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ORIGINAL PAPER

Predictors of Language Acquisition in Preschool Children with Autism Spectrum Disorders

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Abstract In 118 children followed from age 2 to 5 (59 with autism, 24 with PDD-NOS and 35 with non-spectrum developmental disabilities), age 2 and age 3 scores of non-verbal ability, receptive communication, expressive communication and socialization were compared as predictors of receptive and expressive language at age 5. Non-verbal cognitive ability at age 2 was generally the strongest predictor of age 5 language, while at age 3 communication scores were a stronger predictor of age 5 language for children with autism. Early joint attention as well as vocal and motor imitation skills were more impaired in children who did not develop language by age 5 (but had relatively strong non-verbal cognitive skills) than in children who did develop language by 5.

Keywords Autism · Language · Preschool · Predictors · Outcome

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Introduction

Autism is a neurodevelopmental disorder that by definition includes impairments in communication, social interaction, and repetitive and restricted patterns of interest (APA, 2000). One of the most important features of autism spectrum disorders (ASD) is an individual's degree of language delay and/or impairment. Language delay, a component of the broader communication deficits involved in autism, is among the most frequent reasons for initial referral for young children with autism (Chakrabarti & Fombonne, 2001; Ohta, Nagai, Hara, & Sasaki, 1987; Siegel, Pliner, Eschler, & Elliott, 1988).

Language skills are one of the most strikingly variable characteristics of children and adults with these disorders. By later preschool and early school age, some children with ASD are highly fluent, with large vocabularies and complex grammar. Others have no meaningful production of words and minimal language comprehension. Many children fall in between. Language outcome for individuals with autism appears affected by both early language and other cognitive abilities (Szatmari, Bryson, Boyle, Streiner, & Duku, 2003), though questions of how these predictive relationships change over the course of development remain (Charman et al., 2005). How and how much early language and communication skills directly affect outcomes in later years is an empirical question.

At ages 2 through 5, language skills have been related to the severity of autistic characteristics (e.g. social impairments), adaptive behaviors, certainty of diagnosis and other features, such as specific socio-communicative behaviors (Lord & Pickles, 1996;

Stone, Ousley, Hepburn, Hogan, & Brown, 1999). Expressive language level at age 5 has been proposed as a strong predictor of eventual functioning (Gillberg & Steffenburg, 1987; Kobayashi, Murata, & Yoshinaga, 1992; Rutter, Greenfield, & Lockyer, 1967), though a recent study of relatively high functioning adults found this to be less the case than might have been expected for an early general measure of language (Howlin, Goode, Hutton, & Rutter, 2004). Apart from their predictive value, language skills at age 5 have important implications for school placements, access to social opportunities, acquisition of academic skills and ease of communication for children with ASD or other developmental delays (Venter, Lord, & Schopler, 1992).

The goal of this paper is to determine predictors of age 5 receptive and expressive language in children with diagnoses of autism, pervasive developmental disorder-not otherwise specified (PDD-NOS), and non-spectrum developmental disorders. [Of note, in this paper we use terminology consistent with the measures in the study. For instance, the term *language* is used to describe both receptive and expressive skills, in the age 5 outcome variables (based on use of the Mullen Scales of Early Learning (MSEL, Mullen, 1989) and Differential Ability Scales—DAS; Elliot, 1990), and communication refers to age 2 predictor variables from the communication domain (which includes receptive and expressive subdomains, as well as non-verbal communication items) of the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984).]

Earlier research emphasized the use of general measures of cognitive impairment, and other specific behaviors in predicting later language in children with autism (e.g., Mundy, Sigman, & Kasari, 1990). However, these studies often failed to employ multivariate models that control for different levels of early language ability. In an earlier paper, to address this question, we placed children with autism into two groups on the basis of language at approximately age 4 and then again in two groups at age 10. Then, we compared children who had not reached a basal level, defined as a 23-month age equivalent on the Peabody Picture Vocabulary Test (PPVT: Dunn, 1959) by age 10 to children who reached this level of language comprehension between ages 4 and 10 to children who had reached this level by age 4. We found that the former Vineland Social Maturity Scale (which gave one summary score that combined social skills with other areas of adaptive behavior) (Doll, 1965) more clearly differentiated children who developed a minimum vocabulary between 4 and 10 and children who had not developed this vocabulary by 10, than did non-verbal IQ. However, when children who already had a receptive language level of 23 months or more at age 4 were included in the analysis, non-verbal IQ was also a strong predictor (Lord & Schopler, 1989).

Our hypothesis at that time was that general intellectual level (as measured on non-verbal intelligence scales) was a primary factor in predicting early language level, but that, given a significant language delay at age 4, social factors, such as measured in the earlier Vineland scales, had an independent effect on the development of receptive language in autism from preschool to early school years. These conclusions were supported by Sigman and colleagues (1999), who tested children with autism at age 4 and followed them to age 12. These researchers found that general cognitive ability at age 4 differentiated children who had a 23-month or higher receptive language level at age 4 from those who did not, but did not differentiate those who gained receptive language by age 12 from those who did not. Follow-up testing at average age of 19 found that play skills, responding to joint attention, and requests predicted language outcomes in this sample (Sigman & McGovern, 2005).

Similar to the earlier research, the focus of this paper is on outcomes in very general aspects of language. However, with access to the more detailed breakdown of behaviors, including communication, in the commonly used second version of the VABS (Sparrow et al., 1984), we are now able to study both receptive and expressive aspects of more broadly defined communication and socialization in much younger children with autism. We were particularly interested in studying the utility of an easily administered parent report measure, such as the Vineland, because it takes a relatively short amount of time to complete, does not require the child is present, and is used for multiple purposes (including documenting adaptive behavior for a mental retardation diagnosis). In contrast, direct testing with measures such as the Mullen Scales of Early Learning (MSEL: Mullen, 1985), that are normed on ages low enough for young children with autism (who are often quite language impaired), requires substantial time from the child while still often requiring parent report. Such tests also often contain few items (i.e. have limited variability) at young ages.

At later ages, this balance between the contributions of parent report and direct assessments shifts somewhat. First, the early Vineland (Sparrow et al., 1984) receptive and expressive subdomains have "sticky ceilings" for children at later preschool years, such that there are very few items that discriminate summary scores, particularly for receptive language, in children with age equivalents between 3 and 4.5 years (Taylor, Pickering, Lord, & Pickles, 1997). Consequently, Vineland communication scores are not an appropriate measure of receptive and expressive outcome for 5-year-old children. Second, by school-age, many children with autism have been in structured settings, and may handle direct testing sessions more easily.

Expressive and receptive language skills are highly correlated in both typically developing children (Mullen, 1995; Zimmerman, Steiner, & Pond, 2004) and in children with autism (Dyck, Piek, Hay, Smith, & Hallmayer, 2006). Nevertheless, we chose to study them as separate outcomes at age 5 for several reasons. First, we wanted to explore the distinctiveness (regarding predictors) of these separate domains/scores on tests such as the MSEL. Second, although expressive language level has been frequently studied as a functional outcome in autism, we wanted to explore whether unique predictors warranted further study of receptive language as an outcome in autism. In particular, we were interested in the possibility of the unique social deficits in autism relating to comprehension (Philofsky, Hepburn, Hayes, Hagerman, & Rogers, 2004; Watson, 2001). Expressive language, on the other hand, may be influenced more by specific speech-related pre-linguistic capabilities. Thus, in a relatively large sample that was seen prospectively at ages 2, 3, and 5, we wished to explore which early variables (e.g. non-verbal cognitive ability, Vineland social and communication skills) at ages 2 and 3, best predicted receptive and expressive language at age 5.

Besides a general interest in predictors of language, we also had a particular interest in describing the specific characteristics of children with ASD who continued to have very little receptive or expressive language at age 5 despite presumably adequate cognitive ability, and those who acquired at least a minimal level of language between 2 and 5. For these analyses, we chose to examine specific social-communicative behaviors found in other studies to be associated with autism and language impairment. These included joint attention (Dawson et al., 2004; Mundy et al., 1990; Sigman et al., 1999) and imitation (Rogers, Hepburn, Stackhouse, & Wehner, 2003). In young children, these behaviors may be even more associated with language skills than non-verbal intelligence. For instance, categorical measurement of joint attention at 20 months has been found to be associated with receptive language status at age 42 months (Charman et al., 2003). This led us to ask whether joint attention at age 2, independent of age 2 Vineland communication, predicts language skills (and receptive language in particular) in later preschool or school age.

Likewise, specific early motor and imitation skills have been suggested as important predictors of later expressive language. These motor measures include imitating actions and reproducing certain sounds (such as ‘‘blowing raspberries’’) (Gernsbacher et al., 2002; Stone & Yoder, 2001). Recent studies have shown a relationship between general language skills and imitation ability in children with autism (Charman et al., 2003; Rogers et al., 2003). Based on previous findings of a relationship between imitation skills (in particular, imitation of body movements but not imitation of actions) at 2 and later expressive language (Stone, Ousley, & Littleford, 1997), one could predict specific relationships between expressive language at 5 and early motor imitation measures at age 2 that might not parallel those for receptive language.

To summarize, it was predicted that, in addition to age 2 receptive communication, age 2 socialization skills would be significantly associated with the growth of receptive language from 2 and 5. Expressive communication at 2 was anticipated to be associated with expressive language at age 5. Non-verbal cognitive ability and communication scores at 2, along with diagnosis, were also hypothesized to be associated with both receptive and expressive language development at age 5. We also predicted that particular relationships would be found between oral-motor imitation at 2 and expressive language at 5, and between joint attention at 2 and receptive language at 5, based on emerging theories of language development in ASD (Gernbsbacher et al., 2002; Mundy et al., 1990; Stone & Yoder, 2001).

Methods

This study was conducted as part of a larger longitudinal investigation on the early diagnosis of autism, prospectively following toddlers referred for autism or other developmental disorders before age 3. The present study analyzes data obtained at age 2 and age 3, as well as between the ages of 4 and 5. The specific tests administered were chosen according to the developmental level of the child, in order for each child to reach a basal and ceiling score on every test. Tests differed according to age, because many of these tests are standardized according to chronological age and developmental level. All children received a test to determine overall intellectual ability that included separate verbal and non-verbal intelligence scores, as well as the measures described below. This study was approved by the Institutional Review Boards of University of North Carolina, University of Chicago and University of Michigan.

Participants

Participants were recruited from an ongoing longitudinal study of the early diagnosis of autism occurring in four regions of North Carolina. Groups were based on diagnosis at age 5. The sample comprised 110 children referred for possible autism and 21 children with developmental delays and no evidence of autism. The latter group was a heterogeneous group of children with IQ's below 70 that was recruited from early intervention programs or pediatric neurology clinics. It included children with various developmental problems and/or language delay, including some with genetic etiologies (e.g., 1 child with Down syndrome, 1 child with fragile X syndrome). All children referred for autism (regardless of final diagnosis of autism, PDD-NOS or non-spectrum developmental delay) were seen for an additional assessment at age 3; the non-autism referral group was seen only at age 2 and age 5. Of the 131 participants, 13 children (all autism referrals) did not receive a full battery during the age 5 year of testing due to relocation, unreachable status, or refusal to participate, resulting in 118 children with complete longitudinal data.

Information on all interventions and treatments, including school placements, in-home therapy, speech therapy, physical therapy and pharmacologic treatments, were documented, and are analyzed elsewhere (see Lord et al., 2006; D. Anderson & C. Lord, submitted). Many children in this sample received at least some intervention within the North Carolina state-funded TEACCH service delivery system, as TEACCH clinics were the main source of referrals. Table 1 summarizes the demographics of children who participated in the larger study (n = 118).

Measures

Autism Diagnostic Interview-Revised

The Autism Diagnostic Interview-Revised (Lord, Rutter, & LeCouteur, 1994; see LeCouteur, Lord, & Rutter, 2003 for most recent version) is a comprehensive, investigator-based interview covering developmental and behavioral aspects of autism. The interview is typically administered to caregivers. There is a scoring algorithm based on DSM-IV/ICD-10 criteria for autism, which discriminates children with autism from chronological age and IQ matched non-autistic developmentally delayed children. All interviewers had previously established research reliability. Reliability checks were made at least every tenth interview. A ''toddler'' version of the ADI-R was administered to all children in the study at ages 2 and 5 (and all children in the autism group at age 3). It included 32 questions and codings specifically relevant to onset of difficulties in the early years (see Lord et al., 2006).

The current study used the summary item of the ADI-R, ''overall level of language'' to categorize age 2 and age 5 expressive language. Consistent with the instrument's convention, scores range from 0 to 2; 2 equals ''no words'' (i.e. had fewer than 5 words and/or speech not used on a daily basis), 1 equals ''some language'' (i.e. had used meaningful words on a daily basis for the last month) and 0 equals phrase speech. This item was chosen as a categorical expressive language variable (instead of direct assessment measures) because of the frequency of floor effects on direct assessment measures. In previous studies these codes have been found to correspond to reasonable ranges on standardized language measures (Lord & Risi, 2004).

Pre-Linguistic Autism Diagnostic Observation Schedule (PL-ADOS)

The PL-ADOS is a standardized observation of social and communicative behavior (DiLavore, Lord, & Rutter, 1995; modified and now published as Module 1 of the Autism Diagnostic Observation Schedule; Lord, Rutter, DiLavore, & Risi, 1999). Psychometric data indicate very good reliability and validity for autism diagnosis (DiLavore et al., 1995). The researchers who administered this instrument had previously obtained research reliability, and every tenth administration was double-scored and discussed in order to assess and maintain inter-rater reliability.

Several items of this measure were chosen as potential predictors of language acquisition, due to their theoretical and empirical associations with language. These items included ''responding to joint attention,'' which measures performance on a series of ''presses'' in which a child follows an examiner's vocalization and shift in gaze or point, and ''initiating joint attention,'' which is a summary item quantifying frequency and quality of a child's attempts to use gaze coordinated between an object and an adult.

Sequenced Inventory of Communication Development (SICD)

The SICD (Hedrick, Prather, & Tobin, 1975) is a standardized measure of receptive and expressive

Table 1 ANOVA of demographic, language, adaptive and cognitive variables

Variable	Autism Mean (SD) n = 59	PDD-NOS Mean (SD) n = 24	Non-spectrum Mean (SD) n = 35[d]	F ($df_{between}$, df_{within})
Demographic variables				
CA at 2 in months	29.98 (4.28)	30.38 (4.69)	28.14 (6.21)	1.93 (2, 115)
CA at 5 in months	57.00 (7.39)	57.08 (6.53)	53.51 (7.22)	2.94 (2, 115)
Gender				
Male (%)	52 (88.1)	19 (79.2)	21 (60.0)	Chi-square = 10.15, $p < 0.01$
Female (%)	7 (11.9)	5 (20.8)	14 (40.0)	
Ethnicity[e]				
African-American (%)	30 (50.8)	11 (45.8)	9 (25.7)	Chi-square = 5.83, $p = 0.05$
Asian-American (%)	1 (1.7)	0	0	
Hispanic-American (%)	1 (1.7)	0	3 (8.6)	
White (%)	27 (45.8)	13 (54.2)	23 (65.7)	
Maternal Education and Occupation (Hollingshead)	38.26 (16.07)[f]	36.29 (18.17)	33.06 (14.23)	1.15 (2, 114)
Age 2 measures				
Non-verbal IQ AE Ratio at 2	0.57 (0.17)[a]	0.71 (0.20)[b]	0.73 (0.25)[b]	8.48 (2, 115)
Total VABS Comm AE Ratio at 2	0.29 (0.12)[a]	0.41 (0.17)[b]	0.53 (0.20)[c]	26.48 (2, 115)
VABS Social AE Ratio at 2	0.29 (0.12)[a]	0.41 (0.14)[b]	0.51 (0.17)[c]	26.02 (2, 115)
Age 3 measures	*N = 59*	*N* = 23	*N = 13*	
Non-verbal IQ AE Ratio at 3	0.55 (0.18)[a]	0.72 (0.21)[b]	0.73 (0.32)[b]	7.81 (2, 92)
Total VABS Comm AE Ratio at 3	0.30 (0.14)[a]	0.50 (0.18)[b]	0.55 (0.19)[b]	21.76 (2, 92)
VABS Social AE Ratio at 3	0.28 (0.11)[a, g]	0.43 (0.12)[b]	0.47 (.18)[b]	19.32 (2, 90)
Age 5 measures	n = 59	n = 24	n = 35	
Composite Expressive Language AE Ratio at 5	0.38 (0.26)[a]	0.69 (0.31)[b]	0.69 (0.26)[b]	19.17 (2, 115)
Composite Receptive Language AE Ratio at 5	0.35 (0.20)[a]	0.61 (0.26)[b]	0.69 (0.26)[b]	27.35 (2, 115)

Note: Chi-square was used to examine gender and race. CA is chronological age. AE is age equivalent

[a,b,c] Numbers in the same row with the same letter are not statistically different at $p \le 0.05$ (two-tailed)

[d] Includes all 21 children who were not autism referrals at 2, as well as 14 children who were referred for possible autism at 2, but never received ASD diagnosis during any assessment

[e] Chi-square test was performed by comparing African-American and White only (Asian and Hispanic were excluded)

[f] $n = 58$

[g] $n = 57$

communication, commonly used in children with ASD. The measure includes both observationally based items as well as parent report items. For the current study, we used one item, parent report of raspberry/tongue click motion in imitation, as it offered information on oral-motor preverbal imitation skills specifically hypothesized to predict expressive language in autism (Gernsbacher et al., 2002). The SICD also includes direct assessment of a raspberry/tongue click, but so few children passed this item that there was not enough variability for valid analysis.

VABS Survey Form

The VABS is a parent report measure of personal and social independence designed to examine the domains of communication (separating receptive and expressive), daily living skills, social skills and motor development (Sparrow et al., 1984). At the time of this study, the VABS was the most widely used instrument in autism for measuring adaptive skills (Carter et al., 1998). The measure was standardized with a carefully selected national sample, and has excellent levels of reliability for each domain. VABS profiles are also related to the diagnosis of autism (e.g. Volkmar et al., 1987). The current study examines VABS communication and socialization age equivalent scores at age 2 (computed as ratio scores to take into account actual chronological age). Age equivalents were used because they are easily interpretable and represent ordinal scales that have more validity than raw scores (because the number of items per age was deliberately selected to reflect the presumed amount of variation at that age). Analyses were conducted with both raw scores and age equivalents, and there were no appreciable differences. Standard scores were not used because they are restricted in range for younger children and children with limited abilities (Carter et al., 1998). In addition, several specific items were chosen for analysis based on their theoretical links with language in autism (Rogers et al., 2003; Stone & Yoder, 2001), including ‘‘imitates sounds’’ and ‘‘imitates simple movements.’’

Differential Ability Scales

The DAS is a cognitive abilities test consisting of verbal and non-verbal scales (Elliot, 1990). The preschool portion of the test is divided into lower preschool (ages 2.5-3.5) and upper preschool (ages 3.5-6), based on cognitive level. All children were given this test if they were able to obtain basal scores on all but one subtest. If they could not, they were given the MSEL. Receptive language was measured on the DAS through the Verbal Comprehension subtest, and expressive language was measured through the Naming Vocabulary subtest. Non-verbal cognitive ability was measured through the special Non-verbal Composite if the child fell in the lower preschool level, and the Non-verbal Cluster, if the child fell in the upper preschool level.

The Mullen Scales of Early Learning

The MSEL consist of four sets of tasks covering the domains of non-verbal cognitive perception (i.e., visual receptive organization), fine motor skills (i.e. visual expressive organization), receptive language organization and expressive language organization (Mullen, 1989), as well as a gross motor subtest, which is not discussed here. One of two earlier forms of the Mullen Scales was administered according to the child's developmental level, either the Infant Mullen Scales of Early Learning (Mullen, 1985) or the MSEL (Mullen, 1989). An average of the age equivalent scores from the visual receptive organization and the visual expressive organization scales was used as a measure of age 2 non-verbal cognitive ability for the 103 of the 131 children at age 2 who could not complete the DAS. The receptive and expressive language scales were used as one of the measures of age 5 language abilities.

Age 5 Language Outcome Variables

Age 5 language scores were based on a hierarchical selection procedure. If possible, scores from the DAS were used ($n = 52$). If the child did not receive a basal on both DAS verbal subtests, scores were taken from the verbal subtests of the MSEL ($n = 66$). Age equivalent scores are provided, because many children fell below the ''floors'' of the tests and so were not able to receive standard scores. In order to account for variation in the chronological age of children at the age 5 testing, ratio scores were computed by dividing age equivalents of receptive and expressive language scores at age 5 by the exact chronological age of each child at testing.

Procedure

The larger longitudinal study consisted of an initial assessment at age 2, with follow-up assessments at age 3 (for children referred for possible autism), and between age 4 and 5. Assessment batteries were typically divided into two sessions. Each child received an independent diagnosis at age 2 and again at age 5 (with age 5 diagnosis used in the current study). Procedures for age 5 diagnoses are outlined in a separate publication (Lord et al., 2006).

Data Analysis

Bivariate analyses were performed using Analysis of Variance (ANOVA) with post hoc Scheffe tests, Pearson correlations, and *t*-tests. Specifically, ANOVA was used to compare the differences between autism, PDD-NOS, and non-spectrum groups; Pearson correlations were used to examine relations between the key predictive and outcome variables; *t*-tests were used to compare mean differences of age 2 predictors between ''language'' and ''no language' groups at age 5.

Multiple linear regressions were carried out to explore associations between Vineland communication and socialization scores, and non-verbal cognitive variables measured at age 2 and age 3, with verbal or language measures from the DAS and Mullen Scales at age 5. Separate models were constructed for age 2 and age 3 predictors as well as for receptive and expressive language at age 5. Distributions of dependent variables, that is, the age equivalent language scores divided by exact chronological age (ratio scores), were examined and found to be sufficiently symmetrical. Working from the hypotheses that early socialization scores were particularly associated with later receptive language outcomes, models were therefore first fit with only socialization to determine the variance in receptive language outcome explained by socialization. In the next step, non-verbal cognitive and total communication abilities were added to socialization. Finally, models were constructed by forcing in continuous terms for socialization, total communication, and non-verbal cognitive ability at age 2, as well as dummy variables for the diagnosis (autism, PDD, other developmental delay) at age 5.

Gender, ethnicity, and socioeconomic status (measured by maternal education and occupation (A. Hollingshead, unpublished manuscript, 1975)) were considered as potential confounding factors. Each variable was added individually to the models that included language, socialization, and cognitive measures. In no case did adjustment for any sociodemographic variable lead to appreciable change in the effect estimates for other variables. Therefore the models presented exclude these terms. The question of whether the effect of age 2 and age 3 communication, socialization and cognitive variables on age 5 language was related to participants' ultimate, year 5 diagnosis was of interest, however, because of the small number of children with age 5 diagnoses other than autism, it was not possible to include diagnostic group interaction terms. The age 5 receptive and expressive language models developed in the full sample were refit to the subsample of children with age 5 autism diagnoses, allowing comparison between effects for autism only models versus the full sample models.

Results

Results from ANOVA with post hoc Scheffe tests ($p < .05$) of relevant VABS age equivalent ratio scores (ratio scores = age equivalent scores/chronological age) and other key variables indicated that children with autism had significantly lower ratio scores than children with PDD-NOS on non-verbal cognitive ability and on both the socialization and communication domains of the VABS at ages 2 and 3, as well as on the composite expressive and receptive language age equivalent ratio scores at age 5 (as shown in Table 1). The PDD-NOS group scored significantly lower than the non-spectrum group on the communication and socialization domains of the VABS at age 2. Only data from children with autism were analyzed as age 3 predictors of later language, because the sample size for PDD-NOS was too small to justify separate analyses and children with non-spectrum developmental delays from the non-referral group were only seen at age 2 and 5 years.

