MATERNAL RESPONSES TO COMMUNICATION OF INFANTS AT LOW AND HEIGHTENED RISK FOR AUTISM

by

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The current study investigated maternal responses to infant communication among mothers of infants at heightened risk (HR) for autism spectrum disorder (ASD) and mothers of infants at low risk (LR) for the disorder at 13 and 18 months. Infants and mothers were observed during naturalistic in-home interactions and semi-structured play. By 18 months, HR infants demonstrated delays in developmentally advanced communicative behaviors (pointing, showing, words) as compared to LR infants. Regarding maternal responses, overall mothers of HR infants responded as frequently as mothers of LR infants. However, our data indicated that from 13 to 18 months, mothers of LR infants increased their responsiveness to non-word vocalizations while mothers of HR infants did not. In addition, mothers of both HR and LR infants were more likely to label the referent of developmentally advanced gestures (pointing/showing) than earlier emerging gestures (giving/requesting). These findings suggest that mothers may provide richer responses to more developmentally advanced communication. Thus, delays in infant gesture and speech could alter the input infants receive leading to potential cascading effects on language development.

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PREFACE

I would like to thank my advisors, Dr. Jana Iverson and Dr. Susan Campbell for their support and guidance throughout the process. I would also like to thank the Infant Communication Lab for their help and encouragement. Most importantly, I am grateful to the infants and families who participated in the project.

1.0 LITTERATURE REVIEW

A 9-month-old is sitting in his high chair across from his mother. His bottle is on the kitchen table out of his reach. The baby extends his arm toward the bottle repeatedly opening and closing his hand and vocalizing, indicating desire for his bottle. His mother smiles and hands him the bottle. A 17-month-old is at the zoo with her family. She sees a monkey and points at it and then looks back at her mother. Her mother says, "That's a monkey." In each of these examples, infants not only directed a caregiver's attention to an object in order to satisfy a need or an interest in sharing, they also elicited a response from the caregiver.

1.1 SOCIAL COMMUNICAION: TYPICAL DEVELOPMENT

Prior to the acquisition of fluent speech, typically developing (TD) infants communicate through behaviors such as gestures, vocalizations, eye-gaze, and facial expressions (Bates Benigni, Bretherton, Camaioni, & Volterra, 1979; Harding & Golinkoff, 1979; Wetherby, Cain, Yonclas, & Walker, 1988). Social communicative competence gradually develops as infants acquire new skills that enable them to communicate with a social partner using behaviors with shared meanings (Bates et al., 1979). Bates (1976) sheds light on this progression by delineating a developmental sequence leading to the emergence of intentional social communication. Starting at birth, infants have a systematic effect on their listeners through the production of vocalizations, facial expressions, and other behaviors which usually result in prolonged dyadic social interactions between the infant and caregiver. Gradually, infants' interactions become triadic. From approximately 6 to 9 months of age, infants start to shift their eye-gaze between an object and a person (Bakeman & Adamson, 1984). Over time, infants develop more efficient methods for signaling their attention to referential objects. For example, by 10 to 12 months of age, infants begin actively directing gestures (i.e., requesting, giving, showing, and pointing) and other preverbal signals such as non-word vocalizations in coordination with eye contact to communicate their needs and interests (Harding & Golinkoff, 1979). According to Bates, this newly acquired ability to coordinate gaze with other prelinguistic signals marks the onset of intentional social communication.

Gesture is an important form of social communication and one of the earliest ways in which TD infants signal their current attentional focus to a communicative partner (Bates, Camaioni, & Volterra, 1975). The infant initiated gestures described above share two defining characteristics: they are spontaneous actions and are directed towards another person with the purpose of communicating (Iverson & Thal, 1998). Researchers have distinguished between two primary categories of gesture: deictic and representational. Deictic gestures mark the current focus of an infant's attention and are communicative signals that express the infant's intent to request or declare (Bates, 1976; Bates et al., 1979). Infants use deictic gestures to refer to objects, locations, or events by directly touching or indicating them to a communicative partner (Bates, 1976). Representational gestures refer to objects, persons, locations, or events through hand movement, body movement, or facial expression (Acredolo & Goodwyn, 1988; Goldin-Meadow & Morford, 1985). These gestures differ from deictic gestures in that they represent specific referents and carry some fixed semantic content (Iverson & Thal, 1998). Because deictic gestures are more frequently produced by infants (Thal & Tobias, 1992) and have been found to predict later language development (Iverson & Goldin-Meadow, 2005), they will be the focus of the present study.

The four types of deictic gestures include requesting, giving, showing, and pointing. Typically appearing between 8 and 9 months of age, open handed reaching or requesting is the first to emperge (Carpenter, Nagell, & Tamasello, 1998; Crais, Douglas, & Campbell, 2004). This is followed by giving and then showing between 9 and 13 months of age (Masur, 1983). Bates et al. (1975) reported that showing develops approximately one month after giving. Lastly, pointing emerges between 11 and 14 months of age (Bates et al., 1975; Masur, 1983). A number of studies have reported that infants first produce gestures alone and then begin to combine gestures with vocalizations (Carpenter, Mastergeorge, & Coggins, 1983; Masur, 1983; Wetherby et al., 1988).

Studies have also described the course of vocal development in TD infants (Oller, 2000). Specifically, infants begin their first year by producing immature vowel sounds. Between 6-10 months the emergence of canonical babble (i.e., consonant vowel syllables with speech-like voice quality) occurs, which is followed by the production of closed syllables (consonant-vowel-consonant) at the end of the first year. In addition, as infants develop their consonant repertoires expand, and researchers have classified the developmental order and approximate age of emergence of consonant acquisition in English (Shriberg, 1993). While prior to 12 months word production is minimal, a slow increase in word production from fewer than 10 words at 12 months to approximately 40 words at 16 months has been documented among TD infants (Fenson et al., 1994).

1.2 SOCIAL COMMUNICAITON: AUTISM SPECTRUM DISORDER

Impairments in social communication are a hallmark of the autism diagnosis (American Psychiatric Association, 1994; Volkmar, Lord, Bailey, Schultz, & Klin, 2004). Although individuals with autism spectrum disorder (ASD) display heterogeneity in terms of language ability, limitations with regard to social communication are ubiquitous across cognitive level and age (Tager-Flusberg, Joseph, & Folstein, 2001). A large body of research has revealed that children with ASD display deficits in the use of social communicative behaviors (Dawson et al., 2004, Mundy, Sigman, & Kasari, 1990; Stone, Ousley, Yoder, Hogan, & Hepburn; 1997; Wetherby, Prizant, & Hutchinson; 1998). Compared to TD children and children with developmental delays (DD), toddlers with ASD display less overall communication, fewer spontaneous deictic gestures for the purpose of sharing attention, and a more limited repertoire of conventional gestures (Wetherby, Watt, Morgan, & Shumway, 2007).

Not only do children with ASD display deficits in the use of specific social communicative behaviors, but they also exhibit atypical patterns of nonverbal communication. While these children produce fewer developmentally advanced gestures such as showing and pointing, they display relatively typical rates of earlier emerging gestures such as requesting and giving. In addition, children with ASD display reduced eye gaze and fewer vocalizations in coordination with gestures (Stone et al., 1997).

The general consensus among clinicians and researchers is that ASD cannot be diagnosed reliably before age two (Lord, 1995; Stone et al., 1999). Nevertheless, caregivers of children with ASD report noticing abnormalities dating back to their child's first two years of life (Stone, Hoffman, Lewis, & Ousley, 1994); and growing evidence exists that ASD has its origins in abnormal brain development early in prenatal life (Courchesne, Carper, & Akshoomoff, 2003).

Accumulating research indicates the effectiveness of early diagnosis and intervention for children with ASD (Dawson & Osterling, 1997; Harris & Handleman, 2000; National Research Council, 2001). Based on these findings, interest has surged to understand the early development of infants who are later diagnosed with ASD (Rogers, 2009).

