.78$, $SD = 4.47$) versus the PDD-NOS subgroup ($M = 29.52$; $SD = 3.99$, $t(256) = 10.07$, $p < .001$).

The above procedure resulted in a total pool of 318 children (77% male), ranging in age from 22 to 71 months with a mean age of 51.70 months ($SD = 12.51$). The sample included 192 children with Autistic Disorder, 66 children with PDD-NOS, and 28 children with MR (with autism ruled out). An additional 32 children had been diagnosed with an ASD by a professional in the community prior to referral for the autism intervention programs affiliated with two of the sites. Although these children were seen by one of the authors to confirm eligibility (either autism or PDD-NOS), they were not diagnosed as rigorously. Thus, these children were not included in the specific autism or PDD-NOS subgroups, but were included alongside children diagnosed with autism and PDD-NOS in a large *All ASD* subgroup ($n = 290$) which was used for the majority of the analyses. A subset of children in the present sample was included in an earlier study evaluating the validity of the CARS (Perry et al. 2005).

The All ASD group varied considerably in cognitive level and VABS scores. Sample characteristics may be found in Table 1. For analyses relating to the first two research questions, children were divided into the following six groups based on cognitive level: Average ($IQ \geq 85$; $n = 24$), Borderline ($IQ 70-84$; $n = 35$), Mild MR ($IQ 55-69$; $n = 53$), Moderate MR ($IQ 40-54$; $n = 66$), Severe MR ($IQ 25-39$; $n = 82$), and Profound MR ($IQ \leq 24$, $n = 30$).

Table 1 Sample characteristics for all ASD sample ($n = 290$)

	Standard scores		Age equivalents	
	<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)	Range
Cognitive ^a	50.2 (21.8)	14–109	25.56 (12.69)	6–73
VABS				
Com	57.2 (11.9)	38–114	18.5 (10.8)	1–63
DLS	57.3 (10.3)	27–86	23.0 (7.2)	8–52
Soc	58.8 (7.8)	43–88	15.9 (8.0)	4–57
Motor	63.6 (14.6)	32–114	30.8 (9.4)	14–71
ABC ^b	54.7 (9.1)	34–90	22.1 (7.8)	9–51

^a Cognitive standard score IQ, Age equivalent score MA

^b Age equivalent comparable to ABC is mean of four domain scores

Measures

The following measures were included in the analyses described below. All measures were administered or supervised by experienced psychologists, during routine clinical assessments for diagnostic or treatment planning purposes.

The Vineland Adaptive Behavior Scales—Survey Form (Sparrow et al. 1984). The VABS Survey Form is a semi-structured interview which was administered in person to primary caregivers. As mentioned previously, the VABS assesses adaptive functioning in Communication, Socialization, Daily Living Skills, and Motor Skills domains. Age equivalent scores and standard scores were obtained for each domain, and scores were combined to create overall Adaptive Behavior Composite (ABC) standard score.

Standardized cognitive measures: A number of standardized tests with established psychometric properties were used to evaluate intellectual skills due to differences in the age and functioning level of children, as is common in autism practice and research. These included (in order of use): the Bayley Scales of Infant Development: Second Edition (Bayley 1993; $n = 171$), the Stanford Binet: Various Editions (Roid 2003; Thorndike 1972; Thorndike et al. 1986; $n = 60$), the Mullen Scales of Early Learning (Mullen 1995; $n = 60$), the Wechsler Preschool and Primary Scale of Intelligence: Third Edition (Wechsler 2002; $n = 19$), the Cattell Infant Intelligence Scale (Cattell 1940; $n = 4$), and the Leiter International Performance Scale: Revised (Roid and Miller 1997; $n = 4$). Many children could not obtain basal scores on tests normed for their age group. Therefore, they were tested using measures designed for younger children and their IQ was estimated by calculating a Ratio IQ ($[MA/CA] \times 100$). Similarly, when children were assessed using tests that provided standard scores but no age equivalent scores, MA was derived ($[CA \times IQ]/100$). These procedures yielded scores in both metrics for each participant. As many of these tests provide only a global cognitive score, separate verbal and nonverbal IQ scores were not available.

The Childhood Autism Rating Scale (CARS; Schopler et al. 1988). The CARS is a widely used behavioral observation measure designed to assist in the diagnosis of autism. It contains 15 items that are rated by a trained observer on a 7-point scale (1–4 with half-points). Total scores range from 15 to 60, with higher scores indicating greater severity. This Total score was used as a measure of severity of autism symptomatology in the study. Many studies have examined the psychometric properties of the CARS, demonstrating high inter-rater reliability, internal consistency, criterion-related validity, and discriminant validity (DiLalla and Rogers 1994; Eaves and Milner 1993; Garfin and McCallon 1988; Magyar and Pandolfi 2007;

Perry et al. 2005; Schopler et al. 1988; Tachimori et al. 2003). We have previously established inter-rater reliability across our three sites on this measure (Perry et al. 2005).

Results

Relationship Between Cognitive and Adaptive Levels

Our first research question examined the relationship between adaptive and cognitive scores in children with ASD at the six different levels of cognitive functioning. Age was similar, but not equivalent across subgroups ($F(5, 284) = 3.73, p < .01$) and thus age was included as a covariate in these analyses.

