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Spontaneous Initiation of Communication in Infants at Low and Heightened Risk for Autism Spectrum Disorders

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Abstract

Communication spontaneously initiated by infants at heightened risk (HR; $n = 15$) for Autism Spectrum Disorders (ASD) is compared to that in low-risk (LR; $n = 15$) infants at 13 and 18 months of age. Infants were observed longitudinally during naturalistic in-home interaction and semi-structured play with caregivers. At both ages, HR infants spontaneously produced Words, Communicative Non-Word Vocalizations, SHOW and POINT Gestures, and Gesture+Non-Word Vocalization Combinations at lower rates than LR peers. This difference also held for Gesture +Word Combinations at 18 but not 13 months. At 36 months, all HR children were evaluated for ASD and three received a diagnosis of Autistic Disorder (AD). At both 13 and 18 months, these three children had been at or near the bottom of the distribution on all spontaneous communication variables.

Keywords

Autism Spectrum Disorders; Communication; Gesture; Vocalization

Spontaneous Initiation of Communication in Infants at Low and Heightened Risk for Autism Spectrum Disorders Despite the fact that many parents of children diagnosed with Autism Spectrum Disorders (ASD) report being concerned about behavioral atypicalities during the child's first year and a half (e.g., Coonrod & Stone, 2004), children do not generally receive an ASD diagnosis before the age of 3 (Charman & Baird, 2002; Fombonne, 2005; Mandell, Novak, & Zubritsky, 2005). As a result, a great deal of research is currently being directed toward the identification of early indices that might predict an eventual ASD diagnosis (e.g., Zwaigenbaum et al., 2005; see also Rogers, 2009, for a review).

While the ideal study design for identifying early diagnostic markers would involve following a representative sample of children in the general population longitudinally from infancy through early childhood, distinguishing those who go on to receive an ASD diagnosis from those who do not, and then looking for infant behaviors that are both

sensitive and specific to the later diagnosis, this is not practically feasible. Assuming an ASD prevalence rate of 1 in 88 (Baio, 2012) a total sample of 1,760 children would be needed to obtain a sub-sample of just 20 who eventually receive a diagnosis.

For this reason, researchers have turned to studying a group of infants at significantly higher risk for ASD than those in the general population. This group, infants who have an older brother or sister with an autism diagnosis, have an ASD recurrence risk of approximately 18.7% (Ozonoff et al., 2011). Careful observation of the behavior of these heightened-risk (HR) infants has the potential to provide valuable information about possible early indices of a later diagnosis. In addition, because HR infants as a group are also at risk for delays in other developmental milestones (e.g., Iverson & Wozniak, 2007), they are worth studying in their own right, even apart from the issue of early identification. The research presented here focuses on the development of infant-initiated communicative behavior in this HR group as compared to that in a group of low-risk (LR) peers.

Communicative Impairments in HR Infants

Infants communicate with social partners in a variety of ways, among which perhaps the most salient are communicative non-word vocalizations (CNWVs), gestures, and, of course, eventually words. CNWVs are vocal utterances produced by the infant that are accompanied by gesture and/or eye contact with the interlocutor but do not contain words or speech sounds consistently used by the child to refer to a specific object or event. Thus, for example, a preverbal infant who wants a cookie but does not yet have the word “cookie” in her productive verbal repertoire might indicate her desire for a cookie by pointing to the cookie while vocalizing “aaahn, aaahn, aaahn” (see Method for more detail on the coding of CNWVs). A preverbal child who sees a cat enter the room but does not yet say “cat” might indicate awareness of the cat’s presence by pointing to the cat and vocalizing “aaaaa.”

Not surprisingly, preverbal behaviors of this sort have joint attentional consequences, where joint attention is construed to be a shared mental state in which partners in an interaction focus attention respectively on the same objects or events. A child who not only points at something of desire or interest but vocalizes while doing so produces a powerful stimulus for parent behavior, a stimulus likely to bring about a state of joint attention. Thus, for example, while a parent who is engaged in her own activities might very well fail to notice her infant silently pointing to a cookie or cat, when the infant accompanies her point with a vocalization, the parent is much less likely to miss the gesture and more likely to shift attention to the object of infant desire or interest. This shift in parent attention then provides the parent with a topic for relevant verbal comment (e.g., “What is it that you want? Oh, you want a cookie.” Or “yes, that’s a kitty, look at the kitty, what a nice kitty.”). The child’s attention to the cookie or the cat and the parent’s use of sentence frames repeating the relevant lexical items coincide; and the child is provided with language input precisely adapted to the focus of her attention at just the moment at which she may be presumed to be optimally receptive (Tomasello & Farrar, 1986).

Because CNWVs are very common in the communicative repertoires of typically-developing (TD) infants and effective in influencing parental attention and behavior (Harding & Golinkoff, 1979; Golinkoff, 1986; Hsu & Fogel, 2001; Goldstein, King, & West, 2003; Gros-Louis, West, Goldstein, & King, 2006), it is surprising that they have not been systematically addressed in research on spontaneous communication in HR children. This is especially so because: a) CNWVs have the potential to redirect caregiver attention and establish joint attentional states; and the establishment of states of joint infant/caregiver attention is known to be impaired in older children with ASD (Mundy, Sigman, & Kasari, 1993); and b) young children’s ability to establish joint attention is predictive of later

language skill (e.g., Tomasello & Farrar, 1986; Mundy et al., 1990; Dunham, Dunham, & Curwin, 1993); and later language skill is frequently impaired in older children with ASD.

Rather than examining the production of CNWVs, studies of communication patterns in HR infants to date have instead generally focused on gesture and/or language. Gesture studies with HR infants have typically employed one of three standardized assessments to evaluate performance: a) the Early Social Communication Scales (ESCS; Mundy, Hogan, & Doehring, 1996); b) the Communication and Symbolic Behavior Scales-Developmental Profile (CSBS-DP; Wetherby & Prizant, 2002); and c) the MacArthur-Bates Communicative Development Inventory (CDI; Fenson et al., 2007). The ESCS and the CSBS-DP both involve direct observation of the infant's behavior under highly controlled circumstances; the CDI is a parent report instrument. Although results vary somewhat by age of the child, the typical result in studies using the ESCS has been that, relative to LR infants, those at heightened risk employ significantly fewer gestures (e.g., showing, pointing) to make behavioral requests and to initiate joint attention (Cassel et al., 2007; Goldberg et al., 2005; Yirmiya et al., 2006).

