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Language profiles in young children with autism spectrum disorder: A community sample using multiple assessment instruments

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Abstract

This study investigated language profiles in a community-based sample of 104 children aged 1–3 years who had been diagnosed with autism spectrum disorder using *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.) diagnostic criteria. Language was assessed with the Mullen scales, Preschool Language Scale, fifth edition, and Vineland-II parent-report. The study aimed to determine whether the receptive-to-expressive language profile is independent from the assessment instrument used, and whether nonverbal cognition, early communicative behaviors, and autism spectrum disorder symptoms predict language scores. Receptive-to-expressive language profiles differed between assessment instruments and reporters, and Preschool Language Scale, fifth edition profiles were also dependent on developmental level. Nonverbal cognition and joint attention significantly predicted receptive language scores, and nonverbal cognition and frequency of vocalizations predicted expressive language scores. These findings support the administration of multiple direct assessment and parent-report instruments when evaluating language in young children with autism spectrum disorder, for both research and in clinical settings. Results also support that joint attention is a useful intervention target for improving receptive language skills in young children with autism spectrum disorder. Future research comparing language profiles of young children with autism spectrum disorder to children with non-autism spectrum disorder developmental delays and typical development will add to our knowledge of early language development in children with autism spectrum disorder.

Keywords

assessment, autism spectrum disorder, communication and language, development, Mullen scales, predictors, preschool children, Preschool Language Scale, Vineland

Autism spectrum disorder (ASD) (American Psychiatric Association (APA), 2013) refers to a heterogeneous group of neurodevelopmental disorders that affects from 1% to 2% of the general population (Christensen et al., 2016). Deficits in communication skills are among the key characteristics of ASD, yet language ability can vary significantly between individuals. In total, 25%–30% of individuals may present as nonverbal (Anderson et al., 2007), others may exhibit echolalia, be highly verbal, or even verbose. Under the previous *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; DSM-IV) (APA, 2000) diagnostic criteria, a diagnosis of Asperger's syndrome was applied to individuals who did not present with a clinically significant language delay, but who otherwise presented with symptoms consistent with ASD. It is nonetheless important to acknowledge that individuals who are verbally fluent often exhibit pragmatic deficits, atypical prosody, or a limited conversational repertoire

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centered on a restricted range of interests or topics (Grossman et al., 2010).

Studies have consistently indicated that early communication skills in young children with ASD predict subsequent language development (Charman et al., 2003, 2005; Ellawadi and Ellis Weismer, 2015; Ellis Weismer and Kover, 2015; Luyster et al., 2007). These early communication skills include play, gestures, joint attention, and motor imitation (Bottema-Beutel, 2016; Ellis Weismer et al., 2010; Luyster et al., 2008; Stone and Yoder, 2001). For example, Yoder et al. (2015) found that language development was significantly predicted by joint attention at a 16-month follow-up of minimally verbal 24- to 48-month olds with ASD. Intentional communication attempts and parent linguistic responses were also found to predict later receptive and expressive language development.

Early intervention for children with ASD should include speech and language therapy in addition to social and behavioral difficulties (Bishop et al., 2016). Children with ASD may also present with structural language difficulties similarly to children without ASD, which may be addressed through specialized intervention (Bishop et al., 2016). Intensity of intervention may also be important. The number of hours of speech and language therapy in 2-year olds has been shown to be a significant predictor of language skills at 4 years (Stone and Yoder, 2001). A recent meta-analysis of 26 studies revealed a significant positive relationship between early speech and language intervention and expressive language outcomes, thereby providing additional support for the efficacy of early intervention targeting speech and language skills (Hampton and Kaiser, 2016). Speech and language intervention therefore forms a core part of recommended services for young children with ASD (Venter et al., 1992).

In individuals with both typical and atypical development, language ability is considered to lie on a continuum which is sensitive to social and other environmental factors, along with biologic determinants (Bishop et al., 2016). Early language abilities are important milestones that provide prognostic indicators of functional development in adulthood (Tager-Flusberg et al., 2009; Volden et al., 2011). Furthermore, behavior problems and language ability are associated (Helland et al., 2014), and the degree of language impairment is related to the degree of symptom severity (Volden et al., 2011). Given the impact on prognosis, including the potential benefits of early intervention and the relationship between language, symptom severity, and behavior, speech and language assessment also features in the diagnostic and assessment process for ASD (Johnson and Myers, 2007). Considering the significant heterogeneity in language ability between individuals, it is particularly important that language assessment in children with ASD is comprehensive, valid and reliable, and developmentally appropriate (Paul et al., 2008; Volden et al., 2011).

Given that ASD can be reliably identified in children as young as 18 months (Zwaigenbaum et al., 2005), assessment instruments must be appropriate and meaningful for use in very young children. However, language skills in typically developing children develop rapidly from birth, which suggests that assessment instruments designed for typical development may be less sensitive when assessing children whose language development does not follow a normative trajectory (Volden et al., 2011). There are several features important for determining whether a language assessment is appropriate for use in children with ASD or other developmental delays. First, the instrument must be sensitive to early milestones, such as use of first words (Paul and Norbury, 2012). Second, it should target deficits specific to ASD, including pragmatic and social communication skills (Bishop et al., 2016; Camarata, 2014; Chawarska et al., 2014). Third, it needs to provide a broad measure of expressive and receptive functioning that map onto the average developmental milestones of a typical child of the same chronological age (Camarata, 2014; Chawarska et al., 2014).