Aberrant patterns of social communicative development may by one of the earliest distinguishing features of ASD because the deficits identified are in skills that typically develop during the first 12-18 months of life (Wetherby et al., 2004; Zwaigenbaum et al., 2005). Research on social communication deficits in infants who eventually receive a diagnosis of ASD is emerging from both retrospective analysis of home videotapes of children later diagnosed with ASD and prospective systematic observational studies (Wetherby et al., 2007). Findings from retrospective studies have revealed that by 12 months of age, infants who were later diagnosed with ASD use significantly fewer communicative gestures in comparison to their TD peers (Osterling, Dawson, & Munson, 2002). However, Zwaigenbaum and colleagues raise the concern that these retrospective studies may not provide a clear and accurate picture of the behavioral manifestations of ASD since the home videos used vary considerably between children and depend on the particular contexts selected for taping.

Prospective longitudinal studies are now being conducted on infants who have an older sibling with ASD, given their high level of genetic risk for ASD or other disorders such as language impairments relative to children in the general population (Zwaigenbaum et al., 2007). Findings from prospective research studies examining high risk infant siblings (HR siblings) have revealed that as early as 12 months, infants later diagnosed with ASD showed delays in both gesture and language development (Zwaigenbaum et al., 2005).

In addition, preliminary evidence suggests that a subset of HR infants who do not go on to develop ASD display atypical or delayed patterns of communicative development (Cassel et al., 2007; Goldberg et al., 2005; Paul, Fuerst, Ramsay, Chawarska, & Klin, 2011; Winder, Wozniak, Parladé, & Iverson, 2009; Yirmiya et al., 2006). Specifically, Paul et al. (2011) found that on average HR infant siblings produced significantly fewer speech-like vocalizations, consonant types, and canonical syllable shapes as compared to infant siblings with no family history of ASD (Low Risk; LR). With regard to gesture development, results from the Winder et al. (2011) study revealed that at both 13 and 18 months HR and LR infants displayed similar rates of spontaneous initiation of communicative giving and requesting gestures. However, LR infants at both ages produced showing gestures at a rate nearly four times that of the HR infants. In addition, while the rate of production of pointing gestures was similar between groups at 13 months, by 18 months this rate had increased dramatically for the LR infants but only slightly for the HR infants. Although the majority of these HR infants did not receive a diagnosis of ASD, they displayed delays in the development of more advanced deictic gestures (i.e., showing and pointing) across the second year.

1.3 MATERNAL RESPONSE TO INFANT COMMUNICATION: TYPICAL DEVELOPMENT

Early communicative behaviors enable infants to share intentions, thoughts, and desires as well as elicit contingent responses from a communicative partner prior to the development of speech. Bornstein and Tamis-LeMonda (1989) have defined responsiveness as prompt and contingent responding by caregivers to children’s exploratory and communicative overtures. It has been well documented that a responsive and structured social environment is optimal for infant development and that infants are able to recognize caregivers' contingent behaviors from a young age (Bigelow, 1998; Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008; Goldstein, Schwade, & Bornstein, 2009; Millar & Watson, 1979). Research indicates that contingent social responses to infants' prelinguistic behaviors create opportunities for infants to learn from the consequences of their behaviors and acquire an understanding of the contingencies defining communicative interaction (Goldstein & Schwade, 2008).

The social-interactive view of early language acquisition (Bruner, 1983) and, more recently, the interactionist perspective on the acquisition of language (Chapman, 2000) suggest that caregivers provide an interpretive scaffold for many of their children's social communicative behaviors, which in turn supports language development. Accumulating evidence indicates that the language directed to young children interacts with the developing language system. Researchers have proposed that the large variability in timing observed in TD children's language acquisition may be explained at least in part by differences in the quantity and form of input provided by their social interactive partners (Gathercole & Hoff, 2007). Specifically, input that is relevant to the focus of an infant's attention has been shown to provide the optimum occasion for language learning to occur (Bloom, 1993, 1998; Carpenter, Nagell, & Tomasello, 1998; Tamis-LeMonda, Bornstein, & Baumwell, 2001). By responding verbally to infants' prelinguistic communicative signals, caregivers maximize the matching of words/phrases with targets of their children's current attentional focus, thus scaffolding language learning (Carpenter et al., 1998; Tomasello & Farrar, 1986).

Longitudinal research has revealed that maternal verbal responsiveness in infancy predicts later achievements in language (Tamis-LeMonda et al., 2001). Mothers who responded contingently to their infants' non-word vocalizations at 13 months of age had infants who spontaneously expressed first words, achieved 50 words in expressive language, and produced combinatorial speech earlier than infants with less responsive mothers. However, not all responses are equally beneficial for language development. Research has demonstrated that maternal responses such as repetitions and expansions correlate positively with language development (Giralametto, Weitzman, Wiigs, & Pearce, 1999; Tamis-LeMonda et al., 2001) while other responses, such as directives, correlate negatively with language development (Tomasello & Todd, 1983).

To date, very few studies have examined maternal input in response to infants' gestures. Young children use gestures to communicate meaning that they may have difficulty expressing verbally. This raises the possibility that gesture serves a facilitating function for language learning (Iverson & Goldin-Meadow, 2005). Indeed, Iverson and Goldin-Meadow found that at the lexical level, items that were initially in the infants' gesture repertoires subsequently appeared in their verbal lexicons. At the sentence level, the onset of gesture-plus-word combinations conveying two elements of a proposition predicted with great precision the onset of two-word combinations. In another study, infants who conveyed many different meanings in gesture at 14 months had larger receptive language vocabularies at 24 months (Rowe, Ozcaliskan, & Goldin-Meadow, 2008).

The next logical question, proposed by Iverson and Goldin-Meadow (2005), is how gesture may facilitate language learning. One possibility is that when young children produce gestures, they are communicating a readiness for a particular kind of verbal input. Consider the example of the infant who points at the monkey in the zoo. Her mother responded by saying, "That's a monkey," in effect "translating" the infant's gesture into speech and providing the infant with timely verbal input. The translation of gestures into words is the most common response of mothers to their infants' gesture bids (Golinkoff, 1986; Masur, 1982). Experimental evidence indicates that when a target word is modeled while infants are attending to the referent for the target word, they acquire the word more readily than when it is modeled at other times (Tomasello & Farrar, 1986; Yoder, Kaiser, Alpert, & Fischer, 1993). This raises the possibility that such gesture translations may be particularly likely to facilitate vocabulary development because the child is already attending to the referent of the word an adult is modeling (Nelson, 1989).

Goldin-Meadow, Goodrich, Sauer, and Iverson (2007) found that mothers' translations of their children's deictic gestures were related to later word and sentence production in their children. Specifically, the verbal equivalent of an infant's gesture was significantly more likely to enter the infant's vocabulary when the mother translated the gesture into speech than when she did not translate the gesture. In addition, infants whose mothers produced a large proportion of translation responses to their infants' gestures were the first to produce two-word utterances. Thus, young children may be displaying their readiness to learn a word or sentence through gesture, which elicits particular responses from caregivers and in turn facilitates language learning.

The variability observed in maternal responsiveness is not only reflective of maternal agency, but also reflects child agency and the dyadic interplay between child and mother that constitutes their past and present experiences. The transactional model of development emphasizes the bidirectional influence of mother and child over time (Sameroff, 1983). This dynamic, nonlinear process requires a joint examination of maternal responsiveness and child communication. As Snow (1986) noted, "Mothers are able to provide children with semantically relevant and interpretable speech because they follow up on topics introduced by the child. It seems that some mothers will be better at doing this than others, but also that some children will be better at eliciting semantically relevant and interpretable speech than others (p. 86)."

Evidence supports that maternal responsiveness varies depending on the developmental status of infant initiated signals. For example, in naturalistic play sessions mothers of TD infants are more likely to respond contingently to infant non-word vocalizations that contain more speech like elements as compared to more immature vowel-like vocalizations; this suggests that infants' sounds shape their mothers' behavior (Gros-Louis, West, Goldstein, & King, 2006). In addition, an earlier study by Masur (1982) provides some evidence that mothers display distinct patterns of responses to their infants' different deictic gestures. Masur found that mothers of TD infants were significantly more likely to respond by labeling the indicated object when infants produced pointing gestures than when they produced either requesting or showing gestures. Although the difference was not significant, it appeared that mothers responded by labeling the indicated object with greater frequency in response to showing gestures than in response to requesting gestures. More recently, research on Japanese infants suggests that nursery staff were significantly more likely to respond verbally to infants' pointing gestures than to infants' requesting gestures (Kishimoto, Shizawa, Yasuda, Hinobayashi, & Minami, 2007). Taken together, the results from these studies suggest that caregivers may be more likely to label developmentally advanced gestures (e.g., pointing) than developmentally prior gestures (e.g., requesting).