Results using the CSBS-DP are generally congruent with those of the ESCS. In a comparison of 20-month-old HR and LR children using the CSBS-DP, for example, Toth, Dawson, Meltzoff, Greenson and Fein (2007) found HR siblings to be significantly lower than LR peers in overall communication rate and in use of distal gestures. Using the Systematic Observation of Red Flags (SORF), a behavior coding system developed by Wetherby & Woods (2002) as an ASD screening tool, Wetherby et al. (2004) rated a videotaped sample of behavior obtained from 21-month-old infants during administration of the CSBS-DP. These infants had been identified during a general population screen as at risk for communicative delay and were later diagnosed at age three with ASD. Of three SORF items focusing on atypical gesture use, the ASD group was rated significantly higher than a TD comparison sample on two: lack of pointing and lack of showing. In a follow-up study employing a larger sample, those toddlers who eventually received an ASD diagnosis scored significantly lower than a TD group at 21 months on all 14 social communication measures scored from the CSBS-DP behavior sample, including the number of different gestures (e.g., reach/request, give, point, show, wave, head shake) displayed by the child. Indeed, the number of activities in which the child used vocal or gestural communication to regulate behavior and the number of different gestures were the strongest predictors of ASD symptoms at age three (Wetherby, Watt, Morgan, & Shumway, 2007).

Finally, the CDI has also been used to examine gesture use in HR infants. Thus, for example, Stone, McMahon, Yoder, and Walden (2007) found that parents of 16-month-old HR infants reported significantly fewer gestures than parents of children in a comparison LR sample. In addition, Mitchell et al. (2006) found that, at both 12 and 18 months, HR infants who eventually received an ASD diagnosis were reported to have both fewer early gestures (e.g., showing, pointing, waving) and fewer late gestures (i.e., play gestures such as pounding with a hammer, and feeding, dressing, and bathing a doll) than either HR peers who did not go on to receive an ASD diagnosis or those in an LR comparison group.

Prospective studies of HR infants have also looked at language development using either standardized instruments such as the Bayley Scales of Infant Development (BSID-II; Bayley, 1993) and the Mullen Scales of Early Learning (MSEL; Mullen, 1995) or parent report via the CDI. Thus, for example, Yirmiya et al. (2006) found that although HR and LR infants did not differ significantly on either overall Bayley mental or motor scores at 14 months, HR infants' average developmental language age was significantly lower than that of an LR comparison group. Indeed, at 14 months, 8 of 30 HR infants achieved a language developmental age below their current age. Six of these HR infants' scored at the 9 month

developmental language age, while two infants scored at 12 and 13 months respectively. Using the MSEL, Ozonoff, Rogers, and Sigman (2005) found lower receptive and expressive language scores in HR than LR infants at 18 months, a result also reported by Toth et al. (2007) for receptive but not for expressive language at 20 months. With regard to the CDI, Stone, et al. (2007) found that parents of HR infants reported significantly fewer words and fewer phrases understood than parents of LR infants; and Mitchell et al. (2006) has indicated that HR infants who received an eventual ASD diagnosis were rated by parents at both 12 months and 18 months as understanding fewer phrases and at 18 months as comprehending and producing significantly fewer words than either HR infants without a diagnosis or LR comparison infants.

In sum, the literature suggests not only that the communicative patterns of HR and LR infants differ but that especially low levels of gestural and verbal communication may be indicative of an eventual ASD diagnosis. There are, however, a number of limitations to this research. First, despite the fact that CNWVs are generally common in the repertoire of prelinguistic infants and may have joint attentional consequences, no study to date has systematically examined these behaviors in HR infants or differences in the production of such vocalizations between HR and LR infants.

Second, studies in this area have been limited to data generated from standardized assessments of communicative ability, generally taking place in a laboratory or clinic setting, rather than reflecting spontaneous patterns of communication in familiar, everyday environments. Standardized instruments are specifically designed to elicit certain types of behavior in response to presses of various sorts and are generally administered in settings that are relatively unfamiliar for the infant; and when infants are in unfamiliar situations, the overall frequency of spontaneous communicative behavior is likely to be reduced (cf., Lewedag, Oller, & Lynch, 1994, for differences in rates of vocalization in laboratory and home settings; and compare Iverson, Capirci, and Caselli, 1994, to Thal & Tobias, 1992, for comparable differences in frequency of gesture production). It is therefore not yet clear to what extent observed differences in infant behavior under standardized conditions are characteristic of the child in the everyday environment.

Third, no study in this area to date has distinguished between communicative events spontaneously initiated by the child (i.e., without presentation of a structured activity designed to elicit communication) and those that occur in response to such an activity or to communication from an interlocutor. There are at least three reasons why focusing on spontaneously initiated communication may be important. First, there is a diagnostic presumption in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV, American Psychiatric Association [APA], 1994) that ASD reflects “marked impairment in the ability to initiate or sustain a conversation with others” (p. 75), a presumption retained as “lack of initiation of social interaction” in the proposed DSM-V revision (APA, 2011). Second, a number of studies of older children with ASD have indicated a significant reduction in spontaneous language use. Thus, for example, Charlop, Schreibman, and Thibodeau (1985) concluded that the speech of verbal children with ASD was dependent on others’ verbal prompts. Stone and Caro-Martinez (1990) reported that on average children with ASD only initiated communication three to four times per hour during the school day; and in a recent study of dinner-time communication within the family, Jones and Schwartz (2009) found that, in relation to a TD comparison group, a group of high-functioning children with ASD initiated significantly fewer verbal bids for interaction that included either directives or comments. Lastly, research on symbolic play in older children with autism suggests that the locus of impairment lies not in children’s ability to play symbolically when such play is directly elicited by an experimenter, but rather in the tendency to initiate symbolic play spontaneously (Jarrod, Boucher, & Smith, 1993).

In light of the above, the present study was designed to be the first: a) to evaluate the rate and type (CNWVs, Gestures, and Words, singly and in combination) of spontaneously initiated communication by 13- and 18-month-old HR infants as it occurs in the naturalistic setting of the home; and b) to compare these data to that of a similarly observed comparison group of LR peers. In addition, we also focus on data concerning the spontaneous communicative activity of a small subgroup of HR infants, namely those who eventually received a diagnosis of Autistic Disorder (AD).

Method

Participants

HR infants were 15 later-born infant siblings (8 female, 7 male) of children with a confirmed diagnosis of Autistic Disorder (AD). Infants in the HR group were recruited from western Pennsylvania by flyer, professional referral, and word of mouth through the Autism Research Program at the University of Pittsburgh, parent support groups, and local agencies and schools serving children with ASD. Prior to infant enrollment in the study, the older siblings were administered the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al., 2000) by a trained clinician at the Autism Research Program at the University of Pittsburgh. In order for an infant to qualify for the study, the infant's older sibling needed to score above the threshold for Autism on the ADOS-G. Informed consent was obtained from the infants' parents prior to the start of the study.

For purposes of comparison, 15 LR infants (8 female, 7 male) with no family history of ASD (i.e., no first- or second-degree relatives diagnosed with ASD) were recruited from a larger sample participating in an ongoing longitudinal study of vocal-motor coordination in infancy being conducted by the last author. In order to control for potential effects of birth order, LR infants were selected from the larger sample on the basis of being later born. All later-born infants in the larger sample were chosen for the comparison group. No factor other than birth order systematically distinguished comparison infants from those in the larger sample.