Instruments that are included as part of a screening or diagnostic assessment should additionally assess a child's nonverbal social skills and engagement, as these behaviors are developmentally sensitive to ASD and predictive of subsequent outcomes, including language (Camarata, 2014; Chawarska et al., 2014; Mundy et al., 1990). For example, Chawarska et al. (2014) found that outcomes in toddlers with ASD aged 18 months were predicted by three distinct behavioral combinations: poor eye contact combined with lack of communicative gestures; poor eye contact combined with a lack of imaginative play and lack of giving; and presence of repetitive behaviors with intact eye contact. A recent meta-analysis by Camarata (2014) found that nonverbal social communication, including response to joint attention, reciprocal social smile, and shared enjoyment, were key differential markers of ASD and receptive language disorder diagnoses. Consequently, instruments are likely to benefit from assessment of both verbal and nonverbal communication skills.

Tager-Flusberg et al. (2009; see also Bishop et al., 2016) suggest that multiple sources (e.g. direct assessment combined with caregiver report, observation, standardized tests) can yield a more robust assessment of language development than single source assessments. Instruments may be language specific, form part of a general developmental assessment, or be included in parent-report questionnaires or interviews. These assessments may therefore differ in their focus and comprehensiveness, each potentially providing unique information not covered by other assessments. Research comparing profiles produced by different language assessments in very young children with ASD is limited, particularly in clinical or community-based settings. Further research is needed to identify whether multiple sources (e.g. parents and clinician) and formats (report or direct assessment) of assessments provide unique information that cannot be gained from other sources, and therefore have additive value when making clinical decisions (Ellawadi and Ellis Weismer, 2015). Knowing whether parent-report adds to information gained from direct assessment, or whether a targeted language assessment is superior to data gained from a general developmental assessment, is crucial for informing current assessment protocols.

A further factor that is important to consider when discussing language of children with ASD, both from a diagnostic and prognostic perspective, is whether they exhibit unique or atypical language profiles and, importantly, whether the identified profiles are contingent upon the assessment measure used to derive the profile. While it is argued that there is little basis for distinguishing between children with language delay versus those with a language disorder, children who present with uneven language profiles may receive different or preferential treatment compared to children with even (but delayed) profiles (Bishop et al., 2016; see also Bishop et al., 2017). Seol et al. (2014) examined the language profiles of Korean toddlers with ASD and children with non-ASD language delays using the Sequenced Language Scale for Infants (SELSI) (Kim, 2002). Consistent with others (e.g. Hudry et al., 2010; Kjelgaard and Tager-Flusberg, 2001; Luyster et al., 2008), toddlers with ASD exhibited more significant impairments in receptive compared to expressive language skills. This profile was most apparent in toddlers aged from 20 to 29 months. Ellis Weismer et al. (2010) examined the language profiles of toddlers with ASD using the Vineland Adaptive Behavior Scales, Second Edition (Vineland-II) (Sparrow et al., 1984), the Mullen Scales of Early Learning (Mullen, 1995), and the Sequenced Inventory of Communication Development (SICD) (Hedrick et al., 1975). While expressive skills were higher than receptive language skills when using direct assessments (i.e. Mullen, SICD), the opposite profile was found using the Vineland-II parent-report. This suggests that different sources (i.e. direct assessment vs parent-report) may provide conflicting information.

Furthermore, a child's developmental level may affect the relationship between receptive and expressive language. Volden et al. (2011), using the Preschool Language Scale, fourth edition (PLS-4) (Zimmerman et al., 2002), found that although expressive skills were significantly stronger than comprehension skills in preschoolers with ASD, this profile was affected by nonverbal developmental level. Specifically, while this profile was evident in children with lower overall developmental levels, the opposite profile was evident in children with more advanced nonverbal skills.

Luyster et al. (2008) suggested the number of items that contribute to receptive and expressive language domains on different instruments may influence the relationship *between* these skills (i.e. the language profile). For example, the Vineland has fewer than half the number of receptive compared to expressive items than the Mullen scales. This results in a disproportionate increase in age-equivalent scores for successful attainment on a single receptive item when compared to attainment on a single expressive item (Luyster et al., 2008). Nonetheless, there is evidence of reasonable agreement between direct assessment and parent-report for overall language levels, suggesting that absolute performance may be less dependent on the assessment instrument or method (Charman, 2004; Condouris et al., 2003; Stone and Yoder, 2001). Thus, while there is some evidence of a disparity between receptive and expressive language skills in young children with ASD, the direction of this pattern may be influenced by the instrument used, and whether information is obtained by direct or indirect means.

In this study, we examined language profiles in young children with ASD using multiple assessment measures and different assessors or informants. All children had been referred to a hospital child developmental center for assessment and thus represent a relatively unique, well-characterized community-based clinical cohort. Language measures were derived from the clinician-administered Mullen (1995), the parent-report Vineland-II (Sparrow et al., 1984), and the Preschool Language Scale, fifth edition (PLS-5) (Zimmerman et al., 2011), the latter being administered by an experienced speech and language therapist. We aimed to characterize language profiles in young children with ASD and determine the extent to which profiles are dependent on the assessment instrument and informant. Based on previous research (Ellis Weismer et al., 2010; Luyster et al., 2008), we predicted that language profile would be dependent on the source used to obtain the assessment of language development, for example, whether the instrument was a parent-report (Vineland-II) or direct assessment (Mullen and PLS-5). However, it was not possible to predict whether there would be differences between general developmental (Mullen) and language specific (PLS-5) instruments. We also aimed to explore how language profiles and abilities were related to child characteristics such as concurrent nonverbal developmental level, overall ASD severity, and communicative behaviors, which have been previously identified as predictors of language outcomes in young children with ASD (e.g. Bottema-Beutel, 2016; Ellis Weismer et al., 2010; Luyster et al., 2008; Stone and Yoder, 2001; Yoder et al., 2015). Consistent with previous research, we predicted that language level would be negatively associated with developmental level and that receptive-to-expressive profile would be dependent on developmental level (Volden et al., 2011), and, given developmental level is likely to be associated with symptom severity, we also predicted language level would be negatively associated with ASD severity. Finally, based on research by Ellis Weismer et al. (2010), we predicted early

Table 1. Gender, ethnicity, additional diagnoses, and maternal education ($n = 104$).

	Label	Frequency	%
Gender	Male	86	82.69
	Female	18	17.30
Child ethnicity	White	74	71.15
	Black	13	12.50
	Hispanic Latino	5	4.81
	Asian, Asian American, Pacific Islander	1	0.96
	More than one	7	6.73
	Not selected or missing	4	3.85
Additional diagnoses[a]	Communication disorders	75	72.12
	Developmental coordination disorder	15	14.42
	Global developmental delay	23	22.12
Mother's highest education level	Some high school	4	3.85
	Completed high school	14	13.46
	Post-high school training (not college)	5	4.81
	Some college or university	27	25.96
	Completed college or university	19	18.27
	Postgraduate	8	7.69
	Missing	27	25.96

[a]Cumulative and % totals more than 104 and 100% due to some participants having more than one additional diagnosis.

communicative behaviors (spontaneous vocalization, gestures, joint attention, play, and imitation) would predict language level.

Method

Participants

Participants were 104 children aged 19–46 months who had been diagnosed with ASD. Demographic information for the study sample is provided in Table 1. Inclusion criteria for this study were being aged 3 years or under at the time of first visit, having received a diagnosis of ASD using *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5) criteria (APA, 2013) and the appropriate Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) module, and having had language evaluated using the Mullen scales, PLS-5, and Vineland-II. The current sample had a 4:1 male to female gender ratio which is consistent with the previously estimated gender prevalence of ASD identified in the literature (Fombonne, 2009). The majority of children were identified as White by their caregiver, and over 70% had a comorbid diagnosis of a communication disorder. The most frequently reported highest maternal education level was some college or university training.

Measures

ADOS-2. The ADOS-2 is a semi-structured, play-based instrument designed to elicit behaviors associated with ASD (Lord et al., 2012a, 2012b). Children in the current sample were administered either the Toddler Module ($n=48$), Module 1 ($n=52$), or Module 2 ($n=4$). ASD severity was based on ADOS-2 calibrated Comparison Scores (CS). The CS is a standardized 10-point scale anchored to ADOS-2 classifications which can be used to compare severity across modules. Total CS are provided by the publisher for Modules 1–3 (Lord et al., 2012b), and algorithms are available to calculate the CS for Social Affect (SA) and Restricted and Repetitive Behavior (RRB) subdomains (Hus et al., 2014). In this study, total and subdomain CS for the Toddler Module were derived from Esler et al. (2015; see also Hedley et al., 2016).

Mullen Scales of Early Learning. The Mullen is a developmental assessment for children from birth to 68 months which provides standardized and age-equivalent scores on four subscales: Visual Reception, Fine Motor, Receptive and Expressive Language, and an overall Early Learning Composite score (Mullen, 1995). For this study, age-equivalent scores were used for receptive and expressive language. Following Ellis Weismer et al. (2010), a composite nonverbal cognitive score was derived from the mean of the visual receptive and fine motor subscales. The manual reports satisfactory to good internal consistency (Cronbach's $\alpha=0.75$–0.83), satisfactory to excellent test–retest reliability ($r=0.71$–0.96), and excellent inter-rater reliability ($r=0.91$–0.99).

PLS-5. The PLS-5 is a clinician-administered assessment tool designed to evaluate Auditory Comprehension (receptive language), Expressive Communication (expressive language), and overall language functioning in children from birth to age 7 years, 11 months (Zimmerman et al., 2011). It has been shown to be a psychometrically valid and reliable measure of language skills. Cronbach's alpha is fair to excellent for children under 2 years, 5 months (α=0.80–0.96), and excellent for older children (α=0.91–0.97).

Vineland Adaptive Behavior Scales, Second Edition (Vineland-II). The parent-report Vineland-II is one of the most commonly used measures of adaptive functioning in children with developmental disorders and is suitable for individuals from birth through to adulthood (Sparrow et al., 2005). The Vineland-II provides four standardized domain scores (M = 100, standard deviation (SD) = 15) in the areas of Daily Living, Communication, Socialization, and Motor Skills, and several standardized and age-equivalent subdomain scores. Age-equivalent receptive and expressive language scores were used in this study. The Vineland-II shows adequate to strong internal consistency (Cronbach's α=0.77–0.96), adequate to strong test–retest reliability (r=0.75–0.95), and adequate to strong inter-rater reliability (r=0.75–0.82) for the language subscales in the 0–4 years age group.

Procedure

All procedures associated with this study were approved by the hospital Institutional Review Board. Data were collected through retrospective medical record review as part of a larger study, which included children who presented at the hospital child development center for assessment from May 2013 to February 2015 and were aged 3 years or under on their first visit to the center. The developmental assessment center where the study occurred is part of the Autism Treatment Network (ATN) and follows a national protocol for the evaluation and management of ASD by a multidisciplinary team. Multidisciplinary diagnostic and assessment teams included a developmental pediatrician or neurologist, social worker (who typically completed the intake interview), psychologist, speech and language therapist, and medical nurse. Assessments for ASD were completed over 3 days and included the ADOS-2, parent or caregiver interviews, child observation, and language and developmental assessments. Diagnostic and developmental assessments were completed by doctoral-level licensed psychologist or a psychology assistant, pre-doctoral intern, or postdoctoral fellow under the supervision of a licensed psychologist. ADOS-2 administrators were trained by a representative from the University of Michigan Autism and Communication Disorders Center (UMACC). The PLS-5 was administered by a licensed speech language therapist, and the Vineland-II was completed by a parent or primary caregiver. All instruments reported in this study were administered during the diagnostic assessment. Typically, the ADOS-2 and PLS-5 were administered on the first day of the diagnostic assessment, and the Mullen and Vineland-II were completed on the second day.

Analyses

Normality tests indicated that the language scales were positively skewed (please refer to Table 3). Analyses were thus performed through bootstrapping using 5000 resamples to provide more robust statistics (Efron and Tibshirani, 1993; Tabachnick and Fidell, 2014). Where appropriate, Bonferroni corrections were applied to control for multiple comparisons. The data plan first involved a review of descriptive data, including ASD severity as determined by ADOS-2 raw and CS, and comparison of language level to chronological age and nonverbal cognition. To determine whether a consistent receptive-to-expressive language profile emerged for all scales, age-equivalent language profiles for each of the three assessment instruments were examined. Following Volden et al. (2011), a receptive-to-expressive discrepancy score (EL−RL=discrepancy) was then calculated for the Mullen and PLS-5. Positive discrepancy scores reflected an expressive over receptive advantage, whereas negative scores indicated the opposite. Correlations between the discrepancy scores and Mullen nonverbal cognition were used to explore the relationships between developmental level and language profile, and correlations and partial-correlations controlling for nonverbal cognition were calculated to explore the relationship between language and ASD severity (ADOS-2 CS). The final set of analyses explored predictors of expressive and receptive language using step-wise regression controlling for nonverbal cognition. ADOS-2 items were identified as potential predictors based on a literature review (Bottema-Beutel, 2016; Ellis Weismer et al., 2010; Luyster et al., 2008; Stone and Yoder, 2001; Yoder et al., 2015) and included frequency of spontaneous vocalizations directed to others, gestures, joint attention, and play and imitation.

Frequency of spontaneous vocalization directed to others (range: 0–3) was derived from ADOS-2 Toddler and Module 1 only, this item is not provided in Module 2. Gestures (range: 0–2), Toddler and Module 2 scores of 1 or 2 were collapsed for consistency with Module 1 score range. Joint attention (range: 0–5) combined initiation and response items; Toddler spontaneous scores of 1 or 2 were collapsed for consistency with Module 1 and Module 2 score range. Play and imitation combined functional and imaginary play items. Imitation is coded under both functional and imagination items for all modules. The Toddler Module includes an additional item "Functional and Symbolic Imitation." All Toddler administrations were reviewed to ensure any imitation coded here was reflected in the participant's score on the functional and imaginary play items. No participant who failed to demonstrate imitated play for these items had demonstrated imitation on the Functional and Symbolic Imitation item; hence, no adjustments were necessary.

Based on methodology from previous studies (Ellis Weismer et al., 2010; Luyster et al., 2008; Yoder et al., 2015), composite expressive and receptive language scores

Table 2. Mean and standard deviations for age, cognition, and ADOS-2 Raw and Comparison Scores ($n = 104$).

Variable		n				Mean	SD	Range
Age (months)		104	–	–	–	32.60	6.57	19.70–46.80
Nonverbal cognition (months)		104	–	–	–	20.01	5.41	8.50–37.00
ADOS-2 Module		n	Raw score, M (SD)			Comparison score, M (SD)		
			SA	RRB	Total	SA	RRB	Total
Toddler	Pre-verbal	42	16.67 (3.95)	4.52 (1.82)	21.21 (4.94)	8.60 (2.03)	7.50 (1.70)	8.43 (2.00)
	Single words	6	13.83 (5.78)	3.67 (1.03)	17.50 (6.03)	7.00 (2.68)	7.67 (1.03)	8.00 (1.90)
Module 1	Pre-verbal	43	17.21 (2.43)	4.35 (1.72)	21.56 (3.28)	7.70 (1.52)	7.81 (1.45)	7.65 (1.57)
	Single words	9	14.56 (3.25)	3.89 (1.62)	18.44 (3.97)	8.11 (1.69)	7.89 (1.62)	8.11 (1.54)
Module 2	Younger than 5 years	4	15.75 (2.36)	3.00 (1.41)	18.75 (3.30)	9.50 (0.577)	7.00 (1.41)	9.75 (0.500)

ADOS-2: Autism Diagnostic Observation Schedule, Second Edition; SD: standard deviation; SA: Social Affect; RRB: Restricted and Repetitive Behavior (Lord et al., 2012a, 2012b).

Table 3. Age-equivalent means, standard deviations, range, normality, and bootstrapped comparisons between receptive and expressive language level for each of the three language outcome measures ($n = 104$).

	Receptive language			Shapiro–Wilk	Expressive language			Shapiro–Wilk	t(103)	p	Cohen's d	95% BCa CI	
	Mean	SD	Range		Mean	SD	Range					Lower	Upper
Mullen	10.08	7.68	1–39	0.87*	12.70	6.69	2–37	0.89*	−5.43	<0.001	−0.54	−3.58	−1.70
PLS-5	12.77	6.84	4–49	0.85*	11.29	6.04	3–43	0.87*	4.03	<0.001	0.40	0.755	2.25
Vineland-II	11.68	8.60	1–59	0.84*	12.42	7.38	1–38	0.91*	−1.17	0.24	−0.12	−1.97	0.454

95% BCa CI: 95% bias-corrected and accelerated confidence interval; SD: standard deviation; PLS-5: Preschool Language Scale, fifth edition.
*$p < 0.001$.

which were used as outcome variables, were calculated for each child by averaging age-equivalent scores across the three assessment instruments. Strong, positive inter-correlations between measures for receptive ($r = 0.577$–0.661, $p < 0.001$) and expressive ($r = 0.602$–0.828, $p < 0.001$) language variables provided support for the creation of the composite scores (see Yoder et al., 2015).

Results

Chronological age, nonverbal cognitive level, and ASD severity

Descriptive data for chronological age, nonverbal cognition, and ASD severity (ADOS-2 raw and CS scores by module) are provided in Table 2. Across modules, ADOS-2 total scores ranged from 8 to 27 ($M = 20.81$, $SD = 4.36$), and the CS ranged from 3 to 10 ($M = 8.11$, $SD = 1.79$). The sample was characterized by a significant delay in nonverbal cognition (composite Mullen Visual Receptive and Fine Motor subscales) relative to chronological age (delay $M = 12.59$, $SD = 7.30$ months), $t(103) = 17.60$, $p < 0.001$, 95% bias-corrected and accelerated confidence interval (95% BCa CI) [11.24, 14.02]. The sample also exhibited significant receptive and expressive language delays relative to chronological age ranging from 7.25 to 9.94 months (Bonferroni adjusted pairwise comparisons, all $ps < 0.001$).

Language profiles using multiple instruments

Statistics for receptive and expressive language age equivalence for the three language scales are provided in Table 3. Age-equivalent scores were generally consistent across instruments; however, profiles representing the relationship between receptive and expressive language skills varied depending on the instrument. In the case of the Mullen, receptive language was significantly lower than expressive language (RL < EL) with the effect size for the difference in the medium range (Cohen, 1988), the PLS-5 returned an opposite profile (RL > EL; small-to-medium effect size), while receptive and expressive age-equivalent language levels on the Vineland-II were not found to differ significantly (RL = EL; small effect size).

Effect of development on receptive and expressive language discrepancy

The Mullen and PLS-5 discrepancy scores were positively correlated with each other, $r = 0.22$, $p = 0.028$, 95% BCa CI [0.03, 0.39]. The PLS-5 discrepancy score was negatively

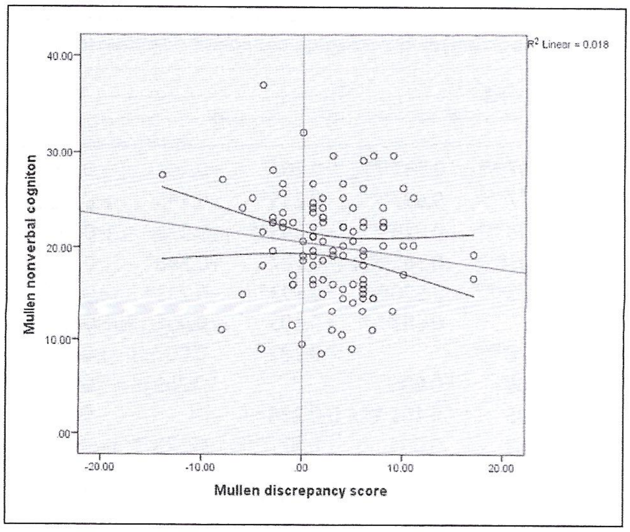

Figure 1. Scatter plot showing age-equivalent Mullen receptive-to-expressive (EL − RL) discrepancy scores relative to nonverbal cognition. The figure shows the regression line (red) with 95% CI bands and the vertical reference (blue) indicating no discrepancy between age-equivalent receptive and expressive language scores.

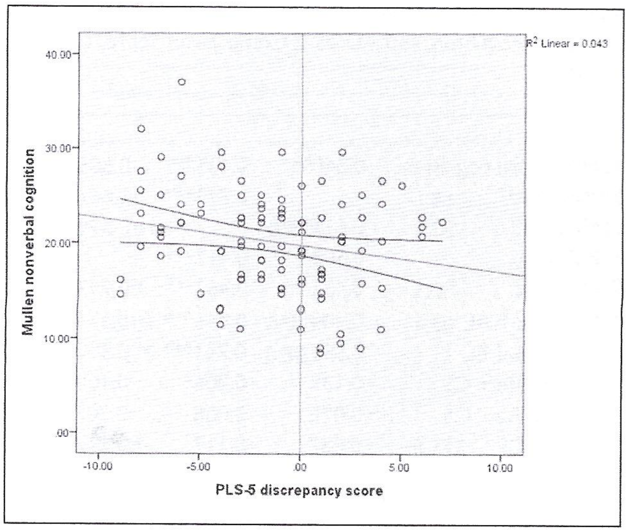

Figure 2. Scatter plot showing age-equivalent PLS-5 receptive-to-expressive (EL − RL) discrepancy scores relative to nonverbal cognition. The figure shows the regression line (red) with 95% CI bands and the vertical reference (blue) indicating no discrepancy between age-equivalent receptive and expressive language scores.

associated with Mullen nonverbal cognition, $r = -0.21$, $p = 0.035$, BCa [−0.38, −0.02]. This suggested that children with lower nonverbal cognition showed an expressive over receptive language advantage when assessed with the PLS-5, whereas children with higher nonverbal cognition showed an advantage of receptive over expressive skills. Mullen discrepancy was not significantly associated with nonverbal cognition $r = -0.14$, $p = 0.173$, BCa [−0.33, 0.09]. Figure 1 (Mullen) and Figure 2 (PLS-5) show scatterplots of discrepancy scores plotted against nonverbal cognition. The figures include a reference line indicating equivalent expressive and receptive language skills and the regression line including 95% CIs.