1.4 MATERNAL RESPONSE TO INFANT COMMUNICATION: HIGH RISK INFANT SIBLINGS

To date, no published research studies have examined maternal responses to HR infants' communicative behaviors. In the literature on typical development, evidence reveals that maternal responsiveness to infant social communicative bids facilitates language development (Goldin-Meadow et al., 2007). In light of the finding that a subset of HR infants display atypical delayed patterns of social communicative development, an investigation of maternal responsiveness to HR infants is clearly warranted.

Empirical studies examining the communicative interplay between mothers and their toddlers with ASD have documented that mothers of children with ASD display some differences in the duration, focus, and form of communicative bids directed to their children when compared to mothers of children showing typical development (Adamson, McArthur, Markov, Dunbar, & Bakeman, 2001; Watson, 1998). Likewise, research suggests that mothers of children with ASD may differ from mothers of children who are TD in their affective expressions directed to their children (Dawson, Hill, Spencer, Galpert, & Watson, 1990). A recent study examining the temporal characteristics of child-adult vocal exchanges among children with ASD and typical controls revealed that adults' response times tended to be longer when responding to children with ASD (Warlaumont, Oller, Dale, Richards, Gilkerson & Xu, 2010). These findings underscore the transactional view that early differences or delays observed in children with ASD may be reflected in different patterns of responses by caregivers.

The challenges associated with parenting a child on the autism spectrum are important to keep in mind. Caregivers of children with ASD report significantly elevated levels of parenting stress and affective symptoms compared to caregivers of TD children and caregivers of children with other disabilities (Bristol & Schopler, 1984; Davis & Carter, 2008; Dumas, Wolf, Fisman, & Culligan, 1991; Holroyd & McArthur, 1976; Koegel et al., 1992). Evidence from studies on TD children suggests that increased levels of parenting stress are related to changes in parent-child interactions (Crnic, Gaze, & Hoffman, 2005). Results from recent studies investigating caregivers' concerns about their HR infants during the first two years of life indicate that caregivers of HR infants demonstrate significantly more concerns about their infants' development than caregivers of LR infants (Ozonoff et al., 2009). In addition, communication concerns are the most frequent type of concerns reported by caregivers early on in their infants' development (Hess & Landa, in press). The findings from the literature cited above have implications for how caregivers who have an older child with ASD interact with their younger HR infants. Specifically, increased parenting stress as well as heightened levels of concern regarding their younger infants' development may lead caregivers to provide more structure and scaffolding when interacting with their HR infants.

2.0 PRESENT STUDY

A transactional model of development emphasizes the bidirectional influence of caregiver and child as being the foundation for early learning (Sameroff, 1983). The literature reviewed above provides specific evidence that infants' early communicative behaviors elicit responses from mothers that can scaffold communication development (Goldin-Meadow et al., 2007). In addition, previous research suggests that mothers' responses may vary based on the developmental status of their infants' communicative behaviors (Gros-Louis et al., 2006).

Prospective studies of HR infants have revealed delayed patterns of communication development during their second year (e.g., Yirmiya et al., 2006). Specifically, prior work suggests that a subset of HR infants display decreased instances of more developmentally advanced communicative behaviors (e.g., pointing and showing gestures) while displaying relatively typical rates of earlier emerging communicative behaviors (e.g., giving and requesting gestures) (Winder et al, 2009). Based on these findings, HR infants may afford their mothers fewer opportunities to provide contingent verbal input to more developmentally advanced communicative behaviors. Understanding the communicative interplay between mothers and their HR infants could potentially shed light on the language learning process for this understudied population.

The aim of the current study was to describe maternal responses to their HR infants' communication at 13 and 18 months and compare them with responses observed among mothers of LR infants. These two age points were chosen because they bracket a period of rapid developmental change in language and communication (Bloom, 1993). Based on the evidence reviewed above, the following predictions and questions have been generated.

2.1 INFANT COMMUNICATION DIRECTED TOWARDS MOTHERS

As previously discussed, research suggests that a subset of HR infants who do not go on to develop ASD display delays in communication and language development during the second year of life (e.g., Yirmiya et al., 2006). In addition, some evidence indicates that these HR infants are particularly delayed in the production of more developmentally advanced communicative behaviors. Thus, it is predicted that on average HR infants in the current study will display delays in the production of more developmentally advanced forms of communication (pointing gestures, showing gestures, and words) directed towards their mothers as compared to the LR infants.

2.2 MATERNAL RESPONSES TO INFANT COMMUNICAITON

To date, there are no known published studies examining the communicative interplay between mothers and their HR infants. The current study addresses this gap in our knowledge by exploring response patterns of mothers of HR vs. LR infants to their infants' communicative behaviors. Specifically, we answer the following questions:

Questions A: What proportion of infants' non-word vocalizations, words, and gestures receive a contingent maternal response (verbal response, non-verbal response, or verbal and non-verbal response)? Overall, do mothers of HR and LR infants respond contingently to infants' communicative behaviors at significantly different levels?

Questions B: When mothers respond to their infants' non-word vocalizations, words, and gestures, what proportions of those responses are specifically verbal? Are mothers of HR and LR infants equally as likely to respond verbally to their infants' communicative behaviors?

Question C: When mothers respond to their infants' gestures verbally, what proportion of those responses are translations? Do mothers of HR and LR infants provide similar levels of translations?

2.3 CHANGES IN MATERNAL RESPONSES TO INFANT COMMUNICAITON ACROSS DEVELOPMENT

Data from the Paul et al. (2011) study indicate that HR infants demonstrate delays in vocal development. In addition, research on TD infants suggests that mothers are sensitive to the developmental level of their infants' non-word vocalizations and that as infants become more skilled, mothers demonstrate an increase in contingent responsiveness (Gros-Louis et al., 2006). Thus, it is predicted that from 13 to 18 months, mothers of LR infants will increase in their responses to infants' non-word vocalizations, whereas HR mothers will not show a similar increase in responding.

2.4 MATERNAL RESPONSES TO INFANT GIVING/REQUESTING VERSUS POINTING/SHOWING GESTURES

As infants' communicative behaviors become more developmentally advanced, these signals become clearer and more salient. Thus, it is predicted that mothers will respond with significantly higher rates of translations to infants' more developmentally advanced gestures (pointing and showing) than to earlier emerging gestures (requesting and giving).

3.0 METHOD

3.1 PARTICIPANTS

The study sample consists of 27 infant-mother dyads who were drawn from two larger longitudinal studies conducted by Dr. Jana Iverson. Twelve infants (7 females and 5 males) had an older biological sibling with a confirmed diagnosis of autism and 15 infants (8 females and 7 males) had an older TD sibling and no family history of ASD (i.e., no first or second-degree relatives diagnosed with ASD). The infants with a biological sibling with autism were identified as High Risk (HR), given their heightened level of genetic risk for ASD or other disorders such as language impairments relative to infants in the general population (Zwaigenbaum et al., 2007). The infants with no family history of ASD were identified as Low Risk (LR).

Families in the HR group were recruited through the Autism Research Program at the University of Pittsburgh, parent support organizations, and local agencies and schools serving families of children with ASD. Prior to enrollment, all older siblings identified as having autism were administered the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) by a trained clinician to confirm their diagnosis. The families in the LR group were recruited from two separate sites, a small Midwestern city and a Northeastern city, through local newspaper birth announcements and word of mouth. Eligible families were contacted by an introductory letter and follow-up phone call.

All infant participants in both samples were full-term, from uncomplicated pregnancies and deliveries, and came from monolingual, English-speaking homes. Twenty-seven (10 HR infants, 14 LR infants) were Caucasian, two (both HR infants) were Hispanic, and one LR infant was Asian American. The education levels of mothers and fathers in both groups were comparable. The majority of mothers either had college degrees or had completed some college. Caregiver ages did not differ significantly by group (mean maternal age was 34 and mean paternal age was 36).

