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Mothers of Children with Autism Spectrum Disorders: Play Behaviors with Infant Siblings and Social Responsiveness

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Abstract

Mother-infant interactions are a proximal process in early development and may be especially salient for children who are at risk for social difficulties (i.e., infant siblings of children with autism spectrum disorder; ASD). To inform how indices of maternal behaviors may improve parent-mediated interventions designed to mitigate ASD risk the present study explored maternal social responsiveness ratings and social behaviors during dyadic play interactions.

Dyads were recruited from families with at least one older child with ASD (high-risk group, n = 90) or families with no history of ASD (low-risk group, n = 62). As part of a prospective study, interactions were coded when infant siblings were 6, 9, and 12 months of age, for gaze, affect, vocalizations, and multimodal bids or responses (i.e., social smiles). Maternal social responsiveness was indexed via the Social Responsiveness Scale (SRS).

Mothers in both risk groups had comparable SRS scores and social behaviors during play. Two maternal behaviors emerged as potential promotors of infant social behaviors and are thus of high relevance to parent-mediated interventions. Specifically, more maternal positive affect and the use of multimodal bids or responses were associated with more infant positive affect, vocalizations, gaze to face, and multimodal bids or responses.

Keywords

mother-infant interaction; infant sibling; autism spectrum disorder; social responsiveness; parent-mediated intervention

Families serve as the primary context for infant development and daily dyadic interactions provide the proximal processes of early social development. These ‘building blocks’ often occur within play and other daily caregiving activities. For children developing at elevated risk for social communication difficulties (i.e., infant siblings of children with autism spectrum disorder; ASD), this context may be especially salient during the first year. Additionally, in families raising children with ASD, marked difficulties in social responsiveness and communication have been documented in parents (e.g., Page et al., 2017;

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Parr, Gray, Wigham, McConachie, & Couteur, 2015). These parental difficulties create a potential barrier to care because parent-mediated interventions are now common practice when supporting children with or at risk for ASD (Green et al., 2013, 2015, 2017; Jones, