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Adaptive behavior profiles in young children with autism spectrum disorder diagnosed under *DSM-5* criteria

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ABSTRACT

Background: This study explored adaptive behavior profiles in a clinical sample of well-characterized children aged one to three years with ASD.
Method: Profiles were compared to a sample of children with non-ASD developmental delays. Cluster analyses were performed to determine whether differences in adaptive skills effectively distinguished children with ASD from other young children presenting for assessment due to behavioral or other concerns, but who received other non-ASD diagnoses.
Results: A profile of motor > daily living > socialization > communication skills was found in both children with ASD and children with non-spectrum diagnoses, showing that this profile is not unique to young children with ASD. A two-group cluster solution was found which differentiated children by developmental functioning level rather than by diagnosis.
Discussion: The results of this study provide support for two developmental profiles for adaptive functioning in children with ASD: an average to borderline delayed profile and a borderline to more severely delayed profile that may remain stable or worsen over time. They additionally highlight the importance of delivering early targeted interventions to children with ASD who have greater deficits in adaptive functioning due to their association with poorer long-term outcomes.

1. Introduction

Adaptive behavior describes skills necessary for independent functioning within society, including practical, conceptual, social, and linguistic skills (Schalock & Borthwick, 2010; Sparrow, Cicchetti, & Balla, 2005). In individuals with developmental disabilities, level of adaptive functioning has been strongly linked with prognosis (Gillham, Carter, Volkmar, & Sparrow, 2000; Klin et al., 2007), and measurement of adaptive behavior is essential for tracking developmental gains and identifying appropriate educational and habilitative goals (Tassé et al., 2012). Children with Autism Spectrum Disorder (ASD) often demonstrate higher rates of deficits in adaptive than cognitive functioning, even when impairments in intellectual functioning are not present (Perry, Flanagan, Geier, & Freeman, 2009; Pugliese et al., 2015). Since adaptive skills are typically learned through interaction with one's social environment, children with ASD are likely to have greater difficulties in this area due to the nature of their social deficits. For example, daily living skills such as personal hygiene are difficult for a child to learn if he or she does not attend to the adult modeling these skills. Initial difficulties in acquiring adaptive skills are compounded by evidence that the adaptive functioning of children with ASD does not increase at a rate proportional to their aging, resulting in relatively greater deficits over time (Green & Carter, 2014; Pugliese

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et al., 2015). Given that children can be reliably diagnosed with ASD under three years (Stone et al., 1999), having a clear understanding of adaptive behavior profiles associated with ASD in this age range can be pivotal in providing targeted interventions to facilitate developmental outcomes. The current paper adds to existing knowledge by examining adaptive behavior profiles in very young children at a pivotal age for early intervention, aged one to three years, who were diagnosed with ASD using *Diagnostic and Statistical Manual – Fifth Edition (DSM-5)* criteria (American Psychiatric Association, 2013).

1.1. Adaptive behavior profiles in ASD

Individuals with ASD of a broad age range may exhibit a unique adaptive behavior profile based on core adaptive areas: relative strengths in motor functioning, followed by daily living skills, communication, and a relative weakness in socialization (i.e., motor > daily living skills > communication > socialization) (Fenton et al., 2003; Mouga, Almeida, Café, Duque, & Oliveira, 2015; Paul, Loomis, & Chawarska, 2014; Perry et al., 2009; Yang, Paynter, & Gilmore, 2015); however, not all studies have shown this profile. A summary of studies published in the last 10 years reviewing adaptive behavior profiles and predictors of adaptive behavior in children with ASD can be seen in Table 1.

In summary, evidence for this profile has been found based on standard scores in under two-year-olds with moderate delays (Paul et al., 2014), and under six-year-olds with profound delays (Perry et al., 2009). Support has also been found based on age-equivalent scores in children aged one to five years (Yang et al., 2015), under six-year-olds with average to moderate delays (Perry et al., 2009), and in one to nine-year-olds with moderate to severe delays (Fenton et al., 2003). In contrast, a profile of daily living skills > socialization > communication has been found using standard scores in nonverbal three to 15-year-olds (Sparrow et al., 2005), in two to three-year-olds with low average cognitive functioning (Ray-Subramanian et al., 2011), and using standard and age equivalent scores in children aged one to four with moderate to severe delays (Fenton et al., 2003).

1.2. Predictors of adaptive functioning

Inconsistencies in adaptive behavior profiles of children with versus without ASD may be attributed to ASD symptom severity, chronological age, intellectual quotient (IQ), language (Paul et al., 2014), and socio-cultural variables (Tassé et al., 2012). For example, young children with ASD have been found to be more impaired on the Receptive Language subdomain and Daily Living Skills domain of the Vineland Adaptive Behavior Scales-Second Edition (Vineland-II; Sparrow et al., 2005) than peers with non-spectrum developmental delay (Paul et al., 2014). Children with ASD aged six to 18 years were differentiated, regardless of cognitive functioning, by more significant adaptive socialization deficits when compared to children with other neurodevelopmental disabilities (Mouga et al., 2015). These findings may not represent the core adaptive profiles of ASD versus non-ASD as they were drawn from children with a wide age range who were likely to have experienced variability in adaptive outcomes because of the educational, intervention-based, and social influences they received up to that point.

These findings regarding adaptive profiles contrast to results from Balboni, Tasso, Muratori, & Cubelli (2016), who found significantly lower adaptive communication scores in six-year-old children with ASD compared to children without ASD, while scores for other domains were comparable. Samples were matched on age, gender, cognitive functioning, language abilities, and parents' educational level. Receiver Operating Characteristic (ROC) and linear regression analyses were conducted with individual Vineland-II items to identify a) which Vineland-II item subsets from each domain would classify children with ASD versus without and b) the proportion of the ASD sample that would be correctly classified. Only items from the Communication and Socialization domains (i.e., Playing and Imitating skills, Following Instructions, Beginning to Talk, and Interactive Speech) significantly differentiated children, correctly categorizing 73% of the sample overall and 75% of children with ASD.

In other studies, adaptive functioning in ASD has been linked more strongly to child cognitive functioning or developmental level, rather than ASD severity (Klin et al., 2007; Mouga et al., 2015; Paul et al., 2014; Ray-Subramanian et al., 2011; Yang et al., 2015). For example, while adaptive communication or socialization was found to be unrelated to ASD symptom severity measured via Autism Diagnostic Observation Schedule-Generic (ADOS-G) (Lord, Rutter, DiLavore, & Risi, 2002) Comparison Scores (Gotham, Pickles, & Lord, 2009) in a sample of two-year-olds, it was related to cognitive functioning (Ray-Subramanian et al., 2011). In another large sample of children with ASD aged four to 17 years, Socialization, Communication, and Daily Living Skills were shown to be positively associated with IQ, and Communication and Socialization were poorer in older children, suggesting that adaptive functioning may show a relative decline with age (Kanne et al., 2011). This study additionally found that the Receptive Language subscale of the Communication domain and the Interpersonal Skills subscale of the Socialization domain were less strongly correlated with IQ than remaining subscales, suggesting that these elements of socio-communication, which are areas of deficit associated with ASD, were less strongly tied to cognitive development than other adaptive areas. Significant negative relationships were found between measures of Socialization and Communication on the Vineland-II and ASD severity based on the ADI-R (Rutter, Le Couteur, & Lord, 2003) and Social Responsiveness Scale (Constantino, 2012), whereas no significant relationships were found between adaptive behavior and measures of ASD severity using ADOS Social Comparison Scores.

1.3. Current gaps in knowledge of adaptive behavior in ASD

Inconsistencies in adaptive behavior profiles may also be attributed to the format in which IQ, ASD severity, and adaptive behavior were measured and reported (i.e., standard scores, ratio IQs, age equivalent scores) (Kanne et al., 2011; Ray-Subramanian et al., 2011). Current knowledge on adaptive behavior profiles in young children with ASD is limited in that most published studies

Table 1
Literature summary of studies examining adaptive behavior profiles in children with ASD.

