HHS Public Access

Author manuscript

Infant Behav Dev. Author manuscript; available in PMC 2021 May 01.

Published in final edited form as:

Infant Behav Dev. 2020 May ; 59: 101445. doi:10.1016/j.infbeh.2020.101445.

Differences in caregiver behaviors of infants at-risk for autism and typically developing infants from 9 to 15 months of age

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Abstract

During an object sharing paradigm, we compared caregiver interactions with their infant between two groups: i) infants at high-risk (HR) for being diagnosed with Autism Spectrum Disorder (ASD) and ii) low-risk (LR) infants, observed at 9, 12, and 15 months of age. **16 HR infants (14 infants with an older sibling diagnosed with ASD and 2 preterm infants that received a diagnosis of ASD at 2 years) and 16 LR infants (typically developing infants without older siblings diagnosed with ASD) were included in the study.** At each visit, infants played with objects in the presence of their caregivers as crawlers or walkers. Previously, we found that HR infants are less likely to share their object play with caregivers at walker ages. **The present study found that caregivers of HR infants used greater directive bids including being more proximal to infants and using greater verbal and non-verbal bids to sustain their infant's attention and to ensure their compliance with the task compared to caregivers of LR infants.** Our study emphasizes the bidirectional and dynamic nature of infant- caregiver interactions. Our findings have implications for caregiver training programs that teach parents appropriate strategies to promote early social communication skills in at-risk infants.

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Author Statement

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Conflicts of Interest

Both authors confirm that there are no conflicts to disclose.

Keywords

Object sharing; high-risk infants; Autism Spectrum Disorder; caregiver; parent; interactions; dyadic; triadic; parent training

1. Introduction

Autism Spectrum Disorder (ASD) is currently the most common pediatric developmental disorder with a growing prevalence rate of 1 in 150 children in 2000 to reports of 1 in 40 children in 2016 (Kogan et al., 2018). This increase in prevalence is accompanied by a growing emphasis on developing better methods for early diagnosis of ASD and targeted early interventions to improve outcomes in this population (Fein et al., 2013; Robins, Fein, Barton, & Green, 2001). A stable diagnosis of ASD is not typically offered before three years of age (Steiner, Goldsmith, Snow, & Chawarska, 2012). In order to identify behavioral markers of ASD in early infancy, several research groups have been prospectively studying younger siblings of children diagnosed with ASD. Siblings of children diagnosed with ASD are at a greater genetic risk to develop ASD, with close to 20% of 'high-risk' (HR) infants receiving a diagnosis by three years of age (Messinger et al., 2013; Ozonoff et al., 2011). **Prospective studies have identified several social communication delays in HR infants compared to typically developing or low risk (LR) infants including fewer social smiles, fewer bids of shared attention with caregivers, and difficulties engaging in social interactions** (Cassel et al., 2007; Chawarska, Klin, Paul, & Volkmar, 2007; Ibanez, Messinger, Newell, Lambert, & Sheskin, 2008; Presmanes, Walden, Stone, & Yoder, 2007; Stone, McMahon, Yoder, & Walden, 2007). **Similarly, research has also identified perceptuo-motor delays including delayed attainment of head and postural control, atypical fine motor control and problem solving skills, as well as perseverative object play in this population relative to LR infants** (Bhat, Galloway, & Landa, 2012; Flanagan, Landa, Bhat, & Bauman, 2012; Landa & Garrett- Mayer, 2006; Libertus, Sheperd, Ross, & Landa, 2014; Nickel, Thatcher, Keller, Wozniak, & Iverson, 2013; Ozonoff et al., 2008; Kaur, Srinivasan, & Bhat, 2015; Srinivasan & Bhat, 2019).

Studies on parent-child interactions in LR infants suggest that infants engage enthusiastically in naturalistic play episodes and both share their play spontaneously with parents and also respond to parental bids (Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008). Caregivers in turn reinforce, scaffold, and expand on infants' responses to advance existing social communication and cognitive abilities of infants (Bornstein & Tamis-LeMonda, 1989; Landry, Smith, Swank, Assel, & Vellet, 2001). For instance, caregivers often respond to infant gestures by labeling the object of their attention to scaffold language development (e.g. a parent may respond to an infant's pointing gesture towards a ball by saying, "You want the ball?"). Parental input is thus crucial in promoting sophisticated forms of communication and object interactions in early infancy (Masur, 1982; Saint-Georges et al., 2011). Moreover, infant and caregiver behaviors are highly interdependent and mutually influence each other in an ongoing manner to promote infant development (Sameroff & Fiese, 1990; Sameroff, 2009).

In infants at-risk for ASD, early social atypicalities may alter the nature of the dynamic, bidirectional interactions between infants and their caregivers (Adamson, McArthur, Markov, Dunbar, & Bakeman, 2001; Leezenbaum, Campbell, Butler, & Iverson, 2013; Wan et al., 2012; Wan et al., 2013). For instance, from 6 to 9 months, **compared to LR infants,** HR infants showed reduced spontaneous social gaze, reduced orienting to name, reduced social smiles, and fewer episodes of joint attention and shared engagement within the context of parent-child interactions (Bhat, Galloway, Landa, 2010; Nichols, Ibañez, Foss-Feig, & Stone, 2014; Osterling, Dawson, & Munson, 2002; Ozonoff et al., 2010; Rozga et al., 2011; Werner, Dawson, Munson, & Osterling, 2005). Given their difficulty in spontaneously initiating and maintaining social interactions, HR infants may provide caregivers with fewer opportunities for social interaction compared to LR infants (Sullivan et al., 2007; Dolev, Oppenheim, Koren-Karie, & Yirmiya, 2009). Infants with ASD demonstrate lower levels of motoric activity and vocalizations during dyadic interactions within the first year compared to LR infants. The lack of responsiveness by infants with ASD is mirrored by a parallel decrease in effort by caregivers to attract infants' attention to engage them in a social interaction (Apicella et al., 2013). The authors hypothesized that caregivers may consider their infant's behavior as a reflection of their temperamental attitude and back-off by reducing their involvement over time.