3.2 PROCEDURE

Infants were videotaped at home with a primary caregiver for approximately 45 min. monthly during the first two years of life (for further details describing the procedures employed in the two larger studies, see Iverson & Wozniak, 2007). For the present study, two sessions for each dyad were selected including the 13 month visit and the 18 month visit. Visits were conducted to coincide with the monthly anniversary of the infant's birthday. Observations were scheduled for a time during the day when infants were expected to be alert and playful. Scheduled observations that were missed due to illness or family obligations were rescheduled at the earliest possible opportunity. Every effort was made to schedule home visits within three days of the targeted observation date. In an effort to ensure continued participation, families were compensated for their time. At 36 months infants were evaluated by a clinician using the ADOS.

None of the infants in the current study met diagnostic criteria for autism based on their performance on the ADOS and clinical impression.

3.3 VIDEOTAPED OBSERVATIONS

Infants were videotaped for approximately 45 minutes in two major settings: while engaged in everyday household activities and routines and during a semi-structured toy play session. 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.

The first and final 15-minute segments consisted of unstructured, naturalistic observation. Caregivers were asked to continue their normal activities during this time; no attempt was made to structure this portion of the session in any way. During the middle 15-minute segment, infants and primary caregivers participated in a semi-structured play session involving play with toys and social interaction. In this portion of the session, the caregiver was seated on the floor with the infant while playing with some favorite toys. The same fixed order of observational contexts was employed for all infants at all sessions.

3.4 CODING

The current study will focus on maternal responses to infant spontaneous communication. Since mothers' responses are contingent on infants' communicative acts, infant behavior will be described first.

3.4.1 Infant speech and gestures

As part of a previous study by Winder et al. (2009) spontaneous gestures, communicative non-word vocalizations, and words produced by the infants during the 45-minute session were identified and coded for onset and offset. Coding categories to identify infant communicative expressions were derived from earlier work on the speech and gestures of very young children (Iverson & Goldin-Meadow, 2005). To permit detailed analyses of the relative timing of communicative behaviors, coding was done using a time-linked, computer-based video interface system (The Observer Video-Pro, Noldus Information Technologies). Only those expressive behaviors deemed to be infant initiated were included. Episodes in which the mothers' speech or movement may have elicited the infants' communicative bids were excluded. Distinct from the Winder et al. (2009) study, the current study only focused on infant communicative behaviors directed towards mothers during the 45- minute interaction and all other communicative bids were excluded.

Deictic gestures were coded as Request, Give, Show, or Point. Pointing was coded when the child used an extended index finger to indicate his/her interest in or desire for an object or event. Requesting was coded when the child extended his/her arm toward an out of reach object. Gives were coded when the child pushed, threw, or handed an object to the mother. Shows were coded when the child raised a toy or object upward toward the adult's face while making eye contact. Instances in which gestures were produced contemporaneously with speech were classified as gesture + vocalization or gesture + word combinations. For the purposes of the current 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, Camaioni, & Voltera, 1975).

All words and communicative non-word vocalizations were coded. Words are either actual English words (e.g., “dog,” “cat,” “duck,” “hot”) or speech sounds that are 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). For communicative non-word vocalizations, all infant sound productions, with the exception of sneezing, coughing, breathing, and other vegetative noises, directed towards the mother were coded. Affective vocalizations such as laughing, squealing, fussing, and crying were coded separately and will not be analyzed in the current study.

Infant communication was coded by independent observers trained to criterion. To assess inter-observer reliability, a secondary trained observer independently coded a sub-sample of approximately 20% of the videotaped data. Average percentage agreements for identifying the occurrence of a vocalization and the occurrence of a gesture were 87% and 88%, respectively. Once it was established that the behavior was a vocalization or gesture, the percent agreements within these general categories were as follows: 93% for non-word vocalizations, 94% for words, 100% for reaches, 97% for gives, 100% for shows, and 99% for points. Disagreements were resolved by joint viewing of the video clips and discussion; and if a resolution was not reached, the lead coder decided on the appropriate code.

3.4.2 Maternal responses to infant communication

For purposes of the current study, we were interested in mothers’ immediate responses to their infants’ communicative non-word vocalizations, words, and deictic gestures. The coding system developed for the current study was derived from earlier work on maternal responses to young children’s behavior (e.g., Goldin-Meadow et al., 2007; Gros-Louis et al., 2006; Tamis-LeMonda et al., 2001). The criteria that were used in coding maternal responses are described below (for further details, see the coding scheme included in the Appendix).

All mothers' responses were coded as contingent if they occurred any time following the onset of the infant's communicative behavior and within two seconds of its offset. Mothers' responses to infants' non-word vocalizations, words, and deictic gestures were classified into one of three response categories: 1) verbal response, 2) non-verbal response, and 3) verbal and non-verbal response. Non-verbal responses consisted of both gestures and actions. A verbal response consisted of any verbalizations produced by the mothers following the infants' communicative behavior (e.g., repetition of the infants' vocalizations or speech that does not contain the infants' vocalizations). In addition, a verbal response could contain more than one utterance as long as the time elapsed between utterances did not exceed two seconds. Verbal responses following infant gestures were further classified into two different response type categories: a) translation of the child's gesture by labeling its referent, or b) speech that does not contain any meanings gestured by the child.

Videotapes were coded by two independent observers trained to criterion. Inter-observer agreement for maternal responses to infant communication was assessed for a random sub-sample of 20% of the videotapes at 13 and 18 months using Cohen's kappa statistics. For mothers' response types to all infant communication, ($\kappa13 = .94$, range13 = .78-1.00; $\kappa18 = .88$, range18 = .70-1.00), identical classifications of mothers' responses (verbal, non-verbal, verbal and non-verbal, or no-response) were counted as agreements. For mothers' verbal response types to infants' gestures ($\kappa13 = .93$, range18 = .83-1.00; $\kappa18 = .94$, range18 = .82-1.00), identical classifications of mothers' verbal response types (translation or speech that does not contain a translation) were considered an agreement. Disagreements were resolved by joint viewing of the video clips and discussion. If necessary, a third coder was consulted in those instances where the primary coders could not resolve the disagreement. The third coder made the final decision in those particular cases.

4.0 RESULTS

The aim of the current study was to describe mothers' responses to their HR infants' communication and compare them with those observed among mothers of LR infants. We begin by outlining the number of non-word vocalizations, words, and gestures produced by both groups of infants while interacting with their mothers. We then present results on mothers' responses to their infants' communicative behaviors.

4.1 PRELIMINARY ANALYSES

Preliminary analyses of gender differences in the frequency of infant communication directed towards their mothers, as well as, the proportion of infants' communicative behaviors that received a maternal response were completed. To compare male versus female infants' mean frequency of communicative bids directed towards their mothers at 13 and 18 months, a series of Mann-Whitney U tests were conducted. Similarly, to compare the mean proportion of maternal responses to male versus female infants' communicative behaviors at 13 and 18 months, a series of Mann-Whitney U tests were conducted. No significant effects of infants' gender on infants' communication production or mothers' responses to their infants' communicative behaviors were found.

Preliminary inspection of the data using Mann-Whitney U tests also indicated that when directing gestures towards their mothers' LR infants were not significantly more likely than HR infants to accompany their gestures with non-word vocalizations at 13 or 18 months. Therefore, gestures and gesture-non-word vocalization combinations were collapsed. Because so few instances of gesture-word combinations these behaviors were not included in the current study.

4.2 INFANT COMMUNICAITON DIRECTED TOWARDS MOTHERS

Descriptive statistics and between group analyses (Mann-Whitney U) for infant production of spontaneous non-word vocalizations, words, and gestures while interacting with their mothers at 13 and 18 months are presented in Table 1. As can be seen in Figure 1, at 13 months both the HR and LR infants predominantly produced non-word vocalizations and almost no words. By 18 months the LR infants produced mainly words and fewer non-word vocalizations while the HR infants produced similar numbers of non-word vocalizations and words. Mann-Whitney U tests indicated no significant differences between the HR and LR infants at either 13 or 18 months in the production of non-word vocalizations or words. However, it is important to note that at 18 months the frequency of words produced was almost twice as high for the LR infants (Mdn = 18, AD = 9.62) compared to the HR infants (Mdn = 7.5, AD = 9.94). This difference was not statistically significant due to the high variability.

Table 1. Descriptive Statistics for Infant Communication Directed Towards Mothers at 13 and 18 Months: Percentage of Infants Who Produced Behaviors, Median Number of Behaviors, Average Deviation, and Mann-Whitney U Results

	13 Months								18 Months							
	Low Risk (N=13)			High Risk (N=10)					Low Risk (N=15)			High Risk (N=12)				
Behavior	%	*Mdn*	*AD*	%	*Mdn*	*AD*	U	*p*	%	*Mdn*	*AD*	%	*Mdn*	*AD*	*U*	*p*
Non-Word Voc.	100	12	7.8	100	14.5	13.54	94	.826	100	6	4.4	100	3.5	2.75	67	.259
Word	69	2	1.8	40	0	3.44	70	.304	100	18	9.62	92	7.5	9.94	63	.187
Give/ Request	85	4	2.4	80	7	3.92	102	.535	80	2	1.43	83	4	7.42	127	.068
Point/Show	69	2	3.3	90	1	7.52	89	.980	93	5	2.98	66	1	6.38	35	.007

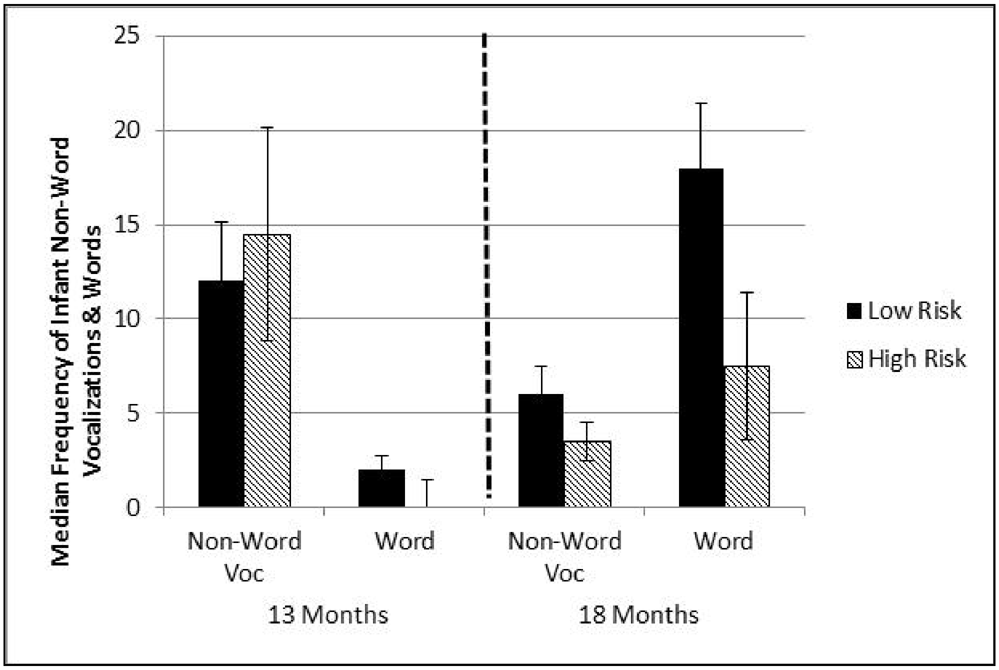

Figure 1. Frequency of Infant Non-Word Vocalizations and Words Directed Towards Mothers at 13 and 18 Months

With regard to gesture production, Figure 2 illustrates that both HR and LR infants produced largely giving/requesting gestures and fewer pointing/showing gestures at 13 months. By 18 months the LR infants produced a higher number of pointing/showing gestures and fewer giving/requesting gestures while the HR infants continued to produce many giving/requesting gestures and very few pointing/showing gestures. A Mann-Whitney U analysis revealed that at 18 months the frequency of points/shows was significantly higher for LR infants (Mdn = 5, AD = 2.98) than for HR infants (Mdn = 1, AD = 6.38), U = 35, p = .007. This study found no other significant differences between the HR and LR infants at either 13 or 18 months in the production of gestures.

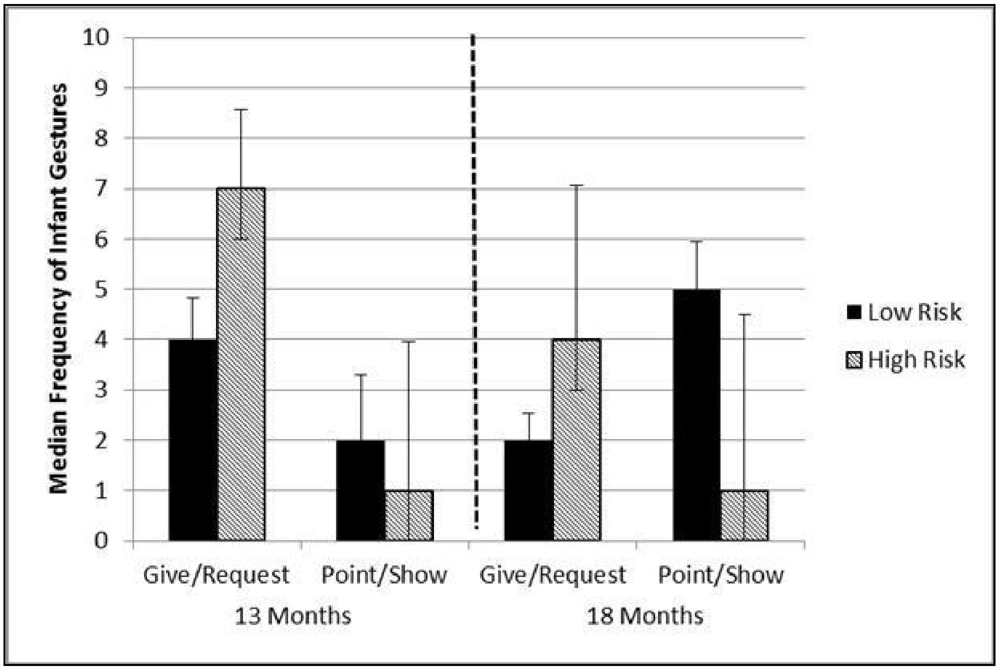

Figure 2. Frequency of Infant Gestures Directed Towards Mothers at 13 and 18 Months

4.3 MATERNAL RESPONSES TO INFANT COMMUNICAITON: BETWEEN SUBJECTS COMPARISONS

Because infants varied widely in the number of communicative behaviors they produced, mothers' opportunities to respond also varied. Thus, proportion scores were utilized to examine maternal responses to infant communication. Arcsine transformations were performed on the proportional data prior to conducting analyses.

4.3.1 Non-word vocalizations

Descriptive statistics for maternal responses to infant non-word vocalizations at 13 and 18 months are presented in Table 2. We first calculated the proportion of non-word vocalizations that received any type of maternal response by dividing the number of infant non-word vocalizations that received a response by the total number of infant non-word vocalizations. As noted earlier in the methods section, overall responses consisted of any maternal response that occurred within two seconds of the offset of the infants' behavior. The response could be verbal (repetition of infants' vocalizations or speech that does not contain the infants' vocalization), non-verbal (gesture or action), or verbal and non-verbal. To compare mothers of HR and LR infants on the proportion of overall responses produced at 13 and 18 months, we used a 2 (risk status) by 2 (age) repeated measures ANOVA. The main effect of risk status $F(1,21) = 2.84$, $p = .107$ and of age $F(1,21) = .024$, $p = .879$ were not significant. However, a significant interaction effect emerged, $F(1,21) = 5.92$, $p = .024$, $\eta 2 = .220$, indicating that the change in proportion of maternal responses to infants' non-word vocalizations from 13 to 18 months differed between the two groups (Figure 3). Simple effects analyses conducted to assess the source of the interaction indicated that the mothers of LR infants showed a marginally significant increase in relative proportion of responses to infant non-word vocalizations between 13 and 18 months ($M13 = .70$, $SD = .18$; $M18 = .85$, $SD = .15$), $p = .063$, while the opposite pattern was observed for the mothers of HR infants ($M13=.72$, $SD = .18$; $M18 = .59$, $SD = .33$), $p = .145$.