Authors	VABS edition	Tools for ASD diagnosis	Cognitive assessment	Full Sample Age range	Study groups	ASD Mean IQ(SD) or Mean mental age(SD)	Adaptive Profile found in ASD group	Identified Predictors of Adaptive Behavior
Balboni et al. (2016)	II	DSM-IV-TR, ADOS	Leiter-R	3–6 years	ASD (n = 32) and Non-ASD developmental delay (n = 20)	ASD = 70.1(25.1) NDD = 89.7(24.6)	DLS > Soc > Com	Raw IQ and receptive language scores
Kanne et al. (2011)	II	ADI-R, ADOS, CARS	DAS-II (91% of sample) WASI (4%) WISC-IV (3%) Mullen (2%)*	4–17 years broken into 4–8 and 9–17 age groups	N = 1,089 verbal children with ASD as confirmed by ADI-R 4–8 (n = 581) 9–17 (n = 508)	4–8 years: FSIQ = 89.2(20.7) VIQ = 86.4(21.6) NVIQ = 92.3(20.4) 9–17 years: FSIQ = 87.5(26.5) VIQ = 84.6(31.3) NVIQ = 89.5(24.6)	Com > DLS > Soc	ASD severity, age, IQ
Klin et al. (2007)	I	ADI-R, ADOS	WISC-III WASI-III*	7–18 years	Males with ASD (n = 187) with VIQ > 70 from two sites (n_1 = 84; n_2 = 103)	Site 1: FSIQ = 99.8(20.6) VIQ = 104.7(21.3) NVIQ = 94.5(19.7) Site 2: FSIQ = 99.0(17.1) VIQ = 101.2(18.2) NVIQ = 98.5(18.9)	Com > DLS > Soc	Correlated with age (Soc, Com), IQ (DLS, Com), and weakly correlated with ASD severity
Mouga et al. (2015)	I	DSM-V, ADOS, ADI-R	WISC-III	6–18 years	ASD with ID (n = 43), ASD without ID (n = 72) other neurodevelopmental disorder with ID (n=48), other neurodevelopmental disorder without ID (n=54)	ASD with ID: FSIQ = 60.1(6.7) VIQ = 58.8(8.2) NVIQ = 69.7(12.0) ASD without ID: FSIQ = 92.4(15.2) VIQ = 93.1(15.7) NVIQ = 95.5(18.5)	ASD with ID = Soc > Com > DLS ASD without ID = Com > Soc > DLS	Correlated with age (Com, Soc) and IQ
Perry et al. (2009)	I	DSM-IV-TR, CARS	Bayley-III (54% of sample), Stanford-Binet (19%), Mullen (19%), WPPSI (6%), Cattell (1%), Leiter (1%)*	22-71 months	ASD (n = 290) Non-ASD intellectual disability (n = 28) matched on CA and MA	SS = 50.2(21.8) AE = 25.56(12.69)	SS: Average to borderline IQ= Com > Motor > Soc > DLS > Com Mild to severe ID = Motor > Soc > DLS > Com Profound ID = Soc > Motor > Com > DLS AE Motor > DLS > Com > Soc	Age, IQ, ASD severity
Paul et al. (2014)	II	DSM-IV-TR, ADOS	Mullen	13-27 months	ASD (n = 54) and non-ASD developmental delay (n = 18)	Visual Reception T = 35.4(12.6)	Motor > DLS > Com > Soc	Correlated with ASD severity, nonverbal developmental level
Ray-Subramanian et al. (2011)	II	DSM-IV-TR, ADOS	Bayley-III	23-39 months	ASD (n = 125)	SS = 85.0(12.0) Developmental age = 23.9(5.4)	Motor > DLS > Soc > Com	Age, IQ

(*continued on next page*)

Table 1 (*continued*)

Authors	VABS edition	Tools for ASD diagnosis	Cognitive assessment	Full Sample Age range	Study groups	ASD Mean IQ(SD) or Mean mental age(SD)	Adaptive Profile found in ASD group	Identified Predictors of Adaptive Behavior
Yang et al. (2015)	II	DSM-IV-TR, ADOS	Mullen	29-66 months	ASD (n = 77): Divided into verbal (n = 26) versus nonverbal (n = 51) and high functioning (n = 21) versus low functioning (n = 57)	High functioning: 85.61(16.03) Low functioning: 47.89(21.79)	Verbal sample (SS): Motor > DLS > Soc > Com Nonverbal sample (SS): Motor > Soc > DLS > Com Both (AE): Motor > DLS > Com > Soc	Age, IQ

Key: ADI-R = Autism Diagnostic Interview Schedule – Revised (Rutter, Le Couteur, & Lord, 2003); ADOS = Autism Diagnostic Observation Schedule; ADOS G = ADOS-Generic (Lord et al., 2002); AE = Age equivalents; Com = Vineland-II Communication domain; CARS = Childhood Autism Rating Scale (Schopler, Van Bourgondien, Wellman, & Love, 2010); DAS = Differential Abilities Scale (Elliot, 2007); DLS = Vineland-II Daily Living Skills domain; DQ = Developmental quotient; DSM = Diagnostic and Statistical Manual of Mental Disorders; FSIQ = Full scale IQ; NVIQ = Nonverbal IQ; RRB CSS = ADOS Restricted and Repetitive Behavior Scale Calibrated Severity Score; Soc = Vineland-II Socialization domain; SS = Standard scores; VIQ = Verbal IQ; WASI = Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999); WISC = Wechsler Intelligence Scale for Children (Wechsler, 2005).

* Standardized or ratio IQs were calculated to yield comparable scores across measures.

have used now out-of-date diagnostic criteria and assessment tools, children were assessed using measures that are not sensitive to within-group differences in early ages, and ASD profiles were explored across large age ranges in which children typically experience substantial growth and variability in adaptive skills. Best-practice recommendations from the *Diagnostic and Statistical Manual – Fifth Edition* (*DSM-5*; American Psychiatric Association, 2013) Committee on Intellectual Disability stated that adaptive behavior should be measured using assessments that are individualized, standardized, and culturally-appropriate. While many studies have implemented adaptive behavior assessments meeting these criteria to identify adaptive behavior profiles in children with ASD, few studies (Balboni et al., 2016; Kanne et al., 2011; Paul et al., 2014; Ray-Subramanian et al., 2011; Yang et al., 2015) have used the second edition of the Vineland (Sparrow et al., 2005). To our knowledge, only one study (Mouga et al., 2015) has also examined adaptive behavior profiles in children with ASD diagnosed under updated diagnostic criteria from the *DSM-5* (American Psychiatric Association, 2013) or *International Statistical Classification of Disease and Related Health Problems – 10th Revision* (*ICD-10*, World Health Organization, 2010). Studies have also used a wide range of developmental assessments: the Bayley Scales of Infant Development: Second Edition, (Bayley, 1993); Mullen Scales for Early Learning (Mullen, 1995); Stanford Binet, various editions (Roid, 2005; Thorndike, 1972; Thorndike, Hagen, & Sattler, 1986); and Wechsler Intelligence Scales for Children: Third Edition (Wechsler, 1991), as well as score formats (full scale IQ, verbal or nonverbal IQ, verbal or nonverbal developmental quotients) to represent developmental functioning, which makes it challenging to compare outcomes across studies and draw clear conclusions. Given the wide age ranges examined to date and the importance of age in predicting adaptive functioning, there is a need for research on adaptive behavior profiles in younger children, focusing on narrower age ranges (e.g., Perry et al., 2009; Ray-Subramanian et al., 2011). In addition to identifying clear adaptive profiles in young children with ASD, it is necessary to determine how such profiles differentiate children with ASD from those with other neurodevelopmental disorders or delays.

1.4. The current study

To our knowledge, this is one of the first studies (e.g., Mouga et al., 2015) to explore how adaptive behavior profiles in early childhood are associated with an ASD diagnosis based on *DSM-5* criteria (American Psychiatric Association, 2013). It extends upon previous studies exploring adaptive behavior profiles in children under three years of age (Paul et al., 2014; Ray-Subramanian et al., 2011; Yang et al., 2015) by presenting a clinical sample of children with ASD compared to children with non-ASD neurodevelopmental delays as they presented for their initial diagnostic evaluation. We provide a clinical characterization of our sample using measures considered sensitive to between and within-group differences in early childhood (Akshoomoff, 2006; Esler et al., 2015; Gotham et al., 2009; Hus, Gotham, & Lord, 2012). To further investigate the relationship between adaptive behavior and ASD symptoms, we adopted an individual differences approach by using cluster analysis procedures to determine how variability in adaptive profiles predicted diagnostic status and differentiated early profiles of functioning in ASD that were separated across clusters.

2. Method

2.1. Participants

The current sample contained 158 young children aged 17–46 months who had been assessed through the developmental assessment clinic of a US pediatric hospital specializing in the diagnosis of ASD and other neurodevelopmental disorders. Primary diagnostic groups in this sample were ASD (n = 122) and non-ASD developmental delay (NDD; n = 36). Children with non-spectrum diagnoses included children who received a final diagnosis of language disorder (n = 29) or global developmental delay (n = 7).

The sample was primarily male (87%). Reported ethnicities included Caucasian (72%), African or African American (10%), Hispanic/Latino (4%), Asian (1%), multi-racial (12%), and unspecified (1%). Most frequently endorsed highest level of education was some college for mothers (30%) and college graduate for fathers (30%). Table 2 provides details on demographic variables for the ASD and NDD groups. Due to small cell sizes, non-parametric alternatives were calculated to compare group frequencies and means. Groups differed significantly in child ethnicity, p = 0.03, Fisher's exact test. They did not differ on other demographic variables: age, U = 2259, p = 0.79, r = *0.14*; gender, p = 0.12; maternal education, p = 0.84; and paternal education, p = 0.08.

2.2. Measures

The Vineland Adaptive Behavior Scales, Second Edition (Vineland-II; Sparrow et al., 2005). The Vineland-II provides a measure of adaptive behavior for individuals from birth through adulthood. It includes four domains: Communication, Daily Living Skills, Socialization, and Motor skills. Each domain contains multiple subdomains: a) communication: receptive language and expressive language; b) daily living skills: personal, domestic, and community, c) socialization: interpersonal relationships, play and leisure time; and d) motor skills: fine motor and gross motor. Standard scores are calculated for each domain as well as an overall measure of adaptive behavior, the Adaptive Behavior Composite (ABC), while standardized V-scale scores are calculated for subdomains. The manual reports reliability data for internal consistency (α = 0.70–0.97), test-retest reliability (r = 0.70–0.90), and inter-rater reliability (κ = 0.70–0.80).

Autism Diagnostic Observation Schedule – Second Edition (Lord, Luyster, Gotham, & Guthrie, 2012; Lord, Rutter et al., 2012). The ADOS-2 is a 'gold standard' assessment instrument for ASD. The current sample was administered either the Toddler module (n = 68), Module 1 (n = 81), or Module 2 (n = 7). The ADOS-2 manual indicates fair to excellent internal consistency for the

Table 2
Demographic characteristics of children with ASD versus non-ASD developmental delay.

	ASD (n = 122)	NDD (n = 36)
Gender (Male:Female)	104:18	34:2
Chronological age		
Mean(SD)	32.41(6.40)	32.43(6.77)
Child Ethnicity (%)		
White	72.1	63.9
Black	12.3	2.8
Hispanic Latino	4.1	2.8
Asian, Asian American, or Pacific Islander	0.8	2.8
More than one	7.4	25.0
Not selected	3.3	2.8
Mother's highest education level (%)		
Some high school	4.1	5.6
High school graduate	16.4	27.8
Post-high school training other than college	6.6	5.6
Some college	23.0	22.2
College graduate	18.0	13.9
Post-graduate degree	6.6	5.6
Missing	25.4	19.4
Father's highest education level (%)		
Grade school graduate	2.5	0.0
Some high school	6.6	13.9
High school graduate	17.2	19.4
Post-high school training other than college	1.6	2.8
Some college	11.5	19.4
College graduate	23.0	5.6
Post-graduate degree	4.1	8.3
Missing	33.6	30.6

Toddler module (α = 0.60– 0.95) and modules 1 and 2 (α = 0.74– 0.90). Inter-rater reliability is good to excellent across modules (κ = 0.89 0.96). Test-retest reliability is fair to excellent for Module 1 (r = 0.68– 0.92), fair for Module 2 (r = 0.73– 0.84), and fair to good for the Toddler module domain scores (r = 0.64-0.88) (Lord, Luyster et al., 2012; Lord, Rutter et al., 2012). Comparison Scores (CS; Esler et al., 2015; Gotham et al., 2009; Hus et al., 2012), which allow for the assessment of severity of ASD symptoms and can be compared across modules, were used for the current analyses.

Mullen Scales of Early Learning (Mullen, 1995) comprise standardized, activity-based developmental assessments designed for children from birth to 68 months. Mullen scales provide standardized and age-equivalent scores on four subscales: Visual Reception, Fine Motor, Receptive and Expressive Language, and an overall Early Learning Composite score. Validation studies of the Mullen showed satisfactory internal consistency (α = 0.75–0.83), test–retest reliability (r = 0.71–0.96), and inter-rater reliability (κ = 0.91–0.99). As recommended in the literature and performed by previous similar studies (Lord et al., 2006; Messinger et al., 2013), developmental quotients (DQs) were calculated for the current sample. DQs use chronological age and age equivalent scores while avoiding the limitations present to the latter two score formats: age equivalent scores do not have equivalent meanings across ages and are not normally distributed (Sattler, 2008), and standard scores are often less helpful for young children with developmental delays due to floor effects. DQs are therefore beneficial as they avoid floor and ceiling effects and increase comparability across ages. DQs are calculated by dividing each subscale age equivalent score by the child's chronological age and multiplying by 100. A composite verbal DQ was calculated by averaging receptive and expressive language DQ scores, and a nonverbal DQ was calculated by averaging the Fine Motor and Visual Reception DQ scores.

2.3. Procedure

All procedures associated with this study were approved by the institutional review board of the hospital at which data collection occurred. Hospital records were reviewed for children aged one to three years who had been evaluated for ASD or a related neurodevelopmental disorder at the developmental assessment center between 2014 and 2015. Children with ASD were assessed by multidisciplinary assessment teams comprising a developmental pediatrician or pediatric neurologist, clinical psychologist or supervised clinical intern, and a speech and language pathologist, and were consistent with Autism Treatment Network (ATN) national guidelines, of which the center was a member site. Multidisciplinary assessments included the completion of a diagnostic interview using *DSM-5* criteria and administration of the appropriate ADOS-2 module, Mullen scales, and the Vineland-II.

2.4. Data analysis plan

All analyses were completed in IBM SPSS version 24.0 (IBM Corporation, 2016). Tests of normality found that variance in

nonverbal DQ scores, the Vineland-II Communication domain, and ADOS-2 calibrated severity scores were non-normally distributed, which was unsurprising given that the majority of the sample had ASD. Additionally, kurtosis (Cramer and Howitt, 2004; Cramer, 1998; Doane and Seward, 2011) was found in the Vineland-II Daily Living Skills domain and both kurtosis and equality of variances was found in the ADOS-2 Restricted and Repetitive Behavior CS (Nordstokke & Zumbo, 2010; Nordstokke, Zumbo, Cairnes, & Saklofske, 2011); consequently, non-parametric statistics with bias-corrected and accelerated bootstrapped estimates (BCa) were calculated when appropriate (Efron & Tibshirani, 1993; Tabachnick & Fidell, 2007). Diagnostic groups were compared on demographic variables. To explore associations between Vineland-II subscales, DQ scores, and ADOS-2 CS, Spearman's correlations between subscale scores and partial correlations between subscale scores while controlling for age, nonverbal functioning, and language were calculated. Diagnostic groups were compared using *t*-tests, or Mann-Whitney *U* tests on outcomes for which assumptions of normality were violated, to determine group differences on measures. Group effects (*d*) were interpreted using Cohen's (1988) recommendations (i.e., small < 0.3, medium 0.3–0.49, and large > .5), as this is an appropriate estimate of effect size to use for unequal sample sizes (Hedges & Olkin, 1985).