On the other hand, it has been postulated that caregivers may in fact recognize the early signs of ASD and try to provide richer input to elicit responses from their passive at-risk infants. Caregivers may use a variety of strategies including taking charge of the interaction, increasing verbal and non-verbal prompting to direct the child's attention, and using physical proximity to solicit greater infant compliance (see Doussard-Roosevelt, Joe, Bazhenova, & Porges, 2003; El-Ghoroury & Romanczyk, 1999; Lemanek, Stone, & Fishel, 1993). Along these lines, retrospective home video analyses demonstrated that caregivers of children with ASD were able to accurately detect their infant's lack of social interest within the first 18 months; furthermore, caregivers responded by increasing the duration of their solicitations and touching behaviors to elicit responses from infants compared to caregivers of LR infants (Saint-Georges et al., 2011). Similarly, parents of children with ASD tend to overstimulate their child to compensate for their lack of activity and may use more physical contact and fewer verbal bids while interacting with them (Trevarthen & Daniel, 2005; Van IJzendoorn et al., 2007).

Overall, although there is still some debate about the amount of caregiver input received by HR infants. Caregiver input offered to HR infants might be lower or greater than that received by age-matched LR peers. The evidence presented earlier suggests that caregivers of HR infants and young children with ASD are able to detect their child's early social difficulties. Further research examining the differences in early infant-caregiver interaction patterns between LR and HR infants may provide insights into the altered reciprocal interactions between infants and caregivers within the context of emerging ASD. Such work has implications for the design of caregiver training programs aimed at coaching caregivers to provide optimal scaffolding to promote positive outcomes in HR infants.

In the present study, we compared caregiver behaviors of HR and LR infants within the context of a naturalistic object sharing task that involved object-based play between infants and caregivers. Our previous manuscript demonstrated that following the onset of independent walking, LR infants typically showed a surge in sharing their object play with caregivers (i.e. total rates/minute of bids to share objects with caregivers, termed "object sharing performance" henceforth in the manuscript) compared to at crawling ages (Srinivasan & Bhat, 2016). In contrast, HR infants were less likely to use their new-found locomotor abilities to share objects with caregivers. Moreover, HR infants were less likely to share objects with caregivers both spontaneously as well as when requested by caregivers (see Srinivasan & Bhat, 2016 for details). In the current manuscript, we were interested in examining how infant behaviors differentially influence caregiver interactions in both groups over the transition from crawling to walking. We coded for a variety of concurrently occurring caregiver behaviors to get a complete picture of caregiver interactions with infants, including gestural bids, verbal bids, and bids to initiate proximity towards infants. Based on the literature discussed above, we hypothesized that there would be clear differences in interaction patterns between caregivers of LR and HR infants especially at walking ages. Specifically, in response to poor object sharing skills (lower total rates of sharing objects with caregivers), caregivers of HR infants would use greater verbal and non-verbal cues in order to encourage infants to share their play; caregivers may perhaps also get physically closer to their infants and use tactile cues in order to control the interaction and ensure greater infant compliance compared to caregivers of LR infants. Moreover, we hypothesized that infant object sharing performance would be positively correlated with caregiver gestures and speech but negatively correlated with caregiver proximity in both groups.

2. Materials and Methods

2.1. Design

Data reported in this study are part of a larger prospective longitudinal study that compared the development of HR and LR infants over the first 15 months of age using a battery of standardized tests and behavioral paradigms (Srinivasan & Bhat, 2016; Kaur, Srinivasan, & Bhat, 2015; Srinivasan & Bhat, 2018). Infants in both groups were seen at 3, 6, 9, 12, 15 months as part of this longitudinal study; however, in the current manuscript, we are reporting data from only a single task conducted at 9, 12, and 15 months.

2.2. Participants

Sixteen infants (13 males, 3 females, 15 White and 1 African American) at high risk for a diagnosis of ASD (HR infants) and 16 typically developing (11 males, 5 females, 15 White and 1 mixed ethnicity), low-risk infants (LR infants) participated in the study along with their caregivers. The HR infants were so classified based on having a sibling with ASD as diagnosed at 2 years (N = 14) or preterm birth and later themselves receiving an ASD diagnosis at 2 years (N = 2). Infants siblings of children diagnosed with ASD are at greater risk for being diagnosed with ASD (Ozonoff et al., 2011; Messinger et al., 2013). Similarly, preterm infants are another sub-group at-risk for receiving a diagnosis of ASD (Limperopoulos et al., 2008). Inclusion criteria for HR infants included an ASD diagnosis for their older siblings based on the Autism Diagnostic Interview-Revised (ADI-

R) of the older proband with ASD (Lord, Rutter, & Couteur, 1994) and clinical judgment. For the 2 preterm infants, preterm birth (<37 weeks of gestation) was confirmed through medical records. Exclusion criteria for LR infants included family history of ASD, significant birth-related neurological injury, or prematurity. Out of the 16 infants in the HR group, 3 infants were diagnosed with ASD and 5 infants were diagnosed with language delays at 2 years of age. None of the infants in the LR group reported any developmental delays during follow-up at 2 years of age (for more details of future outcomes of participating infants, please refer to Srinivasan & Bhat, 2016).

We used the Mullen Scales of Early Learning (MSEL) to assess the developmental level of infants in both groups. Table 1 provides details of infants' developmental status in both groups.

