J Autism Dev Disord (2012) 42:1064–1074
DOI 10.1007/s10803-011-1349-z

ORIGINAL PAPER

To What Extent Do Joint Attention, Imitation, and Object Play Behaviors in Infancy Predict Later Communication and Intellectual Functioning in ASD?

Kenneth K. Poon · Linda R. Watson · Grace T. Baranek · Michele D. Poe

Published online: 20 August 2011

Abstract The extent to which early social communication behaviors predict later communication and intellectual outcomes was investigated via retrospective video analysis. Joint attention, imitation, and complex object play behaviors were coded from edited home videos featuring scenes of 29 children with ASD at 9–12 and/or 15–18 months. A quantitative interval recording of behavior and a qualitative rating of the developmental level were applied. Social communication behaviors increased between 9–12 and 15–18 months. Their mean level during infancy, but not the rate of change, predicted both Vineland Communication scores and intellectual functioning at 3–7 years. The two methods of measurement yielded similar results. Thus, early social communicative behaviors may play pivotal roles in the development of subsequent communication and intellectual functioning.

Keywords Infant · Autism spectrum disorders · Joint attention · Imitation · Object play · Retrospective video analysis

Introduction

Despite the commonalities in symptoms associated with diagnoses of autism spectrum disorders (ASD), the course of development varies considerably among individuals with ASD. Research has consistently identified functional language use and better intellectual functioning in young children with ASD as robust predictors of positive outcome in later childhood, adolescence, and adulthood (Anderson et al. 2007; Baghdadli et al. 2007; Billstedt et al. 2007; Howlin et al. 2000; Szatmari et al. 2003; Thurm et al. 2007; Venterb et al. 1992). Despite this established link between the preschool indicators and subsequent outcome, little is known about the specific developmental mechanisms by which these indicators impact positively upon development. The examination of the relationship among earlier indicators, developmental changes across time, and later outcomes may help clarify the mechanisms and processes involved. Furthermore, this knowledge may guide early intervention by suggesting pivotal behaviors to target for early intervention in order to optimize outcomes.

Of the early characteristics of young children with ASD that may potentially predict language and intellectual outcomes, the class of social communicative behaviors comprising joint attention, imitation, and object play particularly merit investigation. All three of these behaviors emerge and undergo rapid development from the end of the first year through the second year of life (e.g., Belsky and Most 1981; Carpenter et al. 1983; Crais et al. 2004). In addition, these behaviors are associated with both language and cognitive development among typically developing children (Bates et al. 1979; Carpenter et al. 1998; Charman et al. 2000; Laasko et al. 1999; McEwen et al. 2007; Mundy et al. 2007). Of particular importance for the current study, young children with autism are challenged in all three of these areas (Charman et al. 1998; Lewis and Boucher 1988; Mundy et al. 1994; Rogers et al. 2003; Stone et al. 1997). Furthermore, individual differences in joint attention, imitation, and object play skills in children with ASD aged 18 months and above are associated with

K. K. Poon (✉)
National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, Singapore
e-mail: kenneth.poon@nie.edu.sg

L. R. Watson · G. T. Baranek · M. D. Poe
University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

later language and intellectual functioning (Charman et al. 2003; Luyster et al. 2007; Shumway and Wetherby 2009; Sigman et al. 1999; Stone and Yoder 2001; Wetherby et al. 2007).

Bates and colleagues (1979) suggested that symbolic capacity may underlie the associations of early joint attention, imitation and object play to later language and cognitive development. Alternatively, these associations may be due to a shared general maturational factor. The current study is based on the assumption that joint attention, imitation, and object play are specifically linked to later cognitive and language development in infants with autism. If the predictive value of these variables is only based on the extent to which they reflect infants' overall developmental status, the theoretical and clinical implications of any predictive associations would be less clear. The removal of the variance in outcomes attributable to global delay would allow a better understanding of the role these predictors play in language and cognitive development. A methodological challenge in studying the correlation between social communicative behaviors in infancy and later outcomes among children with ASD is how to control for overall level of developmental delay during the infancy period, before a diagnosis has been made. A possible index of general maturation within the nine to 18 month age period is the age the child began to walk, a motor development skill. Early motor development and language development are linked to one another (Ejiri and Masataka 2001; Iverson 2010), reinforcing the need to account for general maturational influences in a study such as this one.

The trend towards earlier diagnoses (e.g., Lingam et al. 2003), practice guidelines emphasizing early screening for ASD (e.g., Johnson et al. 2007), and the push towards early intervention (National Research Council 2001) indicate a corresponding need to study predictors of language and intellectual outcomes in children with ASD under the age of 20 months. Given that most children with ASD are diagnosed past the age of 2 years, the observation of early features of ASD in infancy requires methods providing data prior to diagnosis. Such methods include prospective studies of high risk infant siblings of children with ASD, retrospective parent reports, and retrospective video analyses (see review by Barbaro and Dissanayake 2009). To date, the emphasis in these studies of the features of ASD during infancy has been on predicting later diagnostic outcomes of children (i.e., ASD versus non-ASD) rather than on predicting later developmental outcomes within the population of children with ASD.

The current study uses retrospective video analysis (RVA) methods to investigate the longitudinal trajectories of social-communicative behaviors, as well as their associations with later developmental outcomes. Specifically, we aim to (1) measure overall levels, as well as rates of change, in joint attention, imitation and object play from early infancy (9–12 months) to later infancy (15–18 months) in children who are later diagnosed with ASD, and (2) determine the extent to which overall levels and rates of change across these three prelinguistic social-communicative behaviors during infancy predict later language and intellectual functioning in children with ASD in the 3- to 7-year-old age range. Finally, we wished to explore the extent to which quantitative (i.e., frequencies of occurrence) versus qualitative (i.e., developmental ratings) methods of coding have differential utility in measuring these early features.