2.4.1. Cluster analysis

An exploratory hierarchical clustering procedure based on squared Euclidean distance and Ward's method was applied to the full sample. This is considered an appropriate clustering procedure for larger samples (Aldenderfer & Blashfield, 1984 Hair & Black,2000) when using behavioral data (Milligan & Cooper, 1987), and has previously been applied to ASD samples (Brennan, Barton, Chen, Green, & Fein, 2014; Ji, Capone, & Kaufmann, 2011; Lecavalier, 2006). Scores from the four Vineland-II domains were entered as predictors and transformed into normalized *z*-scores to account for non-normality of data. Next, a *k*-means cluster analysis was run, applying the number of clusters as identified through the hierarchical procedure as the targeted cluster output. *K*-means clustering is a confirmatory approach that allows for clustering samples over 100 that was measured using continuous variables (Kaufman & Rousseeuw, 1990; Hair & Black,2000). The external validity of final clusters was established by testing for between-group differences on Vineland-II domain scores and on ADOS-2 CS, which were considered important differentiating factors between diagnoses. Additionally, within and between-cluster differences on chronological age, verbal functioning, and nonverbal functioning were examined.

3. Results

3.1. Correlations between outcome measures

Spearman's correlations using bias-corrected and accelerated estimates of confidence intervals were calculated between: chronological age; Mullen nonverbal DQ as an indicator of cognitive functioning; Mullen verbal DQ as an indicator of language; Vineland-II domain scores: Communication, Daily Living Skills, Socialization, and Motor; the Vineland-II ABC as an indicator of overall adaptive functioning; and the ADOS-2 CS as measures of ASD symptom severity: Social Affect, Restricted and Repetitive Behavior, and Total (see Table 3). The internal consistency of Vineland-II scores in the current sample was strong, $\alpha = 0.89$, and consistent with that found for the validation sample (Sparrow et al., 2005). There were no significant relationships between Vineland-II domain scores and the ADOS-2 CS. All Vineland-II domain scores except the Socialization score were moderately to largely negatively correlated with chronological age ($r = -0.63$ to -0.30, $p < 0.01$). Chronological age had small negative associations with both the Vineland-II Socialization domain ($r = -0.28$, $p < 0.01$) and the ADOS-2 Social Affect CS ($r = -0.26$, $p < 0.01$), indicating that as children with ASD age, social skill deficits become more prevalent. All Vineland-II domain scores were moderately to

Table 3
Spearman's (upper panel) BCa correlations between Vineland-II domain scores, Mullen verbal and nonverbal developmental quotient scores, and ADOS-2 comparison scores for the ASD sample; partial (lower panel) correlations controlling for chronological age, nonverbal DQ, and verbal DQ.

	Communication SS	Daily Living Skills SS	Socialization SS	Motor SS	Adaptive Behavior Composite	ADOS-2 Social Affect CS	ADOS-2 RRB CS	ADOS-2 Total CS
Chronological age	**−0.63****	**−0.35****	**−0.36****	**−0.41****	**−0.42****	**−0.23***	0.13	−0.18
Nonverbal DQ	**0.42****	**0.52****	**0.44****	**0.40****	**0.54****	−0.03	**−0.26****	−0.07
Verbal DQ	**0.40****	**0.48****	**0.44****	0.15	**0.49****	**−0.28****	−0.16	**−0.24***
Communication SS		**0.68****	**0.70****	**0.52****	**0.80****	0.04	−0.17	0.03
Daily Living Skills SS	0.52		**0.65****	**0.61****	**0.89****	−0.05	−0.13	−0.03
Socialization SS	0.51	0.50		**0.54****	**0.85****	−0.002	**−0.25****	−0.07
Motor SS	0.40	0.54	0.49		**0.75*****	0.12	−0.07	0.12
ABC	0.69	0.81	0.79	0.79		0.02	−0.16	0.01
ADOS-2 SA CS	−0.08	−0.03	−0.07	0.06	0.02		**0.24***	**0.85****
ADOS-2 RRB CS	0.002	−0.04	−0.19	−0.07	−0.11	0.23		**0.61****
ADOS-2 Total CS	−0.02	−0.003	−0.12	0.06	0.02	0.87	0.57	

CS = comparison score; RRB = Restricted and Repetitive Behavior; SS = standard score; DQ = developmental quotient.
* $p < 0.05$ (two-tailed).
** $p < 0.001$ (two-tailed).
*** $p < 0.001$ (two-tailed).

Table 4
Group descriptors of performance on key outcome variables and comparisons for subsamples of the ASD and non-ASD developmental delay groups.

	ASD				NDD				Group Comparisons	
	N	Range	Mean	*SD*	*N*	Range	Mean	*SD*	*d*	95% CI
Chronological age	122	19.50–46.60	32.41	6.40	36	17.70–46.70	32.43	6.77	0.003	−0.37–.38
Mullen Nonverbal DQ	112	18.16–126.71	62.61	17.64	27	42.24–113.01	82.52	17.12	1.14	.69–1.58
Mullen Verbal DQ	111	5.88–126.71	35.12	20.60	27	30.12–94.08	62.61	18.21	1.36	.91–1.81
VABS-II Communication SS	122	23–116	58.39	17.06	36	36–110	68.00	17.17	0.56	.19–.94
VABS-II Daily Living Skills SS	122	43–120	77.07	12.62	36	31–127	83.56	16.18	0.48	.11–.86
VABS-II Socialization SS	122	44–95	72.85	9.78	36	63–106	81.08	10.79	0.82	.44–1.20
VABS-II Motor SS	122	54–124	83.38	12.43	36	64–121	84.81	12.48	0.12	−0.26 to −.49
VABS-II ABC	122	50–102	71.70	10.20	36	60–111	78.64	10.96	0.67	.29–1.05
ADOS-2 Social Affect CS	121	2–10	8.17	1.81	35	1–8	4.31	1.92	−2.10	-2.55 to −1.66
ADOS-2 RRB CS	121	1–10	7.67	1.60	35	1–8	4.31	2.42	−1.85	-2.82 to −1.42
ADOS-2 Total CS	121	3–10	8.16	1.75	35	1–8	4.03	2.23	−2.21	-2.66 to −1.76

ABC = Adaptive Behavior Composite; CS = Comparison Score; DQ = Developmental Quotient; RRB = Restricted and Repetitive Behavior; SS = standard score; VABS-II = Vineland-II.

largely correlated with nonverbal DQ (r = 0.40–0.52, $p < 0.01$). Vineland-II domain scores were moderately correlated with Verbal DQ (r = 0.40–0.48, $p < 0.01$) except the Motor domain, with which there were trivial non-significant relationships.

Next, partial correlations were calculated controlling for chronological age, cognitive functioning as measured by nonverbal DQ, and language as measured by verbal DQ. The Vineland-II domain scores continued to be moderately to largely positively intercorrelated (r = 0.41–0.81, p's < 0.01). Vineland-II scores were not found to be significantly associated with ADOS-2 Total or domain CS.

3.2. Adaptive behavior profiles and developmental functioning

Mann-Whitney *U* tests were performed to compare groups on assessment scores due to evidence of non-normality (see Table 4). Analyses found a medium effect on Vineland-II Communication (Cohen's *d*) (Cohen, 1988), Socialization, and Aberrant Behavior Checklist, a moderate effect of group on Daily Living Skills, and a small effect on Motor skills scores. There was a very large effect of group on verbal DQ and ADOS-2 CS, and a large effect on nonverbal DQ. Average ADOS-2 CS for the ASD group fell in the moderate-to-severe range of concern for Social Affect, Restricted and Repetitive Behavior, and Total CS, and in the mild-to-moderate range for the non-spectrum group on Total and domain CS scores.

The ASD sample displayed an adaptive behavior profile of relative strengths in Motor Skills (M = 84.65, SD = 11.46) followed by Daily Living Skills (M = 81.88, SD = 13.34), a relative weakness in Socialization (M = 75.46, SD = 12.58), and the greatest weakness in Communication (M = 64.00, SD = 14.58). The same profile was found in the non-ASD developmental delay group. The two diagnostic groups did not perform significantly differently on Vineland-II domain scores. Both groups demonstrated stronger nonverbal than verbal skills based on DQs. The ASD group demonstrated mild delays in nonverbal functioning (M = 62.61, SD = 17.64) and severe delays in verbal functioning (M = 35.12, SD = 20.60). The non-spectrum group fell within one standard deviation from the mean on nonverbal DQ (M = 86.94, SD = 18.94) and in the mildly delayed range on the verbal DQ (M = 68.02, SD = 21.18).