Correlations between language scales, nonverbal cognition, and ASD severity

Pearson correlation and partial-correlation coefficients for the language scales, nonverbal cognition, and ASD severity are provided in Table 4. As can be seen from the table, the language scales from all three instruments were positively correlated with each other, and with nonverbal cognition, the latter result indicating, as would be expected, that children with stronger language skills also returned stronger nonverbal cognition scores. However, the language scales showed a pattern of inconsistent and mostly negative associations with the ADOS-2 domain and total CS. Parent reported language measures from the Vineland-II were uncorrelated with any ADOS-2 CS scores; however, Mullen receptive and expressive and PLS-5 expressive age-equivalent scores were negatively associated with the SA CS. Similarly, the RRB CS was negatively correlated with PLS-5 receptive and expressive language age equivalents. These findings indicate that children with more severe ASD symptoms have more significant language difficulties. Partial correlations between language scales controlling for nonverbal cognition were significant. Controlling for nonverbal cognition reduced the number of significant correlations between the ADOS-2 CS and language scales, with only correlations with Mullen expressive language and PLS-5 receptive language scales remaining significant.

Behavioral predictors of language ability

Step-wise regression analyses were used to examine concurrent behavioral predictors of receptive and expressive language ability. To determine entry into the model, correlations between composite receptive and expressive language scores, nonverbal cognition, gestures, play and imitation, joint attention, and frequency of vocalizations were examined (see Table 5). All predictors were significantly correlated with the composite receptive and expressive language scores. The highest correlation was between nonverbal cognition and expressive language ($r = 0.60$, $p < 0.001$), which was lower than the 0.70 threshold suggestive of multicollinearity (Tabachnick and Fidell, 2014). The highest value for the collinearity Condition Index in the regression model predicting receptive language was 11.31 (maximum variance = 0.87), and 10.82 (maximum variance = 0.83) for expressive language. Values were below the recommended threshold values of 15 for a

Table 4. Pearson's bootstrapped correlations (top) between receptive and expressive language scores on multiple measures, nonverbal cognition, and ADOS-2 Comparison Score, and partial correlations (bottom) controlling for nonverbal cognitive level (n = 104).

	2	3	4	5	6	7	8	9	10
1. Nonverbal cognition	0.640***	0.635***	0.505***	0.444***	0.467***	0.547***	−0.203*	−0.141	−0.190
2. Mullen RL	–	0.773***	0.661***	0.595***	0.577***	0.697***	−0.235*	−0.145	−0.187
3. Mullen EL	0.617***	–	0.599***	0.602***	0.608***	0.828***	−0.285**	−0.045	−0.210*
4. PLS-5 RL	0.508***	0.417***	–	0.838***	0.641***	0.565***	−0.187	−0.248*	−0.191
5. PLS-5 EL	0.452***	0.462***	0.793***	–	0.575***	0.590***	−0.193*	−0.233*	−0.169
6. Vineland-II RL	0.409***	0.456***	0.531***	0.465***	–	0.683***	−0.103	−0.035	−0.043
7. Vineland-II EL	0.539***	0.744***	0.399***	0.462***	0.578***	–	−0.182	0.007	−0.100
8. Social Affect CS	−0.139	−0.206*	−0.100	−0.117	−0.009	−0.086	–	0.259**	0.881***
9. Rest. & Rep. CS	−0.072	0.058	−0.207*	−0.192	0.035	0.101	0.238*	–	0.589***
10. Total CS	−0.087	−0.117	−0.112	−0.096	0.053	0.004	0.877***	0.578***	–

RL: receptive language; EL: expressive language; CS: ADOS-2 Comparison Score (Social Affect, Restricted and Repetitive Behavior, Total); ADOS-2: Autism Diagnostic Observation Schedule, Second Edition; PLS-5: Preschool Language Scale, fifth edition.
For partial correlations (bottom panel), df = 101.
$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$.

Table 5. Pearson's bootstrapped correlations between nonverbal cognition, composite receptive and expressive language scores, frequency of vocalizations, gestures, joint attention, and play and imitation.

	1	2	3	4	5	6
1. RL composite	–					
2. EL composite	0.860***					
3. Nonverbal cognition	0.568***	0.603***				
4. Frequency of vocalizations	−0.392***	−0.409***	−0.230*			
5. Gestures	−0.272***	−0.221*	−0.224*	0.340**		
6. Joint attention	−0.525***	−0.455***	−0.336**	0.544****	0.298**	
7. Play and imitation	−0.361***	−0.310**	−0.347**	0.236*	0.122	0.318**

RL: receptive language; EL: expressive language.
$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$.

Condition Index with 90% variance (Hair et al., 2009), thereby indicating multicollinearity was not a concern.

Following Ellis Weismer et al. (2010), two step-wise multiple regressions were used to identify predictors of receptive and expressive language, respectively (Table 6). Two-step regression models significantly predicted both receptive and expressive language. In the model predicting receptive language, the final step accounted for 46.4% of variance, $F(2, 93)=39.42$, $p<0.001$, with nonverbal cognition and joint attention acting as unique independent predictors of language scores. In the model predicting expressive language, the final step accounted for 45.9% of variance, $F(2, 93)=38.55$, $p<0.001$, with nonverbal cognition and frequency of vocalizations acting as unique independent predictors of language scores. Gestures and play and imitation did not account for a significant amount of variance in receptive or expressive language and were therefore excluded from both models.