Preliminary Analysis of Predictor Variables

Pearson correlation analysis revealed significant and strong correlations between non-verbal cognitive ability at age 2, VABS age 2 communication and socialization scores, and age 5 receptive and expressive language outcome scores. Correlations between concurrent measures ranged from .60 to .63 (non-verbal IQ with communication and social ratio scores at 2) to .90 (expressive and receptive language at 5). All were significant at $p < .01$. We were also particularly interested in the correlation between socialization and communication domains of the VABS over time; at age 2 their correlation was .87, $p < .001$, and at age 3 their correlation was .57, $p < .001$. Scores across time (all 2 year Vineland domains with both 5 year language scores) were between .63 and .71, $p < .01$.

Predictors of Expressive Language

Table 2 shows regression models for expressive language. Socialization at age 2 predicted expressive language at age 5 when it was alone in the model (model 0). Non-verbal cognitive ability and communication totals at age 2 were both significantly associated with age 5 expressive language, even after adjusting for socialization (model 1). These associations persisted after additional adjustment for age 5 diagnostic categories (model 2), though no diagnostic category independently contributed to expressive language outcome. Socialization at age 2 was no longer associated with age 5 expressive language after adjustment for communication and non-verbal cognitive ability scores at age 2. Analyses limited to the autism subsample at age 2 revealed similar patterns in all models.

Analyses were conducted for age 3 predictors of expressive language at age 5 in the autism sample only. When socialization at age 3 was placed alone in a model, it was found to be a significant predictor of age 5 expressive language in children with autism (adjusted $R^2 = .48$; $p < .001$). Alone, socialization explained more variance at age 3 than at age 2 (adjusted $R^2 = .17$). When non-verbal cognitive ability and communication at age 3 were added to the model, communication at age 3 ($p < .001$) but not non-verbal cognitive ability ($p = .38$) was significantly associated with expressive language at age 5, with socialization falling to a value of $p = .06$.

Predictors of Receptive Language

Table 3 presents the results of regression models for receptive language. When socialization at age 2 alone was placed in a regression model, it significantly predicted receptive language at age 5 (model 0). When age 2 non-verbal cognitive ability and total (receptive and expressive combined) communication at age 2 were added to the model, both were significantly associated with age 5 receptive language (model 1). Socialization at age 2 was not associated with age 5 receptive language after adjustment for baseline communication skills and non-verbal cognitive ability. Associations between receptive language at age 5 and non-verbal ability and communication skills at age 2 persisted after age 5 diagnostic

Table 2 Regressions predicting expressive language at age 5 from age 2 measures

	Total sample (n = 118)			Autism sample only (n = 59)		
	Beta	Standard Error	p-value	Beta	Standard Error	p-value
Model 0						
VABS Social AE Ratio at 2	1.15	0.13	<0.001	0.90	0.25	<0.001
Adjusted R^2	0.39			0.17		
Model 1						
Non-verbal AE Ratio at 2	0.67	0.11	<0.001	0.76	0.17	<0.001
Total VABS Comm AE Ratio at 2	0.74	0.18	<0.001	1.31	0.37	<0.001
VABS Social AE Ratio at 2	–0.10	0.21	0.65	–0.71	0.38	0.07
Adjusted R^2	0.61			0.46		
Model 2						
Non-verbal AE Ratio at 2	0.64	0.11	<0.001			
Total VABS Comm AE Ratio at 2	0.72	0.180	<0.001			
VABS Social AE Ratio at 2	–0.17	0.21	0.42			
Autism	–0.06	0.05	0.22			
PDD-NOS	0.09	0.05	0.08			
Adjusted R^2	0.63					

Table 3 Regressions predicting receptive language at age 5 from age 2 measures

	Total sample (n = 118)			Autism sample only (n = 59)		
	Beta	Standard Error	p-value	Beta	Standard Error	p-value
Model 0						
Social AE Ratio at 2	1.08	0.12	<0.001	0.76	0.19	<0.001
Adjusted R Square	0.42			0.21		
Model 1						
Non-verbal AE Ratio at 2	0.54	0.10	<0.001	0.43	0.13	<0.01
Total VABS Comm AE Ratio at 2	0.67	0.16	<0.001	1.12	0.29	<0.001
Social VABS AE Ratio at 2	–0.00	0.19	0.99	–0.45	0.30	0.14
Adjusted R^2	0.61			0.44		
Model 2						
Non-verbal AE Ratio at 2	0.54	0.09	<0.001			
Total VABS Comm AE Ratio at 2	0.57	0.16	<0.001			
VABS Social AE Ratio at 2	–0.13	0.18	0.49			
Autism	–0.14	0.04	<0.01			
PDD-NOS	–0.02	0.05	0.72			
Adjusted R^2	0.64					

categories were added to the model (model 2). The diagnosis of autism also significantly predicted age 5 receptive language. Analyses limited to the autism subsample at age 2 yielded identical patterns.

Analyses were also conducted in the autism sample only, using age 3 measures as predictors of receptive language at age 5. When socialization at age 3 was placed alone in a model, it was found to be a significant predictor of age 5 receptive language (Adjusted R^2 = .41; p < .001). When non-verbal cognitive ability and communication at age 3 were added to the model, as was found for expressive language, communication at age 3 (p = .01) but not non-verbal cognitive ability (p = .52) was significantly associated with receptive language at age 5 (with socialization once again falling to a value of p = .06).