There was an interesting pattern of relationships between cognitive and adaptive level in the different IQ subgroups, as shown in Table 2. Two repeated measures analyses of covariance (one for standard scores, one for age equivalents) were conducted with 2 within-group levels (cognitive vs. adaptive) and 6 between-group levels (levels of cognitive functioning) with age covaried. One ANCOVA was carried out to examine the relationship between IQ and VABS composite standard scores, while the other examined the relationship between MA and the VABS mean age equivalent scores. Looking first at the standard scores, there was a significant interaction between measure (cognitive or adaptive) and IQ level group (Wilks $\Lambda = .16, F(5, 283) = 294.96, p < .001$) with a very large effect size ($\eta^2 = .84$) indicating that the relationship between cognitive and adaptive scores varied across skill levels. An examination of simple effects within subgroups indicated that for children at the higher cognitive levels (average and borderline), IQ was significantly higher than ABC score. However, for the children with mild MR, the two scores did not differ, and for the lower functioning

groups (moderate, severe, and profound MR), IQ scores were significantly lower than ABC scores. See Table 2.

The same analysis was computed for age equivalent composite scores. There was again a significant interaction between measure (cognitive or adaptive) and IQ level group (Wilks $\Lambda = .39, F(5, 283) = 88.70, p < .001, \eta^2 = .61$). An assessment of simple effects by subgroup indicated that adaptive functioning age equivalents were significantly lower than cognitive age equivalents for the average, borderline, mild MR, and moderate MR groups. However, adaptive scores were significantly higher than cognitive scores for groups with severe and profound MR. See Table 2.

Profile Across Domains

Our second research question was whether there is a characteristic “autism profile” on the domains of the VABS, at least for age equivalents. Because of the previously described differences as a function of cognitive level, we decided to examine profiles across the four VABS domains and across our six cognitive level subgroups, using the logic of Profile Analysis as outlined by Tabachnick and Fidell (2007). Figure 1 depicts standard scores and Fig. 2 age equivalent scores on each domain on the VABS for each cognitive level subgroup. Two repeated measures multivariate analyses of covariance were performed, one for each type of score, with 6 cognitive levels (between) and 4 VABS domains (within), and CA as a covariate. The first step in profile analysis is to examine the interaction (the parallelism test). In the case of the standard scores, the profiles were not parallel (Wilks $\Lambda = .64, F(15,776) = 9.16, p < .001, \eta^2 = .14$). As seen in Fig. 1, the Communication domain is highest for the average and borderline subgroups whereas it tends to be the lowest among the other groups. The second step in profile analysis

Table 2 Adjusted^a cognitive and adaptive summary scores in children with ASD ($n = 290$) in different cognitive level subgroups

	<i>n</i>	IQ <i>M</i> (SE)	ABC <i>M</i> (SE)	<i>F</i> (1,283)	<i>p</i>	MA <i>M</i> (SE)	VABS AE <i>M</i> (SE)	<i>F</i> (1,283)	<i>p</i>
Average	24	94.5 (.9)	62.7 (1.3)	455.2	<.01	48.8 (.7)	29.8 (1.0)	368.4	<.01
Borderline	35	77.1 (.8)	63.7 (1.0)	118.7	<.01	40.0 (.6)	29.0 (.8)	180.7	<.01
Mild MR	53	60.7 (.6)	58.9 (.9)	3.2	ns	30.9 (.5)	25.9 (.7)	56.9	<.01
Moderate MR	66	46.1 (.6)	53.0 (.8)	59.4	<.01	23.8 (.4)	21.1 (.6)	20.7	<.01
Severe MR	82	33.0 (.5)	49.9 (.7)	441.6	<.01	17.0 (.4)	18.6 (.5)	8.7	<.01
Profound MR	30	20.5 (.9)	45.7 (1.2)	339.9	<.01	8.1 (.9)	13.0 (.9)	29.3	<.01

^a Scores are corrected to account for differences in chronological age across groups

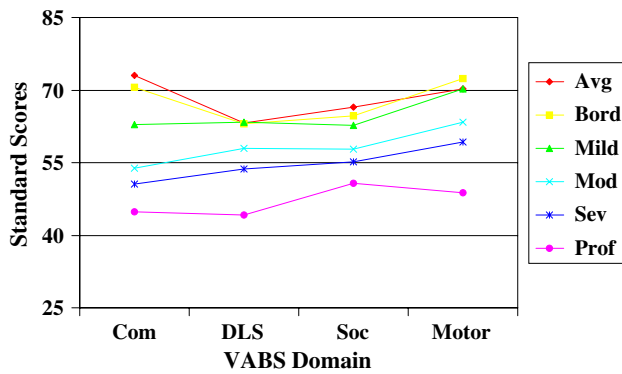


Fig. 1 Profile of VABS standard scores at different levels of cognitive functioning

is the between-subjects test (the levels test), which indicated that the higher IQ groups in general had higher scores across domains ($F(5,283) = 54.26, p < .001, \eta^2 = .49$). The third step is the within-subjects test (the flatness test), which suggested that some domains are higher than others regardless of group, although with a medium effect size ($F(3,283) = 29.06, p < .001, \eta^2 = .09$). Although there was a profile associated with standard scores, it was clearly not the “autism profile” described previously (highest to lowest: Motor, Daily Living, Communication, Socialization). Although Motor scores tended to be the highest in most cases, Socialization was generally higher than Daily Living and Communication.

