HHS Public Access

Author manuscript

Autism. Author manuscript; available in PMC 2015 July 21.

Published in final edited form as:

Autism. 2014 August ; 18(6): 694–703. doi:10.1177/1362361313491327.

Maternal verbal responses to communication of infants at low and heightened risk of autism

Nina B Leezenbaum[1], **Susan B Campbell**[1], **Derrecka Butler**[2], and **Jana M Iverson**[1]

[1]University of Pittsburgh, USA

[2]Northern Illinois University, USA

Abstract

This study investigates mothers' responses to infant communication among infants at heightened genetic risk (high risk) of autism spectrum disorder compared to infants with no such risk (low risk). A total of 26 infants, 12 of whom had an older sibling with autism spectrum disorder, were observed during naturalistic in-home interaction and semistructured play with their mothers at 13 and 18 months of age. Results indicate that overall, mothers of low-risk and high-risk infants were highly and similarly responsive to their infants' communicative behaviors. However, examination of infant vocal and gestural communication development together with maternal verbal responses and translations (i.e. verbally labeling a gesture referent) suggests that delays in early communication development observed among high-risk infants may alter the input that these infants receive; this in turn may have cascading effects on the subsequent development of communication and language.

Keywords

autism spectrum disorder; communication development; gesture; parent verbal responsiveness

Introduction

With the goal of identifying the earliest behavioral markers of autism spectrum disorder (ASD), researchers have begun to focus on the early development of infants who have an older sibling with the disorder and therefore are at heightened risk of developing ASD themselves (Ozonoff et al., 2011: high-risk (HR) infants). While infant sibling studies to date have yielded mixed evidence with regard to specific behavioral markers of ASD prior to the first birthday, one of the most widely replicated findings is the extensive variability in the early development of HR infants, even among those who do not receive an ASD diagnosis later (for a review, see Rogers, 2009). In relation to infants with no family history

Corresponding author: Nina B Leezenbaum, Department of Psychology, University of Pittsburgh, 3309 Sennott Square, 210 S. Bouquet Street, Pittsburgh, PA 15260, USA. nbl3@pitt.edu.

Portions of these data were presented at the 2010 Biennial Meetings of the Society for Research in Child Development, Montreal, QC, Canada, the 2011 International Meeting for Autism Research, San Diego, CA, USA, and the 2012 Biennial International Conference on Infant Studies, Minneapolis, MN, USA.

of ASD (low-risk (LR) infants), a substantial number of HR infants who do not go on to receive an ASD diagnosis exhibit delays in gestural and vocal communication as well as in subsequent language development (e.g. Cassel et al., 2007; Paul et al., 2011; Yirmiya et al., 2006).

Communication development and parent responsiveness

Prior to the acquisition of fluent speech, typically developing (TD) infants communicate through behaviors such as gestures, nonword vocalizations, and eye gaze (e.g. Bates et al., 1979; Harding and Golinkoff, 1979). Over the course of the first 2 years of life, communicative competence gradually develops as infants acquire new skills that enable them to interact with a social partner using behaviors with shared meanings (e.g. Wetherby et al., 1988). The onset of intentional communication between 9 and 13 months is marked in part by the emergence of a series of gestures—ritualized requesting, giving, showing, and pointing—that often precede the appearance of first words (e.g. Bates, 1976; Iverson and Thal, 1998). They are referred to as deictic gestures and are used by infants to reference external objects and events and to express communicative intent before infants are able to communicate verbally.

The transactional model asserts that development unfolds through continuous and dynamic interactions between infants and their environments (Sameroff, 1983). The cornerstone of this framework is that parent and infant behaviors are mutually influential and affect infant development in significant ways. Parents talk to their infants long before infants begin to engage in intentional communication with them; thus, parental input is a first step in this reciprocal process, whether it is meant to initiate social interaction or to respond to infants' behavior. As intentional communication develops over the course of the first year, infants begin to play a more central role in the reciprocal interplay of social and communicative interaction.

Recent empirical work provides support for this theoretical perspective by demonstrating that infants' early communicative and play behaviors elicit verbal responses from their parents that, in turn, scaffold language development (e.g. Tamis-LeMonda et al., 2001). For example, parents often respond to infants' communicative gestures by translating those gestures into words, thereby providing the verbal equivalent of the gesture referent (e.g. an infant points at a bird and in turn her mother responds by saying, "You see the bird"; Golinkoff, 1986; Masur, 1982). This type of response may be particularly valuable for language development because parents provide timely models for the verbal expression of ideas, thus maximizing the matching of words or phrases with targets of children's current attentional focus. Indeed, Goldin-Meadow et al. (2007) found that when a mother translated her child's gesture referents into words, those referents were more likely to become part of the child's word vocabulary than referents that were not translated. While this work emphasizes the importance of parental verbal responsiveness for infant language learning, it also suggests that infants play an important role in shaping their own environments through the production of communicative behaviors that elicit rich input from parents.

Just as the propensity to respond to infants' communication with rich verbal input varies across individual parents, the ability to elicit semantically relevant speech varies across

infants (Snow, 1986). For example, parents of TD infants are more likely to imitate and expand on infant nonword vocalizations that are more developmentally advanced (e.g. consonant–vowel syllables) as compared to less complex vocalizations (e.g. single vowels; Gros-Louis et al., 2006). In addition, caregivers are more likely to respond by labeling the indicated object when infants produce pointing gestures than when they produce less developmentally advanced requesting gestures (Kishimoto et al., 2007; Masur, 1982). These studies suggest that parents are sensitive to their infants' growing communicative competence and are more likely to respond with rich verbal input to infant behaviors that are more developmentally advanced. Therefore, delays in spontaneous communication may reduce the frequency of infant-initiated joint engagement with caregivers. This may then lead to a reduction in linguistic input from caregivers, which is adapted to moments of shared attention, ultimately leading to further delays in communication and language. Overall, this research supports a view of development that acknowledges the bidirectional nature of parent–infant interaction and the importance of examining both parent and infant behavior in an effort to understand the development of communication and language.