Other Predictors of Expressive Language Acquisition by Age 5

As shown in Fig. 1, to explore the contributions of age 2 variables in discriminating children's expressive language acquisition at age 5, dichotomous groups of all 131 children referred for either autism or developmental disabilities were formed, categorized as either "no spontaneous words" or "at least some language" (i.e. no language = 2, versus some language = 1 or 0 on the ADI-R overall level of language question) at age 2. Our particular interest was children who had no or very little expressive language at age 2, and the characteristics that predicted whether they would acquire some words by age 5. For this reason, we used a step-wise process to identify them. First, they were

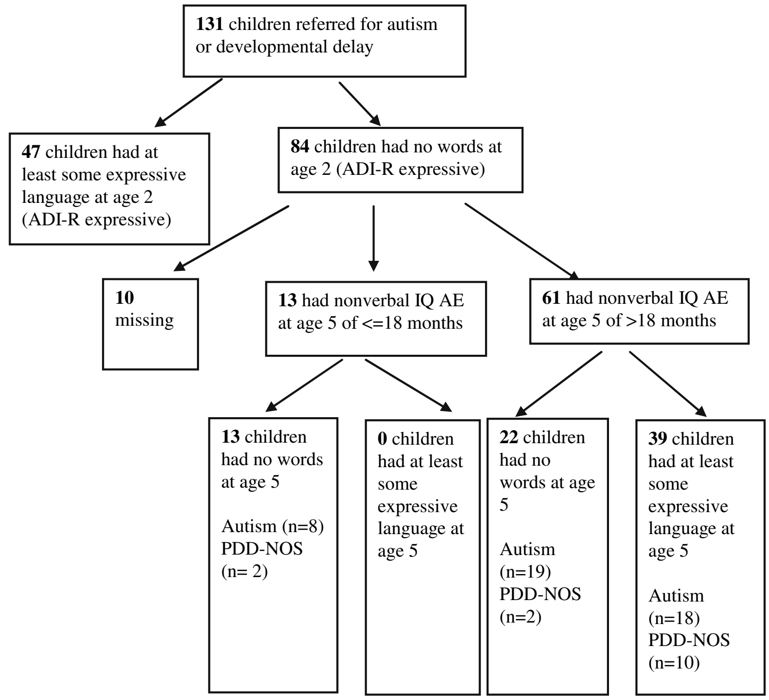


Fig. 1 Tree diagram of participants according to expressive language and cognitive ability status (expressive language is defined by using ADI-R item—overall level of language)

selected by their language level at age 2 (verbal, non-verbal) and then by eliminating children whose non-verbal cognitive skills were still under age 18 months at age 5. We were particularly interested in accounting for what factors were associated with failure to progress in language in children whose non-verbal skills would have led us to expect greater changes. We excluded children with non-verbal skills under 18 months at 5 because their non-verbal skills were so limited that their language delays could be accounted for by severe general mental retardation or developmental delays.

Eighty-four of 131 children had no expressive language as defined by the ADI-R at age 2. Subcategorizing according to whether there was ‘‘sufficient’’ non-verbal cognitive ability at age 5 (defined as above an age equivalent of 18 months on direct testing measures at age 5); 61 of the 84 children were in this group, as shown in Fig. 1. Eighteen months was selected as a non-verbal age equivalent by which time most children would have 5 or more words used spontaneously on a daily basis. This ‘‘sufficient non-verbal ability’’ group was then subdivided into children who acquired at least some language by age 5 (using the same ADI-R criterion); 39 of the 61 children were in this category. Children within the autism spectrum (28/39 of the children with some language at age 5 and 21/22 of the children with no language at age 5) were then compared on the specific socio-communicative, imitation and cognitive variables described earlier, to determine discriminators of the two groups of children who had sufficient non-verbal ability but different language outcomes at age 5 (see Fig. 1).

Results of *t*-tests displayed in Table 4 indicate that age 2 non-verbal cognitive ability, VABS socialization domain, and both expressive and receptive communication subdomains of the VABS differed significantly for children with ASD who either acquired or did not acquire some expressive language by age 5. In addition, both PL-ADOS items of responding to joint attention and initiating joint attention at age 2 were significantly different between the language outcome groups. The specific VABS expressive communication item ‘‘imitating sounds of adults immediately after hearing them’’ and the VABS socialization domain item, ‘‘imitates simple adult movements, such as clapping hands or waving good-bye, in response to a model’’ were also significantly different between the groups.

Other Predictors of Receptive Language in Samples by Non-verbal Ability

Predictors of measurable improvement in receptive language between 2 and 5 were also explored, focusing on the contributions of age 2 socio-communicative, imitation and cognitive variables in children who did and did not acquire at least minimal receptive language by age 5. Dichotomous groups of all 131 children referred for either autism or developmental disabilities were formed, categorized as either ‘‘little or no

Table 4 Predictors from age 2 of age 5 expressive and receptive language acquisition among children with age 5 non-verbal abilities over 18 months

	No expressive language at 5 (*n* = 21)	Has expressive language at 5 (*n* = 28)			No receptive language at 5 (*n* = 28)	Has receptive language at 5 (*n* = 32)		
	Mean (SD)	Mean (SD)	Effect size	*t* (df)	Mean (SD)	Mean (SD)	Effect size	*t* (df)
Non-verbal AE Ratio	0.56 (0.14)	0.67 (0.17)	–0.71	–2.40* (47)	0.56 (0.14)	0.67 (0.14)	–0.79	–2.84** (58)
VABS Social AE Ratio	0.27 (0.10)	0.34 (0.14)	–0.58	–2.14* (47)	0.27 (0.11)	0.37 (0.12)	–0.87	–3.43** (58)
VABS Daily Living AE Ratio	0.55 (0.11)	0.54 (0.13)	0.08	0.25 (47)	0.53 (0.12)	0.55 (0.13)	–0.16	–0.70 (58)
VABS Expressive Communication AE Ratio	0.18 (0.12)	0.28 (0.13)	–0.80	–2.68** (47)	0.20 (0.13)	0.30 (0.14)	–0.74	–2.85** (58)
VABS Receptive Communication AE Ratio	0.24 (0.10)	0.35 (0.23)	–0.62	–2.07* (47)	0.25 (0.12)	0.35 (0.12)	–0.83	–3.19** (58)
VABS—Imitates Sounds	0.19 (0.51)	0.82 (0.67)	–1.06	–3.60*** (47)	0.35 (0.56)	0.79 (0.79)	–0.64	–2.21* (43)
VABS—Imitates Simple Movements	0.71 (0.56)	1.32 (0.72)	–0.95	–3.19** (47)	0.81 (0.63)	1.37 (0.68)	–0.85	–2.84** (43)
PL-ADOS Response to JA	2.14 (0.57)	1.61 (0.88)	0.71	2.44* (47)	2.21 (0.57)	1.50 (0.67)	1.14	4.41*** (58)
PL-ADOS Initiate JA	1.80 (0.52)	1.39 (0.74)	0.64	2.12** (46)	1.74 (0.59)	1.44 (0.72)	0.46	1.75 (57)
SICD Raspberry/tongue click imitation (parent report)	0.26 (0.45)	0.40 (0.50)	–0.29	–0.94 (42)	0.25 (0.44)	0.50 (0.51)	–0.52	–1.69 (40)