3.3. Cluster analysis

Before initiating cluster analyses, hierarchical regression analyses were performed to produce normalized z-score residuals for each Vineland-II domain score for the subsample that had Mullen scores available (ASD, n = 111; NDD, n = 27). Those children for whom Mullen scores were unavailable did not perform significantly differently on the Vineland-II or ADOS-2. Analyses confirmed that age, nonverbal and verbal DQ accounted for significant variance in Communication and Daily Living Skills scores, and that age and nonverbal DQ, but not verbal DQ, accounted for significant variance in Socialization and motor skills (see Table 5).

3.4. Cluster analyses

Normalized *z*-score residuals of Vineland-II domains were then entered as predictors into a hierarchical cluster analysis, specifying a minimum of two and a maximum of six group solutions. Analyses returned a two-group solution. Cluster 1 contained 95 children, which included 62% (n = 76) of the ASD sample and 53% (n = 19) of the non-spectrum sample. Cluster 2 contained 43 children, including 29% (n = 35) of the ASD sample and 22% (n = 8) of the non-spectrum sample. Fig. 1 displays the dendrogram resulting from the hierarchical analysis, which shows the resulting grouping of two clusters.

Next, a *k*-means cluster approach using a two-group solution was applied to group subjects based on adaptive behavior domain scores. A solution was found after three iterations. Resulting clusters included 90 children in Cluster 1 and 48 children in Cluster 2. Cluster 1 contained 66% of ASD group and 63% of NDD group. Cluster 2 contained 34% of ASD group and 37% of non-spectrum

Table 5
Predictive values of chronological age, nonverbal DQ, and verbal DQ in predicting Vineland-II domain scores from hierarchical regression analyses used to calculate normalized z-score residuals for cluster analyses.

Dependent Variable	Step 1		Step 2			Step 3		
	Chronological Age		Nonverbal DQ			Verbal DQ		
	R^2	$\Delta F(1136)$	R^2	ΔR^2	$\Delta F(1135)$	R^2	ΔR^2	$\Delta F(1134)$
Communication	0.44	105.37***	0.56	0.12	38.31***	0.61	0.05	17.86***
Daily Living Skills	0.06	8.46**	0.35	0.29	61.16***	0.37	0.02	4.84*
Socialization	0.05	7.66**	0.26	0.21	38.86***	0.28	0.01	1.94
Motor	0.14	22.48***	0.24	0.10	18.37***	0.26	0.02	3.06

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

group. Centroids (averages) of domain scores across clusters are shown in Fig. 2. Average Vineland-II scores for Cluster 2 fell in the average to borderline delayed range and were consistently higher than scores for Cluster 1, which fell in the borderline to mildly delayed range for Daily Living (Cluster 1 $M = 73.03$, $SD = 9.96$; Cluster 2 $M = 88.94$, $SD = 12.35$), Socialization (Cluster 1 $M = 70.73$, $SD = 7.90$; Cluster 2 $M = 81.27$, $SD = 10.20$), and Motor Skills (Cluster 1 $M = 79.11$, $SD = 10.48$; Cluster 2 $M = 92.71$, $SD = 11.40$). Both samples demonstrated delays on the Communication domain (Cluster 1 $M = 55.68$, $SD = 16.49$; Cluster 2 $M = 68.23$, $SD = 18.19$).

Next, *t*-tests were calculated to compare clusters on Vineland-II scores to confirm significant differences in performance across groups, as well as on measures considered important predictors of group differences: verbal and nonverbal DQ scores and ASD calibrated severity scores (see Table 6). *T*-tests were also calculated to compare diagnostic subsamples within clusters to identify within-group differences. As anticipated, there were no significant differences between clusters in chronological age, nonverbal DQ, and verbal DQ. There were also no significant differences in diagnostic subsamples between clusters in ADOS-2 Total and domain CS. Diagnostic groups in Cluster 1 performed significantly lower than diagnostic groups in Cluster 2 on Vineland-II domain scores, except the non-ASD developmental delay group on the Communication domain.

Within clusters, the ASD subsample scored significantly lower than the NDD group for both verbal and nonverbal DQ; Daily Living Skills, Socialization, and Adaptive Behavior Composites; and had significantly higher ADOS-2 CS. While the ASD subsample in Cluster 1 did perform significantly lower than the NDD subsample in Cluster 1, there were no significant differences between diagnostic subsamples in Cluster 2. Adaptive behavior profiles in diagnostic subsamples within both clusters continued to demonstrate a profile of strongest skills in Motor, followed by Daily Living Skills, Socialization, and weakest skills in Communication.

4. Discussion

The current paper explored adaptive behavior profiles in young children with ASD in comparison to non-ASD developmental delay. Children were diagnosed against updated *DSM-5* criteria and assessed using measures sensitive to differences in young children aged one to three years, specifically developmental quotient (DQ) scores and ADOS-2 comparison scores (CS). Relationships between adaptive behavior measures and early diagnosis were explored, as well as associations between diagnosis, adaptive functioning, verbal and nonverbal cognitive functioning, chronological age, and ASD symptom severity, which are shown to be among the predictors of outcomes in early childhood. An individual differences approach was used through clustering analysis to determine the extent to which adaptive behavior profiles differentiated children with ASD from children with non-ASD neurodevelopmental disorders. Clusters were compared on key outcome measures to determine how developmental profiles may inform diagnostic status in early childhood.

We confirmed a relative strength of motor skills followed by daily living skills, socialization skills, and communication as the weakest area (i.e., motor skills > daily living skills > socialization > communication). This adaptive behavior profile in children with ASD was also found in previous studies (Balboni et al., 2016; Fenton et al., 2003Ray-Subramanian, Huai, & Weismer, 2011; Sparrow, Cicchetti, & Balla, 2005; Yang et al., 2015), while a conflicting profile was found by others (Kanne et al., 2011; Klin et al., 2007; Mouga et al., 2015; Paulet al., 2014; Perry et al., 2009). The age and relative language ability of the samples likely accounts for these discrepancies: studies which found the same adaptive profile also sampled children between the ages of two and six years, whereas studies with conflicting profiles mostly sampled older children, with the exception of Paul et al. (2014). Both the ASD and non-ASD developmental delay groups presented with low language levels, which is significant in that in early childhood, an evaluation for ASD typically is first considered in the first year of life after observing initial delays in receptive and expressive language (Zwaigenbaum et al., 2005). The current profile may therefore be better thought of as an adaptive behavior profile characteristic of children with ASD with language impairment with or without cognitive impairment. Comparing the ASD sample with the non-ASD developmental delay sample, diagnostic group membership had a large effect on ASD symptom severity, based on the ADOS-2 CS (and as would be expected given the contribution of ADOS-2 scores to the end diagnosis), DQ scores, and on adaptive socialization and communication skills.