The present study

Several prospective studies of HR infants have revealed delayed patterns of communication development during the second year. Specifically, prior work suggests that a subset of HR infants produce fewer nonword vocalizations containing consonant–vowel syllables (e.g. Paul et al., 2011) as well as fewer words (Iverson and Wozniak, 2007). They also produce fewer instances of more developmentally advanced communicative gestures (e.g. pointing, showing) but relatively typical rates of earlier emerging communicative gestures (e.g. giving, requesting; Winder et al., 2012). Based on these findings, HR infants may afford their parents fewer opportunities to provide contingent verbal input in response to more developmentally advanced communicative behaviors. However, because parents of HR infants are aware that their infants are at increased risk of language and communication delays as well as ASD (Hess and Landa, 2012; Ozonoff et al., 2011), they may be particularly vigilant about scaffolding language. Thus, parents of HR infants may provide contingent responses more often than parents of LR infants to less advanced vocal and gestural communicative bids. To date, no published studies have examined parents' responses to HR infants' communicative behaviors. Understanding the communicative interplay between parents and their HR infants may shed light on the language learning process of this population.

In this study, we sought to further our understanding of the enhanced variability in communication and language development among HR infants who do not go on to receive a diagnosis of ASD by focusing on mothers' responses to their infants' communicative behaviors (i.e. nonword vocalizations, words, and gestures) at 13 and 18 months of age. These two age points were chosen because they bracket a period of rapid developmental change in language and communication (Bloom, 1993). Two primary questions were addressed in this study: (a) Do mothers of HR and LR infants differ in the relative frequency of verbal responses to their infants' nonword vocalizations, words, and gestures? and (b) Do mothers of HR and LR infants differ in the relative frequency of translations of their infants' gestures?

Method

Participants

A total of 12 infants (7 females and 5 males) with an older biological sibling with ASD participated in this study. Families in the HR group were recruited through the Autism Research Program at the University of Pittsburgh, parent support organizations, local agencies, and schools serving families of children with ASD. Prior to each HR infant's enrollment, the Autism Diagnostic Observation Schedule–Generic (ADOS-G; Lord et al., 2000) was administered to his or her older sibling by a trained clinician to confirm diagnosis. Older siblings had to score above the threshold for autism on the ADOS in order for infants to be eligible for inclusion in the study. At 36 months, all HR infants visited the Autism Research Program for a diagnostic assessment conducted by a clinician blind to all previous study data using the ADOS and *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; *DSM-IV-TR*) criteria (American Psychiatric Association, 2000). All the infants in this study scored below the threshold for ASD. In addition, all families who initially joined the study completed the 13-month visit, 18-month visit, and outcome visit at 36 months. There was no attrition in our sample.

A comparison group of 14 infants (7 females and 7 males) with no family history of ASD (i.e. no first- or second-degree relatives diagnosed with ASD) was selected from a separate longitudinal study of vocal-motor coordination in infancy conducted by the last author (J.M.I.). LR infants were chosen so as to include only later-born infants from the larger sample. No developmental concerns were ever reported for any of these infants during the course of their involvement in the study. We have remained in contact with these families since this time, and no children have subsequently received a diagnosis of a developmental disorder of any sort (e.g. ASD, language impairment).

All infant participants in both samples were full-term, from uncomplicated pregnancies and deliveries, and came from monolingual, English-speaking homes. Of these participants, 23 (10 HR infants and 13 LR infants) were Caucasian, 2 (both HR infants) were Hispanic, and 1 LR infant was Asian American. The education levels of mothers and fathers in both groups were comparable, with the majority of parents either holding college degrees or having completed some college. Mean maternal (M_{HR} = 34.46, standard deviation (SD) = 4.18; M_{LR} = 32.79, SD = 4.48) and paternal (M_{HR} = 36.08, SD = 3.40; M_{LR} = 34.14, SD = 3.82) ages also did not differ significantly by group.

Procedure

Infants were videotaped at home with their mothers for 45 min on a monthly basis during the first 2 years of life. This study focused on sessions when infants were aged 13 and 18 months. Visits were conducted to coincide with the monthly anniversary of the infant's birthday. In an effort to ensure continued participation, families were compensated for their time. To enhance the audio component of the recordings, infants wore a small wireless microphone clipped to a cloth vest worn over their clothing during the session.

During home visits, dyads were observed in two major contexts. The first and final 15-min segments consisted of unstructured, naturalistic observation. Mothers were asked to continue

their normal activities during this time; no attempt was made to structure this portion of the session in any way (with the exception that parents were asked to keep the television off). Typically, the infants played with available toys during this time. During the middle 15-min segment, infants and mothers were seated on the floor and participated in semistructured play interactions with favorite toys.

Coding

Coding for this study was completed by members of the research team blind to group membership using a time-linked, computer-based video interface system (The Observer Video-Pro, Noldus Information Technology). Infants' communicative nonword vocalizations, words, and deictic gestures directed toward mothers during the 45-min session were identified and coded for onset and offset. Vocalizations and gestures were classified as mother-directed if the infant combined eye contact with the behavior and/or was involved in a reciprocal social interaction with the mother. Because we were interested in infant-initiated communication, all vocalizations and gestures produced in response to communications by the mother (e.g. "say cow," "where's the doggie") were excluded from analyses. Coding categories to identify infant communicative expressions were derived from earlier work on the speech and gestures of very young children (Iverson and Goldin-Meadow, 2005).

All infant sound productions with the exception of sneezing, coughing, breathing, and other vegetative noises were coded as nonword vocalizations. Affective vocalizations such as laughing, squealing, fussing, and crying were coded separately and were not analyzed in this study. Words were coded if they were either actual English words (e.g. "dog," "cat," "duck," and "hot") or speech sounds that were consistently used by a particular child to refer to a specific object or event (e.g. using "bah" to refer to a bottle in a variety of different contexts).

Deictic gestures were coded as request, give, show, or point. Request involved the infant extending the arm with an open palm or repeated opening or closing of the hand. Give involved extension of the arm with an object in hand and directed toward the hand of another person. Show occurred when the infant presented the object in the general direction of a communicative partner while making eye contact. Point involved clear articulation of the index finger toward an object. For the purposes of this study, deictic gestures were further classified into one of two categories (give/request or point/show) based on empirical evidence that giving and requesting gestures appear earlier in development than pointing and showing gestures (Bates et al., 1979).

Maternal verbalizations were coded as verbal responses to infant communication if they occurred any time following the onset of the infant's communicative behavior and within 2 s of its offset (e.g. Gros-Louis et al., 2006; Tamis-LeMonda et al., 2001). A verbal response could contain more than one utterance as long as the time elapsed between utterances did not exceed 2 s. verbal responses to infant gestures were further classified according to whether or not they contained a translation, defined as labeling the referent of the infant's gesture. We took a liberal approach to classifying maternal speech as a translation of infant gesture. For example, if an infant pointed at a cat and his mother referred to the cat by its name or as

"cat," "pet," or "animal," the mother's label was classified as a translation of the pointing gesture (Goldin-Meadow et al., 2007).

Reliability

Because there were 26 infants and each infant was observed at two age points, a total of 52 sessions were coded for this study. To assess intercoder reliability, a second trained rater independently coded a subsample of 25% of the videotaped data (N = 13 sessions). Sessions were chosen at random with the constraint that the two age points and risk groups were equally represented. Using this procedure, mean percentage of agreement ranged from 87% to 100% for all infant communicative behaviors, and Cohen's Kappa statistics ranged from . 88 to .94 for all maternal response behaviors. Disagreements were resolved by joint viewing of the video clips and discussion following reliability calculation.

Results

All of the statistical analyses reported below were performed using IBM Statistical Package for Social Sciences (IBM SPSS, version 19.0).

Infant communication directed toward mothers

We investigated infants' spontaneous communication directed toward their mothers by tabulating the frequencies of nonword vocalizations, words, gives/requests, and points/ shows separately for all infants during the 45-min session. Prior to group level analyses, Pearson correlations were conducted between all infant communicative behaviors directed toward mothers at 13 and 18 months; the results are presented in Table 1. There were significant positive correlations between infant nonword vocalizations, words, and points/ shows at 13 months and point/ show production at 18 months. In addition, the frequency of words directed toward mothers at 13 months was positively correlated with the frequency of words directed toward mothers at 18 months.

In our primary analyses, we first examined *within-group* changes in mother-directed infant communication from 13 to 18 months. This was followed by analyses exploring *between-group* differences in mother-directed infant communication at each age point. Inspection of the distributions indicated significant skewing and substantial individual variability, especially among the HR infants. Therefore, when examining infant communication, we utilized nonparametric statistics (Siegel and Castellan, 1988). In addition, we present medians and average deviations (ADs) rather than means and SDs. Descriptive statistics for infant communication are presented in Table 2, along with the percentages of infants who produced at least one instance of a given communicative behavior.

To examine within-group changes from 13 to 18 months in infant nonword vocalizations, words, gives/requests, and points/shows, we utilized the Wilcoxon rank-sum test. For both HR and LR groups, the median frequency of mother-directed nonword vocalizations decreased from 13 to 18 months; however, this decrease was only significant for LR infants, T = 16, p = .022. In contrast, an increase in word production from 13 to 18 months was observed in both groups of infants (LR: T = 0, p = .001; HR: T = 0, p =.003). With regard to gesture production, LR infants' production of mother-directed gives/requests decreased over

time, although not significantly. By contrast, HR infants produced similar numbers of gives/requests at both 13 and 18 months. A different pattern was observed for pointing/ showing gestures. Specifically, production of mother-directed points/shows nearly quadrupled from 13 to 18 months for LR infants, $T = 17$, $p = .046$, but remained low and relatively unchanged across both ages for HR infants.

We utilized the Mann–Whitney *U* test to assess between-group (HR vs LR) differences in infant nonword vocalizations, words, gives/requests, and points/shows at both 13 and 18 months. By 18 months, HR infants as a group produced significantly fewer mother-directed points/shows than their LR peers, $U = 30.50$, $p = .004$. None of the other group comparisons were statistically significant.

Maternal responses to infant communication directed toward mothers

Because infants varied widely in the number of communicative behaviors they produced, mothers' opportunities to respond to infants also varied. Thus, proportions were utilized to examine maternal responses to infant communication. Proportions were calculated separately for maternal verbal responses to infant nonword vocalizations, words, and gestures and for maternal translations of infant gestures for each individual infant. This was done by dividing the number of maternal responses (e.g. verbal responses to nonword vocalizations) by the total number of each infant communicative behavior (e.g. nonword vocalizations); proportions were then averaged across infants in each group.

Prior to the main analyses, Pearson correlations were calculated between maternal verbal responses to infant communication at 13 and 18 months; the results are presented in Table 3. As can be seen in the table, there were significant positive correlations between the proportion of points/shows receiving a maternal verbal response at 13 months and both the proportion of gives/requests and the proportion of points/shows receiving verbal responses at 18 months.

Responses to nonword vocalizations—Because all of the infants produced nonword vocalizations at both 13 and 18 months, we were able to examine differences between groups in maternal verbal responses to infant nonword vocalizations longitudinally utilizing a 2 (Risk Status) × 2 (Age) repeated measures analysis of variance (ANOVA). Data were arcsine transformed prior to analysis. The main effects of Risk Status, $F(1, 24) = 1.58$, $p = .222$, and Age, $F(1, 24) = .14$, $p = .713$, were not statistically reliable, but the Risk Status × Age interaction was significant, $F(1, 24) = 4.35$, $p = .048$, $\eta^2 = .220$. As evident from Figure 1, the change from 13 to 18 months in the mean proportion of infant nonword vocalizations to which mothers responded verbally differed between the HR and LR groups. Simple effects analyses conducted to assess the source of the interaction indicated that for the LR group, the mean proportion of nonword vocalizations receiving a maternal verbal response underwent a nearly significant increase between 13 and 18 months, $p = .083$. The opposite pattern was observed for the HR group, although this was not significant, $p = .255$. We also compared the number of mothers from each group who demonstrated an increase in the proportion of nonword vocalization to which they responded verbally from 13 to 18 months. Whereas 79% of mothers of LR infants demonstrated an increase in responding from 13 to

18 months, only 33% of mothers of HR infants demonstrated an increase, $p = .044$, Fisher's exact test.

Responses to words—Our analysis of maternal verbal responses to infant words focused only on the 18-month data because too few HR infants (42%) produced words at 13 months, and thus it was not possible to conduct longitudinal analyses. A Mann–Whitney *U* test demonstrated that both groups of mothers responded verbally to their infants' words at similarly high frequencies, $Mdn_{LR} = .78$, AD = .20; $Mdn_{HR} = .75$, AD = .22; $U = 71.50$, $p = .763$.

Responses to gestures—Because not all infants produced gestures at both ages, a series of Mann–Whitney *U* tests was carried out separately at 13 and 18 months to examine potential LR/HR group differences in maternal verbal responses and maternal translations to infant gestures. Descriptive statistics are presented in Table 4. As can be seen, for both groups, the median proportion of infant gestures that received a maternal verbal response at 13 and 18 months was relatively high and did not differ significantly. With regard to maternal translations of infant gestures (i.e. providing a verbal equivalent of the infant's gesture referent), at 13 months, mothers of HR infants responded to gives/requests with a significantly higher proportion of translations than mothers of LR infants, $U = 18.50$, $p = .033$.

Next, we examined maternal translation responses among the subset of LR and HR infants who produced both gives/requests and points/shows in the same session. This allowed us to examine whether maternal translations varied as a function of infant gesture type (give/request vs point/ show) when mothers had opportunities to respond to both types of gestures. At 13 months, 13 of the 27 infants (8 LR and 5 HR) produced both giving/requesting and pointing/ showing gestures, and at 18 months, 16 infants (11 LR and 5 HR) produced both gesture types. The median proportions of LR and HR infant give/request and point/show gestures that received a maternal translation response are presented in Figure 2. Wilcoxon rank-sum tests revealed that mothers of LR infants who produced both types of gestures in the same session responded with significantly higher proportions of translations to infants' points/shows than to gives/ requests at both 13 months, $T = 0$, $p = .043$, and 18 months, $T = 7.50$, $p = .041$. Among mothers of HR infants who produced both gesture types, the opposite pattern was observed at 13 months, with maternal translations more common for gives/requests than for points/shows (although not significantly so). By 18 months, however, a pattern similar to that observed among mothers of LR infants was apparent; mothers of HR infants tended to provide a greater proportion of translations to points/shows than to gives/requests, but the difference was not statistically reliable.

Finally, we conducted a series of Pearson correlations between maternal response to infants' gestures at 13 months and infant word production at 18 months. Maternal verbal responses as well as maternal translations of infants' gives/ requests at 13 months were not significantly related to infant word production at 18 months. However, there was a significant positive correlation between maternal translations of points/shows at 13 months and infant word production at 18 months ($r = .593$, $p = .012$).

Discussion

The primary aim of this study was to investigate mothers' responses to infant communication among dyads with infants at heightened risk of ASD as compared to dyads with no such risk. These data suggest that in LR infants, more mature forms of mother-directed gestural communication emerge between 13 and 18 months, reflected in an increase in the frequency of pointing and showing gestures over giving and requesting gestures. Parallel changes were not evident in the HR infants. In fact, by 18 months, the LR group median for pointing/showing gestures was eight times that of the HR group. The pattern of developmental change observed among LR infants is consistent with the view that the infant communicative system undergoes a major reorganization during the second year (e.g. Iverson et al., 1994). As more developmentally advanced gestures (e.g. pointing, showing) and words become increasingly frequent, production of some gesture types (e.g. giving, requesting) and nonword vocalizations declines. In our data, evidence of this developmental change is apparent in the absence of significant correlations across ages for gives/requests and nonword vocalizations.

With regard to maternal responses to infant communication, we found that overall mothers of both LR and HR infants were highly and similarly responsive. However, our data on maternal verbal responses to infant vocalizations and maternal translations of infant gestures suggest that delays in early communication development may alter the input that infants receive, and this may in turn have cascading effects on the subsequent development of communication and language.

While verbal responses of mothers of LR infants to nonword vocalizations increased proportionally from 13 to 18 months, a similar change was not apparent among mothers of HR infants. One potential explanation for this difference is suggested by prior research demonstrating that HR infants produce significantly fewer consonant types and consonant–vowel syllables than their LR peers during the first year (Paul et al., 2011). Because vocalizations containing consonant–vowel syllables are particularly likely to elicit rich verbal responses from mothers (Gros-Louis et al., 2006), group differences in patterns of maternal responses may reflect group differences in infant vocalization quality. The observed increase in verbal responses to nonword vocalizations among mothers of LR (but not HR) infants from 13 to 18 months may be related to increased production of vocalizations containing consonant–vowel syllables among LR (but not HR) infants. Because we did not examine the quality of infant nonword vocalizations in this study, this possibility should be explored in future research, especially in light of prior research documenting delays in vocal development among HR infants (Paul et al., 2011) and children with other pervasive developmental disorders (e.g. Rett syndrome; Marschik et al., 2012).

Turning now to maternal translations of infants' gestures, we found that compared to mothers of LR infants, overall, mothers of HR infants produced higher proportions of translations in response to gives/requests at 13 months. Because mothers of HR infants are aware that their infants are at increased risk of language and communication delays and often report heightened levels of concern about their infants' development (Hess and Landa, 2012; Ozonoff et al., 2011), they may be particularly vigilant about the need to scaffold

language by labeling object referents. In addition, mothers of HR infants likely did not observe their older children with ASD producing social communicative gestures at such young ages, and this may make these behaviors particularly salient and meaningful.

Consistent with previous research (Masur, 1982), we found that mothers of LR infants provided a significantly higher proportion of translations to more developmentally advanced pointing/showing gestures than to earlier emerging giving/requesting gestures at both at 13 and 18 months. Mothers of HR infants demonstrated this pattern of responding by 18 months. One reason why mothers may be more likely to translate points/shows than gives/requests is that pointing and showing gestures are generally produced by infants to initiate episodes of joint attention, while giving and requesting gestures frequently function to regulate the behavior of a communicative partner (Bates, 1976). It is possible that the imperative nature of giving and requesting gestures serves to elicit responses from mothers, which merely fulfill their infants' demands. In contrast, the declarative function of pointing and showing gestures may signal to mothers a readiness to learn language on the part of their infants.

Thus, a potentially significant consequence of reduced production of pointing and showing gestures observed among the HR infants in this study is that mothers of HR infants may have fewer opportunities to provide translation responses. Translations offer valuable input for young language learners; the moment a child gestures toward and focuses on an object of interest, an adult provides the object's label (Goldin-Meadow et al., 2007). Moments of this sort—in which the word to be acquired is provided while a child's attention is actively focused on its referent—are optimal for word learning (e.g. Tomasello and Farrar, 1986). The relationship between translations of infant gestures and subsequent word learning is underscored by our finding indicating that maternal translations of infants' points/shows at 13 months were positively correlated with infant word production at 18 months. Viewed from this perspective, delays in gesture development exhibited by HR infants may have cascading effects on later language development by virtue of alternations in the input that infants may elicit from their caregivers.

As an example, consider the following scenario: an 18-month-old HR infant produces only giving and requesting gestures. His LR peer, in contrast, has shifted to producing primarily pointing/showing gestures. Based on this difference in the developmental level of their communicative repertoires, these two infants are likely eliciting different input from their caregivers. While the HR infant's caregivers are highly likely to respond verbally to his communicative bids, those responses are less likely to contain verbal input that is precisely tailored to his current focus of attention (i.e. translation responses). The LR infant, however, presumably receives more frequent translation responses due to his more frequent production of points/ shows. In addition, since referents that are translated by caregivers are more likely to enter children's vocabularies than those that are not (Goldin-Meadow et al., 2007), this difference in exposure to translation responses may cascade into early differences in vocabulary growth between the two infants. Nevertheless, it is still unknown whether or not delays in gesture development among HR infants suggest that these infants may not be "developmentally ready" to learn from translation responses by their caregivers. Thus, future research on HR infants with delayed gesture development should utilize an intervention

design to examine how translation responses to gestures impact subsequent language development.

Limitations

While this study has numerous methodological strengths, including a longitudinal, prospective design and observation of infants in a naturalistic setting, it is important to note two limitations. First, our sample sizes were relatively small, and caution should be exercised when interpreting the data and making generalizations about maternal responses to infants' communicative behaviors. Second, this study did not examine mothers' overall communication directed toward their infants. It is possible that mothers of HR and LR infants provide different frequencies and types of scaffolding behaviors that are not necessarily in response to their infants' communicative bids.

Conclusion and clinical implications

In line with research on TD children, our results suggest that across the second year, mothers tend to provide richer verbal input to more developmentally advanced communicative behaviors while decreasing responses to earlier emerging behaviors. At the same time, the developmental period for earlier emerging gestures (gives/requests) may be extended for HR infants as a group, and more developmentally advanced gestures (points/shows) appear to be delayed relative to LR infants. Based on the findings from this study, early intervention providers for HR infants with communication delays may consider encouraging parents to respond to infants' gestures with translations. In addition, clinicians can heighten caregiver attention to infant nonword vocalizations and encourage parents to provide contingent responses to them, regardless of their developmental level and/or social salience.