RVA is an established and ecologically valid method for sampling autistic features during the infancy period and is not subject to the limitations of caregiver memory or post-diagnosis recall biases (Baranek 1999; Baranek et al. 2005; Clifford and Dissanayake 2008; Osterling et al. 2002). Whilst there are methodological limitations to RVA (e.g., that the behaviours observed may be constrained to selective and narrow representations of the child's behavior, or that it is not possible to elicit specific behaviors such as response to a social smile; see Baranek 1999), RVA also has advantages of studying development in infants from samples that are not necessarily at high genetic risk for ASD. In addition, a recent comprehensive review of RVA studies of infants with ASD (St. Georges et al. 2010) concluded that the convergence of findings from RVA studies with those of prospective studies supports the validity of RVA methods.

Method

Participants

Home videos were collected from parents of 29 children with ASD (see Table 1) participating in a larger research study conducted by the second and third authors. All children were previously diagnosed by a physician or psychologist as having Autistic Disorder (27 cases), Pervasive Developmental Disorder-Not Otherwise Specified (one case), or Asperger's Disorder (one case). Diagnoses were confirmed for the research study with at least one of three instruments: the ADI-R (Rutter et al. 2003), the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 1999), and/or the Childhood Autism Rating Scale (CARS; Schopler et al. 1988). All participants met criteria for ASD on at least one of these instruments. The ADI-R was conducted for 22 of the participants and all but one met the cutoff for autism. CARS scores were available for all participants; all but two met the CARS cutoff for autism. The five cases who completed the ADOS all met the criteria for autism.

Table 1 Demographics of study participants

	Time point 1 9–12 months (n = 27)	Time point 2 15–18 months (n = 18)	Both time points 9–12 and 15–18 months (n = 16)	Total (n = 29)
Child demographics				
Gender (%)				
Male	23 (85.2)	15 (83.3)	14 (87.5)	24 (82.8)
Female	4 (14.8)	3 (16.7)	2 (12.5)	5 (17.2)
CA	4.54 (1.52)	4.29 (1.57)	4.40 (1.64)	4.46 (1.49)
Child development				
Cars score (SD)	34.5 (7.31)	35.69 (7.07)	35.38 (7.44)	
Age walking (SD)	13.24 (3.48)	12.88 (3.15)	13.07 (3.16)	13.11 (3.47)
Other information				
Mother education (%)				
Partial college	5 (33.3)	3 (23.1)	2 (18.2)	6 (35.3)
College degree	4 (26.7)	5 (38.5)	4 (36.4)	5 (29.4)
Graduate degree	6 (40)	5 (38.5)	5 (45.5)	6 (35.3)

Materials

Two instruments developed in our laboratory (see below) were utilized for measuring the predictor variables (i.e., joint attention, imitation, and object play). An additional variable (covariate), the age when the child began walking, was based on parent report. The developmental outcome variables were based on assessment results using standardized published instruments of communication and intelligence.

The Object Play Coding Scale (OPCS)

The OPCS (Baranek et al 2005) provided the algorithm for the quantitative coding of occurrences of object play (Qty OP). Data coded by Baranek and colleagues using the OPCS were employed in this study, but the continuous method of coding they employed was transformed into an interval recording system for the current investigation. The Qty OP measure represented a count of intervals wherein there was an occurrence of the object play behaviors at the relational level or higher. There are a total of 40 intervals per 10 min of video footage; thus, the potential range was from 0 to 40.

The Naturalistic Observation Schedule of Infant/Toddler Behaviors (NOSIB)

The NOSIB was developed for coding joint attention and imitation quantitatively, and for providing developmental ratings of joint attention, imitation, and object play. As in the case of the OPCS, the quantitatively coded joint attention and imitation behaviors (Qty JA and Qty IM, respectively) reflect the frequency of occurrences of intervals with the respective social-communicative behaviors with a range of 0 to 40. Joint attention behaviors were defined as a set of behaviors whose functions are to monitor or share attention with another person regarding an external object, activity, or event (Mundy and Hogan 1996). Imitation was defined as the motor or verbal repetition of actions or sounds previously performed by a model (Yando et al. 1978). Both spontaneous as well as elicited behaviors that occurred within 15 s of demonstrated behavior were considered imitation behavior.

Developmental ratings of joint attention, imitation, and object play were also recorded. For each of three predictors (i.e., Dev JA, Dev IM, Dev OP), a rating from ‘1’ to ‘5’ was made, with each rating corresponding to a developmental age range (see “Appendix”). The rating of joint attention describes a range of social-communicative overtures that relate to the following and directing of attention, drawing largely from work by Carpenter et al. (1998) and Crais et al. (2004). Dunst’s (1980) operationalization of Užgiris and Hunt’s (1975) assessment protocol provided the source of the developmental rating of imitation behaviors. The object play categories at the relational, functional, and symbolic levels and the corresponding operational definitions of object play from the OPCS (Baranek et al. 2005) were preserved in the developmental rating of play. Coders assigned a global rating for each variable for each video segment based on the highest level skills observed in the segment.