The same analyses were conducted for age equivalent scores. Again VABS profiles differed across levels of cognitive functioning (Wilks $\Lambda = .68, F(15, 849) = 6.94, p < .001, \eta^2 = .11$). As seen in Fig. 2, the profiles were more pronounced than for standard scores and generally had the same pattern except for high Communication scores among the average and borderline groups. There was also a significant main effect for levels or IQ group ($F(5, 283) = 63.90, p < .001, \eta^2 = .53$) and a significant main effect for flatness or domain ($F(3, 283) = 8.78,$

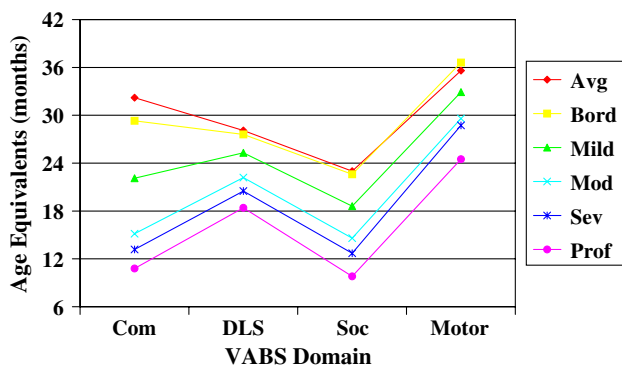


Fig. 2 Profile of VABS age equivalent scores at different levels of cognitive functioning

$p < .001$), although the effect size was small ($\eta^2 = .03$). This significant effect of domain confirms the existence of the “autism profile” for age equivalents, whereby generally Motor is highest, followed by Daily Living and Communication (except in the two highest functioning groups), and then Socialization lowest.

Differences in VABS Scores and Profiles Across Diagnostic Groups

Our third research question examined differences in VABS profiles as a function of specific diagnosis. First, we examined VABS scores in two sets of individually matched subsamples from our dataset: (a) 28 pairs of children with autism versus MR (without autism); and (b) 48 pairs of children with autism versus PDD-NOS. For the first set of analyses, each child with MR in our sample was individually matched to a child with autism of similar CA and MA (both within 3 months). Consistent with best practice for group-matching designs (see Mervis and Klein-Tasman 2004), p values for comparisons involving control variables exceeded 0.50. The two groups were virtually equivalent for CA ($M = 52.25 [SD = 10.76]$ months versus 52.39 [10.55] months, $t(27) = -.51, p = .62$), MA ($M = 26.11 [SD = 6.71]$ months versus 26.24 [7.57] months, $t(27) = -.397, p = .70$) and IQ estimate ($M = 50.64 [SD = 2.02]$ versus 50.31 [2.04], $t(27) = .55, p = .59$). As expected, CARS scores were much lower for the children with MR ($M = 23.23 [SD = .3.02]$ versus autism 34.57 [$SD = 3.30$], $t(54) = 13.42, p < .001$).

Profile analyses similar to those reported above were conducted (except here there were only two groups). Two sets of repeated measures analyses of variance were carried out (one for standard scores, one for age equivalents) to evaluate differences between children with autism and children with MR (age was not covaried as it was controlled by the matching procedure). Results are shown in Figs. 3 and 4. For standard scores, there was a significant

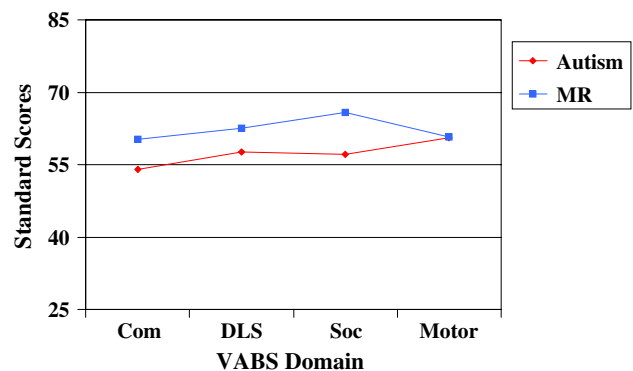


Fig. 3 Profile of VABS standard scores for matched pairs with autism or MR ($n = 28$)

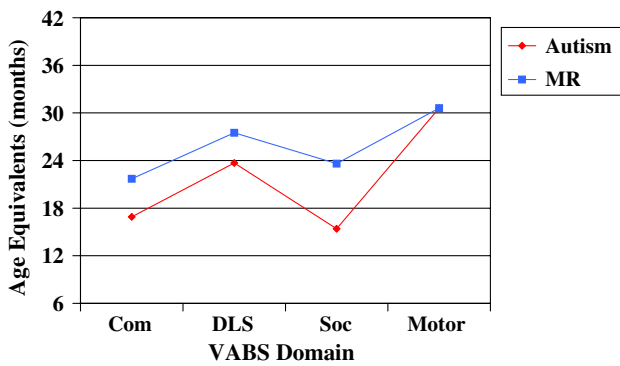


Fig. 4 Profile of VABS age equivalent scores for matched pairs with autism or MR ($n = 28$)

interaction (Wilks $\Lambda = .86$), and Greenhouse–Geisser adjustments were applied because of non-sphericity resulting in $F(2.1, 54) = 4.39, p = .013, \eta^2 = .08$ indicating the profiles differed in the two groups. The within-subjects (domain) effect was also significant ($F(2.1, 54) = 4.86, p = .008, \eta^2 = .08$). Neither of these were very large effect sizes, however. The between-groups test, of greatest interest in this case, was significant and accounted for more variance: $F(1, 54) = 8.24, p = .006, \eta^2 = .13$. Post hoc univariate analyses (using an α level of .01) indicated that children with autism scored lower than children with MR for Communication ($F(1,54) = 10.50, p = .002$) and Socialization ($F(1,54) = 26.44, p < .001$), but there were no differences for Daily Living or Motor Skills.

For age equivalents, the same pattern was seen. The interaction was significant (Wilks $\Lambda = .74$ and with Greenhouse–Geisser adjustment $F(2.4,54) = 7.74, p < .001, \eta^2 = .13$). The within-subjects (domain) effect was also significant and strong ($F(2.4, 54) = 81.63, p < .001, \eta^2 = .60$). Again the relevant between-groups test was significant: $F(1, 54) = 7.37, p = .009, \eta^2 = .12$. Post hoc univariate analyses (using an α level of .01) indicated that children with autism scored lower than children with MR for Communication ($F(1,54) = 7.10, p = .01$) and Socialization ($F(1,54) = 19.98, p < .001$), but again there were no differences for Daily Living or Motor Skills.

The same type of yoke-matching procedure was used to compare scores on the VABS for children with autism versus PDD-NOS. Individual matching within 3 months for both MA and CA produced 48 matched pairs virtually equivalent for CA ($M = 48.48 [SD = 12.24]$ months versus $M = 48.60 [SD = 12.19]$ months, $t(47) = -.636, p = .53$), MA ($M = 28.01 [SD = 12.21]$ months versus $M = 27.94 [SD = 11.63]$ months, $t(47) = .282, p = .78$) and IQ estimate ($M = 57.88 [SD = 2.80]$ versus $M = 57.51 [SD = 2.58], t(47) = .740, p = .46$). However, CARS

scores were lower for the PDD-NOS group ($M = 29.44 [SD = 4.19]$) than for children with autism ($M = 34.44 [SD = 3.91], t(94) = 6.05, p < .001$), confirming our assumption that the PDD-NOS children showed milder symptom severity. A small number of children with PDD-NOS in our larger dataset ($n = 18$) were not included in this analysis as they could not be closely matched to children with autism. On average, these excluded children were older than the PDD-NOS children included in analyses ($M = 58.50 [SD = 6.56]$ months versus $M = 48.48 [SD = 12.24], t(64) = -3.29, p = .002$) and had higher IQ ($M = 75.66 [SD = 19.24]$ versus $M = 57.98 [SD = 19.37], t(64) = -3.31, p = .002$). Thus, the PDD-NOS children used in the matched pairs are not representative of our entire group of children with PDD-NOS. However, their level of symptom severity was similar (CARS Total $M = 29.44 [SD = 4.19]$ versus $M = 29.75 [SD = 3.51], t = -0.28, ns$).

For the autism versus PDD-NOS matched pairs comparison, a similar set of profile analyses were done as reported above. For standard scores, the interaction was nonsignificant (Wilks $\Lambda = .98, F(2.1,94) = 0.60, ns$), suggesting the two profiles do not differ, and the between-groups comparison was marginally significant and quite weak ($F(1,94) = 5.56, p = .02, \eta^2 = .06$). Only the within-subjects effect of domain was significant ($F(2.1,94) = 18.76, p < .001, \eta^2 = .17$), which is not the main comparison of interest for this research question. For age equivalents, a similar pattern was found. The interaction was not significant ($\Lambda = .95, F(2.2, 94) = 2.01, ns$), nor was the between-groups test ($F(1,94) = 2.13, ns$) but there was a significant main effect of domain ($F(2,94) = 136.28, p < .001, \eta^2 = .59$). Therefore, profiles did not differ in these two matched groups.

Developmental Correlates and Predictors of VABS Scores

Our fourth research question involved examining correlations between VABS scores and age, cognitive level, and autism severity. In addition, we were interested in the predictive value of autism severity while controlling for these other developmental variables. These analyses included all children with an ASD in our dataset ($n = 290$).

Correlations between VABS domains and CA, cognitive level, and autism severity are presented in Table 3 (correlations with cognitive level were computed using IQ when correlating with VABS standard scores and MA when correlating with age equivalents). Children’s age (CA) was moderately negatively correlated with VABS standard scores and positively correlated with VABS age equivalent scores, as predicted, with Daily Living skills showing the highest correlations ($r = -.56$ for standard

Table 3 Correlations between VABS scores and chronological age, cognitive level and autism severity ($n = 290$)

		CA	IQ/MA ^a	CARS
SS	Com	-.28	.74	-.54
	DLS	-.56	.51	-.47
	Soc	-.28	.61	-.57
	Motor	-.45	.44	-.33
	ABC	-.44	.65	-.53
AE	Com	.36	.80	-.50
	DLS	.50	.67	-.48
	Soc	.33	.69	-.53
	Motor	.48	.59	-.31

^a VABS age equivalent scores were correlated with MA; VABS standard scores were correlated with IQ. All correlations were significant at $p < .01$

scores and .50 for age equivalents). Cognitive ability was moderately to strongly positively correlated with both types of VABS scores in all domains, with Communication showing the highest correlations ($r = .74$ for standard scores and .80 for age equivalents). Lastly, autism severity was moderately to strongly negatively correlated with both types of adaptive behavior scores in most domains (correlations were lower for Motor Skills). Additional analyses indicated that CA was somewhat correlated with MA ($r = .38$, $p < .01$) and IQ ($r = -.13$, $p < .05$), but not correlated with CARS score ($r = .04$, ns). Furthermore, autism severity was strongly negatively correlated with cognitive skills ($r = -.57$ for MA; $r = -.64$ for IQ, $p < .01$).

Given the intercorrelations among all relevant variables, a series of planned hierarchical regression analyses were carried out to examine the unique contribution of autism severity in predictions of adaptive functioning while controlling for age and cognitive level. Separate analyses were carried out for each domain of the VABS and α was set at .01. For predictions involving standard scores, age and IQ were entered in Step 1; for predictions involving age

equivalents, age and MA were entered in Step 1. Then, CARS score was entered at Step 2 in each case. The total explained variance (R^2) is reported for Step 1 and the coefficients and R^2 change is reported for Step 2. Results are shown in Table 4.