All participants in this study were from full-term, uncomplicated pregnancies and from English-speaking, monolingual families. Twenty-seven infants (13 HR, 14 LR) were White, two (both HR) were Hispanic, and one (LR) was Asian American. Although Mullen Visual Reception scores were not available for HR infants at 18 months, 24-month scores indicated that all HR infants, except those eventually receiving an AD diagnosis, were within the normal range (within 1 SD of the normative mean) with regard to nonverbal cognitive ability. Because one of the infants later receiving an AD diagnosis was uncooperative during the Mullen at 24 months, Mullen VR scores are only available on two of these children, both of whom had VR T scores of 20, below those of all other HR infants. Although it is difficult to assess the impact of low nonverbal cognitive ability on the development of spontaneous communication, it is clearly the case that these two infants differed from other HR infants not only in terms of a later AD diagnosis but also in terms of cognitive delay.

Average numbers of years of mother's education were comparable between groups ($M_{HR} = 16.0$ yrs, $SD = 1.12$; $M_{LR} = 16.8$, $SD = 2.24$) and did not differ significantly. Nor did mean age for mothers ($M_{HR} = 34.7$, $SD = 3.98$; $M_{LR} = 33.2$, $SD = 4.60$) or fathers ($M_{HR} = 35.73$, $SD = 2.74$; $M_{LR} = 34.13$, $SD = 3.98$) differ significantly between groups. Although information on family income was unavailable, parental occupations were identified for the purpose of providing a general index of social class. Because a majority of mothers (10 of 15 in the HR group; 7 of 15 in the LR group) were at home raising their children, Nakao-Teas occupational prestige scores (Nakao & Teas, 1994) were only calculated on fathers' occupations. In 3 cases in the LR group and 1 in the HR group, it was impossible to identify

the father's occupation with enough precision to assign a prestige score. Results from the remaining families indicated that the occupational prestige of HR fathers ($M_{HR} = 64.01$; $SD = 7.36$) was slightly higher than that of LR fathers ($M_{LR} = 60.34$; $SD = 8.74$); but both generally fell within the managerial/professional range and this difference was not statistically significant ($t = 1.1407$, $p = .267$). At 13 months, two HR infants were receiving intervention. For one infant, this consisted of 4 hrs/wk of Occupational Therapy (OT). The other infant received 1 hr/wk of OT plus 1 hr/wk of Developmental Therapy, which consisted largely of OT, Physical Therapy (PT), and play. At 18 months, only one HR infant was receiving intervention (1 hr/wk of OT and 1 hr/wk of PT). HR infants receiving intervention were among those eventually receiving an AD diagnosis. None of the LR infants were receiving intervention and none of the parents in either group was systematically involved in a parent training regimen.

Procedure

As part of a larger, longitudinal program of research, all infants (HR and LR) and their primary caregivers were videotaped at home for 45 minutes when the infants were 13 and 18 months of age. Home observations occurred within three days of the monthly anniversary of the infant's birthday at a time of day when caregivers thought the infant would be alert and playful. To enhance the possibility that results could be generalized across context, videotaped observation sessions were divided into three 15-minute segments. The first and last segments (30 minutes total) were comprised of unstructured naturalistic observation; the middle segment consisted of semi-structured play with the caregiver. During the first segment, infants typically played on the floor with the caregiver present but not specifically initiating involvement with the infant. During the middle segment of the observation, caregivers were asked to make use of the child's toys and play with the child as they would usually play. The final segment was again unstructured and caregivers were free to pursue whatever activities they felt were appropriate, typically play with toys. Prior to initiating the period of observation, caregivers were asked to turn off the television and to allow the child to be free to move about the observation space.

Diagnostic Classification

All HR children were administered the ADOS-G at 36 months. The ADOS-G is a structured play schedule that includes a well-operationalized coding scheme with cutoff scores that reliably differentiate children with ASD from typically developing children and from developmentally delayed children without ASD (Lord et al., 2000). A diagnosis of Autistic Disorder (AD) was given to those HR infants whose scores met or exceeded algorithm cutoffs for Autism on the ADOS-G, with confirmation by clinical judgment using DSM-IV-TR criteria. Clinicians administering the ADOS-G and involved in making a confirmatory diagnosis were blind to all other study data. Based on these criteria, three HR infants were subsequently given a diagnosis of AD (1 female, 2 male). All other HR infants scored below the ADOS-G cutoff for ASD (i.e., none received a PDD-NOS diagnosis). The ADOS-G was not administered to LR infants.

Observational Behavior Coding

All spontaneous infant vocalizations and gestures occurring during the entire 45-minute session were coded from the videotapes using a computer-based video interface system (The Observer Video-Pro version 5.0, Noldus Information Technologies). Because infant-initiated communication was the focus of this study, all vocalizations and gestures produced in response to communications by the interlocutor (e.g., "say cow," "where's the doggie") were excluded from analyses. Because session length varied slightly among participants, all frequency variables were converted to rates per 10 minutes by dividing total frequency by length of observation in minutes, then multiplying by 10. Despite this slight variation in

session length by participant, average session lengths were highly similar by age and group (at 13 months, $M_{HR} = 45.4$; $M_{LR} = 46.7$; at 18 months, $M_{HR} = 44.8$; $M_{LR} = 44.8$). Both the primary and the reliability coder were blind to infant group membership.

Vocalizations—All infant vocalizations were first identified, using two seconds of silence between successive vocalizations as the criterion for completion of one vocalization and the initiation of another. Vocalizations were then classified into three major categories: Words, Non-Word Vocalizations, and Affective/Other Vocalizations. Affective/Other Vocalizations consisted of vocal sounds directly expressing an affective or bodily state (e.g., laughing, squealing, fussing, whining, crying, grunting). They were distinguished from Non-Word Vocalizations on the basis of situational context (e.g., “aaaaah” as a non-word vocalization was distinguished from “aaaaah” as a whine based on the vocalization’s occurrence during an episode of infant noncompliance). Affective/Other vocalizations were excluded from further analysis. Words consisted of verbal utterances containing at least one “word” or verbal marker (e.g., “uh huh” used for the word “yes”, or “nuh uh” used for the word “no”). Words were either actual English words (e.g., “dog,” “cat,” “duck,” “hot,” “walking”) 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). All remaining vocal utterances to oneself, to an object, or to another were classified as Non-Word Vocalizations (NWVs). These included vowel strings (e.g., “aaaaahhh”), reduplicated babbling (e.g., “babababa”), variegated babbling (e.g., “mamagaga”), and short and long strings of gibberish-like sounds (e.g., “bbaieagaaladada...”). NWVs were then further divided into two subcategories: Communicative and Noncommunicative. A NWV was classified as Communicative (i.e., CNWV) if the infant combined eye contact with an interlocutor and/or a deictic gesture (see below) with the NWV. All remaining NWVs (i.e., vocalizations made without eye contact or accompanying gesture, typically in the absence of any interlocutor) were coded as Noncommunicative; and, since the interest here was in infant communication, these were excluded from further analysis. Finally, because Words, unlike NWVs, were rarely if ever uttered outside the context of a social interaction, all Words were by their nature considered to be communicative.