In examining relationships between adaptive functioning and age, ASD symptom severity, cognitive, and language functioning,

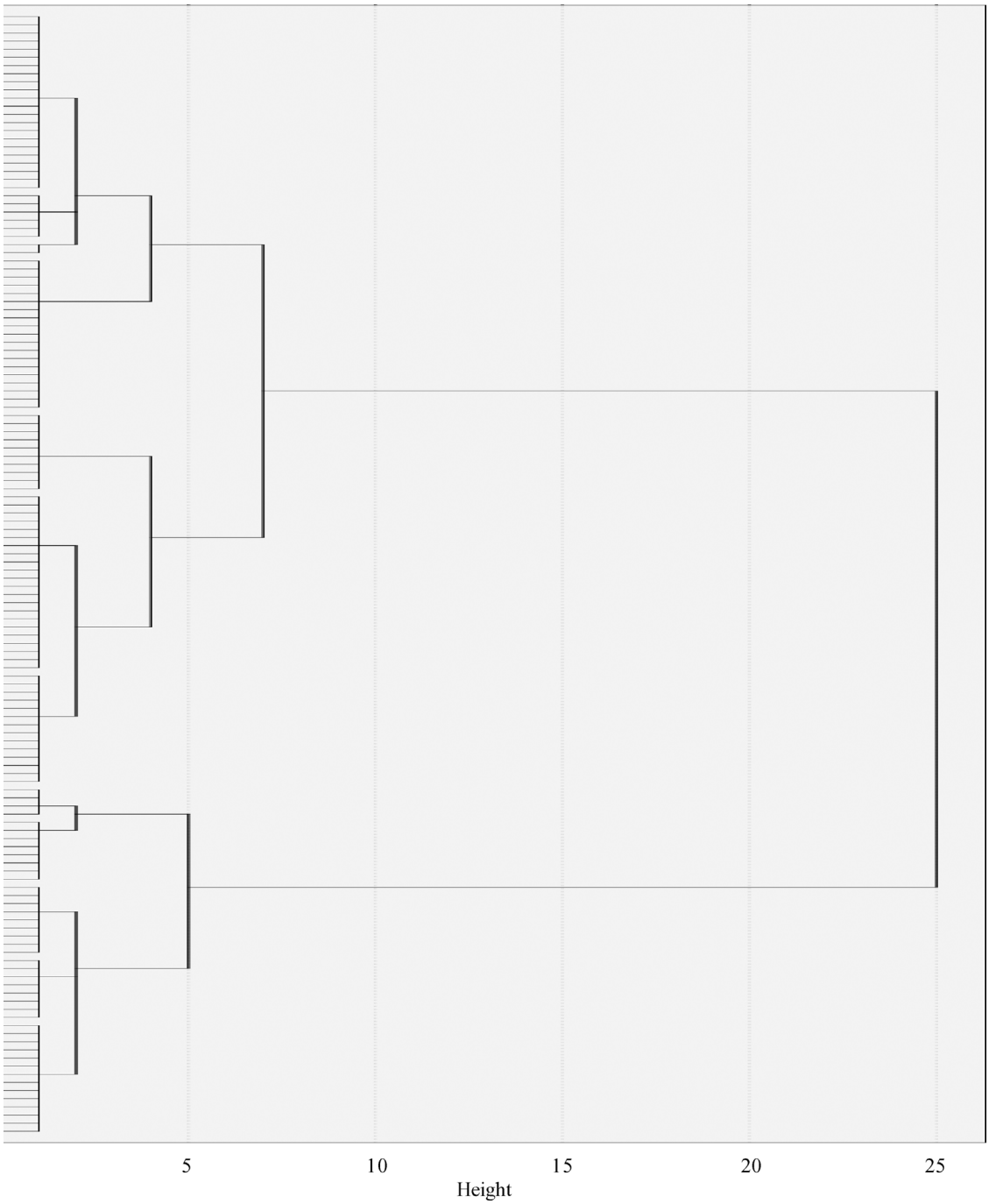

Fig. 1. A graphical display of the dendogram resulting from a hiearchical cluster analysis showing a 2 cluster solution.

we found that overall and specific adaptive areas were moderately to strongly associated with both verbal and nonverbal cognitive functioning, and unrelated to ASD symptom severity. Being younger was slightly associated with higher social deficits and lower adaptive socialization scores, moderately to largely associated with lower adaptive daily living, communication, and motor skills, and moderately associated with reduced nonverbal cognitive functioning.

The cluster analysis controlling for chronological age, cognitive functioning, and language functioning identified a two-group solution consisting of a lower functioning and a higher functioning group. Cluster 1, comprising almost two thirds of the sample, was characterized by borderline to mild delays in adaptive behavior, and Cluster 2 was characterized by average to borderline delayed adaptive functioning. Both clusters had delayed adaptive communication and verbal DQ scores. The lack of differences between clusters in ASD severity further supports the idea that adaptive behavior is relatively independent from ASD symptomatology (Kanne

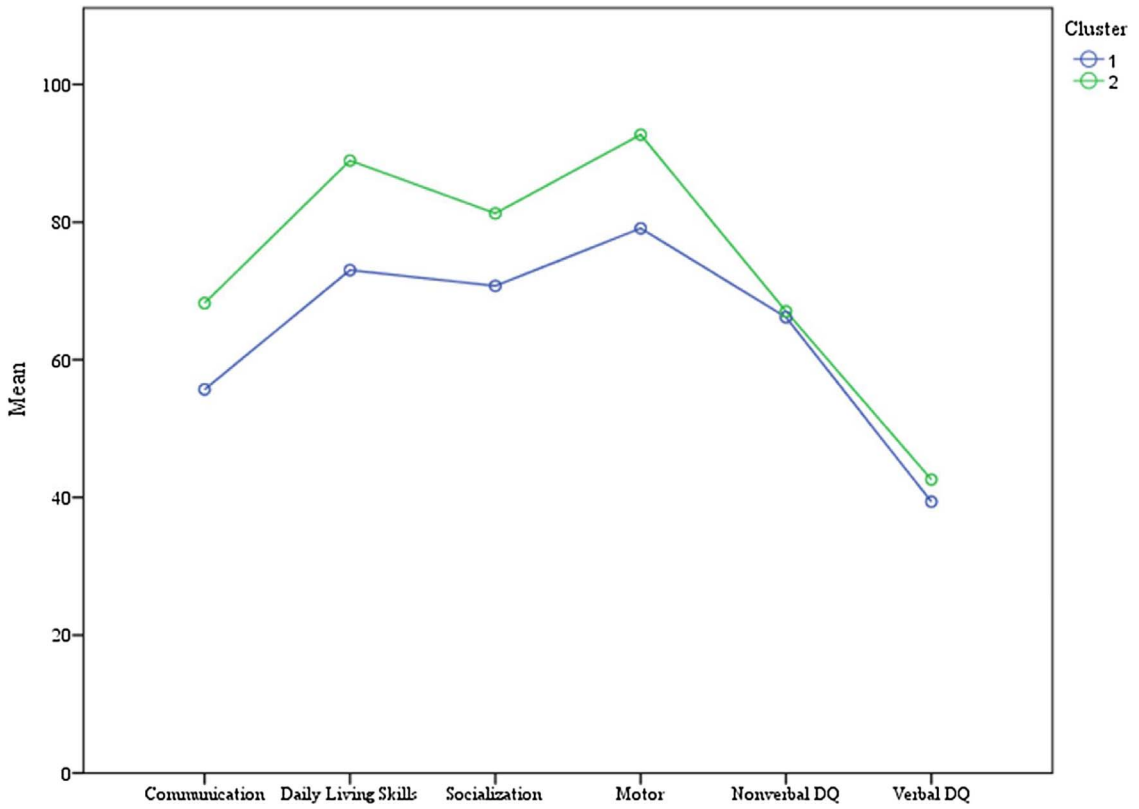

Fig. 2. Final cluster centers.

Table 6
Descriptors of performance outcome variables for groups resulting from a two-cluster solution.