Note: All children in this table were diagnosed at age 5 with either autism or PDD-NOS. See Figs. 1 and 2 for breakdowns

*$p \le .05$; **$p \le .01$; ***$p \le .001$; VABS = Vineland Adaptive Behavior Scales; AE = Age Equivalent; PL-ADOS = Pre-linguistic Autism Diagnostic Observation Scale, SICD = Sequenced Inventory of Communication Development; JA = joint attention

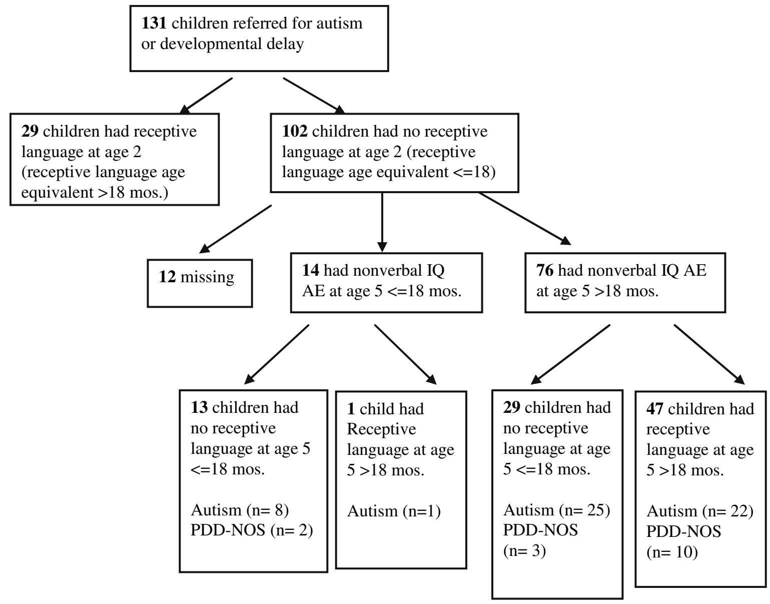
receptive language'' (i.e. less or equal than 18 months on the hierarchically selected language test) or ''some receptive language'' (i.e., more than 18 months on a language test). According to these rules, 102 of the 131 children had little or no receptive language at age 2. As shown in Fig. 2, children were then subcategorized by whether they achieved an 18-month age equivalent on non-verbal ability at age 5 (76 of the 102 children). The ''sufficient'' non-verbal ability group was then subdivided into those who acquired some receptive language by age 5 (using the same criterion): 47 of the 76 children were in this category and children with no or minimal receptive language, who comprised the remaining 29 children. Children within the autism spectrum (38/47 of the children with receptive language at age 5 and 28/29 of the children with no receptive language at age 5) were then compared on socio-communicative, imitation and cognitive variables to provide descriptions of receptive language in children whose non-verbal skills were high enough that a minimal level of receptive language would be expected by age 5.

Results of *t*-tests displayed in Table 4 indicate that age 2 non-verbal cognitive ability, VABS socialization domain scores and both expressive and receptive subdomains of the Vineland communication domain were significant discriminators of the groups of children who either acquired or did not acquire some receptive language by age 5. In addition, the groups differed on the PL-ADOS item of responding to joint attention at age 2, as well as on the specific VABS expressive communication item ''imitating sounds of adults immediately after hearing them,'' and the VABS socialization domain item, ''imitates simple adult movements, such as clapping hands or waving good-bye, in response to a model.''

Best ''Specific Behavior'' Predictors of Expressive and Receptive Language

Based on results of the *t*-tests exploring significant predictors of language status outcome group for both expressive and receptive language in Table 4, regressions were performed to determine which of these specific behaviors best predicted language status group. For these analyses, scores representing summaries (e.g. non-verbal cognitive ability, VABS social and communication domains) were removed, as the strength of their associations with language outcome was demonstrated above. For expressive

Fig. 2 Tree diagram of participants according to receptive language and cognitive ability status



language, when responding to joint attention, initiating joint attention, imitating sounds and imitating simple movements were placed in the regression, imitating sounds was found to be a significant predictor ($N = 48$; Odds Ratio = .24, 95% Confidence Interval .06, .96; $p < .05$), with imitating simple movements marginally significant (Odds Ratio = 0.36, 95% Confidence Interval .12, 1.11; $p = .07$). For receptive language, only responding to joint attention was found to significantly predict receptive language ($N = 45$; Odds Ratio = 4.85, 95% Confidence Interval 1.24, 19.01; $p < .05$).

Discussion

In this unique sample of children diagnosed with autism, PDD-NOS or non-spectrum developmental disorders, age 2 and 3 measures of communication (from both parent reports and direct assessments) and cognitive ability significantly predicted both expressive language and receptive language development at age 5. Non-verbal cognitive ability and earlier communication skills were consistently strong predictors of later language acquisition. Although socialization was not a significant predictor of receptive language when these variables were added to the model, on its own the VABS socialization domain at age 2 predicted approximately 20% of the variance in receptive and expressive language in children with autism.