CARS scores contributed the most incremental variance for Socialization, as expected (6% for standard scores; 5% for age equivalents), but also a similar proportion of variance in Daily Living Skills (5% for both standard scores and age equivalents). For Communication, the proportion of variance was smaller (about 1%; $p = .009$ for standard scores, $p = .016$ for age equivalents). CARS scores did not contribute additional variance to the prediction of Motor Skills. Lastly, CARS scores contributed about 3% of incremental variance to predictions of overall adaptive functioning (ABC).

Discussion

This study builds upon previous research that has examined adaptive functioning in individuals with autism using the VABS. It focuses on adaptive skills during the early childhood years, a time when psychological assessments (including the VABS) are common for diagnostic and treatment planning purposes. First, we examined scores on the VABS in children with ASD at different levels of cognitive functioning, looking at global cognitive–adaptive comparisons as well as a profile analysis across domains. Then, we made comparisons between specific diagnostic groups using smaller individually matched samples equivalent for chronological and mental age. Lastly, we examined relationships between VABS scores and age, cognitive level, and autism severity and ascertained whether autism severity contributed unique variance to adaptive scores.

Because we had a large and heterogeneous sample, we were able to examine VABS scores at various levels of cognitive functioning and try to reconcile some of the

Table 4 Regression results showing incremental variance accounted for by autism severity in predictions of VABS scores ($n = 290$)

		Step 1 (CA and cognitive)	B	Step 2 (Autism severity)	β	ΔR^2
		R^2		SE (B)		
SS	Com	.58	-.296	.112	-.130*	.01
	DLS	.50	-.556	.103	-.281**	.05
	Soc	.41	-.478	.084	-.317**	.06
	Motor	.35	-.324	.173	-.115	.01
	ABC	.55	-.388	.091	-.214**	.03
AE	Com	.65	-.226	.093	-.109	.01
	DLS	.52	-.397	.069	-.287**	.05
	Soc	.48	-.421	.081	-.273**	.05
	Motor	.42	-.147	.105	-.081	.00

Note: For predictions of standard scores, CA and IQ were entered at step 1; for predictions of age equivalents, CA and MA were entered at step 1. CARS Total was entered at step 2 in each case

* $p < .01$, ** $p < .001$

conflicting findings in the literature which has used different, but often more homogeneous, samples. As we predicted, based on some previous studies (e.g., Klin et al. 2007), cognitive functioning was higher than adaptive functioning in subgroups of cognitively more able children with ASD. In spite of their average or borderline IQs, these children are still experiencing substantial difficulties in everyday life. This has clear implications for treatment outcome studies, in which average IQ may be overvalued as a good outcome without sufficient attention to functional skills. There are also clear intervention implications, such that everyday functional skills must be actively targeted in autism intervention programs.

For lower functioning subgroups, adaptive skills were higher than cognitive skills, at least for standard scores, as predicted. This could possibly be interpreted as suggesting that these children are maximizing their potential or have received good life skills instruction. However, it could also be related to the score distributions, as the VABS standard scores have a rather high basal at young ages and Ratio IQs (used for many children who were below the norms tables on the cognitive measures) provide a greater range of possible scores (skewness statistics for these two variables were similar, however). Furthermore, our analysis comparing cognitive and adaptive age equivalents across groups resulted in nonsignificant findings. The fact that age equivalents for cognitive and adaptive measures are similar, especially in lower functioning children, is reassuring in terms of the clinical utility of such scores, in spite of all their psychometric weaknesses.

This study also builds upon previous research about patterns or profiles on the VABS domains that could potentially inform diagnostic decision-making. We wanted to examine whether there was a characteristic “autism profile”, which we hypothesized would exist for age equivalents but not for standard scores (based on the findings of Carter et al. 1998 in particular). In general this hypothesis was supported, as the characteristic profile did not occur for standard scores but did for age equivalents. The expected profile of scores (highest on Motor, followed by Daily Living, then Communication, then Socialization) was seen overall, although not in the two cognitively highest groups, whose Communication scores were higher, likely because the Written subdomain inflated their domain standard scores. These subgroups did show the other aspects of the profile, though, with Socialization scores lowest and Motor Skills highest. However, the proportion of variance accounted for by the main effect for “flatness” was rather modest, suggesting this pattern is not very robust. Although the profile appears to be present in Fig. 2, once age is covaried, the effect is only modest. For this reason, as well as because of the general limitations of age-based scores, we recommend against the use of this

“profile” as confirmatory of a diagnosis of autism, although low Socialization scores may certainly be relevant in diagnosis.

The small matched pairs comparison of children with autism and MR sheds further light on this issue. Both groups showed the “autism profile” suggesting this pattern of scores is, to some extent, common to children with developmental delays. However, children with autism did score significantly lower on Communication and Social compared to children with MR (controlling for age and functioning level), as found by some previous research (e.g., Vig and Jedrysek 1995; Volkmar et al. 1987). This implies that there are some aspects of adaptive functioning which are especially impacted by autism and that developmental level does not entirely determine adaptive scores (a point also made by Liss et al. 2001).

On the other hand, and contrary to prediction, profiles did not differ significantly when comparing another set of matched groups of children with autism to children with PDD-NOS, who were equated for age and cognitive level, a finding which was also similar to that of Vig and Jedrysek (1995). In spite of more severe symptomatology in the autism group (as shown by a large difference in CARS scores), their adaptive behavior scores were not significantly more impaired on the social and communication domains (although they were lower). This finding may be related to the selection of the PDD-NOS children to be matched on developmental level and would perhaps not be true of higher functioning children with PDD-NOS.