In both HR and LR groups, mothers participated for a majority of crawler and walker infant visits (LR=13 and HR = 14 out of 16 infants). In the remaining 2 to 3 infants per group, either the infant's father or grandmother participated. Note that we have analysed the data both with and without these infants and the results remain unchanged. Hence, all infants have been included in the reported analyses.

Caregivers and their infants were recruited through phone calls and fliers sent to autism centers, parent advocacy groups, early intervention centers, day care centers and through online announcements. This study was carried out in accordance with the recommendations of the Human Subjects Institutional Review Board (IRB) of XXXXX who also approved the study protocol. All parents signed a written informed consent approved by the IRB. **The Hollingshead scale that uses marital status, gender, education and occupation of both parents to determine the SES of the family was used in this study (**Hollingshead, 1975**). The scale has score ranges from 8 to 66. All participating families belonged to the social strata of 'major business and professional' or 'medium business, minor professional, or technical' as defined by the Hollingshead scale (**Hollingshead, 1975). There were no group differences in terms of socioeconomic status (LR infants - $M = 55.32$, SD = 9.22; HR infants - $M = 52.03$, SD = 12.66, $p = 0.44$).

2.3. Experimental procedures

Infants along with their caregivers participated in an object sharing task administered at 9, 12 and 15 months of age at the infant's home. Data on object sharing performance of infants has been reported in our previous paper, Srinivasan & Bhat, 2016. At each visit, we also assessed infants' locomotor status. An infant had to demonstrate > 5 independent and successive crawl or step cycles to be classified as a crawling or walking infant respectively. **A walk or crawl cycle is defined as the time from infant's foot/knee contact with the ground to the next successive contact of the same sided foot/knee with the ground.** Since we were interested in examining changes in object sharing skills of infants over the transition from crawling to walking, we analyzed data from one crawling and one walking visit for each infant. In the LR group, 1 infant did not walk independently at 15 months, whereas in the HR group, 4 infants did not walk at 15 months. For these 5 infants, we used data from their 15-month crawling visit as their best performance. To discuss findings in

parallel to our previous paper, in the current analysis, we examined interactions of caregivers with their infants during the object sharing task at the same crawler and walker visits.

The 14-minute object sharing task involved infants seated on the floor with toys, at a distance of around four feet from their caregiver (see Figure 1). Infants were provided with 20 age-appropriate toys including balls, rattles, books, etc. During the first 7 minutes (spontaneous condition) of the task (Mean duration in minutes of spontaneous condition—LR infants: $M = 5.96$, SD = 1.25, HR infants: $M = 6.28$, SD = 1.05), infants were allowed to explore the play materials freely and caregivers were asked to wait for their infant to initiate an interaction. If infants initiated interactions, caregivers were asked to appropriately respond to infant bids by shaking the toy or showing the object's properties and replacing it on the floor (for example, if the infant approached mom with a toy, mom would say, "That is a nice red ball, thank you!" and then perhaps place/roll the ball with/towards the other toys). In the next 7 minutes (social condition) (Mean duration in minutes of social condition—LR infants: 4.51, SD = 1.81, HR infants: $M = 5.33$, SD = 1.94), caregivers were asked to actively initiate a clean-up of the toys. Caregivers would point towards a toy and ask infants for the toy with a show of hands and by saying, "Let's clean up. Can you give me the toy/ball, etc.?" The task was considered complete when infants either gave all the toys to their caregiver or at the end of the social condition, whichever occurred first. Video data of infant and caregiver interactions during the object sharing task were recorded using an oblique camera view capturing the infant and caregiver's face and body (see Figure 1).

2.4. Behavioral coding

We coded the caregiver interactions using the Datavyu video coding software (http://www.datavyu.org/). Specifically, we were interested in coding total rates per minute and types of verbal and non-verbal/gestural input provided by caregivers. In addition, we also coded for caregivers' rates of proximity-initiating behaviors. Below we discuss details of the coding schemes employed for each of these variables.

2.4.1. Rates of caregiver proximity-initiations: We coded for the number of times that caregivers moved closer to their infants during the task. Note that although we instructed caregivers at the beginning of the task to maintain a 4-feet distance from their infant at all times, we noticed that caregivers frequently made attempts to get closer to the infant during the task (see Table 2 for exemplar behaviors). In order to standardize this variable across both visits for an infant as well as across all infants, we calculated the rates per minute of proximity-initiating behaviors. A single coder blind to the grouping of infants coded all sessions after establishing intra-rater reliability and inter-rater reliability with a second coder using a random selection of 20% videos from the entire dataset. Inter-rater and intra-rater reliability for the proximity initiation measure was 0.94 based on intraclass correlation coefficients (ICCs).

2.4.2. Rates of caregiver gestures and actions: We also coded the total rates per minute and types of gestures/actions used by caregivers during their interactions with infants. Specifically, we coded for (1) object-directed actions, (2) directive gestures, (3) affirmative gestures and (4) requesting/accepting gestures (see Table 2 for definitions and

examples of each category of behaviors). Two coders blind to infant grouping coded all sessions after establishing intra-rater and inter-rater reliability using coder using a random selection of 20% videos from the entire dataset. Intra-class correlation coefficients were used to calculate reliability (object-directed = 0.99, **directive** = 0.99, affirmative = 1.00, and requesting/accepting = 0.97).

2.4.3. Rates of caregiver speech: In this category, we coded for total rates per minute and types of caregiver speech directed towards their infants (see Table 2 for details and examples) including (1) Action/information-related speech, (2) attention seeking speech, (3) affirmative speech, and (4) prohibitive speech. Two coders blind to infant grouping coded all sessions after establishing intra-rater and inter-rater reliability using a random selection of 20% videos of the entire dataset. Intraclass correlation coefficients were used to calculate reliability between coders (action/information-related = 0.97, attention seeking = 0.99, reinforcements = 0.99, prohibitions = 0.98).

