J Autism Dev Disord (2008) 38:1426–1438
DOI 10.1007/s10803-007-0510-1

ORIGINAL PAPER

Language Assessment and Development in Toddlers with Autism Spectrum Disorders

Rhiannon J. Luyster · Mary Beth Kadlec · Alice Carter · Helen Tager-Flusberg

Published online: 11 January 2008
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Abstract One of the primary diagnostic criteria for the diagnosis of autism spectrum disorders (ASD) is the presence of a language delay or impairment. Children with ASD are now being identified at significantly younger ages, and prior research has consistently found that early language skills in this population are heterogeneous and an important predictor for later outcome. The goal of this study was to systematically investigate language in toddlers with ASD and to identify early correlates of receptive and expressive language in this population. The study included 164 toddlers with ASD between the ages of 18 and 33 months who were evaluated on several cognitive, language and behavioral measures. Results suggested good agreement among different measures of early language, including direct assessment and parent report measures. Significant concurrent predictors of receptive language included gestures, non-verbal cognitive ability and response to joint attention. For expressive language, the most significant predictors were non-verbal cognitive ability, gestures and imitation. These findings have important implications for intervention programs targeting this population.

R. J. Luyster
Autism Consortium, Boston, MA, USA

M. B. Kadlec · H. Tager-Flusberg (✉)
Department of Anatomy and Neurobiology,
Boston University School of Medicine, 715 Albany St. L-814,
Boston, MA 02118, USA
e-mail: htagerf@bu.edu

A. Carter
University of Massachusetts, Boston, MA, USA

Keywords Language · Toddlers · Early childhood · Development · Assessment

Introduction

Autism spectrum disorder (ASD) is an umbrella term for three developmental disorders: autism, pervasive developmental disorder–not otherwise specified (PDD-NOS) and Asperger Disorder, which are generally viewed as sharing common symptoms and etiology (Lord et al. 2006). Delays and deficits in language acquisition are among the key diagnostic criteria for autism spectrum disorders (American Psychiatric Association 1994), and the absence of first words and phrases is the foremost reason reported by caregivers of children with ASD for their initial concern about their child's development (DeGiacomo and Fombonne 1998; Wetherby et al. 2004). Estimates of the proportion of individuals with ASD who remain non-verbal vary widely, but are generally reported at around one quarter of the population in more recent studies (Lord et al. 2004; Sigman 1998; Sigman and McGovern 2005). Most of these children not only lack conventional language but are also severely limited in their ability to communicate with others often using alternative communication systems, such as sign language or augmentative devices (Bailey et al. 1996; Bosseler and Massaro 2003; Seal and Bonvillian 1997).

There are several important reasons for investigating the early stages of language and communicative development in very young children with ASD. First, studies have consistently reported significant variability in certain language skills among older verbal children with ASD (Bartak et al. 1975; Kjelgaard and Tager-Flusberg 2001), with some children achieving vocabulary and grammatical skills that are similar to typically developing children, while others have significant impairments in these aspects of language. At the same time, all children with ASD, even those with age appropriate scores on standardized language tests, have significant impairments in many aspects of pragmatics and discourse. Exploring the emergence of language and language-related skills in very young children will identify early markers for different language outcomes in this population. Second, research addressing the correlates and predictors of language development in preschoolers has yielded intriguing results, generally suggesting that the factors that are important for language development in ASD are similar to those observed in typical development. Further exploration of early correlates of language in a large sample of toddlers with ASD will address questions about whether the process of language development in children with ASD is qualitatively similar or dissimilar to that observed in typically developing children. Understanding the mechanisms that underlie delays and deficits in language acquisition is especially important because language ability is the key prognostic factor for long-term outcomes among children and adults with ASD (Lord and Ventner 1992). Consequently, exploring the key predictors of language development in ASD has both theoretical and applied implications.

Assessing Language in Children with ASD

Generally, there are two approaches to the measurement of early language skills in this population: standardized testing and parent report. Criticisms have been raised about both methods. Some have suggested that standardized tests are inappropriate for children with ASD because they often tap skills that are too advanced for the child being assessed (Charman 2004) or because of complications arising from a lack of attention or motivation (Koegel et al. 1997). Others have argued that parent report is less accurate, because caregivers tend to over-estimate their child's language, particularly comprehension skills, because children may be responding to non-verbal, rather than verbal, cues (Tomasello and Mervis 1994).

Despite these concerns, both approaches offer valuable information about a child's linguistic skills. Results from standardized language tests administered to children with ASD during the preschool years predict later language outcome (Charman et al. 2005; Sigman and McGovern 2005; Siller and Sigman 2002). Additionally, some researchers (Charman 2004; Condouris et al. 2003; Fenson et al. 1993; Stone and Yoder 2001) have explored the consistency of parent-report data with formal testing results, finding fair to good agreement, although more extensive research has been conducted on expressive than on receptive language. These findings support the argument that a multi-method approach to language assessment may be the most valid practice for measuring language skills and language use in different contexts (e.g., Bornstein et al. 1998). To further address this issue, one goal of the current investigation was to explore the consistency of three common standardized measures used to assess language and communication in toddlers with ASD.

Predictors of Language Acquisition

Within the field of language acquisition in typically developing children, researchers have focused on the role of early social-cognitive developments as important precursors to the onset of vocabulary and other key language milestones (e.g., Bruner and Sherwood 1983; Watt et al. 2006). Carpenter et al. (1998) characterized this cluster of skills, which includes joint attention, gaze following, imitation and gesture use, as indicative of "a newly emerging understanding of other persons as intentional beings whose attention to outside objects may be shared, followed into and directed in various ways" (Carpenter et al. 1998, p. V). They argue that these social-communicative skills are fundamental to the language acquisition process. Other researchers have also implicated behaviors such as play, particularly pretend play, in language development, suggesting that these behaviors permit the establishment of symbolic representation (Leslie 1987; Ungerer and Sigman 1984).

In previous research both concurrent and longitudinal predictors of language development in children with ASD have been explored, with results that parallel those found in other children. Findings from cross-sectional studies have demonstrated that concurrent language is predicted by joint attention skills (Carpenter et al. 2002; Dawson et al. 2004; Mundy et al. 1990; Mundy et al. 1987), imitation (Carpenter et al. 2002; Stone et al. 1997), and play (Mundy et al. 1987). Results from longitudinal studies also show that later language is predicted by early joint attention (Charman et al. 2003; Mundy et al. 1990; Sigman and McGovern 2005), imitation (Charman et al. 2003; Stone et al. 1997; Stone and Yoder 2001), and play (Sigman and McGovern 2005).

Less attention has been paid to the role of non-imitative motor development in the acquisition of language in children with ASD. Proposals about typical development have implicated motor skills in language development, hypothesizing the existence of a common underlying phylogenetic mechanism, such that motor acts might have evolved to verbal communication via gestures (Arbib and Rizzolatti 1996). This theory has received indirect support from studies demonstrating motor cortex activation during linguistic tasks in typically developing individuals (Floel et al. 2003; Meister et al. 2003). Research has provided evidence for a relationship between motor skills and language development in special populations, including children with language delay (Eisenmajer et al. 1998; Paul and Fountain 1999), specific language impairment (Webster and Shevell 2004), and ASD (Ghaziuddin et al. 1994; Rapin 1996). Interestingly, a number of studies have suggested that populations at-risk or diagnosed with language impairments may show higher associations between motor skills and language than do typically developing children (Dyck et al. 2006; Lyytinen et al. 2001; Noterdaeme et al. 2002).

The majority of studies on predictors of language acquisition in children with ASD have included a limited set of factors and included relatively small samples of preschool-aged or older children with ASD. Moreover, most of these studies have focused primarily on predictors of expressive language skills. As a result, it remains unclear which among the various factors implicated in prior studies are the most significant predictors of both receptive and expressive language development or how they might combine to predict the onset of language in very young children with ASD.

Thus, the goal of the present study was to include a comprehensive set of behavioral measures that could be investigated as potential predictors of early receptive and expressive language in a large cohort of toddlers with ASD. The study addressed two key questions:

(1) What are the associations between receptive and expressive language scores that are obtained from different measures of early language in toddlers with ASD?
(2) What are the best predictors of concurrent receptive and expressive language skills? We included measures of non-verbal cognitive ability, joint attention, imitation, play, gesture use, and motor skills.

Methods

Participants

The sample included 164 toddlers with ASD, 129 boys and 35 girls; 142 white, two African-American, four Asian, one American Indian/Alaskan Native and 15 multi-racial. The average age of the sample was 28.41 (SD = 3.95) months, with a range from 18 to 33 months. All but three of the informants (usually mothers) had at least a high school diploma or G.E.D., and 91 (55.49%) had obtained college degrees or above.

Exclusionary criteria included all non-idiopathic cases of autism, including known genetic disorders (e.g., Rett's syndrome, fragile X syndrome), or those with physically handicapping conditions (e.g., cerebral palsy) or frank neurological disease.

All children were assigned a diagnosis of ASD based on meeting research criteria for autism or ASD on the Autism Diagnostic Interview—Revised (ADI-R; Lord, Rutter and Le Couteur 1994) and Autism Diagnostic Observational Schedule—Generic (ADOS-G; Lord et al. 2000) as well as based on clinical impression by an expert clinician. On the ADOS, 56 children met the cutoff for autism spectrum disorder and 108 met the autism cutoff. On the ADI-R, 134 children met the autism cutoff, and the remaining 30 met the expanded ASD research cutoff outlined in previous investigations (Lord et al. 2006; Risi et al. 2006).

Procedure

Participants between the ages of 18 and 33 months were recruited primarily through collaboration with early intervention providers in the state of Massachusetts. Families who met the criteria for study entry on a telephone screen were invited to participate in the study. They were mailed a packet of questionnaires and two visits were scheduled. One visit, lasting approximately 2–3 h, included the direct child assessments and was scheduled in a laboratory setting and videotaped. During this visit, the following assessments were administered: ADOS-G; Mullen Scales of Early Learning (Mullen 1995); Imitation Battery (IB; see Rogers et al. 2003); and the Early Social Communication Scales (ESCS; Mundy and Hogan 1996; ESCS-L; Thorp and Mundy submitted; Van Hecke et al. 2007).

A second visit, lasting approximately 2–4 h, in either homes or project offices, was conducted primarily with mothers and included the ADI-R, and the Vineland Adaptive Behavior Scales (VABS; Sparrow et al. 1984). In addition, parent questionnaire booklets were completed, which included the MacArthur-Bates Communicative Development Inventories (MCDI; Fenson et al. 1993).

Description of Assessment Instruments

Autism Diagnostic Observational Schedule: Generic (ADOS-G; Lord et al. 2000)

The ADOS-G is a semi-structured, interactive observation designed to assess social and communicative functioning in individuals suspected of having an autism spectrum disorder. One of four developmentally appropriate modules is used, based on the child's language level and age. Children in this study were administered either Module 1 (preverbal or single word speech; $n = 157$) or Module 2 (phrase speech; $n = 7$). The assessment involves a variety of social "presses" designed to elicit behaviors relevant to a diagnosis of autism. A standardized diagnostic algorithm can be calculated, consistent with autism criteria in DSM-IV/ICD-10. Established cut-off scores are used to differentiate autism, autism spectrum, and non-autism spectrum participants.

The assessment was scored by both research assistants and a psychologist trained in the ADOS until the research assistants reached a consistent reliability of at least 80% on the total score and the algorithm items. Subsequently, at least 10% of the assessments were co-scored, with an inter-rater reliability of 91.38 for the entire assessment and 91.63 for the algorithm items.

Autism Diagnostic Interview-Revised (ADI-R; Lord et al. 1994)

This is an investigator-based, semi-structured caregiver interview for the diagnosis of autism. Items have been shown to be reliable and the accompanying algorithm adequately discriminates autistic individuals from a mental-age matched non-autistic comparison group (Lord et al. 1994). Prior to administering the ADI-R independently, each examiner achieved reliability of 90% on the entire interview as well as the algorithm items.

Mullen Scales of Early Learning (Mullen 1995)

This is an assessment of developmental functioning for children from birth to 5 years 8 months. The Mullen provides an overall score (Early Learning Composite) and subtest scores for gross and fine motor skills, visual reception, and receptive and expressive language. The split-half internal consistency coefficients of the composite and domain scores are acceptable, with the composite having an internal reliability value of .91, and the individual domains ranging in value from .75 to .83. The 1- to 2- week test-retest reliability in a sample of 1- to 24- month old children was also sufficient for each subscale, ranging in value from .82 to .96. Test-retest reliability for a sample of children 25–56 months ranged in value from .71 to .79. For the current study, Mullen data were missing for one participant due to non-compliance.

Vineland Adaptive Behavior Scales-Expanded Form (VABS; Sparrow et al. 1984)

This interview was administered to the parents to assess their children's personal and social sufficiency in four domains: Communication (Receptive, Expressive, Written), Daily Living Skills (Personal, Domestic, Community), Socialization (Interpersonal Relationships, Play and Leisure Time, Coping Skills), and Motor Skills (Gross, Fine). It also yields a summary score: the Adaptive Behavior Composite. The Vineland has adequate psychometric properties, with reliability coefficients ranging from .83 to .99 (Sparrow et al. 1984).