Thus, we would argue that this “autism profile” is primarily a general phenomenon (accounted for largely by developmental level and the statistical properties of the scores) but that part of the variance is accounted for by the ASD diagnosis specifically. The regression findings in the larger sample support this notion since, in predictions of Socialization, developmental level accounted for 41% of the variance in standard scores and 48% in age equivalents, and then autism severity accounted for about 6% of additional unique variance.

As hypothesized, cognitive level (MA or IQ) was strongly positively correlated with adaptive functioning, especially the Communication domain. Chronological age tended to be moderately positively correlated with VABS age equivalent scores and moderately negatively correlated with VABS standard scores, as predicted. A negative correlation between CA and VABS standard scores has been reported in some previous research (e.g., Klin et al. 2007), and may suggest that children with ASD may fall further behind peers with respect to adaptive functioning as they age. However, as noted earlier, this correlation may also be influenced by floor effects.

Autism severity was moderately to strongly negatively correlated with adaptive behavior. These correlations were

stronger than those reported by Klin et al. 2007 in higher functioning children using the ADOS and similar in magnitude and direction to those reported by Liss et al. (2001) using the Wing questionnaire. Regression analyses indicated that autism severity accounted for a small amount of unique variance in Socialization, as predicted (and discussed above) but also for Daily Living Skills, rather surprisingly. Although autism is associated with deficits in communication, the percentage of variance in Communication skills accounted for by autism severity was very small. This is perhaps due to high proportion of variance subsumed by cognitive level, or the presence of atypical but intact speech in a proportion of individuals on the autism spectrum. Despite statistically unique variance in VABS scores attributable to autism severity, it is important to note that much more variance in VABS scores was accounted for by age and developmental level (both entered at Step 1 in the regression analyses).

This research has a number of important implications for clinical practice with respect to both assessment/diagnosis and treatment planning. Adaptive behavior measures, such as the VABS or the new Vineland-II, continue to be a crucial component of a developmental and diagnostic assessment for children with autism as part of a concomitant diagnosis of mental retardation. In addition, determining strengths and weaknesses in everyday skills has important implications for intervention planning and family support. Our results suggest that adaptive behavior skill levels in children with autism are largely a function of their cognitive level, but that Socialization and Communication are more impaired than would be expected, which is consistent with the main features of the diagnosis of autism. There does tend to be a characteristic “autism profile” of age equivalent scores, at least for children with comorbid MR, but we recommend against relying on this as a diagnostic heuristic. Age equivalents (in spite of general caveats about them psychometrically) may be useful clinically with lower functioning children when standard scores are at the floor of the measure.

It is important for clinicians and parents to recognize that autism is associated with adaptive functioning deficits and that intervention and supports in this area may be necessary. Interventions directly targeting the development of adaptive skills may be warranted in many cases and not only for young children. As the amount of unique variance in adaptive functioning predicted by autism severity is modest, interventions that target only autism symptoms may not be sufficient to improve adaptive skills.

There are a number of limitations in this work which should be acknowledged. First, the study examined adaptive functioning in young children, and additional research would be necessary to extend findings to older samples.

Second, most children had co-morbid cognitive impairments and further research with a larger proportion of higher functioning children would be beneficial. Third, floor effects may have influenced our findings, as described previously. The floor of the VABS varies by age (higher for younger children) and domain (often lower for Daily Living and Motor Skills for this age group). Therefore, floor effects may have influenced VABS standard score profiles in lower functioning children and contributed to the negative correlation observed between age and adaptive functioning.

Another limitation is that the sample of children with MR in the matched pairs analysis is rather small and there might be a concern regarding its representativeness. Although many children with ASD in our sample were assessed in specialized autism programs, children with MR were assessed in diagnostic clinics for children with various developmental disorders. Therefore, there is no reason to expect that they are biased towards the autism spectrum. They had a mean CARS score of 23, which is well below the autism range.

A further limitation of these analyses is that data were derived from clinical practice as opposed to a funded research study. Because of this, we have no inter-rater reliability on the children’s diagnoses. Various tools were used to measure cognitive skills and results were combined assuming they are measuring the same construct. Also, the standard scores and age equivalents were sometimes derived from each other mathematically rather than from norms tables, a process which, though common in this sort of research, is likely fraught with an unknown degree of error. Lastly, a new version of the VABS is now available (Sparrow et al. 2005). As the VABS and the Vineland-II measure similar domains of functioning, it is likely that individuals with autism would perform similarly on the two measures, but this remains to be confirmed by future research. Nevertheless, the study has the strength of providing a large and developmentally heterogeneous sample which has facilitated examining some interesting questions regarding the nature of adaptive behavior in children with autism.

Acknowledgments We are grateful to the following people who assisted in the data entry and checking for this study: Sally Bond, Ryan Chang, Kelly Geier, Carol Haddad, Bharathy Kavallappa, Megan Mak, Catherine Munns, and Alice Prichard. We appreciate the support of the TRE-ADD Program at Thistletown Regional Centre in conducting this study. The views expressed are, however, those of the authors and do not necessarily represent the views of Thistletown Regional Centre or the Ontario Ministry of Children and Youth Services. A preliminary version of these data was presented in poster format at: the Ontario Association on Developmental Disabilities Research Day in April 2006 in Barrie, ON, the International Meeting for Autism, Research (IMFAR) in June 2006 in Montreal, QB, and the

Society for Research in Child Development in Boston, MA in March 2007.