		Cluster 1			Within-cluster diagnostic comparisons			Cluster 2			Within-cluster diagnostic comparisons			Between cluster comparisons		
		N	*M*	*SD*	*t*	*df*	*p*	*N*	*M*	*SD*	*t*	*df*	*p*	*t*	*df*	*p*
Chronological age	ASD	73	32.40	7.20	0.62	34	0.54	38	32.51	5.23	−1.18	46	0.25	−0.09	97	0.93
	NDD	17	31.49	4.94				10	34.89	7.31				−1.44	25	0.16
Communication SS	ASD	73	53.22	15.42	−3.07	88	***	38	67.89	17.86	−0.25	46	0.81	−4.50	109	***
	NDD	17	66.24	17.22				10	69.50	20.35				−0.44	25	0.66
Daily Living Skills SS	ASD	73	71.99	9.86	−2.11	88	*	38	86.11	11.02	−3.44	46	***	−6.88	109	***
	NDD	17	77.53	9.38				10	99.70	11.61				−5.43	25	***
Socialization SS	ASD	73	69.77	7.84	−2.47	88	*	38	79.26	9.28	−2.85	46	**	−5.68	109	***
	NDD	17	74.88	6.95				10	88.90	10.38				−4.21	25	***
Motor SS	ASD	73	78.67	10.56	−0.82	88	0.41	38	92.03	10.88	−0.80	46	0.42	−6.26	109	***
	NDD	17	81.00	10.19				10	95.30	13.52				−3.12	25	***
ABC SS	ASD	73	67.12	7.13	−3.17	88	***	38	79.79	9.58	−2.56	46	**	−7.87	109	***
	NDD	17	73.12	6.52				10	88.90	11.63				−4.55	25	***
ADOS-2 Social Affect CS	ASD	72	8.14	1.78	7.20	87	***	38	8.24	1.95	5.22	46	***	−0.27	108	0.79
	NDD	17	4.59	2.03				10	4.70	1.70				−0.15	25	0.89
ADOS-2 RRB CS	ASD	72	7.58	1.51	5.13	19	***	38	7.63	1.91	3.44	46	***	−0.15	108	0.88
	NDD	17	4.24	2.59				10	5.30	1.89				−1.23	24	0.23
ADOS-2 Total CS	ASD	72	8.04	1.81	6.89	87	***	38	8.29	1.72	6.08	46	***	−0.69	108	0.49
	NDD	17	4.47	2.35				10	4.60	1.65				−0.15	25	0.88
Nonverbal DQ	ASD	73	62.95	16.72	−3.86	88	***	38	61.85	19.71	−3.53	46	***	0.31	109	0.76
	NDD	17	80.05	15.08				10	86.71	20.29				−0.98	25	0.34
Verbal DQ	ASD	73	33.77	17.65	−6.11	88	***	38	37.70	25.40	−2.76	46	**	−0.95	109	0.34
	NDD	17	63.43	19.57				10	61.21	16.52				0.30	25	0.77

et al., 2011; Klin et al., 2007; Saulnier & Klin, 2007). This finding is also consistent with the intended function of the ADOS-2 with which we assessed ASD severity, as the instrument was designed to evaluate for symptoms of ASD regardless of the child's developmental level.

Looking at subsamples of diagnostic groups placed in each cluster, the Cluster 1 ASD subgroup had significantly higher severity of ASD symptoms, lower adaptive socialization, daily living, communication, and overall adaptive behavior scores, and lower nonverbal and verbal DQ scores than the Cluster 1 non-spectrum subgroup. The Cluster 2 ASD subgroup had significantly lower daily living skills, socialization, higher ASD symptom severity, and lower nonverbal and verbal DQ scores than the Cluster 2 NDD subgroup. This further supports our interpretation that Cluster 1 was primarily characterized by children with a poorer overall developmental trajectory than Cluster 2.

4.1. Implications

Findings suggest that the severity of adaptive functioning in children with ASD falls along a continuum. Profiles of early adaptive functioning may contribute to improved prediction of long-term outcomes for children with ASD. Our finding of a dichotomized severity level in the adaptive behavior profile, with one borderline to mildly delayed adaptive functioning group and one average to borderline adaptive functioning group is consistent with recent longitudinal data identifying two trajectories of development in daily living skills (Bal, Kim, Cheong, & Lord, 2015), with greater improvement in functioning associated with higher baseline daily living skills at age 2 years, while lower baseline daily living skills predicted only a three to four-year improvement over the same period. These results are also partially consistent with those of Szatmari et al., 2015, who identified a three-group solution in a large sample of two to four-year olds diagnosed with ASD under *DSM-IV* criteria: one mildly delayed group with a worsening trajectory, one borderline delayed group with a stable trajectory, and one borderline delayed group with an improving trajectory. It is possible that had the current sample been tracked longitudinally, Cluster 2 may have diverged into two groups based on improvement versus stability in adaptive functioning over time, to match the findings of Szatmari et al., 2015. Alternatively, differences in groupings may be due to the current sample being younger overall (calculations of group effect on average age yielded a moderate effect size, Cohen's $d = 0.76$), and presenting with less variability in adaptive scores. This would also explain why our findings of a two-group solution are in agreement with those of Bal et al. (2015), who also used a younger sample.

The current profiles identified may be useful for further characterizing children to whom it is imperative to provide early intervention due to their risk of stable or worsening trajectories over time. Making early improvements in adaptive behavior can be pivotal for improved long-term trajectories of development, particularly given the pervasiveness of the socio-communication deficits associated with ASD that are more challenging for caregivers to treat. Therefore, building adaptive skills may be dually beneficial for children with ASD and their families by increasing the child's independence and empowering caregivers as therapists.

4.2. Strengths and limitations

Our study examined adaptive behavior profiles for young children with ASD who had been assessed and diagnosed using current *DSM-5* criteria compared to a group of children with non-ASD developmental delay. Strengths of this study included the use of measures sensitive to differences in early childhood development and diagnostic criteria in a narrow age band, and a comparison group of children with non-spectrum diagnoses who, nevertheless, had all presented for assessment due to developmental concerns. The present sample was limited by unequal sample sizes across diagnostic groups and a lack of typically developing comparison group. Given that the non-ASD developmental delay group went on to receive another diagnosis that had symptom overlap with ASD, and because it cannot be ruled out that some children initially diagnosed with a non-ASD developmental delay may have received an ASD diagnosis later on, group differences found in the current study may not have been as clear cut as they would have been if a typically developing comparison group had been used. It would be useful for future studies to include a typically developing comparison group to further differentiate the developmental trajectories associated with ASD in very early childhood.

4.3. Conclusion

The current findings suggest an adaptive profile of strengths in motor skills followed by daily living skills, socialization, and weakest skills in communication irrespective of developmental level. Clustering children based on adaptive behavior resulted in the division of the sample into a high versus low functioning group, and may be indicative of early developmental profiles that are associated with poorer versus improved outcomes across the lifespan. This makes adaptive profiles necessary to consider during early treatment planning. Our findings support a dimensional understanding of developmental functioning in ASD, which is consistent with recent conceptualizations of ASD as a continuum of symptoms.

Conflict of interest

The authors do not have any conflicts of interest to declare.