MacArthur-Bates Communicative Development Inventories (MCDI; Fenson et al. 2003)

This measure provides a parental assessment of children's early language. The Words and Gestures form is designed for use with children with language skills between the ages of 8 and 16 months and provides a measure of vocabulary comprehension, vocabulary production and use of gestures. The Words and Sentences form is designed for use with children whose language skills are between the ages of 16 and 30 months and measures vocabulary production, sentence complexity, grammatical development and the mean length of the child's three longest utterances. This form does not yield a receptive language score. Participants in the current investigation were given the MCDI Words and Gestures version unless, following the guidelines in the manual, parents of girls reported that their child produced more than 30 words or parents of boys indicated that their child produced more than 20 words, in which case the MCDI Words and Sentences version was completed. In the standardization sample, the average number of words produced for girls was higher than the boys at 16 months of age; therefore, cut-offs for words produced were created for the child's sex and age. MCDI Words and Gestures were missing for 48 participants, as these participants were administered only the Words and Sentences version of this measure. An additional 18 participants were initially given the Words and Gestures version and scored at ceiling; as a result, they were then given the Words and Sentences version. Thus, for these 66 children, only an expressive language score was available, based on the MCDI. Norms were developed on a wide range of children and the MCDI has been found to have excellent validity and reliability for both normal and autistic populations (Charman et al. 2003).

Early Social Communication Scales (ESCS; Mundy and Hogan 1996; ESCS-L; Thorp and Mundy, submitted)

This is a measure of non-verbal social communication skills for children up to age 30 months. Children are presented with a variety of attractive toys to elicit behaviors in three categories: Social Interaction, Joint Attention and Behavior Regulation. Social Interaction presentations include both social and object-based turn-taking games, and joint interactions involving a hat, comb and glasses. Joint Attention opportunities include activated wind-up and hand operated mechanical toys, a picture book interaction and an examiner-initiated pointing task in which the examiner says the child's name three times while pointing to each of four posters on the wall. Opportunities for Behavior Regulation/Requesting occur within the context of the mechanical toy trials. For this study, researchers scored the ESCS using the live scoring (ESCS-L), an abbreviated version of the original ESCS coding scheme (Mundy et al. 2003).

In past research on children with autism, the ESCS-L has been shown to have a high degree of reliability with the ESCS in identifying early social communication behaviors, with intraclass correlations between .63 and .98. For this study, research assistants coded each ESCS with a trained, reliable coder until they reached a reliability of at least 80%. Subsequently, 10% of all assessments were co-scored, and the average interrater reliability was 88.33.

Imitation Battery (IB; see Rogers et al. 2003)

This battery was developed to examine imitation skills in very young children, including children with ASD. The original battery consists of nine tasks involving imitating examiner's manual and oral-facial movements and manipulating objects (three manual acts, three oral-facial actions, and three actions on objects). The child's performance on each task is scored for accuracy on a 0–4 scale. Three additional oral-facial items were incorporated to include less complex movements for this young sample. As for the ESCS, research assistants coded each imitation battery with a trained, reliable coder until they reached a reliability of at least 80%. Subsequently, 10% of all assessments were co-scored, and the average inter-rater reliability was 97.20.

Measures of Core Constructs

Language

Receptive and expressive scores from the Mullen, Vineland (Communication domain) and MCDI were used as measures of language.

Non-verbal Cognitive Ability

The Mullen Visual Reception raw score was the index of non-verbal cognitive ability.

Joint Attention

On the ESCS, joint attention and behavior regulation/requesting behaviors were coded into either high (pointing, showing, giving) or low (eye contact, reaching) responses. Frequency scores were obtained for higher and lower levels of the following behaviors: initiating joint attention, initiating behavioral requests, initiating social interaction and responding to social interaction, yielding one overall score for initiation of joint attention (IJA). Percentage scores were calculated for responding to joint attention and responding to behavioral requests, yielding one overall score for response to joint attention (RJA).

Imitation

A total imitation score (maximum = 48) was generated by summing the child's best score on each item in the IB battery.

Play

Play scores were taken from the two ADOS (Lord et al. 2000) items on functional and symbolic play for children administered Module 1. These two items reflect the ability of the child to use the materials in the ADOS spontaneously in a functional and symbolic manner, and both are given scores between 0 and 3 (3 marking a higher level of impairment). For the analyses reported here, the play variables were reverse coded so that higher scores corresponded to better play skills. Although these items were taken from the ADOS (which is a diagnostic measure), these items do not contribute to the algorithm score and thus do not weigh on the child's diagnostic category assignment.

Gesture

The number of items (out of 12) endorsed by the mother on the MCDI (Fenson et al. 1993) "First Communicative Gestures" was used as the measure of gesture mastery. These items include a variety of early appearing gestures, including imperative, declarative and conventional gestures.

Table 1 Age equivalent scores (in months) and raw scores on measures of receptive and expressive language

	Mullen	Vineland	MCDI
Receptive language[a]			
Median age equivalent (Range)	13.00 (3–36)	16.00 (3–46)	13.00 (8–16)
Mean raw score (SD)	16.25 (6.35)	20.38 (7.91)	90.93 (74.87)
Expressive language[b]			
Median age equivalent (Range)	16.00 (3–45)	13.00 (4–29)	15.00 (8–30)
Mean raw score (SD)	16.75 (7.49)	31.33 (16.30)	86.90 (121.42)

Note: Mullen = Mullen Scales of Early Learning; Vineland = Vineland Adaptive Behavior Scales; MCDI = MacArthur-Bates Communicative Development Inventory

[a] Includes only MCDI Words and Gestures data

[b] Includes both MCDI Words and Gestures and Words and Sentences data

Motor

A composite score for motor skills was created. Five variables were included: Mullen Fine Motor raw score, Mullen Gross Motor raw score, Vineland Fine Motor Subdomain raw score, Vineland Gross Motor Subdomain raw score, and the Vineland Motor Domain raw score. Each raw score was converted into a *z*-score (to standardize), and the five *z*-scores were summed to create the composite motor measure.

Analytic Plan

Analyses were designed to address the two primary questions. The first set of analyses addressed the correlations between receptive and expressive language scores across three measures of language: Mullen, Vineland and MCDI. Related to this first inquiry, analyses were also designed to compare the discrepancy between receptive and expressive language age equivalents across these three measures. The second set of analyses addressed the constructs that were most strongly correlated with concurrent language, separately for expressive and receptive language abilities. The following variables were entered in two hierarchical linear regression models predicting to expressive and receptive language respectively: chronological age, non-verbal cognitive ability, IJA, RJA, imitation, gestures, play and motor skills.

Results

Relationship among Measures of Receptive and Expressive Language

Raw scores from each language measure, Mullen, Vineland and MCDI, and corresponding age equivalents were used in the correlational and discrepancy analyses, respectively. These scores are presented in Table 1. Non-parametric statistical tests were used because these scores were not normally distributed; thus, effect size calculations are not available for all analyses, although they are reported when appropriate.