For all variables except caregiver speech, we calculated behavior rates for the entire session. However, since the total time that caregivers spoke was quite low, we are reporting speech rates normalized to the total time they spoke within the task.

2.5. Statistical analyses

We tested our data for assumptions of parametric statistics. We analysed group differences in caregiver behaviors by conducting ANCOVAs with walking status (crawler and walker) and condition (spontaneous, and social) as the within-subjects factors and group as a between-subjects factor. In order to control for the effects of infants age as well as their language capacities, for all analyses, we added age at walking visit as well as receptive and expressive language abilities of infants at their walking visit as measured using the MSEL as covariates in our analyses. In the ANCOVA for caregiver gestures and actions, gesture/action type (object-directed, **directive**, affirmative, and requests & acceptances) was an additional within-subjects factor. Similarly, in the ANCOVA for caregiver speech, speech type (action/information-related, attention seeking, affirmations, and prohibitions) was also added as a within-subjects factor. For all analyses, if there was a significant main effect and a significant interaction involving the same factor, we conducted post-hoc *t* tests with Bonferroni corrections to assess the significant interaction only. In case the Mauchly's test of sphericity was significant, Greenhouse- Geisser corrections were applied. For all analyses, $p \leq 0.05$ was considered significant. Following Bonferroni corrections, adjusted *p* values of ≤ 0.01 were considered significant with statistical trends reported at *p* values between 0.05 and 0.01. Effect sizes are reported as partial eta squared values (ηp^2) and standardized mean difference (SMD) values with confidence intervals (CI) (Hedges, 1981).

In order to further understand the relationship between infant's object sharing rates and caregiver behaviors, we correlated total object sharing rates of infants (see Srinivasan & Bhat, 2016 for details) with caregiver proximity-initiating behaviors, gestures, and speech using Pearson's product moment correlations. We used Cohen's effect size guidelines for correlation coefficients to assess the magnitude of the association between variables, with

correlation coefficients between 0.1–0.29 considered small, 0.3–0.49 considered moderate, and coefficients ≥0.5 considered a large effect size (Cohen, 1988; Cohen, 1992).

3. Results

3.1. Caregiver proximity-initiating behaviors

The ANCOVA **indicated** only a main effect of group (F (1, 27) = 5.31, $p = 0.05$, $\eta p^2 = 0.13$). After controlling for infant age and language abilities, caregivers of HR infants (Mean(SD) = 0.94(1.11)) initiated greater number of bids to get closer to infants compared to caregivers of LR infants (Mean(SD) = 0.54(0.76), SMD = 0.41, CI = 0.29 to −1.11, $p = 0.01$).

3.2. Caregiver gestures and actions

The ANCOVA **showed** a significant main effect of gesture type (F (1.39, 37.50) = 4.63, $p = 0.03$, $\eta p^2 = 0.15$) and a significant gesture type × group (F (3, 81) = 5.81, $p = 0.001$, $\eta p^2 = 0.18$) interaction. We found that after controlling for infant age and language abilities, caregivers of HR infants engaged in greater rates of **directive** gestures (SMD = 0.58, CI = −0.13 to 1.28, $p < 0.001$), but lower rates of requesting/accepting actions (SMD = 0.42, CI = −0.28 to 1.12, $p = 0.02$) (see Figure 2) compared to caregivers of LR infants across both visits.

3.3. Caregiver speech

There were no statistically significant group differences between the total amount of time that caregivers in both groups spoke to their infants (LR infants: Crawler visit – Mean(SD): 190.09(71.66), Walker visit – Mean(SD): 228.10(104.25); HR infants: Crawler visit – Mean(SD): 200.93(103.29), Walker visit - Mean(SD): 219.68(96.17)).

The ANCOVA **indicated** a significant main effect of group (F (1, 27) = 10.15, $p = 0.004$, $\eta p^2 = 0.27$) as well as significant interaction effects of speech type × group (F (3, 81) = 3.82, $p = 0.013$, $\eta p^2 = 0.12$), and speech type × age at walking visit (F (3, 81) = 2.79, $p = 0.05$, $\eta p^2 = 0.09$).

Post-hoc analyses indicated that after accounting for infant age and language skills at their walking visit, overall, caregivers of HR infants used significantly more action/information-related (SMD = 0.40, CI = −0.33 to 1.07, $p = 0.03$) and attention seeking (SMD = 0.69, CI = −0.02 to 1.40, $p = 0.01$) speech along with a similar trend for the use of prohibitive phrases (SMD = 0.32, CI = −0.38 to 1.01, $p = 0.07$, see Figure 3 for details) compared to caregivers of LR infants.

3.4. Correlations between infant and caregiver behaviors

Within each group, we assessed correlations between total rates of object sharing by infants (Srinivasan & Bhat, 2016) and caregiver behaviors including proximity, gestures, and speech (see Table 3 for correlation matrix). Within the LR group, there was a moderate negative correlation between object sharing rates and caregiver proximity and a large positive correlation between object sharing and caregiver gestures indicating that less proximity and

more gesturing by caregivers was associated with greater object sharing in the LR group (see Table 3A). In the HR group, we found a large positive correlation between object sharing rates and caregiver gestures, a large positive correlation between caregivers' proximity-initiating behaviors and their gestures, and a moderate-sized negative association between caregivers' proximity-initiating behaviors and speech (see Table 3B). This indicates that greater caregiver gesturing was associated with greater object sharing in HR infants. Also, caregivers who engaged in greater proximity-initiating behaviors were providing more gestural inputs but fewer verbal inputs to their HR infants.