Table 2. Descriptive Statistics for Mothers' Overall Responses and Verbal Responses to Infant Non-Word Vocalizations at 13 and18 Months: Mean Proportion and Standard Deviation

	13 Months				18 Months			
	Low Risk		High Risk		Low Risk		High Risk	
Maternal Responses	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Overall	.702	.179	.723	.184	.849	.14	.593	.325
Verbal	.961	.072	.966	.070	.963	.093	1.0	.000

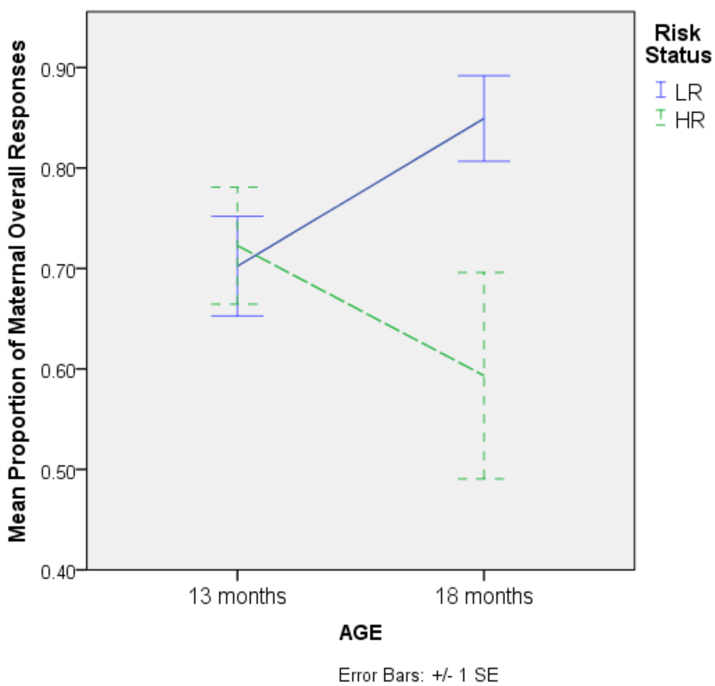

Figure 3. 2 (Risk Status) by 2 (Age) Interaction of Mothers' Overall Responses to Infants' Non-Word Vocalizations

Our next step was to examine the proportion of mothers' responses to their infants' non-word vocalizations that were specifically verbal. We did this by dividing the number of infant non-word vocalizations that received a maternal verbal response by the number of infant non-word vocalizations that received any type of maternal response. Overall, when mothers responded to their infants' non-word vocalizations, they responded with high proportions of verbalizations at both 13 months (MLR = .962, SD = .072; MHR = .966, SD = .070) and 18 months (MLR = .963, SD = .093; MHR = 1.0, SD = .0). A 2(risk status) by 2(age) repeated measures ANOVA revealed a non-significant main effect of risk status and of age. In addition, the interaction between risk status and age was not significant.

4.3.2 Words

Next we evaluated maternal responses to infant words at 18 months. We did not analyze the 13 month data because only about half of the infants produced words at this age point. Descriptive statistics and between group analyses (Mann-Whitney U) for maternal responses to infant words at 18 months are presented in Table 3. As with non-word vocalizations, we first calculated the proportion of words that received any type of maternal response (i.e., verbal or non-verbal) by dividing the number of infant words that received a response by the total number of infant words. The data revealed that at 18 months both mothers of HR and LR infants responded approximately 75 percent of the time to infants' words. We then investigated maternal verbal responses to infants' words by dividing the number of infants' words that received a maternal verbal response by the number of infant words that received any type of maternal response. The results indicated that when responding to their infants' words, both mothers of HR and LR infants on average responded verbally 96 percent or more of the time.

Table 3. Descriptive Statistics for Mothers' Overall Responses and Verbal Responses to Infant Word Production at 18 Months: Mean Proportion, Standard Deviation, and Mann-Whitney U Tests

	Low Risk		High Risk			
Maternal Responses	*M*	*SD*	*M*	*SD*	U	*P*
Overall	.779	.181	.736	.229	74	.658
Verbal	.960	.066	.995	.016	108.5	.084

4.3.3 Gestures

To examine the level of maternal responsiveness to infant gestures, we used separate analyses for the 13 and 18 month data rather than longitudinal analyses because few infants produced both categories of gestures (give/request and point/show) at both age points (13 months and 18 months). Descriptive statistics and between group analyses (Mann-Whitney U) for maternal responses to infant gestures at 13 and 18 months are presented in Table 4. We first calculated the proportion of gestures that received any type of maternal response (i.e., verbal or non-verbal) by dividing the number of infant gestures that received a response by the total number of infant gestures. As is apparent in Table 4, mothers overall were highly responsive to their infants' gestures at both 13 and 18 months.

Table 4. Descriptive Statistics for Mothers' Overall Responses and Verbal Responses to Infant Gesture Production at 13 and 18 Months: Mean Proportion, Standard Deviation, and Mann-Whitney U Results

		13 Months						18 Months					
		Low Risk		High Risk				Low Risk		High Risk			
Infant Gestures	Maternal Responses	*M*	*SD*	*M*	*SD*	U	*P*	*M*	*SD*	*M*	*SD*	U	*p*
Give/ Request	Overall	.843	.163	.903	.163	55	.336	.823	.321	.944	.127	66.5	.604
	• Verbal	.863	.180	.898	.115	46.5	.823	.881	.236	.537	.298	19	.008
	o Translation	.176	.230	.470	.305	69	.036	.273	.410	.192	.320	46	.755
Point/ Show	Overall	.864	.228	.667	.500	39	.880	.829	.211	.866	.351	74	.180
	• Verbal	.944	.167	1.0	.000	30	.414	.976	.089	1.0	.000	52.5	.480
	o Translation	.383	.406	.259	.405	22	.523	.530	.349	.600	.428	57.0	.546

We then investigated maternal verbal responses to infant gestures by dividing the number of infant gestures that received a maternal verbal response by the number of infant gestures that received any type of maternal response. At 13 months, when mothers of both HR and LR infants responded to their infants' gestures, they tended to respond verbally, which is evident from the data presented in Table 4. However, as can be seen in Figure 4, by 18 months the proportion of maternal responses to infant gives/requests that were verbal was significantly higher in the LR group (M = .881, SD = .236) than the HR group (M = .537, SD = .298), U = 19, p = .008. By contrast, the proportion of maternal responses to infants' points/shows that were verbal was extremely high for both groups (MLR = .976, SD = .089; MHR = 1.0, SD = .000), U = 52.5, p = .480.

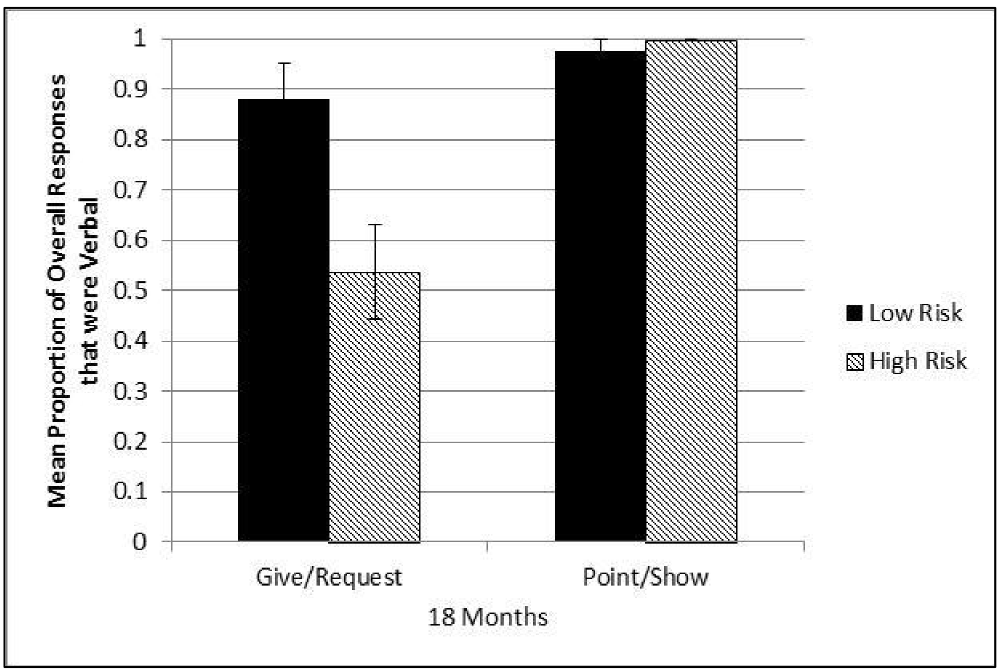

Figure 4. Main Effect of Risk Status on the Proportion of Mothers' Overall Responses to Infant Gestures that were Verbal at 18 Months

Next we examined maternal translation responses (labeling the referent of the child's gesture) to infants' gestures by dividing the number of infant gestures that received a maternal translation response by the number of infant gestures that received a verbal response. As is apparent in Figure 5, at 13 months mothers of HR infants responded with a significantly higher proportion of translations to infants' give/requests than mothers of LR infants (MHR = .470, SD = .305; MLR = .176, SD = .230), U = 69, p = .036 while no differences emerged between groups in the proportion of maternal translation responses to points/shows. In addition, no between group differences in the proportion of translation responses to gives/requests or points/shows at 18 months were found.