At age 3, socialization approached significance as a unique predictor (while non-verbal cognitive ability dropped out), similar to findings in other studies with preschool children (Charman et al., 2005; Lord & Schopler, 1989). One explanation for the increasing contribution of socialization from age 2 to age 3 in predicting later receptive and expressive language acquisition (above and beyond that of non-verbal ability and early language measures) is that the very early social adaptation items on the VABS are difficult to differentiate from communication items, resulting in high collinearity. For example, one item of the receptive communication subscale describes "Raises arms when caregiver says, 'Come here' or 'Up'" while an early item in the socialization scale is "Shows anticipation of being picked up by caregiver." Later items on these scales are more differentiated and the most recent Vineland attempts to remedy this effect (Sparrow, Cicchetti, & Balla, 2005). In addition, with greater social demands placed on 3-year-olds as they enter school or other settings that increase time with peers, parents' awareness of their child's social disengagement may increase.

Results supported theoretical links between skills used in responding to joint attention (i.e. perception of communicative intent of others' words and gestures, social orienting) and language (Dawson et al., 2004), implicating joint attention as a "pivotal skill" (Charman, 2003) for young children with autism. The unique relationship of "responding to" joint attention with receptive language in the current study highlights the role of non-verbal communication in verbal comprehension over time. Improved definitions of responding to, or "receptive" versus initiating, or "expressive" joint attention, will help clarify the degree to which separate communicative functions are involved in initiating gaze shifts versus responding to another's bid for attention. This will be particularly important in light of recent findings indicating that elements of these behaviors (e.g. visual tracking, disengagement of visual attention, imitation skills) may be markers of autism in children as young as 12 months (Zwaigenbaum et al., 2005).

Likewise, imitation of simple sounds was specifically associated with expressive language outcome, supporting the purported link between oral-motor speech abilities and expressive language in autism (Gernsbacher et al., 2002). Recent findings of a possibly distinct behavioral and neuroanatomical specific language impairment phenotype in autism (De Fosse et al., 2004) also support a theory of ''language-specific acquisition mechanisms'' in autism (Tager-Flusberg, Paul, & Lord, 2005).

Patterns of prediction for receptive and expressive language at age 5 from 2- and 3-year-old measures were very similar except that the diagnosis of autism significantly predicted later scores for receptive but not for expressive language. These results may reflect the generally lower receptive language scores of children in the autism group compared to other diagnostic groups. They support previous findings that receptive language impairments may serve as a particularly important red flag for autism in young children with developmental delays (Philofsky et al., 2004; Rogers, Wehner, & Hagerman, 2001).

Our results follow the mixed findings in the autism literature regarding the relationship between early cognitive skills and language development. Charman and colleagues (2003) found no significant relation between non-verbal cognitive skills and language at 42 months when cognitive skill was categorically divided and children were 20 months at initial testing. Using a combined verbal and non-verbal score, Mundy, Sigman and colleagues (Mundy et al., 1990; Sigman et al., 1999) found similar results. Nevertheless, in the current study, non-verbal ratio IQ at 2, but not at age 3, predicted receptive and expressive language skills at 5 when controlling for initial communication skills. The strength of non-verbal cognitive skills in relation to language development was recently emphasized in a study of typically developing twins (Oliver, Dale, & Plomin, 2004). This study found non-verbal cognitive development at ages 3 and 4 was almost as strong as earlier language in predicting language at age 4 and a half, illustrating the complexity of relationships between non-verbal cognition and language over time.

Differences between predictive factors for receptive and expressive language were fewer than expected for children with autism, PDD-NOS and non-spectrum disorders with respect to unique contributions of ''broad'' skill categories (i.e. non-verbal cognitive ability, socialization, and communication skills), though because of the high correlation between the two aspects of language at 5, this should not have been surprising. The one interesting difference was the unique relationship between an autism diagnosis and receptive language, in contrast to expressive language. However, using a novel approach that categorized children based on their longitudinal acquisition of language (and cognitive ability), specific skills differentially related to one aspect of language versus another when children with autism and PDD-NOS were grouped together and analyzed categorically according to language acquisition. Given the high correlations between receptive and expressive language, finding differences according to receptive language outcome for joint attention and according to expressive language outcome for imitation lends tantalizing, but still speculative support for the potential power of early measures that deconstruct developmental components of language.

Most obviously, a significant minority of children with ASD who had minimal levels of expressive (Fig. 1) or receptive (Fig. 2) language at age 5 had severe to profound retardation even on non-verbal measures. However, that left a majority of children who, based on non-verbal skills, would be expected to at least understand and say some words. More children at age 5 had minimal receptive language than expressive language, indicating that deficits were not primarily oral-motor. Almost all of the children who fell into these minimal language groups had a diagnosis of autism or PDD-NOS.

Limitations of this study include its use of different assessments and variables over time for tracking language and cognition. Floor effects as well as appropriateness of assessments at different ages for children of different skill levels affected these decisions. These factors also contributed to our decision to use categorical variables (for example, use of the overall level of language variable). Another limitation was that specific interventions were not taken into account as predictors or moderators of language outcomes. Due to small sample sizes for the PDD-NOS and non-spectrum developmental disorders groups, we were unable to separate groups (other than autism) for comparison, limiting the specificity of our results in finding autism-specific predictors. A statistical limitation was the high degree of multi-collinearity of the data. While we tried to reduce collinearity by using multiple assessment sources for different variables analyzed, this was not always possible. The overlap between test results in independent developmental domains (non-verbal cognitive skills, language, socialization) reflects the multi-dimensional nature of the autism diagnosis.

In sum, the VABS Adaptive Behavior Scales at age 2 and 3 years, a relatively inexpensive, user-friendly measure of adaptive skills in communication, accounted for much of the variability in language acquisition in 5-year-old children with autism and other developmental delays. At age 2, direct assessment of non-verbal cognitive ability, a diagnosis of autism (for receptive language) and specific joint attention and imitation items from both direct observation and parent report also provided critical predictive information about language skills at age 5. Certain specific skills stood out as potentially powerful predictors—imitation of sounds for expressive language, and responding to joint attention for receptive language. As measures such as the Vineland continue to be refined, further exploration of early childhood predictors (and potential markers of later language acquisition) should allow for more focused intervention strategies to be developed and tested.

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