4. Discussion

4.1. Directive behaviors of caregivers of HR infants

Consistent with our hypotheses**, compared to caregivers of LR infants,** we found that caregivers of HR infants used a variety of verbal and nonverbal directive bids – greater proximity-initiating bids, directive gestures, as well as attention seeking, task-related, and prohibitive speech – to engage infants during the shared social-object play**. However, contrary to our hypothesis, we did not find any differences in caregiver behaviors between crawler and walker visits suggesting that irrespective of skill status, caregivers of HR infants are likely to use more directive bids compared to caregivers of LR infants. It is possible that caregivers of HR infants were able to perceive their infants difficulties in social engagement within the object sharing context and perhaps tried to intentionally 'compensate' for these delays by offering more gestural and verbal input or by moving closer to their infants compared to caregivers of LR infants. Alternately, directive interaction strategies may be reflective of a more adult-led interaction style that may be influenced by parents previous and ongoing caregiving experiences with their older child with ASD. Interestingly, we found no group differences in object-directed gestures and speech suggesting that caregivers in both groups were equally likely to demonstrate object affordances and promote object-based play in infants. However, caregivers of HR infants additionally used greater directive bids with infants compared to caregivers of LR infants.**

The use of directive interaction strategies to promote infant/child engagement have been frequently reported in caregivers of children with autism as well as other developmental disabilities including Down syndrome (Lemanek et al., 1993; Kasari, Sigman, Mundy, & Yirmiya, 1988; Blacher, Baker, & Kaladjian, 2013; Cielinski, Vaughn, Seifer, & Contreras, 1995). For instance, during a structured play interaction, young children with ASD were less likely to comply with the social requests of their caregivers compared to age-matched children with language delay, intellectual delay, and typically developing children (Lemanek et al., 1993). As a result, caregivers of children with ASD responded by engaging in more proximal interactions and using structured, verbal and non-verbal bids to seek and maintain children's attention on the tasks (Lemanek et al., 1993). Along the same lines, Wan and colleagues found that interactions were more negatively directive in the HR group, with caregivers being more demanding and intrusive over the first 15 months; in contrast, in the LR group, interactions were more responsive, with caregivers following their infant's lead in contingent and non-intrusive ways (Wan et al., 2013). **Although we saw clear differences**

in interaction styles of caregivers in both groups, our study design did not allow us to assess the long-term impact of directive bids on infant-caregiver interactions in HR infants. It would be important for future studies to systematically assess the longitudinal impact of directive strategies on infant engagement during early naturalistic interactions.

It was not surprising that caregivers of HR infants showed less requesting and accepting gestures compared to caregivers of LR infants; caregivers were simply responding to the lower rates of object sharing initiated by the HR infants. As reported in Srinivasan & Bhat, 2016, HR infants as a group, irrespective of outcomes, often ignored parent bids, tended to engage in solitary, repetitive play with objects, and were less likely to initiate interactions with caregivers. Moreover, 25% of HR infants in our study, were not walking even at 15 months; even HR infants without motor delays did not use their locomotor abilities to boost their social interactions with their caregivers. Other groups have also reported lower levels of motor activity (Apicella et al., 2013; Wan et al., 2012), infants ignoring caregiver bids (Adamson et al., 2001; Lemanek, Stone, & Fischel, 1993), and poor social engagement during the first year in at-risk infants and young children with ASD (Campbell et al., 2015; Saint- Georges et al., 2011; Winder, Wozniak, Parladé, & Iverson, 2013).

4.3. Cyclic nature of infant-caregiver interactions

Caregiver gestures were positively related to infant object sharing rates in both groups. It is possible that caregiver gestures may in fact have facilitated infants' sharing of their object play. Alternatively, infants who shared their play more often likely received greater gestural responses from caregivers. Our study however found salient differences in the type of gestures used by caregivers in both groups. Although our design does not allow us to comment on the direction of causality, our results are supported by other studies that stress the importance of caregiver gestures to facilitate infant engagement during early social interactions in HR & LR infants (Doussard-Roosevelt et al., 2003; Karasik, Tamis-LeMonda, Adolph, & Dimitropoulou, 2008). In the LR group, caregiver proximity was negatively correlated with infant object sharing rates, thus aligning with previous literature suggesting that directive caregiver behaviors discourage infant social engagement in typically developing infants (Doussard-Roosevelt et al., 2003; Lussier, Crimmins, & Alberti, 1994). However, no such correlations were seen in the HR group. Instead, caregiver proximity was positively correlated with gestures rates but negatively correlated with caregiver speech. Caregivers of HR infants may have used multiple concurrent strategies including physical proximity and gestural bids (but not verbal bids) to encourage infant compliance during the task. Children with ASD are known to respond better to high-intensity behaviors including physical contact and gestures rather than verbal cues of caregivers (Doussard- Roosevelt et al., 2003; Kasari et al., 1988; Konstantareas et al., 1988; Lemanek et al., 1993). Moreover, in early infancy, gestures are known to be more salient and unambiguous compared to verbal cues (Deák, Flom, & Pick, 2000; Dimitropoulou, Tamis-LeMonda, Adolph, & Alibali, 2007; Karasik et al., 2008; Schnur & Shatz, 1984). Lastly, past interaction experiences with their older children with ASD with communication difficulties may have also contributed to caregivers preferring non-verbal means to interact with their younger HR infants.