Gestures—All infant gestures were first identified and then classified into five categories. Four of these categories involved Deictic Gestures (viz., REACH/REQUEST, GIVE, SHOW, and POINT). The fifth consisted of Representational Gestures (Iverson, Capirci, & Caselli, 1994; Capirci, Iverson, Pizzuto, & Volterra, 1996). Deictic Gestures are communicative signals that express the child’s intent to request or declare by referring to an object, location, or event through touching it, indicating it, or calling the adult’s attention to it. A REACH/REQUEST gesture consisted of the child extending the arm with an open palm or repeated opening/closing of the hand. GIVE involved extension of the arm with the object in hand and directed toward the hand of another person. SHOW occurred when the child presented the object in the general direction of and made eye contact with the interlocutor. POINT involved clear articulation of the index finger as the child pointed to a proximal (e.g., toy) or distal object (e.g., window). Representational Gestures (e.g., waving BYE-BYE) differ from Deictic Gestures in that they represent specific referents (e.g., departure) and their primary semantic content does not change with context. Deictic Gestures simply “point out” a given referent whereas Representational Gestures “stand for” some referent, or a class of referents, or relations. Because the incidence of Representational Gestures was very low for both groups at both age points, only the data concerning Deictic Gestures will be presented here.

Gesture+Speech (G+S) combinations—G+S Combinations were coded by first identifying Deictic Gestures and Vocalizations (i.e., Words and CNWVs) that overlapped in

time (Iverson & Goldin-Meadow, 2005). These temporally overlapping combinations were then classified by type (e.g., REACH/REQUEST+CNWV, POINT+Word). Finally, summary variables were formed resulting in two types of G+S Combinations: those involving Deictic Gestures combined with CNWVs (G+CNWV Combinations) and those involving Deictic Gestures combined with Words (G+Word Combinations).

Combination repertoire—To obtain an index of how many of the eight different types of G+S Combinations (Words or CNWVs combined with each of four Deictic Gesture types) each child produced, a Combination Repertoire was calculated in which each child could receive a score from zero to eight.

Communication rate—To obtain a measure of the infant's overall tendency to initiate communication, a Communication Rate index was calculated. This was done by adding together the following: a) G+S Combinations; b) separately produced Words (i.e., words that did not appear in combination with a gesture); c) separately produced CNWVs; and d) separately produced Deictic Gestures.

Reliability

Intercoder reliability was measured by having a second rater code every third 45-minute session until more than 20% of the total video footage had been coded by both primary and secondary raters. This method was employed in order to guard against coder drift and to allow for the estimation of reliabilities. Reliabilities were generally high. Percent agreement for the occurrence of Vocalizations was 87% and 88% for Gestures. Cohen's kappa calculated to assess intercoder agreement for categorical decisions was 0.86 for Vocalization type (Words, NWVs, Affective/Other Vocalizations), 1.00 for Gesture type (REACH/REQUEST, GIVE, SHOW, POINT, REPRESENTATIONAL), and 0.90 for NWV type (Communicative vs. Noncommunicative). Disagreements in coding were resolved through discussion following calculation of intercoder reliabilities.

Results

Gestural and Vocal Communication at 13 and 18 Months

Data on rates of production per 10 minutes for the various communication variables are presented for the LR and HR groups as a whole at 13 and 18 months in Table 1. Prior to analysis, all variables were first examined for outliers (data points more than 2 standard deviations from the respective LR and HR means at each age). With a few exceptions (indicated in Table 1), variables had only a single outlier in each group at each age. There were no systematic age or group differences in this regard. Following Tabachnick & Fidell (1996), outliers were replaced with values one unit higher than the next highest value. Distributions, all of which possess an artificial lower bound at 0, were then examined for positive skew. All variables except for Communication Rate, CNWVs, and Combination Repertoire were found to be positively skewed and logarithmically transformed prior to analysis. Means, SEs, and 95% Confidence Intervals are presented in Table 1

Communication rate—As is evident in the table, HR infants were less spontaneously communicative overall than LR infants and both groups were more communicative at 18 months than at 13 months. A 2 (Group) x 2 (Age) analysis of variance (ANOVA) with repeated measures on the latter variable yielded significant Group ($F(1, 28) = 5.93, p = .022, \eta^2 = .18$) and Age ($F(1, 28) = 9.49, p = .005, \eta^2 = .25$) effects. The apparent interaction did not reach significance.

Before proceeding to more detailed analyses, it is important to note the possibility that group differences in frequency of parental vocalization might, in principle, have led to the differences just reported. Thus, for example, especially talkative HR parents might inadvertently reduce the opportunity for HR children to initiate spontaneous communication. To address this possibility, we coded frequencies of parental vocalization at both 13- and 18-month sessions. Results indicated that mean numbers of parental vocalizations for the two groups were highly similar at both 13 months ($M_{HR} = 108.9$; $M_{LR} = 115.2$; $t = .382$, ns) and 18 months ($M_{HR} = 159.0$; $M_{LR} = 155.2$, $t = .163$, ns).

CNWVs and words—At both ages, HR infants on average produced CNWVs and Words at lower rates than did their LR peers. In addition, for both groups, rate of production of CNWVs decreased from 13 to 18 months while that for Words increased. For both variables, ANOVAs yielded significant Group [CNWVs: $F(1, 28) = 4.66$, $p = .040$, $p^2 = .14$; Words: $F(1, 28) = 5.90$, $p = .022$, $p^2 = .17$] and Age [CNWVs: $F(1, 28) = 8.96$, $p = .006$, $p^2 = .24$; Words: $F(1, 28) = 70.36$, $p < .000$, $p^2 = .72$] effects, but no significant interactions.¹

Deictic gestures—Although rate of Deictic Gesture production increased from 13 to 18 months for both groups, HR infants produced Deictic Gestures at lower rates than LR infants at both ages, with a slightly larger group difference at 18 months. An ANOVA conducted on these data yielded a highly significant Age ($F(1, 28) = 20.03$, $p < .000$, $p^2 = .42$) and a nearly significant Group ($F(1, 28) = 3.69$, $p = .065$, $p^2 = .12$) effect. Despite the apparent widening of the group difference in Deictic Gesture rate with age, the interaction was not significant.

Deictic gesture types—As indicated in Table 1, rates of production of REACH/REQUEST decreased and of GIVE increased with age, although the Age effect was only significant for GIVE ($F(1, 28) = 24.21$, $p = .000$, $p^2 = .46$). While neither REACH/REQUEST nor GIVE varied significantly by group (and indeed both were quite similar by group), data for SHOW and POINT revealed strong Group effects. With regard to SHOW, rate of production for HR infants at both ages was much lower than that for their LR peers, with LR infants producing SHOW at a rate nearly four times that of the HR group. Although rates of production of POINT were similar between groups at 13 months, by 18 months this rate had increased dramatically for LR infants but only slightly for those in the HR group. ANOVAs conducted on these data indicated that for SHOW, only the Group ($F(1, 28) = 15.10$, $p = .001$, $p^2 = .35$) effect was significant. For POINT, the Age ($F(1, 28) = 19.00$, $p < .000$, $p^2 = .40$) and Age X Group interaction ($F(1, 28) = 5.36$, $p = .028$, $p^2 = .16$) effects were significant; the overall Group effect was nearly significant ($F(1, 28) = 4.07$, $p = .053$, $p^2 = .13$). Follow-up t-tests performed to identify the locus of the interaction indicated that relative to LR infants, HR infants produced POINT at a significantly lower rate at 18 ($t = 2.785$, $df = 28$, $p = .012$) but not 13 months ($t = .077$, $df = 28$, ns).

Gesture+Speech combinations—Data on combinations consisting of G+CNWVs and G+Words respectively indicated that HR infants produced G+CNWV Combinations at a lower rate than LR infants at both ages and G+Word Combinations at a lower rate at 18 but not 13 months. At 13 months, the G+Word Combination rate was low for both groups, but by 18 months LR infants produced combinations of this type at twice the rate of their HR peers. ANOVAs carried out on these data indicated a significant overall Group effect for G+CNWV Combinations ($F(1, 28) = 5.92$, $p = .022$, $p^2 = .18$). For G+Word Combinations,

¹To address the possibility that decreased CNWV production by HR infants might reflect difficulty in establishing eye contact, we examined group differences in Noncommunicative NWVs (which are independent of eye contact). At both ages, HR infants also produced fewer Noncommunicative NWVs, although the overall group effect was only a trend ($p = .118$).

the Age ($F(1, 28) = 25.40, p < .000, \eta^2 = .48$) effect was significant and the Age X Group interaction ($F(1, 28) = 3.87, p = .059, \eta^2 = .12$) nearly significant. Follow-up t-tests indicated that the group difference was only significant at 18 months ($t = 1.966, df = 28, p = .030$).

Combination repertoire—Finally, each infant's combination repertoire was calculated as the number of different types of G+S Combinations produced (out of a possible eight: two types of speech, Words and CNWVs, combined with four types of Deictic Gestures, REACH/REQUEST, GIVE, SHOW, and POINT). Combination Repertoire data are presented in the last row of Table 1. Although the Combination Repertoire increased from 13 to 18 months for both groups, it was considerably more restricted for HR than LR infants at 13 months and remained restricted at 18 months. An ANOVA carried out on these data yielded significant Age ($F(1, 28) = 12.0, p = .002, \eta^2 = .30$) and Group ($F(1, 28) = 4.55, p = .042, \eta^2 = .14$) effects, but no significant interaction.

In order to clarify the nature of the Combination Repertoire restriction, data for numbers of individuals producing at least one exemplar of the various combination types were examined. These data are presented in Table 2. As is evident, the relative restriction in overall combination repertoire among HR infants at 13 months appeared to reflect the fact that with one exception (GIVE+Word combinations, which were rare for both groups), combinations of all types were produced by fewer HR than LR infants. A Sign Test carried out to assess the significance of 7 of 8 comparisons all in the expected direction yielded a one-tailed $p = .035$. At 18 months, combinations involving SHOW or POINT, but not REACH/REQUEST or GIVE, were generally produced by fewer HR than LR infants. However, only group differences involving POINT were significant (POINT+CNWV, $p = .002$; POINT+Word, $p = .023$, Fisher's Exact Tests, one-tailed).

Differences Between HR Infants With and Without an AD Diagnosis

The HR versus LR group results indicate quite clearly that HR infants as a group were generally less likely to initiate communication using either gestural or vocal behaviors than LR infants. Since, as previously noted, 3 of the 15 children in the HR group eventually received an AD diagnosis at 36 months, two further questions immediately arise. Did spontaneous initiation of communicative behavior at 13 and/or 18 months distinguish these three children (HR-D) from the 12 HR infants who received no such diagnosis (HR-ND)? And to what extent do the overall differences between the HR and LR groups reflect the behavior of these children? Put another way, to what degree do group differences between HR and LR infants remain when the data from the three children receiving an AD diagnosis are removed from that of the HR group?

Data on the various communication variables for the HR-D and HR-ND infants are presented in Table 3. As is evident in the table, even by 13 months the three HR-D infants stood out. Relative to HR-ND infants, they initiated communication at a far lower rate, producing no Words and, more tellingly at this age, relatively few spontaneous CNWVs or Deictic Gestures. Indeed, as a group, these three children produced a total of only two spontaneous Deictic Gestures (one REACH/REQUEST and one GIVE). Furthermore, they were the only infants in the entire sample who did not produce a single G+CNWV Combination at 13 months or a single G+Word combination at either age. Not surprisingly, their Combination Repertoire was markedly restricted. And at 18 months they remained at or near the bottom of the distribution on all measured variables.

Because comparison of the data for the HR-D to that of the HR-ND infants involves small groups of uneven size, all relevant analyses employed nonparametric Mann-Whitney tests. Results of these analyses indicated that, at 13 months, the three HR-D infants were

significantly below their HR-ND peers on the following variables: Communication Rate ($U = 6.0, p = .050$), Deictic Gestures ($U = 1.0, p = .005$), REACH/REQUEST ($U = 4.0, p = .024$), SHOW ($U = 1.5, p = .005$), G+CNWV Combinations ($U = .00, p = .002$), and Combination Repertoire ($U = .00, p = .002$).

At 18 months, results were generally similar, with the three HR-D infants again significantly below their HR-ND peers in Communication Rate ($U = 2.0, p = .009$), Words ($U = 2.5, p = .009$), Deictic Gestures ($U = 2.0, p = .009$), GIVE ($U = 4.5, p = .024$), SHOW ($U = 4.5, p = .024$), G+CNWV Combinations ($U = 6.0, p = .050$), G+Word Combinations ($U = 3, p = .016$), and Combination Repertoire ($U = 1.5, p = .002$).

To determine if the poor communicative performance of the three infants who eventually received an AD diagnosis accounted for the significant HR-LR differences, all previously reported ANOVAs were rerun comparing HR-ND and LR groups. Results of these analyses indicated that the overall pattern of effects was parallel to that obtained with full groups. Of the 17 effects tested in the original ANOVAs, all remained in the original direction. However, significance levels for Group effects and Age X Group interactions were reduced and a number of comparisons that had been significant according to conventional .05 criteria now yielded effects with probabilities only in the .10–.16 range. This change presumably reflects not only the fact that the data excluded were from the three HR infants with rates of production generally lowest among the HR group but also a reduction in statistical power contingent on decrease in sample size.