Vineland Adaptive Behavior Scales, Communication Subscale (VABS-Com)

The standard score of the Communication Subscale of the Vineland Adaptive Behavior Scales (Sparrow et al. 1984) was used as an index of functional language skills between 3 and 7 years of age. The VABS-Com was reported to have strong internal consistency (.89–.93) and test-retest reliability (.86–.89) for children aged between 3 and 7 years (Sparrow et al. 1984). The concurrent validity of the VABS-Com was checked by correlating the VABS-Com score of 15 young children with ASD (not part of the current study) with the Total Language Score the Preschool Language Scale (PLS-4; Zimmerman et al. 2002), revealing a strong association ($r = .95$, $p < .01$) between the two measures.

Intellectual Functioning (IQ-Cat)

The intellectual abilities of 19 participants were ascertained via the Mullen Scales of Early Learning (MSEL; Mullen 1995). The intellectual abilities of six additional participants were ascertained via other varied measures of intellectual and developmental performance. Two were tested on the Bayley Scales of Infant Development—II (Bayley 1993) and three children were tested on other intelligence tests: one each on the Leiter-R (Roid and Miller 1997), the Stanford Binet Intelligence Scales, fourth edition (Thorndike et al. 1986), and the Battelle Developmental Inventory (Newborg et al. 1984). Four participants had no data regarding intellectual abilities and were excluded from analyses involving intellectual functioning. To circumvent potential problems that may stem from the interchangeable use of IQ or DQ scores from different measures, standard scores were converted into four ordinal categories of intellectual functioning: average and above intelligence (IQ/DQ $\geq$ 85), borderline (IQ/DQ = 70–84), mild mental retardation (IQ/DQ = 55–69), and moderate mental retardation to severe/profound mental retardation (IQ/DQ $\leq$ 54).

Procedure

Families of children diagnosed with ASD were recruited via advertisements, direct mailings/brochure distributions to community developmental evaluation clinics, hospital-based clinics, public and private schools, early intervention programs, and advocacy groups for children with ASD, as part of the larger research program of the second and third authors. Once families consented to participate, research staff interviewed the parents and assessed the children. Parents were asked to provide all home videotapes of the target child when aged birth to 2 years. A research assistant blind to the child's diagnosis and to the research questions coded each video scene for content regarding child age, number of people present, social nature of the scene, physical environment, amount of structure provided, and situational content (e.g., bath, mealtime, first birthday party; see Table 2). The age of children born prematurely (i.e., under 36 weeks) was adjusted so the number of weeks born premature was subtracted from the age for video coding. Another research assistant, also blind to the research questions and child's diagnosis, edited the content-coded video footage. For each targeted age range (i.e., 9–12 months and 15–18 months), two five-minute segments with two to nine quasi-randomly selected scenes of quality home video footage (e.g., child visible, varied contexts) were produced (see Table 2 for description of footage content). In addition, footage was selected to represent the child at all available points within the targeted age range. Audio cues marked 15-second scoring intervals in the edited footage.

Quantitative coding of behaviors and developmental ratings were completed for each 5-minute segment. The Qty OP data were derived from preexisting data coded via the OPCS (Baranek et al. 2005). The original data had been coded continually using The Observer 3.0 (Software for Behavioral Research 1996). For the purposes of the current study, the continuous data in the Observer data file were transformed using a customized computer program. For each interval, the absence of the target behaviors was coded as '0'and the presence of the target behaviors was coded as '1'. The interval coding method was chosen to be consistent with the methodology for quantifying Qty JA and Qty IM.

For coding and rating behaviors other than Qty OP, each video segment was watched once for familiarization, again to note target behaviors, and another three to six times to complete quantitative coding and developmental rating for joint attention and imitation, and developmental rating for object play. A second coder coded a randomly selected 20% of the total segments for reliability purposes. Intraclass correlations measuring reliability between coders were .93, .94, and 1.0 for quantitatively-coded joint attention, imitation, and object play, respectively, and .81, .84, and .80, respectively, for developmental ratings.

Table 2 Description of video footage

	9–12 months (n = 27) Mean percentage (SD)	15–18 months (n = 18) Mean percentage (SD)
Average age of child in footage		
Child age	11.08 (0.70)	16.08 (2.30)
Proportion of situations covered in video footage		
Mealtime	13.3 (14.6)	8.6 (8.5)
Special event/party/holiday	26.3 (24.3)	6.0 (13.8)
Active play	50.7 (22.9)	70.6 (17.6)
Passive activity	5.4 (8.2)	3.3 (5.3)
Bathtime/hygiene	3.1 (5.8)	7.5 (13.3)
Others	1.1 (4.3)	4.1 (8.0)

Statistical Methods

For each of the analyses, a linear mixed model was fitted with 6 or 12 repeated measures per child depending upon whether s/he had data at one or two time points. In each model the age (mean age for video footage coded at 9–12 months, 15–18 months), domain (joint attention, imitation, object play), measure (quantitative vs. qualitative developmental rating) and a covariate (i.e., age when the child began walking based on parent report: agewalk) were regressed on the observed social-communicative behavior score. All interaction terms between the predictors were also evaluated. The within person correlation structure was assumed to be the same at times 1 and 2. The Satterthwaite method was used to calculate the denominator degrees-of-freedom for all models and all analyses were performed using SAS 9.1.

Two additional models were then fit to examine the relationship between the two developmental outcome variables (VABS-Com and IQ-Cat) and the social-communicative behaviors coded during the infancy periods. These two models were identical to the previous model except for the addition of the developmental outcome variables. In each case the interaction between age and the developmental outcome variable was examined to test whether the change in the social-communicative behaviors from 9–12 to 15–18 months was associated with later developmental outcomes.

Results

The means and standard deviations of the observed social-communicative behaviors, and those of developmental outcome variables are reported in Tables 3 and 4, respectively.

Developmental Trends

The final model for this analysis (see Table 5) included all 2-way interaction terms but not the 3-way term Age*Measure*Domain as it was not significant and not of a priori interest. As seen in Fig. 1, the slope for the joint attention domain appeared to be flatter than for the domains of object play and imitation. However, the 2 degree-of-freedom test for differences in slopes was not significant ($F_{2,41} = 1.07$; $p = .35$). Furthermore, there was no difference in slopes between the quantitative measures and qualitative developmental rating measures ($p = .68$). The age when the child began walking was significantly related to mean level of social-communicative behaviors ($p = .011$) but not to the rate of change in these behaviors from early to later infancy ($p = .29$).

Table 4 Descriptive statistics of outcome variables

	Descriptive statistics Mean (SD)/ frequency
Vineland ABS—communication subscale (n = 29)	64.24 (22.01)
IQ category (n = 25)	
Moderate to profound mental retardation (IQ < 55)	14
Mild mental retardation (IQ 55–69)	4
Borderline (IQ 70–84)	3
Average and above (IQ > 84)	4

Extent to Which Infant Social-Communicative Behaviors Predict Childhood Communication

The Vineland Communication standard scores at 3–7 years of age were significantly positively associated with the mean levels of joint attention, imitation, and object play during infancy ($\beta = .0064$, $SE = .003$, $p = .035$, standardized coefficient =.08). The correlation did not vary by domain (joint attention, imitation, object play) ($p = .92$) or measure (quantitative measures vs. qualitative developmental ratings) ($p = .62$). There was no evidence that rate of change in the prelinguistic social-communicative behaviors between the two time points (9–12 to 15–18 months) was associated with the Vineland Communication standard score ($p = .79$).

Extent to Which Infant Social-Communicative Behaviors Predict Childhood Intellectual Functioning

Childhood intellectual level was associated with the mean level of the joint attention, imitation, and object play

Table 3 Mean interval count and development rating of social-communicative behaviors

	Mean interval count (SD)		Mean developmental rating (SD)	
	Time point 1 9–12 months (n = 27)	Time point 2 15–18 months (n = 18)	Time point 1 9–12 months (n = 27)	Time point 2 15–18 months (n = 18)
Joint attention	1.67 (2.15)	1.67 (1.37)	2.59 (0.75)	2.89 (0.68)
Imitation	1.52 (1.53)	2.78 (2.29)	2.74 (1.35)	3.44 (1.25)
Object play	0.30 (0.87)	1.61 (3.26)	2.00 (0.78)	2.72 (0.89)

Table 5 Estimates of rate of change in infant social-communicative behavior domains

Label	Estimate	Standard error	DF	*t* value	Pr > |*t*|
Slope across domains	0.09	0.04	31	2.48	0.019
Test for differences between domains	$F_{2,41} = 1.07$				0.353
IM slope	0.13	0.07	37	2	0.053
JA slope	0.04	0.05	37	0.94	0.355
OP slope	0.10	0.04	36	2.53	0.016

domains during infancy ($p = .044$). However, there was no indication that the association varied by measure ($p = .60$) or domain ($p = .28$). Neither was it related to the change between the two time points (9–12 to 15–18 months) (all $p = .64$).

Discussion

Developmental Trajectories

Based on the results of this study, there is distinguishable growth in the social communication behaviors. Although the developmental trajectory for joint attention seemed flat in relation to imitation and object play behaviors, statistical analyses of the slopes do not indicate any significant difference. Nevertheless, as seen in Fig. 1, the average gains for this sample in joint attention are small; for example, the quantitative data indicate that the average number of intervals in which joint attention behaviors were observed at 9–12 months is approximately 1.5, which increases to only about 1.75 at 15–18 months. Studies of young children with ASD have consistently found impairment in joint attention in comparison to typically developing children or children with other developmental disabilities (Baron-Cohen et al. 1996; Mundy et al. 1994; Sigman et al. 1999; Stone et al. 1997). This limited progress in joint attention development during the 9 through 18 month age range, when typically developing infants are showing rapid progress in these skills (Mundy et al. 2007) is consistent with findings reported from research with high-risk samples by Landa et al. (2007) and Sullivan et al. (2007). Their findings demonstrated limited or no progress in joint attention development among infant siblings (between the time points of 14 months and 24 months) who themselves later were diagnosed with ASD. Our study generalizes these findings to a younger sample and to infants not selected due to high genetic risk for ASD. Moreover, these findings were based on observations in the context of natural daily routines captured on video, which provide a more likely representation of typical behavior for our sample.