4.4. Limitations

Our findings are limited by a relatively small sample size of 16 infants per group. The inclusion of two preterm infants in the HR group made our sample more diverse. **Moreover the recruited sample was limited to families with relatively higher SES thereby limiting the generalizability of findings to families with lower SES. Future longitudinal studies are necessary to replicate the results of our pilot study using larger, homogenous samples and across the entire range of SES. Our study design did not allow us to tease apart if caregiver interaction styles were reflective of their sensitivity to infants' early social atypicalities or if they were also influenced by caregivers' prior experiences of interacting with their older children with autism.** Although we looked at infant and caregiver behaviors during the object sharing task, we did not conduct a minute-by-minute coding that compared corresponding infant and caregiver behaviors. **Specifically, we did not systematically evaluate the quality and sensitivity of the caregiver responses within the context of the unfolding interaction dynamic between infants and their caregivers. Moreover, our study did not allow us to assess the long-term impact of caregiver interaction styles on infants' object sharing skills in both groups. For instance, are these strategies effective in promoting infant compliance during object play tasks or do directive interactions in fact reduce infant engagement over the long term. Given the study design, we were able to only assess correlations between caregiver and infant behaviors while not being able to draw any inferences regarding causality; future studies will be needed to replicate our results and more work is needed to understand the differential impact of caregiver interaction styles on infant social skill development.**

4.5. Clinical implications

Our work emphasizes the reciprocal nature of infant-caregiver interactions during infancy and has implications for the design of caregiver training programs aimed at promoting social communication development and positive outcomes in HR infants. The study found that caregivers of HR infants used a variety of directive verbal and non-verbal bids to solicit infant engagement within an object play task**. Two different approaches to promote parent-child engagement have been described within the current literature. The first approach suggests the use of directive (adult-led) interactions involving greater physical contact and verbal/non-verbal bids to control infants' interactions may promote compliance, social and object play, dyadic engagement, and early development of children with developmental disabilities** (Crawley & Spiker, 1983; Doussard-Roosevelt et al., 2003; Mahoney, Gerald & Powell, 1988; Lemanek, Stone, & Fiscel, 1988; Cielinski et al., 1995; Moore, Saylor, & Boyce, 1998; Roach, Barratt, Miller, & Leavitt, 1998**). However, there is a second contrasting approach suggesting that directive caregiver interactions with infants may limit their social development in the long term. For instance, Harker and colleagues followed HR and LR infants over 9 months and found that higher levels of maternal directiveness during interactions predicted slower growth in social smiling whereas greater levels of maternal responsiveness were associated with greater social smiles in infants (**Harker, Ibanez, Nguyen, Messinger, & Stone, 2016**). In fact, several parent-mediated interventions such as the Hanen program, PALS program, Milieu Teaching, etc. have been developed to**

train parents of young children with developmental disabilities in responsive/sensitive parenting strategies (such as following the child's lead, waiting longer for infant initiations, pacing interaction to child's needs, and providing opportunities for independent problem solving) to promote spontaneous social engagement (Green et al., 2015, 2017; Whitehouse et al., 2019; Girolametto, Sussman, & Weitzman, 2007; Landry, Smith, & Swank, 2006; Manolson, Ward, & Dodington, 1995; Warren et al., 2006; Warren & Brady, 2007; Yoder & Warren, 2002). **Given the limited nature of our study, we are unable to support one approach or another; but there is a need for more research to systematically assess the long-term impact of these early differences in caregiver interactions on outcomes of HR and LR infants.**

4.6. Conclusions

The paper compared caregiver behaviors between two groups - HR and LR infants during an object sharing task. **Our previous paper showed that HR infants are less likely to share their object play with caregivers compared to LR infants. Caregivers of HR infants in turn engage in greater directive strategies compared to caregivers of LR infants including being more proximal to infants and using greater verbal and non-verbal bids to direct infants' attention and gain their compliance. Although the long-term impact of these differences in caregiver interaction styles are unclear from the present study, the results provide evidence in support of an altered interaction dynamic between HR infants and their caregivers compared to their LR peers.**

Acknowledgments

We would like to thank all the infants and families who participated in the study. We thank Dr. Deborah Fein and her student Alyssa Orinstein for their support of this research through completion of ADI-R interviews with participating families. We would also like to thank graduate student, Maninderjit Kaur and undergraduate students, Lyly Tran, Esther Cha, Irene Cheng, Isabel Park, Kathleen Lynch at University of Connecticut who helped with data collections and analysis. We are grateful to Lana Karasik for sharing information about her work during the early development phase of this study. Lastly, AB thanks the National Institutes of Child Health and Human Development (NICHHD) for support of this research through a RO3 award (R03HD060809).

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Highlights

- Caregivers of HR infants used more directive bids than caregivers of LR infants.
- Caregivers are more physically proximal to HR infants during dyadic interactions.
- Caregivers of HR infants also use more verbal and nonverbal bids during interactions.

Figure 1:
Experimental setup for spontaneous and social conditions of the object sharing task.