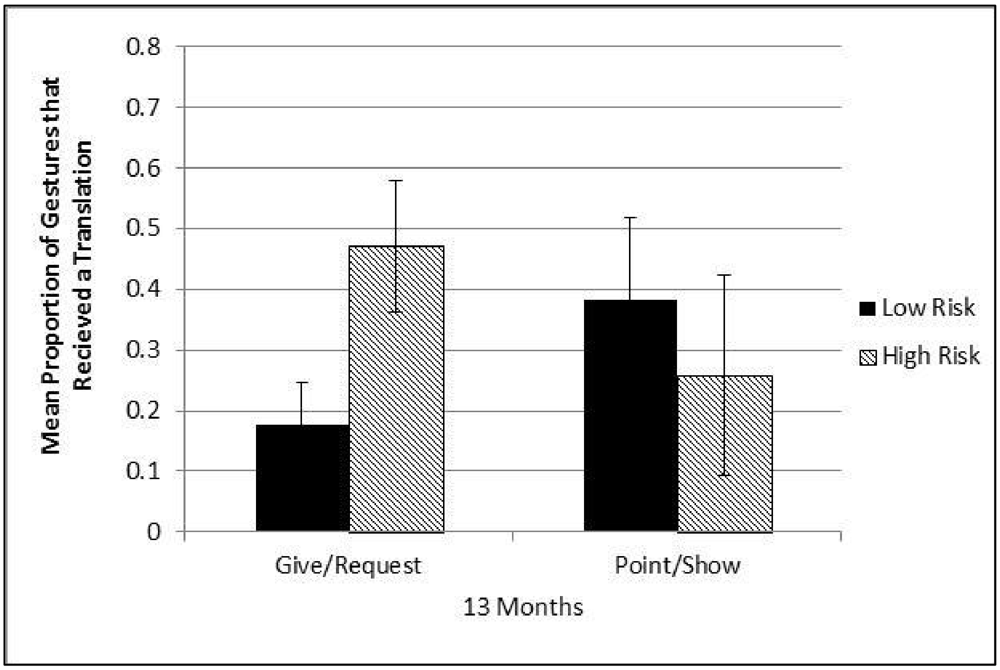

Figure 5. Main Effect of Risk Status on the Proportion of Mothers' Verbal Responses to Infant Gestures that were Translations at 13 Months

4.4 MATERNAL RESPONSES TO GIVES/REQUESTS VERSUS POINTS/SHOWS: WITHIN SUBJECTS COMPARISONS

To address the prediction that mothers would respond to infants' pointing/showing gestures with a higher proportion of translation responses than to giving/requesting gestures regardless of risk status, a repeated measures ANOVA with gesture type as the within subjects factor was performed. At 13 months the proportion of translation responses to gives/requests ($M = .322$, $SD = .258$) and points/shows ($M = .384$, $SD = .402$) was not significantly different, $F(1,12) = .390$, $p = .544$. However, at 18 months mothers responded with a higher proportion of translation responses to points/shows ($M = .566$, $SD = .375$) than to gives/requests ($M = .279$, $SD = .395$), $F(1,15) = 5.093$, $p = .039$, $\eta 2 = .253$ (Figure 6).

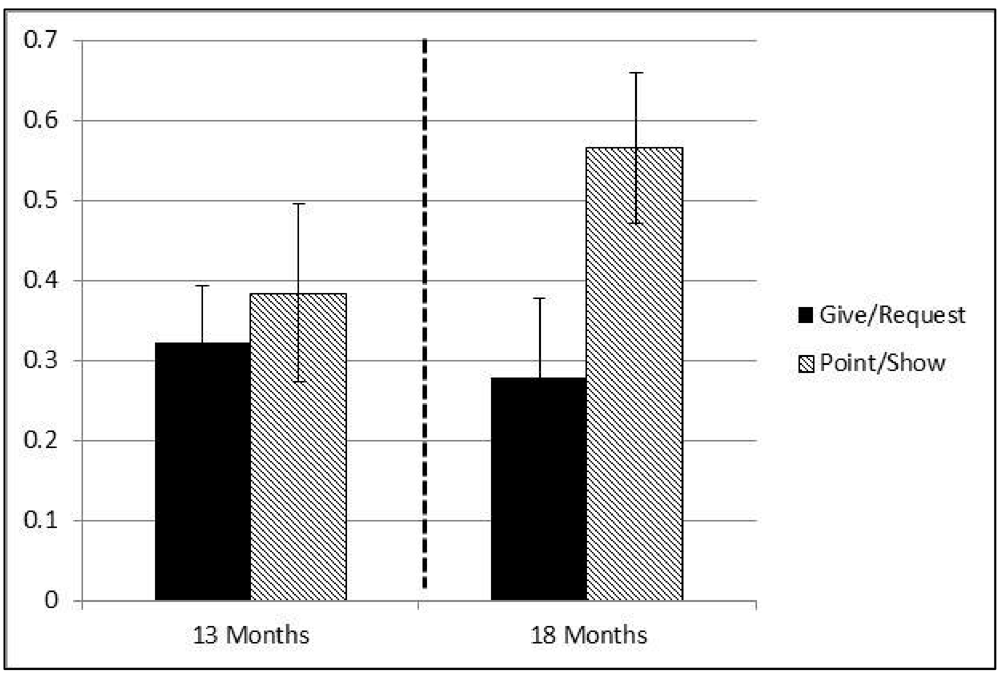

Figure 6. Main Effect of Infant Gesture Type (Give/Request vs. Point/Show) on the Proportion of Mothers' Verbal Responses to Infant Gestures that were Translations at 13 and 18 Months

5.0 DISCUSSION

Research on TD infants has shown that infant initiated communication serves to elicit responses from mothers that in turn scaffold language development (Goldin-Meadow et al., 2007). Importantly, evidence suggests that mothers are sensitive to the developmental level and quality of their TD infants' early communicative behaviors (Goldstein & West, 1999; Gros-Louis et al., 2006). Specifically, this research suggests that mothers may be more likely to provide rich contingent responses to communicative behaviors that are more developmentally advanced (speech like consonant-vowel clusters, pointing and showing gestures). In light of these findings and the recent evidence that a subset of HR infants who do not develop ASD show delays in communication and language (Rogers, 2009), it may be particularly important to examine mothers' responses to their HR infants' communication in order to better understand the language learning process of this population. The current study is unique in that it simultaneously examines communication development of infant siblings of children with ASD and their mothers' responses to their communicative behaviors.

The current study revealed that HR infants on average produced significantly fewer developmentally advanced communicative behaviors than LR infants at 18 months. In addition, this study extends prior work on maternal responsiveness to their TD infants' communication (Goldin-Meadow et al., 2007; Gros-Louis et al., 2006) by demonstrating that mothers of HR infants were highly sensitive to their infants' communicative bids and tended to respond contingently to both gestures and vocalizations as frequently as mothers of LR infants. Several interesting results emerged when examining changes in maternal responsiveness to infant non-word vocalizations from 13 to 18 months as well as specific types of maternal response to infant gestures. These results will be discussed in turn.