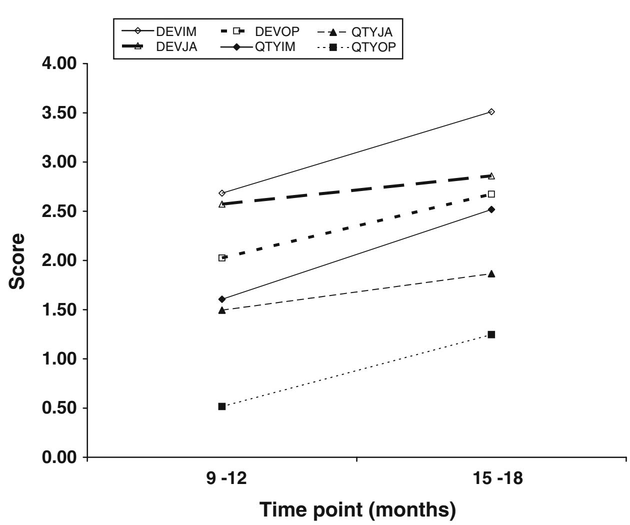

Fig. 1 Rates of change in infant social-communication behavior domains

The current findings demonstrating deficits in imitation and object play across the 9–12 and 15–18 month periods are consistent with prior literature documenting similar deficits in older age groups (e.g., Charman et al. 1997; Rogers et al. 2003), but support generalization to a younger age group. In this study, the mean developmental rating suggests that 9–12 month old infants with ASD have imitation and object play skills representing the 3–9 month age range, on average. By 15–18 months, the average developmental rating for play skills rises slightly to the high end of the 3–9 month age range, and the average rating for imitation skills rises to the 9–12 month age range. Although the qualitative ratings of developmental levels were not validated on an independent sample of typically developing infants, the ratings nevertheless were based on developmental research and represented the typical ages at which different behaviors are observed. As such, these findings support our hypothesis that infants who are later diagnosed with autism are experiencing considerable delays in developing imitation and play skills as early as 9–12 months of age, and that although these skills improve over time, they do so at a slow rate. The findings from the current study do not address whether the sequence of play development among children with ASD varies from what is expected in typical development, or whether there may be 'gaps' in the development of play skills even though progress is occurring, as suggested by VanMeter and colleagues (VanMeter et al. 1997).

Social Communication Behaviors in Infancy as Predictors of Childhood Functioning

The results of this study support the important role of three social-communicative behaviors during infancy as predictors of later developmental outcomes in children with autism. Specifically, children with autism who display higher levels of joint attention, imitation, and object play in infancy are more likely to have stronger communication and intellectual skills in the preschool or early school age years. These findings are consistent with previous research with older age groups reporting an association between joint attention and subsequent language development (e.g., Charman et al. 2003; Mundy et al. 1990; Wetherby et al. 2007), and between imitation and subsequent language (e.g., Charman et al. 2003; Stone et al. 1997; Stone and Yoder 2001), but extend the evidence of these associations to much earlier in infancy and in the context of naturally occurring family routines. Contrary to expectations, the rate of growth in social-communication behaviors between 9–12 and 15–18 months is not significantly associated with later communication outcomes. The period between time 1 (9–12 months) and time 2 (15–18 months) may be too short to establish stable growth trajectories, or possibly early childhood outcomes are mediated by other intervening factors such as the type and intensity of services a child receives following a diagnosis of ASD.

Although many studies have established the predictive association of preschool communication and cognitive performance with later academic and adaptive outcomes in school-aged children (e.g., Anderson et al. 2007; Baghdadli et al. 2007; Billstedt et al. 2007; Howlin et al. 2000; Szatmari et al. 2003; Venter et al. 1992), few have examined infant precursors of later individual differences in functional communication and intellectual performance among children with ASD. Previous research has examined the onset of behavioral symptoms of autism (Ozonoff et al. 2010), suggesting that symptoms are not apparent at 6 months of age, but that by 12 months of age infants who will be later diagnosed with ASD are distinguished as a group from other infants based on several social features. Our findings contribute an important extension to previous literature by examining more specifically the age at which early social-communicative features become predictive of later developmental outcomes. The findings of the present study suggest that by 9–12 months of age, three key behaviors—joint attention, imitation, and object play—play an important role in predicting later communication and intellectual outcomes for children with ASD.

The mechanisms or processes through which these infant social-communicative behaviors are linked to later communication and cognitive functioning were not evaluated in the current study; however, there has been previous debate of the possible reasons for these linkages. For instance, infants who are better at responding to joint attention presumably can take advantage of more opportunities to both learn to associate words spoken by communicative partners with their appropriate referents, and to learn about the functions of communication in the context of a shared focus of attention (e.g., Luyster et al. 2008). Infants who initiate more joint attention may benefit from additional experiences with intentional control of social interactions, thereby advancing both their cognitive and language development (Mundy et al. 2007). Impairments in facial processing (e.g., joint attention) could weaken the link between attention to faces and pleasure/rewards (Dawson et al. 2005), also negatively impacting cognitive development. Similarly, when appropriate play is lacking in infants and young children with ASD, the likely result is fewer learning opportunities about both the world of objects and the world of people. That is, infants and toddlers who are not engaged in play have fewer nonverbal learning opportunities from experiences acting on objects, and fewer social-communicative learning opportunities from others joining in play and talking about the infant's interests and actions. Infants and toddlers who engage in more functional and pretend play may elicit more facilitative interactions from their caregivers, whereby the caregivers maintain and extend the child's play rather than redirecting it (Laasko et al. 1999). Turning to imitation, McEwen et al. (2007) proposed that the association between early imitation and later vocabulary observed in their study might be due to an overlap in the genes controlling basic processes such as attention to faces or motivation to engage with others. Imitation has long been proposed as a strategy through which children learn conventional behaviors, including play and language (Meltzoff 2007); from this perspective, an infant who infrequently imitates would be at risk for later developmental delays in social-communicative behaviors. It is possible that the relationship between these three social-communicative behaviors represent earlier manifestations of a more global impairment (e.g., motor neurons) with impact in language, object play, motor skills, and empathy (Oberman and Ramachandran 2007; Williams et al. 2001). Another possibility is that the frequency of joint attention, imitation, and object play occurrences is related to a common root such as symbolic capacity (Sigman and Ungerer 1984). In any case, this study's finding of the combination of the three social-communicative behaviors, as opposed to them individually, predicting both communication and intellectual functioning requires further investigation. The finding may point to a global impairment (e.g., motor neurons), as opposed to one of a more specific nature, at least from 9–12 and 15–18 months. As mentioned, the current study was not designed to test these hypotheses so they remain as postulations that require further research.

The findings of this study also have clinical implications. They support the current consensus that imitation, play skills, and joint attention skills are important intervention targets for children with ASD (e.g., Kasari et al. 2008; National Research Council 2001). One surprising finding of this study is the lack of difference between methods of coding (i.e., quantitative interval counts versus qualitative developmental ratings). Assuming that both types of assessment are equally valid for characterizing social-communication skills during infancy and predicting to later developmental outcomes, the more efficient method may prove to be clinically more useful. The developmental rating scale used for this study, however, would require further development and validation prior to any use as a clinical tool.

Limitations and Future Research

Findings from this study need to be interpreted with caution given the relatively small sample that may limit the stability of the results from the regression analyses; thus, replication with larger samples of infants with ASD would be desirable. Further examination of the developmental course of other aspects of social-communication in ASD is also of interest. For example, given that sound production predicts subsequent language in typically developing children (Stoel-Gammon 1998), and may be coded from video footage, measuring sound type (e.g., consonants, consonant-vowel combinations) during the 9–12 and 15–18 month periods might be productive when there is sufficient footage with good audio quality. Fuller assessment across multiple and interacting domains of early development is needed to comprehensively test concurrent and predictive associations with later developmental outcomes. Such measures would help to elucidate developmental processes underlying core features of ASD that could help to predict individual differences and inform interventions. Another possible line of investigation arising from this study would be the examination of the links between neurological development and these early social-communication behaviors. Whilst it is known that the development of the language areas of the cortex continues through early childhood (Friauf and Lohmann 1999) and that development of early social-communication behaviors is impaired, little is known about the neurological development of young children with ASD. Such an understanding would guide further research and interventions for ASD.

Acknowledgments This study was supported in part by grants from NICHD (Grant number: HD42168) and Cure Autism Now. We would like to thank Raheleh Tschoepe, Connie Wang, Beth Schultz, and John Bulluck for their assistance in the preparation of this manuscript. We would also like to thank all families who participated and staff who collected data.

Appendix

See Table 6.

Table 6 Operational definitions for developmental rating of social communication behaviors

Coding information		Coding categories		
Code	Approximate age range of behaviors	Joint attention (Carpenter et al. 1998; Crais et al. 2004)	Imitation (Dunst 1980; Užgiris and Hunt 1975)	Object play (Baranek et al. 2005)
1	Atypical behavior or 0–3	A lack of or negative response to opportunities for joint attention presented by others	Oblivious to presence of others or attends to body actions/sounds performed by adult but lacking imitation	Exploratory use of objects: Indiscriminate actions
2	3–8/9	Shows interest in others Response to name Looking at others or object and vocalizing	Vocalizes in response to cooing or babbling Imitation in response to babbling Imitates familiar act by matching own movements to the presented one	Exploratory use of objects: Simple manipulation of single objects
3	8/9–12	Responding to verbal attempts to share focus on external object Alternating gaze Giving/showing Giving/showing and vocalizing Using word or approximation to comment	Partial imitation of familiar words Partial familiar gestures (with or without object) Partial imitation of unfamiliar, visible gestures (with or without object) Partial imitation of familiar invisible gestures	Relational use of objects: Takes combination of objects apart

Table 6 continued

Coding information		Coding categories		
Code	Approximate age range of behaviors	Joint attention (Carpenter et al. 1998; Crais et al. 2004)	Imitation (Dunst 1980; Užgiris and Hunt 1975)	Object play (Baranek et al. 2005)
4	12–15	Pointing without eye contact Following distal pointing or gaze of others Using word w rising intonation Using word or approximation and alternating eye-contact Protodeclarative pointing Protodeclarative pointing with vocalization	Imitation of familiar words or babbles Partial of unfamiliar words/sound patterns Full imitation of familiar visible gestures (with or without object) Full imitation of familiar invisible gestures	Relational use of objects: Presentation/general combinations
5	15–18	Secondary intersubjectivity: Protodeclarative pointing with word or word approximation Gesture to clarify word	Full imitation of unfamiliar words and sounds Full imitation of unfamiliar visible gestures (with or without objects) Partial imitation of unfamiliar, invisible gestures Partial imitation of invisible gesture with object	Functional use of objects: Object-directed

References

Anderson, D. K., Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., et al. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. *Journal of Counseling and Clinical Psychology, 75*, 594–604.

Baghdadli, A., Picot, M.-C., Michelon, C., Bodet, J., Pernon, E., Burstezjn, C., et al. (2007). What happens to children with PDD when they grow up? Prospective follow-up of 219 children from preschool age to mid-childhood. *Acta Psychiatrica Scandinavia, 115*, 403–412.

Baranek, G. T. (1999). Autism during infancy: A retrospective video analysis of sensory-motor and social behaviors at 9–12 months of age. *Journal of Autism and Developmental Disorders, 29*, 213–224.

Baranek, G. T., Barnett, C. R., Adams, E. M., Wolcott, N. A., Watson, L. R., & Crais, E. R. (2005). Object play in infants with autism: Methodological issues in retrospective video analysis. *American Journal of Occupational Therapy, 59*, 20–30.

Barbaro, J., & Dissanayake, C. (2009). Autism spectrum disorders in infancy and toddlerhood: A review of evidence on early signs, early identification tools, and early diagnosis. *Journal of Developmental and Behavioral Pediatrics, 30*, 447–459.