Spearman's partial rank order correlation tests controlling for age were used to assess the relationships among Mullen, Vineland and MCDI receptive and expressive raw scores. As shown in Table 2, these correlations were all highly significant. Friedman's tests revealed significant differences in age equivalents across measures for receptive language [χ^2 (84, 2) = 26.35, $P < .001$] and for expressive language [χ^2 (139, 2) = 41.64, $P < .001$]. A Wilcoxon Signed Ranks test indicated that for the Mullen, expressive language age was significantly higher than receptive ($Z = 4.49$, $P < .001$). In contrast, for the Vineland, receptive language age was significantly higher than expressive language ($Z = 5.72$, $P < .001$). There was also a significant difference in the receptive and expressive age equivalents on the MCDI Words and Gestures ($Z = 2.41$, $P < .05$), with a relative expressive advantage. However, the expressive subdomain of the MCDI is by definition a subset of the receptive subdomain (due to the checklist

Table 2 Spearman's Rho correlations among raw score measures of receptive and expressive language

	MCDI	Vineland
Receptive		
Mullen	.52*	.53*
MCDI		.77*
Expressive		
Mullen	.82*	.85*
MCDI		.88*

Note: Mullen = Mullen Scales of Early Learning; Vineland = Vineland Adaptive Behavior Scales; MCDI = MacArthur-Bates Communicative Development Inventory

* $P < .001$

nature of the measure) rather than a separate scale. In order to address this problem, we followed the approach taken by other researchers (Charman et al. 2003) by comparing the performance of children with ASD in this study to the normative data on the MCDI (Fenson et al. 1993). As shown in Fig. 1, the toddlers with ASD were advanced in their production of words relative to their receptive language level when compared to the MCDI norms.

Predicting Receptive and Expressive Language Abilities

To carry out the analyses on the predictors of receptive and expressive language in toddlers with ASD, we developed two composite variables, one for receptive and one for expressive language, based on the raw scores for the three language measures. Results of principle components factor analyses for expressive and receptive language indicated that each of the three measures loaded fairly equally on the factors. In light of this, and given that there were missing MCDI data that resulted in missing factor scores, average scores based on the standardized raw scores from the three measures of expressive and receptive scores were computed. These mean scores served as the expressive and receptive language composites. For participants with missing MCDI receptive data ($N = 66$) because they were not administered the Words and Gestures scale or had reached ceiling on the measure (see Methods), the

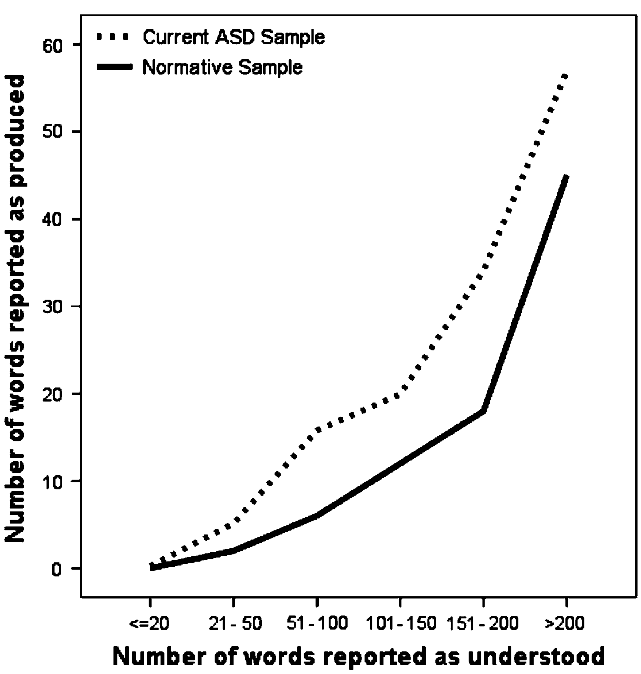

Fig. 1 Relationship between receptive and expressive language scores on the MCDI Words and Gestures form

composite receptive language score was based on the Mullen and Vineland receptive language scores.

Regressions equations predicting receptive and expressive language composites were modeled separately and proposed predictors included the following: (1) chronological age, (2) non-verbal cognitive ability, (3) IJA, (4) RJA, (5) imitation, (6) gestures, (7) play, and (8) motor skills. Means, standard deviations and ranges for these measures are presented in Table 3, and a correlation matrix of the language composites and predictor variables is presented in Table 4.

Hierarchical regression models were used to predict concurrent receptive and expressive language. The control variable (chronological age) was included in block one, and forward variable selection was used to determine the most important predictors (out of the remaining seven presented above) in block two. The results from the regression model predicting receptive language are presented in Table 5. The initial model had an R^2 of 0.04 ($P = .09$); the second model accounted for an additional 44% of the variance ($R^2 = 0.48$, $P < .001$); the third model accounted for a further 9% of the variance ($R^2 = 0.56$, $P < .001$); and the fourth model accounted for a final 4% ($R^2 = 0.60$, $P < .001$). Results indicated that number of gestures was a significant concurrent predictor ($t = 5.06$, $P < .001$), as was non-verbal cognitive ability ($t = 3.15$, $P < .01$) and RJA ($t = 2.69$, $P < .01$). The final model had a large effect size ($f^2 = 1.50$), according to Cohen (1988).

Results from the hierarchical regression model predicting expressive language are presented in Table 6. The initial model, including child age, was not statistically significant (R^2 of 0.01, $P = .54$); the second model, in which non-verbal cognitive ability was entered, accounted for an additional 33% of the variance (Model $R^2 = 0.34$, $P < .001$); the third model, in which gestures was added,

Table 3 Scores on variables used as predictors of receptive and expressive language

	M (SD)	Range
Chronological age (months)	28.41 (3.95)	18–33
Non-verbal cognitive ability (Mullen)	24.09 (5.53)	8–45
Initiation joint attention (ESCS)	4.44 (5.06)	0–36
Response to joint attention (ESCS)	.31 (.33)	0–1.00
Imitation (IB)	13.25 (12.03)	0–45
Gestures (MCDI)	5.71 (2.67)	0–12
Play (ADOS)	2.56 (0.88)	2–6
Motor (composite)	−.20 (4.18)	− 16.99–7.57

Note: Mullen = Mullen Scales of Early Learning; ESCS = Early Social Communication Scales; IB = Imitation Battery; MCDI = MacArthur-Bates Communicative Development Inventory; ADOS = Autism Diagnostic Observation Schedule

Table 4 Correlation matrix of language measures and predictor variables

	Age	Non-verbal cognitive ability (Mullen)	IJA (ESCS)	RJA (ESCS)	Imitation (IB)	Gesture (MCDI)	Play (ADOS)	Motor (composite)	Receptive language (composite)
Age									
Non-verbal cognitive ability	0.32***								
IJA	0.00	0.29***							
RJA	0.33***	0.51***	0.27**						
Imitation	0.26**	0.59***	0.32***	0.46***					
Gesture	0.21*	0.50***	0.05	0.42***	0.48***				
Play	0.07	0.34***	0.15	0.33***	0.30***	0.21*			
Motor	0.43***	0.67***	0.13	0.46***	0.45***	0.47***	0.33***		
Receptive language	0.36***	0.65***	0.21**	0.55***	0.55***	0.65***	0.29***	0.65***	
Expressive language (composite)	0.45***	0.70***	0.35***	0.57***	0.57***	0.55**	0.45***	0.59***	0.72***

Note: IJA = Initiation of joint attention; RJA = Response to joint attention; Mullen = Mullen Scales of Early Learning; ESCS = Early Social Communication Scales; IB = Imitation Battery; MCDI = MacArthur-Bates Communicative Development Inventory; ADOS = Autism Diagnostic Observation Schedule

* $P < .05$; ** $P < .01$; *** $P < .001$

accounted for a further 9% of the variance (Model $R^2 = 0.43$, $P < .001$); and the fourth model, in which imitation was added, accounted for a final 3% (Model $R^2 = 0.46$, $P < .001$). The final model indicated that non-verbal cognitive ability ($t = 3.40$, $P < .01$), the number of gestures ($t = 2.84$, $P < .01$), and imitation ($t = 2.11$, $P < .05$) each contributed unique variance. The effect size of the final model ($f^2 = .85$) was large.