References

- American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders: 4th ed., text revision*. Washington, DC: Author.
- Bayley, N. (1993). *The Bayley scales of infant development* (2nd ed.). San Antonio, TX: Psychological Corporation.
- Bolte, S., & Poustka, F. (2002). The relation between general cognitive level and adaptive behavior domains in individuals with autism with and without co-morbid mental retardation. *Child Psychiatry and Human Development*, 33, 165–172. doi:10.1023/A:1020734325815.
- Carpentieri, S., & Morgan, S. B. (1996). Adaptive and intellectual functioning in autistic and nonautistic retarded children. *Journal of Autism and Developmental Disorders*, 26, 611–620. doi:10.1007/BF02172350.
- Carter, A. S., Volkmar, F. R., Sparrow, S. S., Wang, J. J., Lord, C., Dawson, G., et al. (1998). The Vineland Adaptive Behavior Scales: Supplementary norms for individuals with autism. *Journal of Autism and Developmental Disorders*, 28, 287–302. doi:10.1023/A:1026056518470.
- Cattell, P. (1940). *Infant intelligence scale*. New York: Psychological Corporation.
- Chadwick, O., Cuddy, M., Kusel, Y., & Taylor, E. (2005). Handicaps and the development of skills between childhood and early adolescence in young people with severe intellectual disabilities. *Journal of Intellectual Disability Research*, 49, 877–888. doi:10.1111/j.1365-2788.2005.00716.x.
- De Bildt, A., Kraijer, D., Sytema, S., & Minderaa, R. (2005). The psychometric properties of the Vineland Adaptive Behavior Scales in children and adolescents with mental retardation. *Journal of Autism and Developmental Disorders*, 35, 53–62. doi:10.1007/s10803-004-1033-7.
- DiLalla, D. L., & Rogers, S. J. (1994). Domains of the Childhood Autism Rating Scale: Relevance for diagnosis and treatment. *Journal of Autism and Developmental Disorders*, 24, 115–128. doi:10.1007/BF02172092.
- Eaves, R. C., & Milner, B. (1993). The criterion-related validity of the Childhood Autism Rating Scale and the Autism Behavior Checklist. *Journal of Abnormal Child Psychology*, 21, 481–491. doi:10.1007/BF00916315.
- Fenton, G., D’Ardia, C., Valente, D., Vecchio, I., Fabrizi, A., & Bernabei, P. (2003). Vineland Adaptive Behavior profiles in children with autism and moderate to severe developmental delay. *Autism*, 7, 269–287. doi:10.1177/13623613030073004.
- Filipek, P. A., Accardo, J. P., Baranek, G. T., Cook, E. H., Dawson, G., Gordon, B., et al. (1999). The screening and diagnosis of autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, 29, 439–484. doi:10.1023/A:1021943802493.
- Fombonne, E. (2005). Epidemiological studies of pervasive developmental disorders. In F. R. Volkmar, R. Paul, R. A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (3rd ed., pp. 42–69). Hoboken, NJ: John Wiley.
- Freeman, B. J., Del’Homme, M., Guthrie, D., & Zhang, F. (1999). Vineland adaptive behavior scale scores as a function of age and initial IQ in 210 autistic children. *Journal of Autism and Developmental Disorders*, 29, 379–384. doi:10.1023/A:1023078827457.
- Freeman, B. J., Rahbar, B., Ritvo, E. R., Bice, T. L., Yokota, A., & Ritvo, R. (1991). The stability of cognitive and behavioral parameters in autism: A twelve-year prospective study. *Journal of the American Academy of Child and Adolescent Psychiatry*, 30, 479–482. doi:10.1097/00004583-199105000-00020.
- Garfin, D. G., & McCallon, D. (1988). Validity and reliability of the Childhood Autism Rating Scale with autistic adolescents. *Journal of Autism and Developmental Disorders*, 18, 367–378. doi:10.1007/BF02212193.
- Gillham, J. E., Carter, A. S., Volkmar, F. R., & Sparrow, S. S. (2000). Towards a developmental operational definition of autism. *Journal of Autism and Developmental Disorders*, 30, 269–278. doi:10.1023/A:1005571115268.
- Klin, A., Saulnier, C. A., Sparrow, S., Cicchetti, D. V., Volkmar, F. R., & Lord, C. (2007). Social and communication abilities and disabilities in higher functioning individuals with autism spectrum disorders: The Vineland and the ADOS. *Journal of Autism and Developmental Disorders*, 37, 748–759. doi:10.1007/s10803-006-0229-4.
- Kraijer, D. (2000). Review of adaptive behavior studies in mentally retarded persons with autism/pervasive developmental disorder. *Journal of Autism and Developmental Disorders*, 30, 39–47. doi:10.1023/A:1005460027636.
- Liss, M., Harel, B., Fein, D., Allen, D., Dunn, A., Dunn, M., et al. (2001). Predictors and correlates of adaptive functioning in children with developmental disorders. *Journal of Autism and Developmental Disorders*, 31, 219–230. doi:10.1023/A:1010707417274.
- Loveland, K. A., & Kelley, M. L. (1991). Development of adaptive behavior in preschoolers with autism or Down syndrome. *American Journal of Mental Retardation*, 96, 13–20.
- Magyar, C. I., & Pandolfi, V. (2007). Factor structure evaluation of the Childhood Autism Rating Scale. *Journal of Autism and Developmental Disorders*, 37, 1787–1794. doi:10.1007/s10803-006-0313-9.
- Mandell, D. S., Novak, M. M., & Zubritsky, C. D. (2005). Factors associated with age of diagnosis among children with autism spectrum disorders. *Pediatrics*, 116, 1480–1486. doi:10.1542/peds.2005-0185.
- Mervis, C. B., & Klein-Tasman, B. P. (2004). Methodological issues in group-matching designs: α levels for control variable comparisons and measurement characteristics of control and target variables. *Journal of Autism and Developmental Disorders*, 34, 7–17. doi:10.1023/B:JADD.0000018069.69562.b8.
- Mullen, E. M. (1995). *Mullen scales of early learning*. Circle Pines, MN: American Guidance Service.
- Njardvik, U., Matson, J. L., & Cherry, K. E. (1999). A comparison of social skills in adults with autism, pervasive developmental disorder not otherwise specified, and mental retardation. *Journal of Autism and Developmental Disorders*, 29, 287–295. doi:10.1023/A:1022107318500.
- Paul, R., Miles, S., Cicchetti, D., Sparrow, S., Klin, A., Volkmar, F., et al. (2004). Adaptive behavior in autism and pervasive developmental disorder-not otherwise specified: Microanalysis of scores on the Vineland Adaptive Behavior Scales. *Journal of Autism and Developmental Disorders*, 34, 223–228. doi:10.1023/B:JADD.0000022612.18116.46.
- Perry, A., Condillac, R. A., & Freeman, N. L. (2002). Best practices and practical strategies for assessment and diagnosis of autism. *Journal on Developmental Disabilities*, 9, 61–75.
- Perry, A., Condillac, R. A., Freeman, N. L., Dunn Geier, J., & Belair, J. (2005). Multi-site study of the Childhood Autism Rating Scale (CARS) in five clinical groups of young children. *Journal of Autism and Developmental Disorders*, 35, 625–634. doi:10.1007/s10803-005-0006-9.
- Perry, A., Dunn Geier, J., Penn, H., & Freeman, N.L. (2006, June). Validity of the Vineland “autism profile”. Poster presentation at