Baron-Cohen, S., Cox, A., Baird, G., Swettenham, J., Nightingale, N., Morgan, K., et al. (1996). Psychological markers in the detection of autism in infancy in a large population. *British Journal of Psychiatry, 168*, 158–163.

Bates, E., Camaioni, L., Benigni, L., Bretherton, I., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.

Bayley, N. (1993). *Bayley scales of infant development–II*. San Antonio, TX: Psychological Corporation.

Belsky, J., & Most, R. K. (1981). From exploration to play: A cross-sectional study of infant free play behavior. *Developmental Psychology, 17*, 630–639.

Billstedt, E., Gillberg, I. C., & Gillberg, C. (2007). Autism in adults: symptom patterns and early childhood predictors. Use of the DISCO in a community sample followed from childhood. *Journal of Child Psychology and Psychiatry, 48*, 1102–1110.

Carpenter, R. L., Mastergeorge, A. M., & Coggins, T. E. (1983). The acquisition of communicative intentions in infants eight to fifteen months of age. *Language and Speech, 26*, 101–116.

Carpenter, M., Nagell, K., & Tomasello, M. (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*, 1–143.

Charman, T., Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1997). Infants with autism: An investigation of empathy, pretend play, joint attention, and imitation. *Developmental Psychology, 33*, 781–789.

Charman, T., Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1998). An experimental investigation of social-cognitive abilities in infants with autism: Clinical implications. *Infant Mental Health Journal, 19*, 260–275.

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*, 481–498.

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

Clifford, S. M., & Dissanayake, C. (2008). The early development of joint attention in infants with autistic disorder using home video observations and parental interview. *Journal of Autism and Developmental Disorders, 38*, 791–805.

Crais, E., Douglas, D. D., & Campbell, C. C. (2004). The intersection of the development of gestures and intentionality. *Journal of Speech, Language, and Hearing Research, 47*, 678–694.

Dawson, G., Webb, S. J., & McPartland, J. (2005). Understanding the nature of face processing impairment in autism: Insights from behavioral and electrophysiological studies. *Developmental Neuropsychology, 27*, 403–424.

Dunst, C. J. (1980). *A clinical and educational manual for use with the Uzgiris and Hunt scales of infant psychological development*. Baltimore, MA: University Park Press.

Ejiri, K., & Masataka, N. (2001). Co-occurrences of preverbal vocal behavior and motor action in early infancy. *Developmental Science, 4*, 40–48.

Friauf, E., & Lohmann, C. (1999). Development of auditory brainstem circuitry. Activity-dependent and activity-indendent processes. *Cell Tissue Research, 297*, 187–195.

Howlin, P., Mawhood, L., & Rutter, M. (2000). Autism and developmental receptive language disorder–A follow-up comparison in early adult life. II: Social, behavioral, and psychiatric outcomes. *Journal of Child Psychology and Psychiatry, 41*, 561–578.

Iverson, J. M. (2010). Developing language in a developing body: The relationship between motor development and language development. *Journal of Child Language, 37*, 229–261.

Johnson, C. P., Myers, S., & The American Academy of Pediatrics Council on Children with Disabilities. (2007). Identification and evaluation of children with autism spectrum disorders. *Pediatrics, 120*, 1183–1225.

Kasari, C., Paparella, T., Freeman, S., & Jahromi, L. B. (2008). Language outcome in autism: Randomized comparison of joint attention and play interventions. *Journal of Consulting and Clinical Psychology, 76*, 125–137.

Laasko, M.-L., Poikkeus, A.-M., Eklund, K., & Lyytinen, P. (1999). Social interactional behaviors and symbolic play competence as predictors of language development and their associations with maternal attention-directing strategies. *Infant Behavior and Development, 22*, 541–556.

Landa, R. J., Holman, K. C., & Garrett-Mayer, E. (2007). Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. *Archives of General Psychiatry, 64*, 853-6-864.

Lewis, V., & Boucher, J. (1988). Spontaneous, instructed and elicited play in relatively able autistic children. *British Journal of Developmental Psychology, 6*, 325–339.

Lingam, R., Simmons, A., Andrews, N., Miller, E., Stowe, J., & Taylor, B. (2003). Prevalence of autism and parentally reported triggers in a north east London population. *Archive of Diseases of Childhood, 88*, 666–670.

Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (1999). *Autism diagnostic observation schedule*. Los Angeles, CA: Western Psychological Services.

Luyster, R., Qiu, S., Lopez, K., & Lord, C. (2007). Predicting outcomes of children referred for autism using the MacArthur-Bates communicative development inventory. *Journal of Speech, Language, and Hearing Research, 50*, 667–681.

Luyster, R. J., Kadlec, M. B., Carter, A., & Tager-Flusberg, H. (2008). Language assessment and development in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 38*, 1426–1438.

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

Meltzoff, A. N. (2007). The "like me" framework for recognizing and becoming an intentional agent. *Acta Psychologica, 124*, 26–43.

Mullen, E. M. (1995). *Mullen scales of early learning*. Circle Pines, MN: American Guidance Service, Inc.

Mundy, P., & Hogan, A. (1996). *A preliminary manual for the abridged early social communication scales* (*ESCS*). Retrieved Nov 9 2003 from http://www.psy.miami.edu/faculty/pmundy/ESCS.pdf.

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

Mundy, P., Sigman, M., & Kasari, C. (1994). Joint attention, developmental level, and symptom presentation in young children with autism. *Development and Psychopathology, 6*, 389–401.

Mundy, P., Block, J., Delgado, C., Pomares, Y., van Hecke, A. V., & Parlade, M. V. (2007). Individual differences and the development of joint attention in infancy. *Child Development, 78*, 938–954.