Specifically, the Group effect for rate of production of SHOW ($F(1, 25) = 9.61, p = .005, \eta^2 = .28$) and the Group by Age interaction for POINT ($F(1, 25) = 4.21, p = .050, \eta^2 = .14$) remained significant. Group comparisons for Communication Rate ($F(1, 25) = 2.61, p = .119, \eta^2 = .09$), CNWVs ($F(1, 25) = 2.01, p = .168, \eta^2 = .08$), Words ($F(1, 25) = 2.61, p = .119, \eta^2 = .09$), POINT ($F(1, 25) = 2.08, p = .160, \eta^2 = .08$) and G+CNWV Combinations ($F(1, 25) = 2.39, p = .134, \eta^2 = .09$), and the Group X Age interaction for G+Word Combinations ($F(1, 25) = 2.08, p = .162, \eta^2 = .08$) were no longer significant by conventional standards. Age effects were little influenced by removal of the HR-D infants' data. Across the HR-ND and LR groups, Communication Rate ($F(1, 25) = 8.87, p = .006, \eta^2 = .26$) and rates of production of Words ($F(1, 25) = 79.10, p < .000, \eta^2 = .76$), Deictic Gestures ($F(1, 25) = 15.88, p = .001, \eta^2 = .39$), POINT ($F(1, 25) = 15.20, p = .001, \eta^2 = .38$), GIVE ($F(1, 25) = 25.73, p < .000, \eta^2 = .51$), REACH/REQUEST ($F(1, 25) = 4.24, p = .050, \eta^2 = .15$), G+Word Combinations ($F(1, 25) = 24.37, p < .000, \eta^2 = .49$), and Combination Repertoire ($F(1, 25) = 12.62, p = .002, \eta^2 = .34$) all continued to show significant increase and CNWVs significant decrease ($F(1, 25) = 9.10, p = .006, \eta^2 = .27$) from 13 to 18 months. In short, and unsurprisingly given the very poor communicative performance of the three HR-D infants, the data from these infants did contribute to the poorer overall performance of HR relative to LR groups. Removal of these data, however, did not eliminate the overall tendency for HR infants as a group to be less communicative than their LR peers.

Individual Differences in the Spontaneous Communication of HR and LR Infants

Although rates of spontaneous initiation of communication for HR-D infants fell well below those for HR-ND infants and rates for HR-ND infants tended to fall below those for their LR peers, these overall group comparisons do not tell the whole story. Examination of the distributions for the various communication variables indicates wide individual differences in both groups. To exemplify these individual differences, infants' rates of production for two variables (CNWVs and Deictic Gestures) at 13 months and two variables (Words and G+Word Combinations) at 18 months are illustrated in Figure 1. These four variables were chosen for Figure 1 because they represent the major communicative modes at the respective

ages and because the patterns exemplified are generally characteristic of the broader range of communication variables assessed.

Three patterns are evident in these data. First, as would be expected from the previously reported analyses, the central tendencies of the distributions for HR infants generally fall below those for LR infants. Second, there are individual LR infants whose spontaneous communication rates were quite low, almost as low as those of the lowest HR infants. Third, and importantly, not only are there individual HR infants whose rates of communication were well within the expected range for LR infants, there are some in the HR group whose communicative performance was at or near the top of the distribution for both groups.

Discussion

Most of what is known about the communicative behavior of HR infants has been derived from laboratory or clinic research in which this behavior was directly elicited in standardized tasks, rather than from the observation of infants' spontaneous communication in the home. Furthermore, even though CNWVs are generally common in the communicative repertoire of prelinguistic infants and may have significant consequences for the establishment of joint attention episodes important for language acquisition, research on HR infants' communicative behavior has focused almost exclusively on gestures and words and ignored CNWVs. The present study was therefore designed to evaluate the spontaneously initiated communication (CNWVs, Gestures, and Words, singly and in combination) of 13- and 18-month-old HR infants as this communication occurs in the naturalistic setting of the home and to compare these data to those obtained from a similarly observed comparison group of LR peers. In addition, we also focused on the spontaneous communicative activity of a small subgroup of HR infants, namely those who eventually received a diagnosis of Autistic Disorder (AD).

As a group and across age, HR infants spontaneously initiated communication at lower rates than their LR peers. This difference held for overall Communication Rate, individually for Words, CNWVs, Gestures involving SHOW and POINT, and G+CNWV Combinations. It also held for G+Word Combinations at 18 but not 13 months when Word production was quite low. Separate analysis of the data from the three HR children who eventually received an AD diagnosis at 36 months indicated that their levels of spontaneous communication were at or near the bottom of the distribution on all variables. When the data from these three children were removed from those of the HR group, the broad pattern of HR vs. LR differences remained although significance levels were generally reduced.

Spontaneous Initiation of Communication

Reduced word production in HR infants is, of course, consistent with a growing body of research indicating significant language delay in many HR children (Mitchell et al., 2006; Yirmiya et al., 2006; Yirmiya, Gamliel, Shaked, & Sigman, 2007). The current study extends this finding more broadly to a wider range of vocal and gestural communicative behaviors spontaneously initiated by the child in the naturalistic environment of the home. This pattern of results is also consistent with what is known about older children with ASD, viz., that they are often especially impaired in the spontaneous initiation of various behaviors and behavior combinations. These include the initiation of joint attention (Mundy et al., 1993), spontaneous communication via both gesture (Crais, Watson, Baranek, & Reznick., 2006) and language (Charlop et al., 1985; Stone & Caro-Martinez, 1990; Jones & Schwartz, 2009), the initiation of symbolic play (Hobson, Lee, & Brown, 1999; Sigman & Ungerer, 1984), and the production of behavior combinations involving eye gaze, vocalizations, gestures, and smiles (Adrien, Ornitz, Berthelmy, Sauvage, & Lelord, 1987;

Buitelaar, van Engeland, de Kogel, de Vries, & van Hoof, 1991; Wetherby, Yonclas, & Bryan, 1989).

Although the question of a possible reduction in the spontaneous initiation of behavior in HR infants is just beginning to be addressed, the data that exist suggest that as a group HR infants may also be somewhat impaired in this regard. Thus, for example, Bhat, Galloway, and Landa (2010) have reported that 6-month-old HR infants manifested lower levels of spontaneous gaze to caregivers during a learning task. However, when caregivers initiated the interaction and worked to engage the infant, HR infants produced typical levels of social gaze. Kurtz, Wozniak, and Iverson (2011) have recently obtained evidence for a significant reduction in the spontaneous imitation of caregivers in the naturalistic environment in HR relative to LR toddlers. When caregivers attempted to elicit imitation from the child, however, there were no differences between HR and LR groups. Finally, the data presented here clearly indicate that, as a group, HR children initiate communication spontaneously at rates significantly below those of LR comparison children. Taken together these findings suggest that a critical locus of difference between HR and LR children may lie in the spontaneous initiation of social behavior rather than in response to the behavior of others. As Bhat et al. suggest with regard to the results that they report, HR infants may exhibit an early vulnerability in the developing system underlying initiation of rather than response to social others.