Discussion

Several key findings emerged from this study of early language abilities in a large sample of toddlers with ASD. First, although the measures employed in this study to assess emerging language skills in toddlers with ASD involved direct assessment, parent questionnaire and parent interview, there was very close agreement among these

Table 5 Hierarchical regression for receptive language

Model		Unstandardized coefficients		
		B	SE B	Sig.
1	(Constant)	−1.25	0.61	0.04
	Chronological age	0.04	0.02	0.09
2	(Constant)	−2.00	0.46	0.00
	Chronological age	0.02	0.02	0.17
	Gestures	0.20	0.03	0.00
3	(Constant)	−3.07	0.51	0.00
	Chronological age	0.03	0.02	0.09
	Gestures	0.15	0.03	0.00
	Non-verbal cognitive ability	0.06	0.02	0.00
4	(Constant)	−2.75	0.50	0.00
	Chronological age	0.02	0.02	0.15
	Gestures	0.14	0.03	0.00
	Non-verbal cognitive ability	0.05	0.02	0.00
	Response to joint attention	0.66	0.24	0.01

Table 6 Hierarchical regression for expressive language

Model		Unstandardized coefficients		
		B	SE B	Sig.
1	(Constant)	−0.71	0.45	0.12
	Chronological age	0.01	0.02	0.54
2	(Constant)	−2.28	0.45	0.00
	Chronological age	0.01	0.01	0.49
	Non-verbal cognitive ability	0.07	0.01	0.00
3	(Constant)	−2.11	0.42	0.00
	Chronological age	0.00	0.01	0.75
	Non-verbal cognitive ability	0.05	0.01	0.00
	Gestures	0.08	0.02	0.00
4	(Constant)	−1.96	0.42	0.00
	Chronological age	0.00	0.01	0.85
	Non-verbal cognitive ability	0.04	0.01	0.00
	Gestures	0.06	0.02	0.01
	Imitation	0.01	0.01	0.04

different measures. Second, we found that both receptive and expressive language were significantly correlated with a range of general and social cognitive variables and motor skills, and that the best concurrent predictors for both receptive and expressive language were gesture use (as assessed by parent questionnaire) and non-verbal cognitive ability (measured by direct observation).

There is growing interest in studying early language acquisition in young children with ASD, both in research focusing on the natural course of development and in evaluating the language outcomes of early treatment (Rogers et al. 2006). Our findings on the close agreement between the standardized assessment of language using the Mullen, and parent report measures of expressive and receptive language indicate that there are several measurement options open to researchers, depending on the needs and scope of their investigations. The results reported here are consistent with other studies that have reported higher agreement between direct assessment and parent report measures for expressive language compared to receptive language (Charman 2004). The strong correlations among all three measures for expressive language (ranging from .82 to .88) indicate that parents of children with ASD provide valid and reliable data on their children's language skills. High levels of agreement across measures are consistent with findings reported by other researchers (Charman 2004; Fenson et al. 1994; Stone and Yoder 2001; Zwaigenbaum et al. 2005) and support the usefulness of parent report in assessing early language skills in children with ASD.

Despite these strong correlations, it is also important to note some of the differences among the measures we included in this study. For receptive language, the Vineland yielded a higher age equivalent than either the Mullen or MCDI. This may reflect the greater reliance of the Vineland on evaluating a broader range of communication skills across different social contexts. For expressive language, the Mullen yielded higher estimates than either of the parent report measures. This may be because of differences in the construction of the measures. The MCDI, for example, includes a broader range of linguistic categories (e.g., verbs, adjectives and adverbs) that are not part of the Mullen assessment at the youngest age levels. In addition, the Vineland, relative to the Mullen, has more advanced expectations at earlier ages. For instance, whereas on the Mullen, the item "uses two-word phrase" is expected between 24 and 32 months, on the Vineland, the item "uses phrases with a noun and a verb" is expected between 12 and 24 months.

We also found that the within-test discrepancy between receptive and expressive age equivalents differed across measures. The Mullen and MCDI yielded higher scores for expressive language, supporting other findings in the literature (e.g., Boucher 2003; Charman et al. 2003); however, the Vineland yielded the opposite profile, with higher scores for receptive language. Again, this difference may be an artifact of the items on each measure. Whereas the Mullen and MCDI have relatively equal numbers of items on the receptive and expressive scales, the Vineland has considerably fewer receptive items (20) than expressive items (54). As a result, the attainment of items on the receptive scale may result in larger gains in age equivalent scores than on the expressive scale. The current results suggest that the apparent pattern of relative strength and weakness in receptive and expressive language in young children with ASD is influenced by the assessment used.

The second part of this study focused on the relationship between non-verbal factors and language acquisition in toddlers with ASD, all of whom were at the early stages of developing language. Both receptive and expressive language skills were highly correlated with all the predictors we included. Although the general social-cognitive and motor skills we included correlated with both language composites, receptive and expressive language scores were predicted by a somewhat different set of concurrent skills. Receptive language was predicted by concurrent gesture use, non-verbal cognitive ability and response to joint attention, whereas expressive language was predicted by non-verbal cognitive ability, concurrent gesture use and imitation skills.

Although chronological was correlated with expressive and receptive language skills, it did not remain significant in the final regression models that included social cognitive and motor indices of child functioning. Our finding that non-verbal cognitive ability strongly predicted both receptive and expressive language abilities is consistent with previous findings (Charman et al. 2003; Charman et al. 2005; Lord et al. 1989; Thurm et al. 2007). Interestingly, the social cognitive ability which emerged as the other robust predictor of receptive and expressive language was gestural communication.

The role of joint attention in predicting language is consistent with previous findings in the ASD literature (e.g., Loveland and Landry 1986; Mundy et al. 1994). However, studies have been inconclusive about whether response to or initiation of joint attention are equally important predictors of language development. The current study is a step towards resolving this issue: our findings suggest that initiation of joint attention may be unrelated to concurrent language, and indeed to several other social cognitive abilities, at least in very young children with ASD. Response to joint attention, on the other hand, was robustly correlated with both language composites and was a significant predictor of concurrent receptive language. Several accounts have implicated the importance of being able to establish shared attention in the process of language learning (e.g., Baldwin 1995), in that it permits the child to gain experience sharing a focus on an external object or event with another person and to appreciate the communicative nature of that experience. It is theoretically intriguing then, that response to joint attention predicted concurrent (receptive) language whereas initiation of joint attention did not. It has been argued (Carpenter et al. 1998) that following (response to) and directing (initiation of) joint attention are developmentally distinct processes, and the current results indicate that the former may be more influential for acquiring language in the early stages for toddlers with ASD.