5.1 VOCALIZATION DEVELOPMENT AND MATERNAL RESPONSES

We found that from 13 to 18 months LR infants demonstrated a shift to producing more words than non-word vocalizations. However, HR infants produced equivalent numbers of words and non-word vocalizations at this older age. While the difference was not statistically significant, on average LR infants produced twice as many words as HR infants suggesting that HR infants may have been somewhat delayed in the development of language (e.g., Yirmiya et al., 2006). Importantly, inspection of the infant communication data revealed substantial individual variability and significant skewing at the high end of the distribution especially among HR infants. This pattern has been reported in previous research with infant siblings of children with ASD (Iverson & Wozniak, 2007) and may explain why the difference in word production between HR and LR infants in the current study was not statistically significant.

With regard to maternal responses to non-word vocalizations, our data indicate that from 13 to 18 months as infants presumably progressed in the production of pre-speech vocalizations, mothers of LR infants increased their responsiveness, but mothers of HR infants did not. A seminal study on maternal responses to TD infants' vocalizations by Goldstein and West (1999) demonstrated that an increase in infants' vocal repertoire size led to changes in mothers' responses. The authors concluded that mothers' patterns of responding to prelinguistic sounds may be related to her infants' level of vocal development. A follow up study revealed that in fact mothers showed differential responding to vocalizations that varied in quality (Gros-Louis et al., 2006), providing a higher level of contingent imitation responses to more developmentally advanced vocalizations (consonant-vowel clusters) than to less developmentally advanced vocalizations (vowel-like sounds).

While the current study did not specifically investigate the quality of non-word vocalizations, previous research has demonstrated that on average HR infants produce significantly fewer speech-like vocalizations, consonant types, and canonical syllable shapes than their LR peers across development (Paul et al., 2011). Therefore, group difference in maternal responsiveness to non-word vocalizations from 13 to 18 months observed in the current study could be explained by differences between the HR and LR infants in the development of vocalization quality. Specifically, if LR infants were producing more speech-like vocalizations than HR infants by 18 months, this could explicate why mothers of LR infants were responding at significantly higher levels than mothers of HR infants to non-word vocalizations.

5.2 GESTURE DEVELOPMENT AND MATERNAL RESPONSES

Turning now to gesture development, our findings confirm earlier reports (Winder et al., 2009) relative to LR infants at 18 months, HR infants demonstrated delays in the production of pointing/showing gestures. Specifically, we found that while LR infants increased production of pointing/showing gestures and decreased production of giving/requesting gestures from 13 to 18 months, HR infants did not show an increase in pointing/showing gestures and continued to produce high levels of giving/requesting gestures. These results suggest that while LR infants' repertoires of communicative signals expand from 13 to 18 months, this is not the case for HR infants.

Previous research on TD children found that mothers were more likely to respond to pointing gestures than giving and requesting gestures by labeling the referent of their children's gestures (Masur, 1982). Our data extended this work to a HR population and revealed that pointing/showing gestures received a higher proportion of translation responses than giving/requesting gestures from both mothers of HR and LR infants at 18 months. Based on this evidence and the finding that HR infants produced significantly fewer pointing and showing gestures than LR infants at 18 months, the HR infants from our sample appear to have afforded their mothers fewer opportunities to respond to the very gestures that were most likely to elicit translations. As noted earlier, translations of infants' gestures are a beneficial type of verbal response because they provide input that is directly relevant to the infant's focus of attention (Goldin-Meadow et al., 2007).

Although mothers of HR and LR infants responded similarly to their infants' gestures, two between group differences were observed. First, when responding verbally to their infants' gives/requests at 13 months, mothers of HR infants were more likely to translate the referent of their infants' gestures than were mothers of LR infants. The transactional model of development posits that the ways in which caregivers respond to their infants' behavior is influenced by expectations as well as long-term goals for their infants (Sameroff, 1983). Thus, caregivers' responsiveness is not merely driven by infants' immediate behaviors. Because mothers of HR infants are aware that their infants are at increased biological risk for developing impairments in language and communication and often report heightened levels of concern about their infants' development (Ozonoff et al., 2009; Hess & Landa, in press), they may be hypervigilant about the need to scaffold language, especially during periods of developmental change. Research suggests that prior to 12 months word production is minimal for almost all infants (Fenson et al., 1994). Subsequently, on average, infants show a slow increase in word production, from fewer than 10 words at 12 months to 40 words at 16 months. During this transitional period in development, mothers of HR infants may be particularly attuned to opportunities for teaching object labels.

The second between group difference was that when responding to their infants' gives/requests at 18 months, mothers of LR infants provided a greater proportion of verbal responses than mothers of HR infants. While the current study did not investigate the function or social quality of infant gestures, previous research has found that HR infants produced fewer gestures for the purpose of sharing attention than their LR peers (Cassel et al., 2007). In addition, HR infants displayed fewer smiles during an interaction with their mothers. Thus, the giving/requesting gestures produced by the HR infants in our study may have been less socially salient to their mothers and therefore less likely to receive a verbal response as compared to gestures produced by LR infants.

5.3 LIMITATIONS AND FUTURE DIRECTIONS

In addition to this project's numerous methodological strengths which include a longitudinal prospective design following a HR sample observed in a naturalistic setting, the study also had several noteworthy limitations. First, like many studies of infants at-risk for ASD, it had a relatively small sample size. Therefore, caution is necessary when interpreting the data and making generalizations about maternal responses to their HR infants' communicative behaviors.

Second, the present study focused exclusively on the responses of mothers to infants' non-word vocalizations, words, and gestures in order to examine one potential mechanism that could influence communication development. However, mother-infant interactions are clearly much more complex and involve many other variables that are important for infant development. In line with this limitation, the current study did not examine mothers' overall communication directed towards their infants. Possibly, that mothers of HR and LR infants provided different levels of scaffolding behaviors that were not contingent on their infants' communicative bids. Third, we grouped all non-word vocalizations together which prohibited a detailed analysis of prelinguistic vocalizations. This is important because recent work by Paul and colleagues (2011) indicated that on average HR infants produced fewer consonants and canonical syllable shapes and more developmentally prior non-speech-like vocal behaviors than LR infants. In order to better understand the findings from the present study on changes in maternal responses to infant non-word vocalizations from 13 to 18 months, future work will code specific types of infant non-word vocalizations. Finally, in the future it will be important to examine how maternal responses to their HR infants' communicative bids relate to infants' language development.

5.4 SUMMARY AND IMPLICATIONS

Taken together, the data from the present study demonstrate that the transactional model may be a useful framework for investigating communication development in infants at risk for ASD. These findings suggest that mothers are sensitive to the developmental level of their infants' communicative behaviors. Thus, delays in these behaviors could alter the input infants receive which may have cascading effects on development. Consider the following scenario: by 18 months a HR infant is producing only giving and requesting gestures and vowel-like non-word vocalizations while his LR peer has shifted to producing more developmentally advanced communicative behaviors (e.g., pointing/showing gestures and word-like vocalizations). Based on the difference in the developmental level of their communicative repertoires, these two infants are likely eliciting very different feedback from their caregivers. Specifically, the HR infant is not affording his caregiver the same opportunity to respond to the very gestures that are most likely to elicit translation responses which are important for word learning. This scenario highlights how infants' delays in gesture development may be related to delays in speech development through their effects on the input they receive from caregivers. Based on the findings from the current study, early intervention for infants with communication delays may consider encouraging caregivers to respond to developmentally prior gestures (gives/requests) with translations. In addition, clinicians could teach caregivers to respond contingently to their infants' non-word vocalizations regardless of their developmental level and social salience.

The results from the current study also have broader implications for studying communication development in HR infants. Our results suggest that examining linear-within child developmental effects may obscure researchers' understanding of the processes underlying development in HR infants. For example, a design utilizing early spontaneous communicative skills to predict later language overlooks the bidirectional influence of mother and child over time (Sameroff, 1983). We posit that an alternative view of cascading developmental effects may lead to a better understanding of communication development in HR infants. Specifically, this view suggests that delays in spontaneous communication observed in HR infants could result in a reduction of infant initiated joint engagement with caregivers. This could then lead to a reduction in caregivers' linguistic input that is adapted to moments of shared attention ultimately leading to delays in language. In addition, it is important to consider how caregivers' beliefs about their children's developmental level may alter moment to moment social interactions which could have cascading effects on development. While delays in early spontaneous communication may predict later language delays, our data suggest that this path is a dynamic, nonlinear process that requires a joint examination of child communication and maternal responsiveness.

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