Developmental and Clinical Implications of Reduction in the Spontaneous Initiation of Preverbal Communicative Behavior

Traditionally, language impairment in ASD has been linked to difficulties that children with ASD manifest in establishing joint attention with an interlocutor (e.g., Bruinsma, Kogel, & Kogel, 2004; Loveland & Landry, 1986; Mundy, Sigman, Ungerer, & Sherman, 1987; Mundy, Sigman, & Kasari, 1990, 1993; Sigman & Ruskin, 1997). The results of the current study suggest an intriguing but as yet untested hypothesis, viz., that the roots of communicative impairment in ASD may be evident even earlier than the period of emergence of joint attention, in reduced frequency of spontaneously produced CNWVs. Well before TD children have words, they make extensive use of CNWVs and these vocalizations influence parental behavior (Golinkoff, 1986; Hsu & Fogel, 2001; Goldstein et al., 2003; Gros-Louis et al., 2006). When the infant vocalizes in relation to an object or event, especially when that vocalization is combined with gesture, the parent may be more likely to shift attention to that object or event and to accompany that attentional shift with relevant verbal commentary matched to the child's attentional state. Although the study of CNWVs is in its own infancy and persuasive data on this issue are currently lacking, it seems reasonable to hypothesize that contingent caregiver response to early preverbal vocalizations with joint attentional consequences of this sort may be central to the process of language acquisition (cf., Golinkoff, 1986, for the way in which infants and caregivers negotiate shared meaning when the infant initiates a preverbal communication that the caregiver fails to comprehend and the way in which this process changes over time).

Our data indicate that as a group children at heightened risk for ASD, even those who never receive an eventual ASD diagnosis, when observed at home under naturalistic conditions, exhibit a reduction in the spontaneous initiation of CNWVs, in the spontaneous production of the gestures SHOW and POINT, and in the spontaneous combination of vocalizations and gestures. The developmental implication of this finding seems obvious. The opportunities that such children instantiate for themselves to share states of joint attention and, therefore, topics for comment with the caregiver may be sharply reduced. If, indeed, as has long been thought (Bates, 1979; Tomasello & Farrar, 1986) joint attention provides a foundation for language development, it is little wonder that HR infants as a group might be at risk not only

for ASD but, even in the absence of ASD, for language delay (Mitchell et al., 2006; Yirmiya et al., 2006; Yirmiya et al., 2007).

There are also two important clinical implications of these results. The first has to do with the potential for early preverbal communicative behavior to be used in screening for later developmental outcomes. CNWVs appear early in development, before gestures and well before words. Only some (generally <20%; Ozonoff et al. 2011) HR infants are eventually diagnosed with ASD. However, others (about another 20%, Yirmiya et al. 2007) manifest some degree of language delay without symptoms of autism; and still others appear indistinguishable in behavior from LR peers. It is at least possible that careful surveillance of preverbal communicative behavior, especially as it occurs in the familiar conditions of the home environment, and observation of the timetable for the emergence of critical milestones (e.g., combining non-word vocalizations with eye gaze to caregiver, combining non-word vocalizations with gesture, first use of showing and pointing) might be useful in differentiating among these potential outcomes and in doing so well before the end of the first year.

In considering the relationship between reduced preverbal communicative behavior and later language delay, however, it is important to keep two issues in mind. The first is that it is unknown whether and to what extent reduction in early preverbal communicative behavior of this sort is specific to infants at heightened risk for ASD rather than being a more general marker of potential language delay regardless of ASD-risk status. Research comparing the nature of early communicative behavior in the HR population to that in infants at risk for other developmental issues would be valuable in clarifying this specificity issue. The second is that, in the absence of experimental research focused on the effects on later language (e.g., lexical acquisition) of manipulating contingent caregiver response to early preverbal vocalizations and vocalization-gesture combinations, it is impossible to know whether the effects of preverbal communicative delays are specific to later language impairment or reflect a more general pattern of developmental delay.

Finally, a second clinical implication of our results, especially taken together with the need for experimental research designed to manipulate caregiver response to infant communication, is that it may be valuable to develop interventions designed to enhance the preverbal communicative environment of the home. Such programs might focus on sensitizing parents to the developmental importance of preverbal vocalization and states of joint attention, to the need to respond to them contingently, and, in so doing, to providing the infant with timely and relevant language input. Indeed, positive results of two recent studies of short-term caregiver-mediated intervention suggest the potential fruitfulness of this approach. One (Kasari et al., 2010) has demonstrated the effectiveness of joint attention intervention on responsiveness to joint attention and diversity of functional play acts in toddlers with autism. The second (Siller, Hutman, & Sigman, 2012) has reported enhanced responsivity in parental communication and improved expressive language in children with autism age 3 to 7, but only among those who entered the study with very low baseline language skills (below 12 months). These studies represent first steps in what should become a focused effort.

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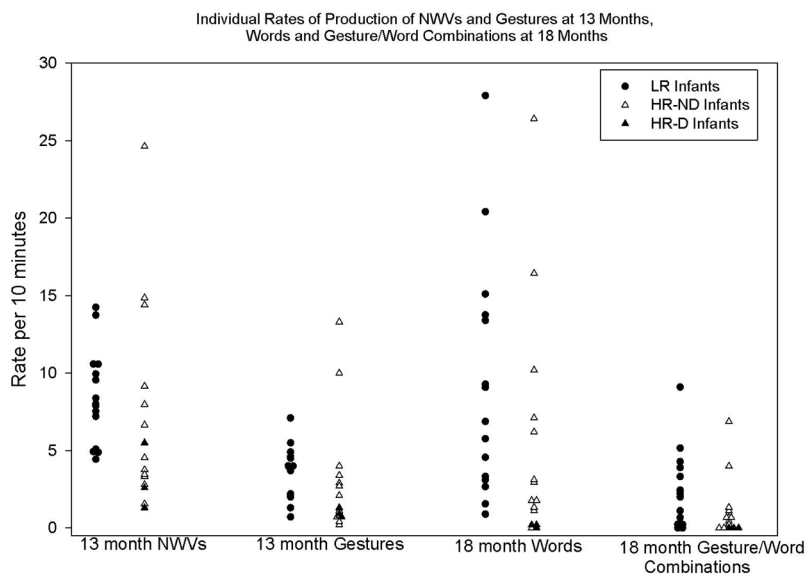


Figure 1. Individual rates of production for CNWVs and Deictic Gestures at 13 months and Words and Gesture+Word Combinations at 18 months.