The significant relationship we found between imitation and concurrent expressive language echoes previous reports (Carpenter et al. 2002; Stone et al. 1997; Toth et al. 2006). It is also consistent with accounts of the role that imitation plays in social learning and acquiring shared communication strategies, for children with typical (Bates et al. 1989; Carpenter et al. 1998; Nagy 2006) and atypical development (Charman 2006). As was the case for joint attention, it remains unclear what components (if any) of imitation are most influential for language development. The current investigation used a composite score, which included manual, oral-facial and object-directed acts. Previous investigations have made a variety of qualitative distinctions among different imitative acts—including immediate versus deferred (Toth et al. 2006), actions with or without objects (McDuffie et al. 2005) or role-reversal imitation (Carpenter et al. 2005)—and have found differing relationships between these variables and language development. It will be important to establish further substantiation for the importance of these distinctions, as well as whether the relationship between imitative skills and language changes over time.

Gesture use (along with non-verbal cognitive ability) was the concurrent predictor that was most robust and consistent across both receptive and expressive language, suggesting that it may be the single most significant social communication predictor of overall language. This finding supports theories of language development that emphasize the close relationship between gestures and language (Bates and Dick 2002). Certain gestures, such as pointing, may be early signs of understanding that one can direct another person's attention (Desrochers et al. 1995), which later becomes a central function of verbal communication. It has been suggested that gestures are a means for a child to express an idea for which they do not yet have the linguistic means (Goldin-Meadow 2000), and that the production of gestures often predicts the emergence of the linguistic structures that are lacking (Iverson and Goldin-Meadow 2005). Others have characterized this process by describing gestures as a "bridge" between language comprehension and language production, with gestures scaffolding language from comprehension to production (Charman et al. 2003; Fenson et al. 1994). Because our measure of gesture use was based on the MCDI, which includes imperative (requesting behaviors, e.g., "requests something by extending arm and opening and closing hand"), declarative (requesting attention, e.g., "extends arm to show you something he/she is holding") and conventional (e.g., "smacks lips in a 'yum yum' gesture to indicate that something tastes good") gestures, it is not possible for our data to determine which of these types of gestures is most significant in predicting early language. The different categories of gestures may be differentially associated with milestones in receptive and expressive language (see Bates and Dick 2002), and thus it might be informative to conduct a more fine-grained analysis of specific types of gestures used based on the MCDI and perhaps to add measures of frequency to further explore this possibility, particularly for young children with ASD.

The overall picture of the relationship between early non-linguistic skills and language development in children with ASD is similar to the non-linguistic skills that have been implicated in the literature on typical development. Language development in the typical population has been associated with early and concurrent gesture use (Carpenter et al. 1998), response to joint attention (Carpenter et al. 1998; Delgado et al. 2002; Laakso et al. 2000; Morales et al. 2000) and imitation (Charman et al. 2000; Laakso et al. 2000; Masur and Eichorst 2002; McEwen et al. 2007). Indeed, a number of these skills are often grouped together under a broader conceptual umbrella of skills pertaining to the development of joint-engagement (Carpenter et al. 1998). Together, attainment of these skills permits a child to gain an understanding of being able to communicate based on shared conventions, whether verbal or non-verbal. Generally, then, the present results suggest that the process of language development may be qualitatively similar to that of typically developing children in terms of its underlying developmental framework.

It is interesting to note that the overall amount of variance for which the predictors accounted was quite similar in the models for receptive (60%) and expressive (46%) language. While the specific child factors that we included in our models account for between half and two-thirds of the variance in language abilities for children with ASD, they do not account for all the variance. Future research should focus on other variables that may be related in significant ways to early language development in children with ASD that were not included in this investigation; for example, gender, temperament, vocal repertoire, severity of autism symptoms, intensity of intervention, and maternal synchrony and linguistic input (Siller and Sigman 2002). It would also be important to extend this line of research longitudinally, to investigate factors that predict to later stages of language development, and to specific domains of language such as vocabulary, grammatical skills and pragmatic abilities. Finally, future studies should focus on children coming from a broader range of ethnic and racial backgrounds and children acquiring languages other than English to investigate whether the findings reported here extend to diverse linguistic and cultural environments.

In sum, parent report and direct standardized assessments of early language in toddlers with ASD showed strong agreement, particularly for expressive language. Furthermore, predictors of concurrent receptive and expressive language suggested that although the primary set of predictors varied slightly across language domains, non-verbal cognitive ability and gesture use were the most consistent and robust predictors of language development. The predictors that emerged were consistent with theories of language acquisition in typical development, suggesting that the language of children with ASD is grounded in the same set of social-cognitive skills that are considered crucial precursors for language development. These findings have important implications for designing interventions for young children with ASD. The acquisition of spoken language should be viewed from a developmental perspective and interventions should target not only training in sound-meaning relationships but also the broader set of social cognitive skills that are intimately linked to the emergence of language in young children with ASD.

Acknowledgements This research was supported by grants from NIH (U54 MH 66398; U19 DC 03610) and funding for the GCRC at Boston University School of Medicine (M01-RR0533). We thank the following people for their help in data collection and management: Anneliese Bass, Christine Connolly, Kristin Dame, Nicole Edwards, Amy Gower, Angelina Rayno and Gretchen Schuman. We also extend our sincere gratitude to the children and families who participated in this study.

References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (Fourth ed.). Washington, DC: Author.

Arbib, M. A., & Rizzolatti, G. (1996). Neural expectations: A possible evolutionary path from manual skills to language. *Communication & Cognition, 29*(3–4), 393–424.

Bailey, A., Phillips, W., & Rutter, M. (1996). Autism: Towards an integration of clinical, genetic, neuropsychological, and neurobiological perspectives. *Journal of Child Psychology and Psychiatry, 37*, 89–126.

Baldwin, D. (1995). Understanding the link between joint attention and language. In C. Moore & P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 131–158). Lawrence: Erlbaum Associates, Inc.

Bartak, L., Rutter, M., & Cox, A. (1975). A comparative study of infantile autism and specific developmental receptive language disorder. *British Journal of Psychiatry, 126*, 127–145.

Bates, E., & Dick, F. (2002). Language, gesture and the developing brain. *Developmental Psychobiology, 40*, 293–310.

Bates, E., Thal, D., Whitesell, K., Fenson, L., & Oakes, L. (1989). Integrating language and gesture in infancy. *Developmental Psychology, 25*(6), 1004–1019.

Bornstein, M., Haynes, M., & Painter, K. (1998). Sources of child vocabulary competence: A multivariate model. *Journal of Child Language, 25*, 367–393.