Acknowledgements

We would like to thank the members of the Infant Communication Lab at the University of Missouri–Columbia and the University of Pittsburgh for helping with data collection; Breanna Winder and Stefanie Poulos-Hopkins for assistance with coding and establishment of reliability; and Celia Brownell, Jessie Northrup, and Eve Sauer LeBarton for their insightful intellectual contributions throughout the project. Special thanks are due to the families and infants who participated in the research. This work could not have been completed without their dedicated and enthusiastic involvement.

Funding

This research was supported by the National Institutes of Health (R01 HD 41607 and HD 054979) and a grant from *Autism Speaks* to J.M. Iverson. Additional support was provided by National Institutes of Health (HD55748 and HD35469) to N.J. Minshew and by the National Institute of Mental Health (R01 MH091036) to S.B. Campbell.

References

American Psychiatric Association (APA). Diagnostic and Statistical Manual of Mental Disorders. Washington, DC: APA; 2000. text rev.

Bates, E. Language and Context. New York: Academic Press; 1976.

Bates, E.; Benigni, L.; Bretherton, I., et al. The Emergence of Symbols: Cognition and Communication in Infancy. New York: Academic Press; 1979.

Bloom, L. The Transition from Infancy to Language. New York: Cambridge University Press; 1993.

Cassel T, Messinger D, Ibanez L, et al. Early social and emotional communication in the infant siblings of children with autism spectrum disorders: an examination of the broad phenotype. Journal of Autism and Developmental Disorders. 2007; 37:122–132. [PubMed: 17186367]

Goldin-Meadow S, Goodrich W, Sauer E, et al. Young children use their hands to tell their mothers what to say. Developmental Science. 2007; 10(6):778–785. [PubMed: 17973795]

Golinkoff R. "I beg your pardon?" The preverbal negotiation of failed messages. Journal of Child Language. 1986; 13:455–476. [PubMed: 3793809]

Gros-Louis J, West M, Goldstein M, et al. Mothers provide differential feedback to infants' prelinguistic sounds. International Journal of Behavioral Development. 2006; 30(6):509–516.

Harding C, Golinkoff R. The origins of intentional vocalizations in prelinguistic infants. Child Development. 1979; 50:33–40. [PubMed: 446215]

Hess C, Landa R. Predictive and concurrent validity of parent concern about young children at risk for autism. Journal of Autism and Developmental Disorders. 2012; 42(4):575–584. [PubMed: 21584850]

Iverson J, Capirci O, Caselli MC. From communication to language in two modalities. Cognitive Development. 1994; 9(1):23–43.

Iverson J, Goldin-Meadow S. Gesture paves the way for language development. Psychological Science. 2005; 16(5):367–371. [PubMed: 15869695]

Iverson, J.; Thal, D. Communicative transitions: there's more to the hand than meets the eye. In: Wetherby, A.; Warren, S.; Reichle, J., editors. Transitions in Prelinguistic Communication. Baltimore, MD: Paul H. Brookes; 1998. p. 59-86.

Iverson J, Wozniak R. Variation in vocal-motor development in infant siblings of children with autism. Journal of Autism and Developmental Disorders. 2007; 37:158–170. [PubMed: 17191097]

Kishimoto T, Shizawa Y, Yasuda J, et al. Do pointing gestures by infants provoke comments from adults? Infant Behavior & Development. 2007; 30(4):562–567. [PubMed: 17561263]

Lord C, Risi S, Lambrecht L, et al. The autism diagnostic observation schedule–generic: a standard measure of social and communication deficits associated with the spectrum of autism. Journal of Autism and Developmental Disorders. 2000; 30(3):205–223. [PubMed: 11055457]

Marschik PB, Pini G, Bartl-Pokorny KD, et al. Early speech-language development in females with Rett syndrome: focusing on the preserved speech variant. Developmental Medicine and Child Neurology. 2012; 54(5):451–456. [PubMed: 22348320]

Masur E. Mothers' responses to infants' object-related gestures: influences on lexical development. Journal of Child Language. 1982; 9:23–30. [PubMed: 7061633]

Ozonoff S, Young G, Carter A, et al. Recurrence risk for autism spectrum disorders: a Baby Siblings Research Consortium study. Pediatrics. 2011; 128:e488–e495. [PubMed: 21844053]

Paul R, Fuerst Y, Ramsay G, et al. Out of the mouths of babes: vocal production in infant siblings of children with ASD. Journal of Child Psychology and Psychiatry, and Allied Disciplines. 2011; 52(5):588–598.

Rogers S. What are infant siblings teaching us about autism in infancy? Autism Research. 2009; 2(3): 125–137. [PubMed: 19582867]

Sameroff, A. Developmental systems: contexts and evolution. In: Kessen, W.; Mussen, PH., editors. Handbook of Child Psychology: Volume 1. History, Theory, and Methods. New York: Wiley; 1983. p. 237-294.

Siegel, S.; Castellan, N. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill; 1988.

Snow, C. Conversations with children. In: Fletcher, P.; Garman, M., editors. Language Acquisition. Cambridge: Cambridge University Press; 1986. p. 69-89.

Tamis-LeMonda C, Bornstein M, Baumwell L. Maternal responsiveness and children's achievement of language milestones. Child Development. 2001; 72(3):748–767. [PubMed: 11405580]

Tomasello M, Farrar M. Joint attention and early language. Child Development. 1986; 57:1454–1463. [PubMed: 3802971]

Wetherby A, Cain D, Yonclas D, et al. Analysis of intentional communication of normal children from the prelinguistic to the multiword stage. Journal of Speech and Hearing Research. 1988; 31:240–252. [PubMed: 3398497]

Winder B, Wozniak R, Parladé M, et al. Spontaneous initiation of communication in infants at low and heightened risk for autism spectrum disorders. Developmental Psychology. 2012:48.