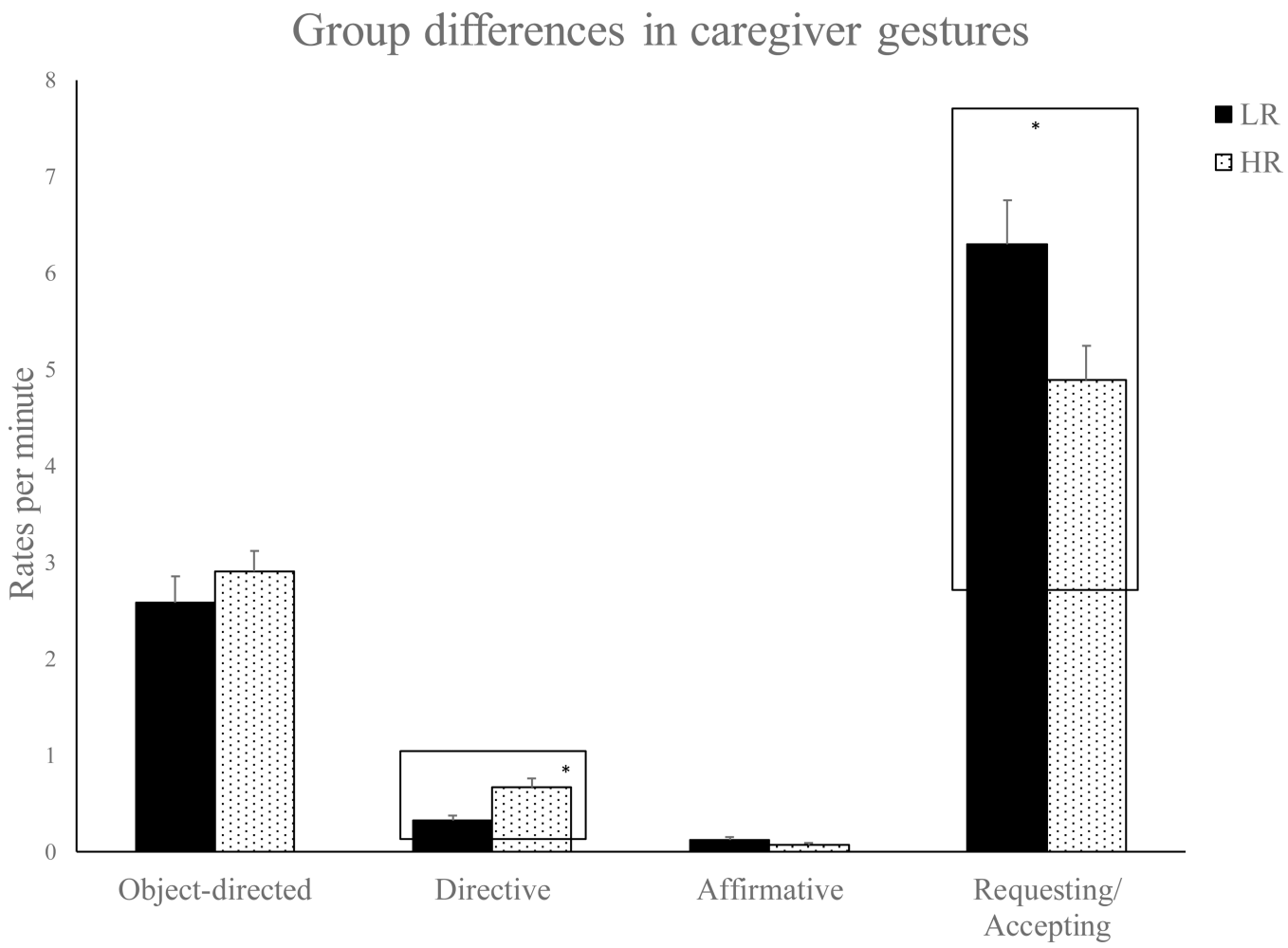

Figure 2:
Group differences in gesture rates by caregivers of LR and HR infants. Error bars represent standard error of the mean