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References

Akshoomoff, N. (2006). Use of the Mullen Scales of Early Learning for the assessment of young children with autism spectrum disorders. *Child Neuropsychology, 12*(4–5), 269–277.
Aldenderfer, M. S., & Blashfield, R. K. (1984). *Cluster analysis.* Beverly Hills, CA: Sage Press.
American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychological Association.
Bal, V. H., Kim, S.-H., Cheong, D., & Lord, C. (2015). Daily living skills in individuals with autism spectrum disorder from 2 to 21 years of age. *Autism, 19*(7), 774–784.
Balboni, G., Tasso, A., Muratori, F., & Cubelli, R. (2016). The Vineland-II in preschool children with autism spectrum disorders: An item content category analysis. *Journal of Autism and Developmental Disorders, 46*(1), 42–52.
Bayley, N. (1993). *Bayley scales of infant development* (2nd ed.). San Antonio: American Psychological Association.
Brennan, L., Barton, M., Chen, C.-M., Green, J., & Fein, D. (2014). Detecting subgroups in children diagnosed with pervasive developmental disorder – not otherwise specified. *Journal of Autism and Developmental Disorders, 45*(5), 1329–1344.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale: Lawrence Erlbaum.
Constantino, J. N. (2012). *The social responsiveness scale – second edition.* Torrance, CA: Western Psychological Society.
Cramer, D., & Howitt, D. (2004). *The SAGE dictionary of statistics.* London: SAGE.
Cramer, D. (1998). *Fundamental statistics for social researcher.* London: Routledge.
Doane, D. P., & Seward, L. E. (2011). Measuring skewness. *Journal of Statistical Education, 19*(2), 1–18.
Elliot, C. (2007). *2nd ed.)Differential Abilities Scale— (DAS-II) manual* (2nd edition). San Antonio, TX: Harcourt Assessment, Inc.
Esler, A. N., Bal, V. H., Guthrie, W., Wetherby, A., Weismer, S. E., & Lord, C. (2015). The autism diagnostic observation schedule, toddler module: Standardized severity scores. *Journal of Autism and Developmental Disorders, 45*(9), 2704–2720.
Fenton, G., D'ardia, C., Valente, D., Vecchio, I. D., Fabrizi, A., & Bernabei, P. (2003). Vineland adaptive behavior profiles in children with autism and moderate to severe developmental delay. *Autism, 7*(3), 269–287.
Gillham, J. E., Carter, A. S., Volkmar, F. R., & Sparrow, S. S. (2000). Toward a developmental operational definition of autism. *Journal of Autism and Developmental Disorders, 30*(4), 269–278.
Gotham, K., Pickles, A., & Lord, C. (2009). Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39*(5), 693–705.
Green, S. A., & Carter, A. S. (2014). Predictors and course of daily living skills development in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44*(2), 256–263.
Hair, J. F., & Black, W. C. (2000). *Cluster analysis. Reading and understanding more multivariate statistics*. Washington, DC: American Psychological Association147–205.
Hus, V., Gotham, K., & Lord, C. (2012). Standardizing ADOS domain scores: Separating severity of social affect and restricted and repetitive behaviors. *Journal of Autism and Developmental Disorders, 44*(10), 2400–2412.
Corporation, I. B. M. (2016). *IBM SPSS statistics for windows, version 24.0.* Armonk, NY: IBM Corporation.
Ji, N. Y., Capone, G. T., & Kaufmann, W. E. (2011). Autism spectrum disorder in Down syndrome: Cluster analysis of Aberrant Behavior Checklist data supports diagnosis. *Journal of Intellectual Disability Research, 55*(11), 1064–1077.
Kanne, S. M., Gerber, A. J., Quirmbach, L. M., Sparrow, S. S., Cicchetti, D. V., & Saulnier, C. A. (2011). The role of adaptive behavior in autism spectrum disorders: Implications for functional outcome. *Journal of Autism and Developmental Disorders, 41*(8), 1007–1018.
Kaufman, L., & Rousseeuw, P. (1990). *Finding groups in data: An introduction to cluster analysis.* New York: Wiley.
Klin, A., Saulnier, C. A., Sparrow, S. 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*(4), 748–759.
Lecavalier, L. (2006). Behavioral and emotional problems in young people with pervasive developmental disorders: Relative prevalence, effects of subject characteristics, and empirical classification. *Journal of Autism and Developmental Disorders, 36*(8), 1101–1114.
Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (2002). *Autism diagnostic observation schedule manual.* Los Angeles: Western Psychological Services.
Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., & Pickles, A. (2006). Autism from 2 to 9 years of age. *Archives of General Psychiatry, 63*(6), 694–701.
Lord, C., Luyster, R. J., Gotham, K., & Guthrie, W. (2012). *Autism diagnostic observation schedule, second edition (ADOS-2) manual (Part II): Toddler module.* Torrance, CA: Western Psychological Services.
Lord, C., Rutter, M., Dilavore, P., Risi, S., Gotham, K., & Bishop, S. L. (2012). *Autism diagnostic observation schedule: Second edition.* Torrance, CA: Western Psychological Services.
Messinger, D., Young, G. S., Ozonoff, S., Dobkins, K., Carter, A., Zwaigenbaum, L., ... Sigman, M. (2013). Beyond autism: A baby siblings research consortium study of high-risk children at three years of age. *Journal of the American Academy of Child & Adolescent Psychiatry, 52*(3), 300–308.
Milligan, G. W., & Cooper, M. C. (1987). A study of standardization of variables in cluster analysis. *Journal of Classification, 5*(2), 181–204.
Mouga, S., Almeida, J., Café, C., Duque, F., & Oliveira, G. (2015). Adaptive profiles in autism and other neurodevelopmental disorders. *Journal of Autism and Developmental Disorders, 45*(4), 1001–1012.
Mullen, E. (1995). *Mullen scales of early learning: AGS edition.* Circle Pines, MN: American Guidance Service.
Nordstokke, D. W., & Zumbo, B. D. (2010). A new nonparametric Levene test for equal variances. *Psicologica, 31*(2), 401–430.
Nordstokke, D. W., Zumbo, B. D., Cairnes, S. L., & Saklofske, D. H. (2011). The operating characteristics of the nonparametric Levene test for equal variances with assessment and evaluation data. *Practical Assessment, Research, and Evaluation, 1*(5), 1–8.
Paul, R., Loomis, R., & Chawarska, K. (2014). Adaptive behavior in toddlers under two with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44*(2), 264–270.
Perry, A., Flanagan, H. E., Geier, J. D., & Freeman, N. L. (2009). Brief report: The Vineland Adaptive Behavior Scales in young children with autism spectrum disorders at different cognitive levels. *Journal of Autism and Developmental Disorders, 39*(7), 1066–1078.
Pugliese, C. E., Anthony, L., Strang, J. F., Dudley, K., Wallace, G. L., & Kenworthy, L. (2015). Increasing adaptive behavior skill deficits from childhood to adolescence in autism spectrum disorder: Role of executive function. *Journal of Autism and Developmental Disorders, 45*(6), 1579–1587.
Ray-Subramanian, C. E., Huai, N., & Weismer, S. E. (2011). Brief report: Adaptive behavior and cognitive skills for toddlers on the autism spectrum. *Journal of Autism and Developmental Disorders, 41*(5), 679–684.

Roid, G. (2005). *Stanford-Binet intelligence scales (SB5)* (5th ed.). Torrance, CA: Western Psychological Services.
Rutter, M., Le Couteur, A., & Lord, C. (2003). *ADI-R: Autism diagnostic interview-Revised.* Los Angeles, CA: Western Psychological Services.
Sattler, J. M. (2008). *Assessment of children; Cognitive applications* (5th ed.). La Mesa, CA: Jerome M. Sattler, Publisher.
Saulnier, C. A., & Klin, A. (2007). Brief report: Social and communication abilities and disabilities in higher functioning individuals with autism and Asperger syndrome. *Journal of Autism and Developmental Disorders, 37*(4), 788–793.
Schalock, R. L., & Borthwick, D. (2010). Intellectual Disability: Definition, Classification, and Systems of Supports. Eleventh Edition. *American Association on Intellectual and Developmental Disabilities*.
Schopler, E., Van Bourgondien, M. E., Wellman, G. J., & Love, S. R. (2010). *Childhood Autism Rating Scale* (Second Edition). Torrance, CA: Western Psychological Services.
Sparrow, S., Cicchetti, D., & Balla, D. (2005). *The Vineland adaptive behavior scales* (2nd ed.). Los Angeles, CA: Pearson.
Stone, W. L., Lee, E. B., Ashford, L., Brissie, J., Hepburn, S. L., Coonrod, E. E., & Weiss, B. H. (1999). Can autism be diagnosed accurately in children under 3 years? *Journal of Child Psychology and Psychiatry, 40*(2), 219–226.
Szatmari, P., Georgiades, S., Duku, E., Bennett, T. A., Bryson, S., Fombonne, E., ... Thompson, A. (2015). Developmental Trajectories of Symptom Severity and Adaptive Functioning in an Inception Cohort of Preschool Children With Autism Spectrum Disorder. *JAMA Psychiatry, 72*(3), 276–283.
Tassé, M. J., Schalock, R. L., Balboni, G., Bersani, H., Borthwick-Duffy, S. A., Spreat, S., ... Zhang, D. (2012). The construct of adaptive behavior: Its conceptualization, measurement, and use in the field of intellectual disability. *American Journal on Intellectual and Developmental Disabilities, 117*(4), 291–303.
Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Stanford-Binet intelligence scale* (4th ed.). Itasca, IL: Riverside Publishing.
Thorndike, R. L. (1972). *Manual for the Stanford-Binet intelligence scale.* Boston, MA: Houghton-Mifflin.
Wechsler, D. (1991). *The Wechsler intelligence scale for children—third edition.* San Antonio, TX: The Psychological Corporation.
Wechsler, D. (1999). *The Wechsler Abbreviated Scale of Intelligence.* San Antonio, TX: The Psychological Corporation.
Wechsler, D. (2005). *Wechsler Intelligence Scale for Children – (WISC-IV)* (Fourth Edition). San Antonio, TX: Pearson.
World Health Organization (2010). *International classification of disease, tenth version (ICD-10).* Geneva: World Health Organization.
Yang, S., Paynter, J. M., & Gilmore, L. (2015). Vineland Adaptive Behavior Scales: II profile of young children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 46*(1), 64–73.
Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 2-3*, 143–152.