Yirmiya N, Gamliel I, Pilowsky T, et al. The development of siblings of children with autism at 4 and 14 months: social engagement, communication, and cognition. Journal of Child Psychology and Psychiatry, and Allied Disciplines. 2006; 47(5):511–523.

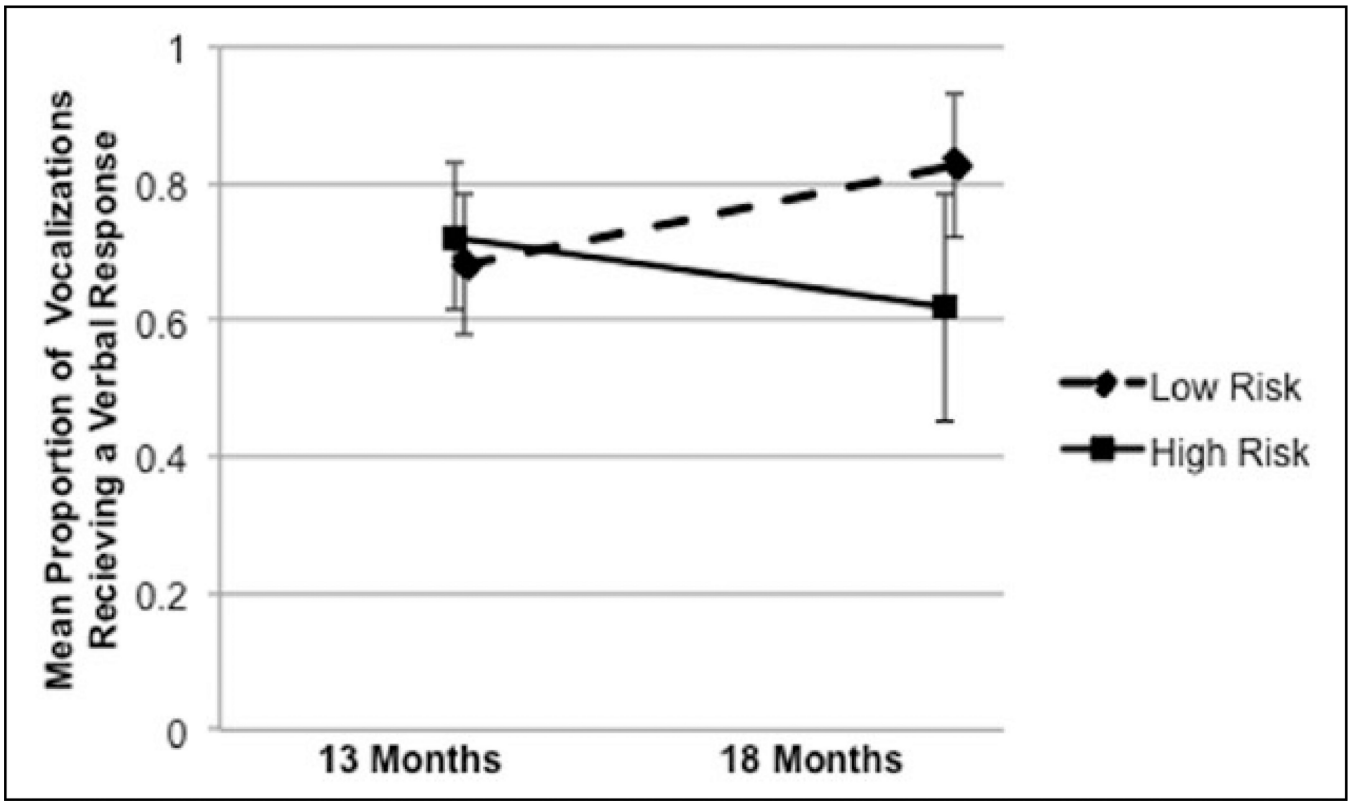

Figure 1.
Mean proportion of infants' nonword vocalizations that received a maternal verbal response at 13 and 18 months. Error bars represent standard errors.