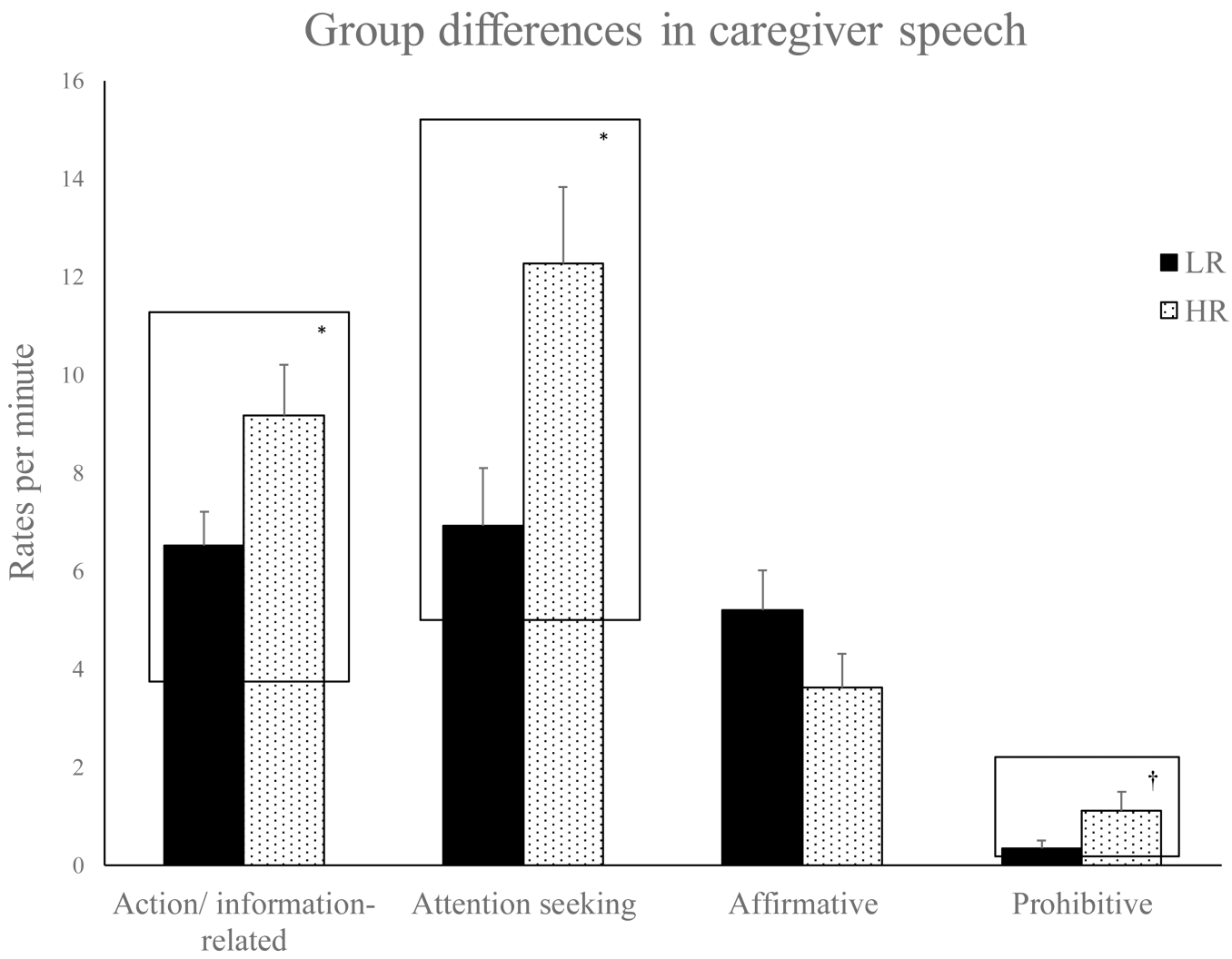

Figure 3:
Group differences in speech rates by caregivers of LR and HR infants. Error bars represent standard error of the mean

Table 1:

Participant characteristics at crawling and walking visits

Group	Crawling Visit			Walking Visit		
	LR	**AR**	**Group differences**	**LR**	**AR**	**Significant group differences**
Age at visit in months Mean (SD)	10.90 (1.68)	10.81 (2.08)	***t*(30) =0.13, *p* = 0.90**	15.36 (1.28)	15.36 (1.51)	***t*(30) =0.003, *p* = 0.99**
T scores on Mullen Scales of Early Learning: Mean(SD)						
Gross motor	43.25 (9.10)	44.06 (12.87)	***t*(30) =−0.21, *p* = 0.84**	47.94 (2.06)	46.07 (11.81)	***t*(30) =0.52, *p* = 0.61**
Fine motor	52 (8.68)	52.25 (8.51)	***t*(30) =−0.08, *p* = 0.94**	52.56 (6.15)	50.44 (11)	***t*(30) =0.68, *p* = 0.51**
Visual reception	52.94 (10.14)	57.38 (10.38)	***t*(30) =−1.22, *p* = 0.23**	46.25 (8.26)	47.31 (8.20)	***t*(30) =−0.37, *p* = 0.71**
Receptive language	50.06 (8.02)	48.38 (10.74)	***t*(30) =0.50, *p* = 0.62**	51.19 (7.22)	48.19 (10.75)	***t*(30) =0.93, *p* = 0.36**
Expressive language	45.75 (5.13)	43.88 (7.49)	***t*(30) =0.83, *p* = 0.42**	44.5 (7.96)	39.88 (6.59)	***t*(30) =1.79, *p* = 0.08** †
Standard scores						
Early Learning Composite	100.5 (12.80)	101.13 (13.82)	***t*(30) =−0.13, *p* = 0.90**	97.31 (8.96)	93.31 (13.54)	***t*(30) =0.99, *p* = 0.32**

† Trend

Table 2:

Coding scheme for caregiver behaviors

Caregiver behaviors	Coding scheme	Description	Examples
Proximity	(a) Proximity-initiating bids	Instances where caregivers moved closer to the infant	- Scooting towards infant in sitting - Taking steps towards infant - Leaning body closer to infant greater than half the distance between them and infant - Pulling infant towards themselves - Reaching out to infant greater than half way the distance between infant and the caregiver
Gestures/ Actions	(a) Object-directed	Actions performed on toys to demonstrate object affordances	- Showing toy to the infant - Showing how a rattle makes a sound, or a koosh ball's threads can be pulled or a box can be opened
	(b) Directive	Actions to solicit child's attention and directive/ controlling behaviors with regard to ensuring infant compliance	- Touching infant's body like a tap on the shoulder to get their attention - Waving to the infant to get their attention - Banging an object on the floor to get the infant's attention - Removing/grabbing toys from child's hand - Positioning hand close to infant to catch objects dropped by infant
	(c) Affirmative	Gestures to applaud and reinforce child's play	- Clapping - Waving hands up high
	(d) Requesting/ Accepting	Actions to coax infants to approach caregiver and/or share objects with them	- Pointing to objects - Using hands to ask for toys - Beckoning gestures to ask infant to move towards mom
Speech	(a) Action or information-related	Speech to explain the task, actions involved in the task, or words to describe toys/objects	- "Let's put the toys away" - "It is clean up time now" - "Give the toy to Mom. I am going to put it away" - "Oh this is a squeaky rattle" - "That is an orange ball"
	(b) Attention seeking	Words or phrases to get the child's attention	- "Child name!" - "Look at mommy" - "Child name, look here, look at the toy"
	(c) Affirmative	Words to encourage and reinforce the infant	- "Good job cleaning up!" - "There you go, you did it!" - "Very nice job giving the toy to Mommy!"
	(d) Prohibitive	Words to prohibit the infant from doing certain actions	- "No, don't eat the toy" - "No touching the wires"

Table 3A:

Correlations between infant object sharing rates and rates of caregiver proximity-initiating bids, gestures, and speech in the LR group

LR group	Caregiver proximity	Caregiver gestures	Caregiver speech
Object Sharing	−0.431 *	0.694 **	0.010
Caregiver proximity		−0.163	0.040
Caregiver gestures			0.075

Table 3B:

Correlations between infant object sharing rates and rates of caregiver proximity-initiating bids, gestures, and speech in the HR group

HR group	Caregiver proximity	Caregiver gestures	Caregiver speech
Object Sharing	0.096	0.546**	−0.042
Caregiver proximity		0.527**	−0.398*
Caregiver gestures			−0.204

** Significant at $p \leq 0.01$

* Significant at $p \leq 0.05$