We repeated the main analyses substituting age-equivalent cognition with nonverbal developmental quotient (DQ; calculated by dividing nonverbal age-equivalent score by chronological age and multiplying by 100), a commonly reported metric of developmental level. The main correlations were not affected by this substitution. The pattern of results for the regression models were similar to the models using age-equivalent scores (receptive language: final step accounted for 38.7% of variance, $F[3, 93]=18.93$, $p<0.001$; expressive language: final step accounted for 30% of variance, $F[2, 93]=19.51$, $p<0.001$) with the exception of play and imitation which emerged as a significant predictor of receptive language scores (please refer to Supplementary Table 1 for results for the regression models using DQ instead of age-equivalent cognition).

Discussion

This study examined language profiles derived from multiple assessment instruments in a community-based sample of children aged 1 to 3 years diagnosed with ASD using DSM-5 (APA, 2013) diagnostic criteria. The study extends previous studies on language profiles and assessment in

Table 6. Step-wise regression models for predictors (nonverbal cognition, frequency of vocalizations, gestures, joint attention, play and imitation) of composite receptive and expressive language levels.

	R^2	ΔR^2	B	SEB	β	t	p
Receptive language							
Step 1	0.383						<0.001
Constant			−3.79	2.10		−1.81	0.074
Nonverbal cognition			0.764	0.101	0.619	7.56	<0.001
Step 2	0.464	0.081					<0.001
Constant			3.18	2.72		1.17	0.244
Nonverbal cognition			0.635	0.101	0.515	6.30	<0.001
Joint attention			−1.41	0.379	−0.303	−3.71	<0.001
Expressive language							
Step 1	0.377						<0.001
Constant			−1.40	1.88		−0.747	0.457
Nonverbal cognition			0.677	0.091	0.614	7.47	<0.001
Step 2	0.459	0.081					<0.001
Constant			4.25	2.33		1.82	0.072
Nonverbal cognition			0.603	0.087	0.548	6.92	<0.001
Frequency of vocalizations			−1.94	0.524	−0.293	−3.70	<0.001

Only significant predictors are shown.

young children with ASD (e.g. Ellis Weismer et al., 2010; Hudry et al., 2010; Luyster et al., 2008; Volden et al., 2011) and is the first study that the authors are aware of to directly compare the PLS-5 language scales with language scales derived from the Mullen and Vineland-II in young children with ASD diagnosed under DSM-V criteria. The study examined whether young children with ASD show a consistent receptive-to-expressive language profile across multiple assessment methods and informants. The study also examined the degree to which nonverbal cognition, early communicative behaviors, and ASD symptoms that had been previously identified as predicting language outcomes, accounted for significant variability in receptive and expressive language age-equivalent scores.

Overall, language scales from the different assessment instruments were significantly correlated with each other. However, and consistent with others (e.g. Ellis Weismer et al., 2010; Luyster et al., 2008; but for an exception see Hudry et al., 2010), the relationship between expressive and receptive language skills (i.e. the language profile) was dependent on the instrument and, in the case of the PLS-5, nonverbal developmental level. The current sample exhibited a significant strength in expressive over receptive language based on the Mullen (RL < EL), the opposite profile was found using scores from the PLS-5 (RL > EL), and the Vineland-II showed no difference between scales (RL = EL). Several explanations may account for these differences in profiles. As the Vineland-II is a parent-report measure, parents may have the opportunity to witness examples of vocal behavior not observed during a relatively brief clinical assessment. Differences may also reflect different item weighting on expressive or receptive language (Luyster et al., 2008), or in the case of the Vineland-II, an emphasis on adaptive communication. It is therefore important to take into consideration the degree to which the instrument assesses functional language, versus language in general. That is, some children with ASD may have expressive language skills in terms of vocabulary, but may not, or may have limited use of these language skills functionally.

The relationship between receptive and expressive skills may also be affected by developmental level (Kim, 2002; Volden et al., 2011). Volden et al. (2011) reported the expected expressive advantage over receptive skills in the youngest developmental levels using the PLS-4, but found that this profile was reversed in children who were more developmentally advanced. To explore this relationship further, we attempted to replicate Volden et al.'s (2011) findings. Our results were consistent but reduced in effect size for the PLS-5 only. Specifically, children with higher nonverbal cognitive skills showed a receptive over expressive advantage, whereas children with lower nonverbal cognition showed the opposite relationship. The PLS-5 may provide a more sensitive assessment of language, particularly with regard developmental level than the Mullen scales. Alternatively, and as suggested by Volden et al. (2011), the PLS items for receptive language may be more challenging for children who are developmentally younger, in particular those with ASD, due to their focus on behaviors such as eye contact and social communication. A third possible explanation is that receptive and expressive language development is asynchronous and strongly linked to developmental level. This discontinuity of development suggests that global development is not a single construct. This is relevant when considering the learning needs of children with more severe learning disabilities who may exhibit quite different learning profiles from average performing children. More work is thus required to understand the finer elements of language development in young children with ASD and other neurodevelopmental disorders (Bishop et al., 2017), in particular those with more severe developmental impairment. Nevertheless, our results overall indicate that different assessment instruments and methods likely provide useful information when interpreted appropriately, and with an appreciation of instrument limitations. This finding is relevant to both research and clinical practice and, furthermore, is consistent with others (e.g. Bishop et al., 2016; Luyster et al., 2008; Tager-Flusberg et al., 2009) who argue that multiple instruments and the incorporation of information from different reporters (i.e. clinician, parent or caregiver) is necessary to obtain a robust language assessment.