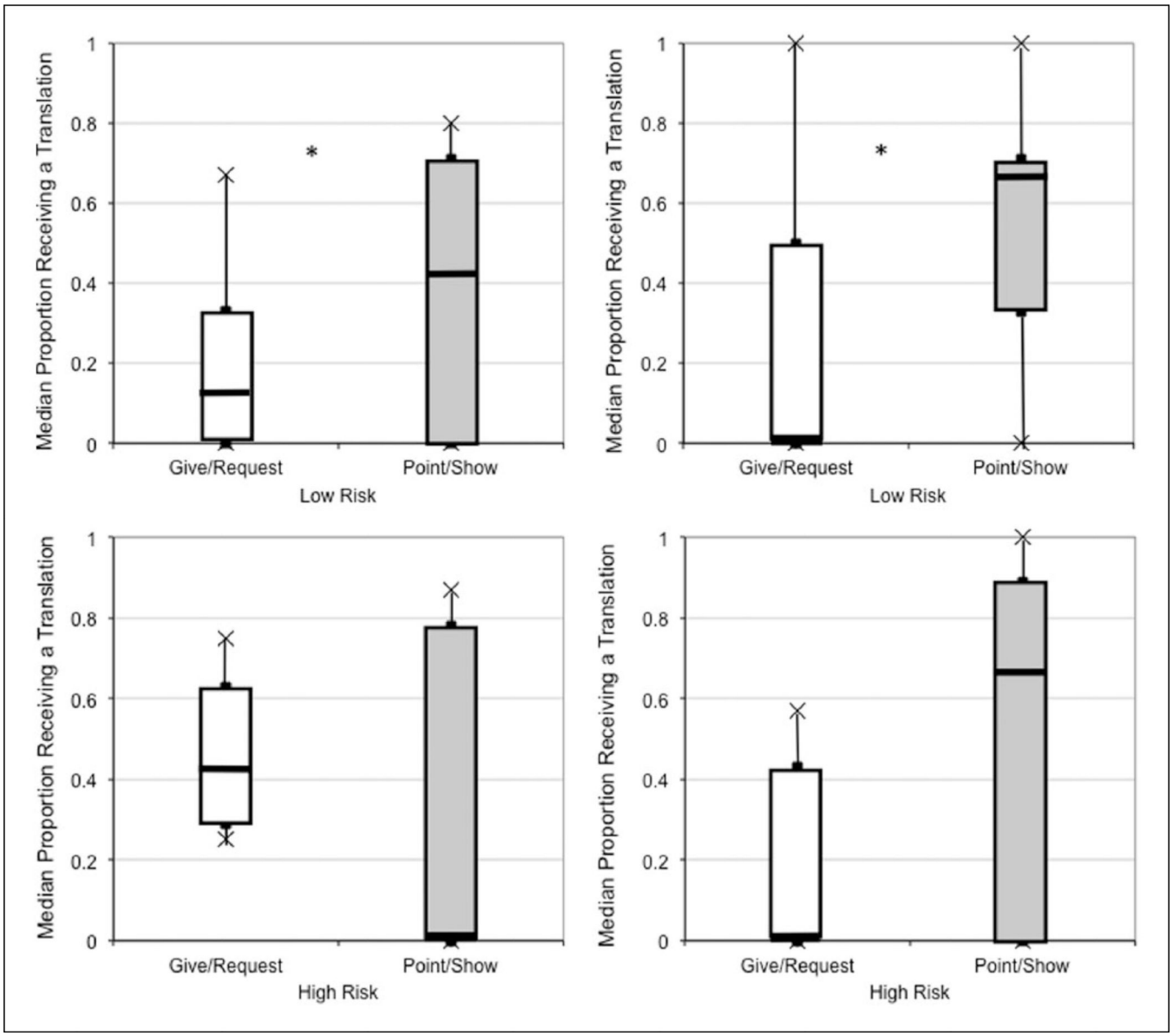

Figure 2.

Boxplots indicating proportions of infant Give/Request and Point/Show gestures that received a maternal translation at13 months (left) and 18 months (right) for the LR group (top panel) and HR group (bottom panel).

HR: high risk; LR: low risk.

The boxes represent the interquartile range for the proportion of gestures that received a translation; the solid lines in the figure represent the median, and the tails represent the minimum and maximum values.

Table 1

Correlations for infant communication directed toward mothers at 13 and 18 months.

	Nonword vocalizations at 18 months	Words at 18 months	Gives/ requests at 18 months	Points/ shows at 18 months
Nonword vocalizations at 13 months	.189	.116	.368	.455*
Words at 13 months	.289	.470*	−.138	.419*
Gives/requests at 13 months	−.027	.140	.388	.068
Points/shows at 13 months	.230	.313	−.158	.644**

* $p < .05$;

** $p < .01$.

Table 2

Descriptive statistics for infant communication directed toward mothers at 13 and 18 months. percentage of infants who produced behaviors (%), median number of behaviors (Mdn), and average deviation (AD).

	13 months						18 months					
	Low risk			High risk			Low risk			High risk		
	%	Mdn	AD	%	Mdn	AD	%	Mdn	AD	%	Mdn	AD
Nonword vocalizations	100	19.50	8.40	100	12.00	18.56	100	8.00	5.55	100	6.00	5.75
Words	71	2.00	2.00	42	0	3.79	100	16.50	12.83	92	9.00	11.70
Gives/requests	79	4.00	2.59	67	5.50	4.67	79	2.00	2.43	92	4.50	7.58
Points/shows	71	2.50	3.55	67	1.00	6.89	93	8.50	3.93	83	1.50	8.43

Table 3

Correlations for the proportion of infant communicative acts receiving a maternal verbal response (VR) at 13 and 18 months.

	VR to vocalizations at 18 months	VR to words 18	VR to gives/requests at 18 months	VR to points/shows at 18 months
VR to vocalizations at 13 months	.063	.182	−.036	.047
VR to gives/requests at 13 months	.140	−.371	−.103	−.247
VR to points/shows at 13 months	.338	.293	.571*	.782**

* $p < .05$;

** $p < .01$.

Table 4

Descriptive statistics for maternal verbal responses to infant gesture production at 13 and 18 months: median proportion (Mdn). and average deviation (AD).

	13 months				18 months			
	Low risk		High risk		Low risk		High risk	
	Mdn	*AD*	*Mdn*	*AD*	*Mdn*	*AD*	*Mdn*	*AD*
Verbal gives/requests	.75	.17	.82	.16	1.00	.24	.58	.23
Translation gives/requests	.13	.16	.38	.23	0	.35	0	.15
Verbal points/shows	.97	.22	1.00	.22	.93	.18	1.00	.22
Translation points/shows	.42	.31	0	.32	.67	.25	.75	.34