Table 1
Production Rates per 10 Mins. for Low- (LR) and High-Risk Infant-Initiated Communicative Types at 13 and 18 Months of Age

| | LRs (N=15) | | | HRs (N=15) | | | | |
|-------------------------------|--------------------------|---------------|--------------------------|----------------|-------------|--------------|---------------------------|--------------|
| | 13 mo. | 18 mo. | 18 mo. | 13 mo. | 18 mo. | 18 mo. | | |
| | M (SE) | 95% CI | M (SE) | 95% CI | M (SE) | 95% CI | | |
| <i>Communication Rate</i> | 11.09 (1.01) | [9.11, 13.07] | 17.02(2.03) ^a | [13.04, 21.00] | 8.28 (1.61) | [5.12,11.44] | 10.55 (1.76) ^a | [7.10,14.00] |
| <i>CNWVs</i> | 8.47 (0.79) ^a | [6.92, 10.02] | 5.88 (0.67) | [4.57, 7.19] | 6.43 (1.23) | [4.02, 8.84] | 4.03 (0.66) ^a | [2.74, 5.32] |
| <i>Words</i> | 1.17 (0.35) | [0.48, 1.86] | 8.69 (1.70) ^a | [5.36, 12.02] | 0.54 (0.28) | [0.00, 1.09] | 4.60 (1.46) | [1.74, 7.46] |
| <i>Deictic Gestures</i> | 3.18 (0.45) | [2.30, 4.06] | 7.01 (1.18) | [4.70, 9.32] | 2.54 (0.82) | [0.93, 4.15] | 4.45 (0.94) | [2.61, 6.29] |
| <i>Reach/Request</i> | 0.88 (0.16) ^a | [0.57, 1.19] | 0.49 (0.15) | [0.20, 0.78] | 0.87 (0.25) | [0.38, 1.36] | 0.58 (0.13) | [0.33, 0.83] |
| <i>Give</i> | 0.61 (0.13) | [0.36, 0.86] | 1.63 (0.31) | [1.02, 2.24] | 0.49 (0.15) | [0.20, 0.78] | 2.37 (0.65) | [1.10, 3.64] |
| <i>Show</i> | 0.78 (0.16) | [0.47, 1.09] | 1.24 (0.33) | [0.59, 1.89] | 0.22 (0.05) | [0.12, 0.32] | 0.33 (0.09) | [0.15, 0.51] |
| <i>Point</i> | 0.90 (0.39) | [0.14, 1.66] | 3.64 (0.80) | [2.07, 5.21] | 0.96 (0.59) | [0.00, 2.12] | 1.19 (0.37) | [0.46, 1.92] |
| <i>Gestures+CNWVs</i> | 1.57 (0.28) ^b | [1.02, 2.12] | 2.18 (0.38) | [1.44, 2.92] | 1.01 (0.42) | [0.19, 1.83] | 1.47 (0.44) | [0.61, 2.33] |
| <i>Gestures+ Words</i> | 0.16 (0.07) | [0.02, 0.30] | 2.38 (0.64) | [1.13,3.63] | 0.21 (0.15) | [0.00, 0.50] | 1.08 (0.49) | [0.12, 2.04] |
| <i>Combination Repertoire</i> | 3.13 (0.34) | [2.46, 3.80] | 4.47 (0.53) | [3.43, 5.51] | 1.67 (0.42) | [0.85, 2.49] | 3.53 (0.70) | [2.16, 4.90] |

^a contained no outliers;

^b contained two outliers; all other distributions had a single outlier.

Table 2
 Number of HR and LR Infants at 13 and 18 Months of Age Who Produced Each of the Various Combination Types

| | RCH/RQST ^a + CNWV | GIVE + CNWV | SHOW + CNWV | POINT + CNWV | RCH/RQST + Word | GIVE + Word | SHOW + Word | POINT + Word |
|-----------|------------------------------|-------------|-------------|--------------|-----------------|-------------|-------------|--------------|
| 13 months | | | | | | | | |
| LR | 10 | 9 | 12 | 8 | 2 | 1 | 1 | 4 |
| HR | 7 | 5 | 6 | 4 | 0 | 1 | 0 | 2 |
| 18 months | | | | | | | | |
| LR | 6 | 8 | 9 | 13 | 3 | 8 | 9 | 11 |
| HR | 6 | 10 | 6 | 9 | 5 | 7 | 5 | 5 |

^aReach/Request

Table 3

Production Rates per 10 mins. for Infant-Initiated Communicative Types at 13 and 18 Months for High-Risk (HR) Infants Who Eventually Received an Autism Diagnosis (HR-D) and Those Who Did Not (HR-ND)

| | HR-D (N=3) | | HR-ND (N=12) | | | |
|-------------------------------|------------------|------------------|------------------|---------------|---------------------------|---------------|
| | 13 mo. M (SE) | 18 mo. M (SE) | 13 mo. M (SE) | 95% CI | 18 mo. M (SE) | 95% CI |
| <i>Communication Rate</i> | 3.30 (1.17) | 3.42 (1.27) | 9.52 (1.71) | [6.17, 12.87] | 12.33 (1.84) ^a | [8.72, 15.94] |
| <i>CNWVs</i> | 3.16 (1.24) | 2.45 (1.23) | 7.24 (1.42) | [4.46, 10.02] | 4.43 (0.74) ^a | [2.98, 5.88] |
| <i>Words</i> | 0.00 (0.00) | 0.15 (0.07) | 0.67 (0.35) | [0.00, 1.36] | 5.72 (1.69) | [2.41, 9.03] |
| <i>Deictic Gestures</i> | 0.15 (0.07) | 0.97 (0.20) | 3.14 (0.96) | [1.26, 5.02] | 5.33 (1.03) | [3.31, 7.35] |
| <i>Reach/Request</i> | 0.07 (0.07) | 0.37 (0.20) | 1.06 (0.29) | [0.49, 1.63] | 0.63 (0.16) | [0.32, 0.94] |
| <i>Give</i> | 0.07 (0.07) | 0.30 (0.15) | 0.60 (0.17) | [0.27, 0.93] | 2.89 (0.74) | [1.44, 4.34] |
| <i>Show</i> | 0.00 (0.00) | 0.00 (0.00) | 0.27 (0.04) | [0.19, 0.354] | 0.41 (0.11) | [0.19, 0.63] |
| <i>Point</i> | 0.00 (0.00) | 0.30 (0.07) | 1.20 (0.73) | [0.00, 2.63] | 1.41 (0.44) | [0.55, 2.27] |
| <i>Gestures+CNWVs</i> | 0.00 (0.00) | 0.15 (0.15) | 1.26 (0.50) | [0.28, 2.24] | 1.80 (0.50) | [0.82, 2.78] |
| <i>Gestures+Words</i> | 0.00 (0.00) | 0.00 (0.00) | 0.27 (0.18) | [0.00, 0.62] | 1.35 (0.59) | [0.19, 2.51] |
| <i>Combination Repertoire</i> | 0.00 (0.00) | 0.33 (0.33) | 2.08 (0.45) | [1.20, 2.96] | 4.33 (0.69) | [2.98, 5.68] |

^a contained no outliers; all other HR-ND distributions had a single outlier.