National Research Council. (2001). *Educating children with autism*. Committee on Educational Interventions for Children with Autism. In C. Lord & J. P. McGee (Eds.), Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Newborg, J., Stock, J. R., Wnek, L., Guidubaldi, J., & Svinicki, J. (1984). *The battelle developmental inventory*. Allen, TX: DLM/Teaching Resources.

Oberman, L. M., & Ramachandran, V. S. (2007). The simulating social mind: The role of the mirror neuron system and simulation in the social and communicative deficits of autism spectrum disorders. *Psychological Bulletin, 133*, 310–327.

Osterling, J. A., Dawson, G., & Munson, J. A. (2002). Early recognition of 1-year-old infants with autism spectrum disorder versus mental retardation. *Development and Psychopathology, 14*, 239–251.

Ozonoff, S., Iosif, A.-M., Baguio, F., Cook, I. C., Hill, M. M., Hutman, T., et al. (2010). A prospective study of the emergence of early behavioral signs of autism. *Journal of the American Academy of Child and Adolescent Psychiatry, 49*, 256–266.

Rogers, S., Hepburn, S., & Wehner, E. (2003). Parent reports of sensory symptoms in toddlers with autism and those with other developmental disorders. *Journal of Autism and Developmental Disorders, 33*, 631–642.

Roid, G. H., & Miller, L. J. (1997). *Leiter international performance scale–revised*. Wood Dale, IL: Stoelting Co.

Rutter, M., LeCouteur, A., & Lord, C. (2003). *autism diagnostic interview-revised: Manual*. Los Angeles: Western Psychological Services.

Schopler, E., Reichler, R. J., & Renner, B. R. (1988). *The childhood autism rating scale (CARS)*. Los Angeles, CA: Western Psychological Services.

Shumway, S., & Wetherby, A. M. (2009). Communicative acts of children with autism spectrum disorders in the second year of life. *Journal of Speech, Language and Hearing Research, 52*, 1139–1156.

Sigman, M., & Ungerer, J. A. (1984). Cognitive and language skills in autistic, mentally retarded, and normal children. *Developmental Psychology, 20*, 293–302.

Sigman, M., Ruskin, E., Arbeile, S., Corona, R., Dissanayake, C., Espinosa, M., et al. (1999). Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development, 64*, 1–114.

Software for Behavioral Research. (1996). Sterling, VA: Noldus Information Technology.

Sparrow, S. S., Balla, D. A., & Cicchetti, D. V. (1984). *Vineland adaptive behavior scales*. Circle Pines, MN: American Guidance Service.

St. Georges, C., Cassel, R. S., Cohen, D., Chetouani, M., Lasnik, M.-C., Maestro, S., et al. (2010). What studies of family home movies can teach us about autistic infants. *Research in Autism Spectrum Disorders, 4*, 355–366.

Stoel-Gammon, C. (1998). Sounds and words in early language acquisition: The relationship between lexical and phonological development. In R. Paul (Ed.), *Exploring the speech-language connection* (pp. 25–52). Baltimore: Paul H. Brookes Publishing Co.

Stone, W. L., & Yoder, P. J. (2001). Predicting spoken language in children with autistic spectrum disorder. *Autism, 5*, 341–361.

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

Stone, W. L., Ousley, O. Y., Yoder, P. J., Hogan, K. J., & Hepburn, S. L. (1997b). Nonverbal communication in two- and three-year-old children with autism. *Journal of Autism and Developmental Disorders, 27*, 677–696.

Sullivan, M., Finelli, J., Marvin, A., Garrett-Mayer, E., Bauman, M., & Landa, R. (2007). Response to joint attention in toddlers at risk for autism spectrum disorder: A prospective study. *Journal of Autism and Developmental Disorders, 37*, 37–48.

Szatmari, P., Bryson, S. E., Boyle, M. H., Streiner, D. L., & Duku, E. (2003). Predictors of outcome among high functioning children with autism and Asperger syndrome. *Journal of Child Psychology and Psychiatry, 44*, 520–528.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Guide for administering and scoring the Stanford-Binet Intelligence Scale (4th ed.)*. Chicago, Il: Riverside.

Thurm, A., Lord, C., Lee, L.-C., & Newschaffer, C. (2007). Predictors of language acquisition in preschool children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37*, 1721–1734.

Užgiris, I. C., & Hunt, J. M. (1975). *Assessment in infancy: Ordinal scales of psychological development*. Urbana, IL: Univeristy of Illinois Press.

VanMeter, L., Fein, D., Morris, R., Waterhouse, L., & Allen, D. (1997). Delay versus deviance in autistic social behavior. *Journal of Autism and Developmental Disorders, 27*, 557–569.

Venter, A., Lord, C., & Schopler, E. (1992). A follow-up study of high-functioning autistic children. *Journal of Child Psychology and Psychiatry, 33*, 489–507.

Wetherby, A. M., Watt, N., Morgan, L., & Shumway, S. (2007). Social communication profiles of children with autism spectrum disorders late in the second year of life. *Journal of Autism and Developmental Disorders, 37*, 960–975.

Williams, J. H. G., Whiten, A., Suddendorf, T., & Perrett, D. I. (2001). Imitation, mirror neurons and autism. *Neuroscience and Biobehavioral Reviews, 25*, 287–295.

Yando, R., Seitz, V., & Zigler, E. (1978). *Imitation: A developmental perspective*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (2002). *Preschool language scale—4*. San Antonio, TX: Psychological Corporation.