- the International Meeting for Autism Research (IMFAR), Montreal, QB.
- Perry, A., & Factor, D. C. (1989). Psychometric validity and clinical usefulness of the Vineland Adaptive Behavior Scales and the AAMD Adaptive Behavior Scale for an autistic sample. *Journal of Autism and Developmental Disorders*, *19*, 41–55. doi:10.1007/BF02212717.
- Roid, G. H. (2003). *Stanford-Binet intelligence scales* (5th ed.). Itasca, NY: Riverside.
- Roid, G. H., & Miller, L. J. (1997). *The Leiter international performance scale-revised edition*. Lutz, FL: Psychological Assessment Resources.
- Sattler, J. M. (2001). *Assessment of children: Cognitive applications* (4th ed.). San Diego, CA: Jerome Sattler Publisher Inc.
- Schatz, J., & Hamdan-Allen, G. (1995). Effects of age and IQ on adaptive behavior domains for children with autism. *Journal of Autism and Developmental Disorders*, *25*, 51–60. doi:10.1007/BF02178167.
- Schopler, E., Reichler, R. J., & Renner, B. R. (1988). *The childhood autism rating scale (CARS)*. Los Angeles, CA: Western Psychological Services.
- Sparrow, S., Balla, D., & Cicchetti, D. (1984). *Vineland adaptive behavior scales*. Circle Pines, MN: American Guidance Service.
- Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005). *Vineland adaptive behavior scales* (2nd ed.). Circle Pines, MN: American Guidance Service.
- Stone, W., Ousley, O., Hepburn, S., Hogan, K., & Brown, C. (1999). Patterns of adaptive behavior in very young children with autism. *American Journal of Mental Retardation*, *104*, 187–199. doi:10.1352/0895-8017(1999)104<0187:POABIV>2.0.CO;2.
- Szatmari, P., Bryson, S. E., Boyle, M. H., Streiner, D. L., & Duku, E. (2003). Predictors of outcome among high functioning children with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *44*, 520–528. doi:10.1111/1469-7610.00141.
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Pearson.
- Tachimori, H., Osada, H., & Kurita, H. (2003). Childhood Autism Rating Scale–Tokyo version for screening pervasive developmental disorders. *Psychiatry and Clinical Neurosciences*, *57*, 113–118. doi:10.1046/j.1440-1819.2003.01087.x.
- Thorndike, R. L. (1972). *Manual for the Stanford-Binet intelligence scale*. Boston, MA: Houghton-Mifflin.
- Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Stanford-Binet intelligence scale* (4th ed.). Itasca, IL: Riverside Publishing.
- VanMeter, L., Fein, D., Morris, R., Waterhouse, L., & Allen, D. (1997). Delay versus deviance in autistic social behavior. *Journal of Autism and Developmental Disorders*, *27*, 557–569. doi:10.1023/A:1025830110640.
- Vig, S., & Jedrysek, E. (1995). Adaptive behavior of young urban children with developmental disabilities. *Mental Retardation*, *33*, 90–98.
- Volkmar, F., Carter, A., Sparrow, S., & Cicchetti, D. (1993). Quantifying social development in autism. *Journal of the American Academy of Child and Adolescent Psychiatry*, *32*, 627–632. doi:10.1097/00004583-199305000-00020.
- Volkmar, F. R., Sparrow, S. S., Goudreau, D., Cicchetti, D., Paul, R., & Cohen, D. J. (1987). Social deficits in autism: An operational approach using the Vineland Adaptive Behavior Scales. *Journal of the American Academy of Child and Adolescent Psychiatry*, *26*, 156–161. doi:10.1097/00004583-198703000-00005.
- Wechsler, D. (2002). *Wechsler preschool and primary scale of intelligence* (3rd ed.). San Antonio, TX: Psychological Corporation.