Language and developmental level inform diagnostic impressions and, along with the interaction between these factors, are critical when assessing learning needs, therapeutic progress, and prognosis. Differences in scores obtained from different measures have important clinical implications, particularly in the assessment of young children with ASD. Pragmatically, clinicians and therapists may focus more attention on skills that are perceived to be relatively less developed than others. It is important to consider multiple sources of information when planning interventions so as not to surreptitiously overlook one or other area based on results from only one instrument. Moreover, clinicians need to be aware of subtle discrepancies in language profiles that may be dependent on the assessment method or instrument used, as well as the potential impact developmental level may have on their language level.

Language levels were moderately-to-strongly correlated with nonverbal cognition, yet only weakly correlated with ASD symptom severity as determined by the ADOS-2 CS. This latter finding may reflect the nature of the ADOS-2, which is intended to detect ASD symptoms independently from an individual's expressive language level. After controlling for nonverbal cognitive functioning, language subscales continued to be inter-related. However, controlling for nonverbal cognition reduced the number of significant correlations between language and ADOS-2 CS. Thus, cognitive ability, rather than ASD symptoms, may be better predictors of language in young children with ASD. Nevertheless, children with ASD are at significant risk of language difficulties, even (as noted in the introduction) when intellectual impairment is not present.

The finding that nonverbal cognitive functioning significantly predicted expressive and receptive language was consistent with previous studies (Ellis Weismer et al., 2010; Luyster et al., 2008). Consistent with others (Dawson et al., 2004; Luyster et al., 2008; Yoder et al., 2015), joint attention (initiation and response) emerged as a predictor of receptive language and, consistent with Luyster et al. (2008), did not predict expressive language. The only significant predictor of expressive language, in addition to nonverbal cognition, was frequency of vocalizations. These findings are relatively unsurprising, particularly given that joint attention reflects pre-linguistic, nonverbal social communication (Mundy, 1995; Mundy et al., 1990). That is, receptive language development may be more strongly associated with social cognition than language production. Knowing that joint attention is an early milestone that is predictive of receptive language increases the importance of targeting this skill in early intervention.

Despite similar methodology, our results varied somewhat from Ellis Weismer et al. (2010). In the present sample, frequency of vocalizations did not emerge as a significant predictor of receptive language, and gestures and play and imitation failed to emerge as significant predictors of either receptive or expressive language. Ellis Weismer et al. (2010) found that play, rather than joint attention, accounted for significant variance in receptive language. Play and imitation were not independently assessed in our sample, which may account for a difference in findings.[1] Interestingly, when the present data were re-analyzed by substituting age-equivalent scores with DQ, we found that play and imitation contributed small but significant additional variance in receptive language scores. Thus, an association of play and imitation with receptive language cannot be ruled out. Other factors that need to be considered when interpreting differences between studies include the measures (i.e. PLS-5 instead of SICD), sample, diagnostic criteria (DSM-IV vs DSM-5) (APA, 2000, 2013) and the experience and training of the instrument administrator (in this study, the administrator of the PLS-5 was a trained speech and language therapist with several years of experience). Nonetheless, it is worth noting that gestures and play and imitation were not strongly associated with language level. Children with ASD may develop language without necessarily developing these behaviors—although it is important to evaluate the degree to which language is functional in the situations where it develops in the absence of, or inconsistently with, other social or communicative behaviors. This raises the question of whether or not it is relevant for language development to target these behaviors in therapy although there may be other benefits of doing so that are associated with different outcomes.

Strengths and limitations

This study used a well-characterized sample of children diagnosed under current DSM-5 diagnostic criteria with a narrow age range that may be considered representative of the ASD population presenting for a diagnostic evaluation in a community-based clinic. The use of multiple informants including a psychologist, speech and language therapist, and a parent or primary caregiver was a notable strength of the study. This study was also the first to compare PLS-5 profiles with other non-specific language assessment instruments in children with ASD aged 3 years and under, diagnosed against DSM-5 criteria. Nonetheless, this study was limited by the fact that it did not include a comparison group of either a non-ASD developmentally delayed group or a typically developing group although previous research (Ellis Weismer et al., 2010; Luyster et al., 2008) has included comparison samples. Future research would benefit from examining language profiles produced across measures, which are sensitive to developmental differences across ages, and comparing profiles of ASD to other neurodevelopmental disorders and to typically developing community samples.

Conclusion

This study supports the use of multiple language assessments and multiple informants, in both research and clinical settings, to gain a clear and comprehensive understanding of a child's developmental level. Our results show that language development in children with ASD, diagnosed under current diagnostic criteria, is strongly tied to nonverbal cognitive development, joint attention, and early vocalizations, yet less strongly tied to other symptoms known to be impacted by ASD, including gesture use, play, and imitation. These findings highlight the need to deliver targeted intervention to build social cognition, joint attention, and early sound production in children with ASD who present with a language disorder or delay, potentially maximizing their opportunity for positive long-term developmental outcomes.

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Note

1. Ellis Weismer et al. (2010) assessed imitation during the Autism Diagnostic Observation Schedule (ADOS) Birthday Party task, which was entered as a unique variable in their regression model. However, it is not clear from the article how they controlled for imitation behaviors that were also coded during play—imitation behavior is coded under both functional and imagination play items for all ADOS-2 modules. Specifically, while play and imitation were entered as unique variables, both may have included examples of imitation.

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