Bosseler, A., & Massaro, D. (2003). Development and evaluation of a computer-animated tutor or vocabulary and language learning in children with autism. *Journal of Autism and Developmental Disorders, 33*, 653–672.

Boucher, J. (2003). Language development in autism. *International Journal of Pediatric Otorhinilaryngology, 67S1*, S159–S163.

Bruner, J., & Sherwood, V. (1983). Thought, language and intersection in infancy. In J. D. Call, E. Galenson, & R. L. Tyson (Eds.), *Frontiers of Infant Psychiatry* (pp. 38–52). New York: Basic Books.

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, 63*(4), 1–166.

Carpenter, M., Pennington, B., & Rogers, S. (2002). Interrelations among social-cognitive skills in young children with autism. *Journal of Autism & Developmental Disorders., 32*(2), 91–106.

Carpenter, M., Tomasello, M., & Striano, T. (2005). Role reversal imitation and language in typically developing infants and children with autism. *Infancy, 8*(3), 253–278.

Charman, T. (2004). Matching preschool children with autism spectrum disorders and comparison children for language ability: Methodological challenges. *Journal of Autism and Developmental Disorders, 34*(1), 59–64.

Charman, T. (2006). Imitation and the development of language. In S. Rogers & J. Willams (Eds.), *Imitation and the social mind: Autism and typical development* (pp. 96–117). New York, NY, US: Guilford Press.

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation and play as infancy precursors to language and theory of mind. *Cognitive Development, 15*, 1–18.

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2003). Predicting language outcome in infants with autism and pervasive developmental disorder. *International Journal of Language and Communication Disorders, 38*(3), 265–285.

Charman, T., Drew, A., Baird, C., & Baird, G. (2003). Measuring early language development in pre-school children with autism spectrum disorder using the MacArthur communicative development inventory (Infant Form). *Journal of Child Language, 30*, 213–236.

Charman, T., Taylor, E., Drew, A., Cockerill, H., Brown, J., & Baird, G. (2005). Outcome at 7 years of children diagnosed with autism at age 2: Predictive validity of assessments conducted at 2 and 3 years of age and pattern of symptom change over time. *Journal of Child Psychology & Psychiatry, 46*(5), 500–513.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Condouris, K., Meyer, E., & Tager-Flusberg, H. (2003). The relationship between standardized measures of language and measures of spontaneous speech in children with autism. *American Journal of Speech-Language Pathology, 12*, 349–358.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology, 40*(2), 271–283.

DeGiacomo, A., & Fombonne, E. (1998). Parental recognition of developmental abnormalities in autism. *European Journal of Child & Adolescent Psychiatry, 7*, 131–136.

Delgado, C., Mundy, P., Crowson, M., Markus, J., Yale, M., & Schwartz, H. (2002). Responding to joint attention and language development: A comparison of target locations. *Journal of Speech, Language & Hearing Research, 45*, 715–719.

Desrochers, S., Morissette, P., & Ricard, M. (1995). Two perspectives on pointing in infancy. In C. Moore & P. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 85–101). Hillsdale, NJ: Lawrence Erlbaum Associates.

Dyck, M. J., Piek, J. P., Hay, D., Smith, L., & Hallmayer, J. (2006). Are abilities abnormally interdependent in children with autism? *Journal of Clinical Child and Adolescent Psychology, 35*(1), 20–33.

Eisenmajer, R., Prior, M., Leekam, S., Wing, L., Ong, B., Gould, J., & Welham, M. (1998). Delayed language onset as a predictor of clinical symptoms in pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 28*(6), 527–533.

Fenson, L., Dale, P., Reznick, J., Bates, E., Thal, D., & Pethick, S. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59*(5), 1–173.

Fenson, L., Dale, P., Reznick, J., Thal, D., Bates, E., Hartung, J., Pethick, S., & Reilly, J. (1993). *MacArthur Communicative Development Inventories: User's guide and technical manual*. Baltimore, MD: Paul H. Brookes.

Fenson, L., Dale, P., Reznick, J., Thal, D., Bates, E., Hartung, J., Pethick, S., & Reilly, J. (2003). *MacArthur communicative development inventories: User's guide and technical manual*. Baltimore, MD: Paul H. Brookes.

Floel, A., Ellger, T., Breitenstein, C., & Knecht, S. (2003). Language perception activates the hand motor cortex: Implications for motor theories of speech perception. *European Journal of Neuroscience, 18*, 704–708.

Ghaziuddin, M., Butler, E., Tsai, L., & Ghaziuddin, N. (1994). Is clumsiness a marker for Asperger syndrome? *Journal of Intellectual Disability Research, 38*(5), 519–527.

Goldin-Meadow, S. (2000). Beyond words: The importance of gesture to researchers and learners. *Child Development, 71*(1), 231–239.

Iverson, J., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science, 16*(3), 367–371.

Kjelgaard, M. M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: Implications for genetic subgroups. *Language and Cognitive Processes, 16*(2/3), 287–308.

Koegel, L. K., Koegel, R. L., & Smith, A. (1997). Variables related to differences in standardized test outcomes for children with autism. *Journal of Autism and Developmental Disorders, 27*, 233–243.

Laakso, M.-L., Poikkeus, A.-M., Eklund, K., & Lyytinen, P. (2000). Social interactional behaviors and symbolic play competence as predictors of language development and their associations with maternal attention-directing strategies. *Infant Behavior & Development, 22*(4), 541–556.

Leslie, A. M. (1987). Pretense and representation: The origins of "Theory of Mind". *Psychological Review, 94*(4), 412–426.

Lord, C., Risi, S., DiLavore, P., Shulman, C., Thurm, A., & Pickles, A. (2006). Autism from two to nine. *Archives of General Psychiatry, 63*(6), 694–701.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P., Pickles, A., & Rutter, M. (2000). The autism diagnostic observation schedule—Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism & Developmental Disorders, 30*(3), 205–223.

Lord, C., Risi, S., & Pickles, A. (2004). Trajectory of language development in autistic spectrum disorders. In M. Rice & S. Warren (Eds.), *Developmental language disorders: From phenotypes to etiologies* (pp. 7–29). Mahwah, NJ: Lawrence Erlbaum Associates.

Lord, C., Rutter, M., Goode, S., Heemsbergen, J., Jordan, H., Mawhood, L., & Schopler, E. (1989). Autism diagnostic observation schedule: A standardized observation of communicative and social behavior. *Journal of Autism and Developmental Disorders, 19*, 185–212.

Lord, C., Rutter, M., & Le Couteur, A. (1994). The autism diagnostic interview–Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism & Developmental Disorders, 24*(5), 659–685.

Lord, C., Spence, S. J., Moldin, S. O., & Rubenstein, J. L. R. (2006). Autism spectrum disorders: Phenotype and diagnosis. In *Understanding autism: From basic neuroscience to treatment* (pp. 1–23). Boca Raton, FL, US: CRC Press.

Lord, C., & Ventner, A. (1992). Outcome and follow-up studies of high-functioning autistic individuals. In E. Schopler & G. Mesibov (Eds.), *High-functioning individuals with autism* (pp. 187–199). New York: Plenum.

Loveland, K., & Landry, S. (1986). Joint attention and language in autism and developmental language delay. *Journal of Autism and Developmental Disorders, 16*, 335–349.

Lyytinen, P., Ahonen, T., Eklund, K., Guttorm, T., Laakso, M.-L., Leinonen, S., Leppanen, P., Lyytinen, P., Poikkeus, A.-M., Puolakanaho, A., Richardson, U., & Viholainen, H. (2001). Developmental pathways of chidlren with and without familial risk for dyslexia during the first years of life. *Developmental Neuropsychology, 20*(2), 535–554.

Masur, E. F., & Eichorst, D. L. (2002). Infants' spontaneous imitation of novel versus familiar words: Relations to observational and maternal report measures of their lexicons. *Merrill-Palmer Quarterly, 48*(4), 405–426.

McDuffie, A., Yoder, P., & Stone, W. (2005). Prelinguistic predictors of vocabulary in young children with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research, 48*(5), 1080–1097.

McEwen, F., Happé, F., Bolton, P., Rijsdijk, F., Ronald, A., Dworzynski, K., & Plomin, R. (2007). Origins of individual differences in imitation: Links with language, pretend play, and socially insightful behavior in two-year-old twins. *Child Development, 78*(2), 474–492.

Meister, I. G., Boroojerdi, B., Foltys, H., Sparing, R., Huber, W., & Topper, R. (2003). Motor cortex hand area and speech: Implications for the development of language. *Neuropsychologia, 41*, 401–406.

Morales, M., Mundy, P., Delgado, C., Yale, M., Neal, A. R., & Schwartz, H. (2000). Gaze following, temperament and language development in 6-month-olds: A replication and extension. *Infant Behavior & Development, 23*, 231–236.

Mullen, E. (1995). *Mullen Scales of Early Learning*. Circle Pines, MN: American Guidance Service, Inc.

Mundy, P., Delgado, C., Block, J., Venezia, M., Hogan, A., & Seibert, J. (2003). A manual for the abridged early social communication scales (ESCS). Available through the university of Miami Psychology Department, Coral Gables, FL.

Mundy, P., & Hogan, A. (1996). *Preliminary Manual for the Abridged Early Social Communication Scales*. Coral Gables, FL: University of Miami.

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism & Developmental Disorders, 20*(1), 115–128.

Mundy, P., Sigman, M., & Kasari, C. (1994). Nonverbal communication, developmental level and symptom presentation in autism. *Development and Psychopathology, 6*, 389–401.

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1987). Nonverbal communication and play correlates of language development in autistic children. *Journal of Autism & Developmental Disorders., 17*(3), 349–364.

Nagy, E. (2006). From imitation to conversation: The first dialogues with human neonates. *Infant and Child Development, 15*(3), 223–232.

Noterdaeme, M., Mildenberger, K., Minow, F., & Amorosa, H. (2002). Evaluation of neuromotor deficits in children with autism and children with a specific speech and language disorder. *European Child & Adolescent Psychiatry, 11*, 219–225.

Paul, R., & Fountain, R. (1999). Predicting outcomes of early expressive language delay. *Infant-Toddler Intervention, 9*(2), 123–135.

Rapin, I. (1996). Preschool children with inadequate communication. London: MacKeith Press.

Risi, S., Lord, C., Gotham, K., Corsello, C., Chrysler, C., Szatmari, P., Cook, E. H. Jr., Leventhal, B. L., & Pickles, A. (2006). Combining information from multiple sources in the diagnosis of autism spectrum disorders. *Journal of the American Academy of Child & Adolescent Psychiatry, 45*(9), 1094.

Rogers, S., Charman, T., & Stone, W. (2006). Evidence-based interventions for language development in young children with autism. New York: Guilford Press.

Rogers, S., Hepburn, S. L., Stackhouse, T., & Wehner, E. (2003). Imitation performance in toddlers with autism and those with other developmental disorders. *Journal of Child Psychology & Psychiatry, 44*(5), 763–781.

Seal, B., & Bonvillian, J. (1997). Sign language and motor functioning in students with autistic disorder. *Journal of Autism and Developmental Disorders, 27*, 437–466.

Sigman, M. (1998). The Emanuel Miller memorial lecture 1997: Change and continuity in the development of children with autism. *Journal of Child Psychology and Psychiatry, 19*(6), 817–827.

Sigman, M., & McGovern, C. (2005). Improvement in cognitive and language skills from preschool to adolescence in autism. *Journal of Autism and Developmental Disorders, 35*(1), 15–23.

Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders, 32*(2), 77–89.

Sparrow, S., Balla, D., & Cicchetti, D. (1984). *Vineland Adaptive Behavior Scales*. Circle Pines, MN: American Guidance Service.

Stone, W., Ousley, O. Y., & Littleford, C. (1997). Motor imitation in young children with autism: What's the object? *Journal of Abnormal Child Psychology, 25*(6), 475–485.

Stone, W., & Yoder, P. J. (2001). Predicting spoken language level in children with autism spectrum disorders. *Autism, 5*(4), 341–361.

Thorp, D., & Mundy, P. (submitted). Observational and parent report measures of social communication skills in young children with autism. *Journal of Autism and Developmental Disorders*.

Thurm, A., Lord, C., Lee, L., & Newschaffer, C. (2007). Predictors of language acquisition in preschool children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 37*(9), 1731–1734.

Tomasello, M., & Mervis, C. B. (1994). The instrument is great, but measuring comprehension is still a problem. *Monographs of the Society for Research in Child Development, 59*, 174–179.

Toth, K., Munson, J., Meltzoff, A. N., & Dawson, G. (2006). Early predictors of communication development in young children with autism spectrum disorder: Joint attention, imitation, and toy play. *Journal of Autism and Developmental Disorders, 36*(8), 993–1005.

Ungerer, J., & Sigman, M. (1984). The relation of play and sensorimotor behavior to language in the second year. *Child Development, 55*, 1448–1455.

Van Hecke, A. V., Mundy, P. C., Acra, C. F., Block, J. J., Delgado, C. E. F., Parlade, M. V., Meyer, J. A., Neal, A. R., & Pomares, Y. B. (2007). Infant joint attention, temperament, and social competence in preschool children. *Child Development, 78*(1), 53–69.

Watt, N., Wetherby, A., & Shumway, S. (2006). Prelinguistic predictors of language outcome at 3 years of age. *Journal of Speech, Language, and Hearing Research, 49*(6), 1224–1237.

Webster, R. I., & Shevell, M. I. (2004). Neurobiology of specific language impairment. *Journal of Child Neurology, 19*(7), 471–481.

Wetherby, A., Woods, J., Allen, L., Cleary, J., Dickinson, H., & Lord, C. (2004). Early indicators of autism spectrum disorders in the second year of life. *Journal of Autism and Developmental Disorders, 34*(5), 473–493.

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 23*, 143–152.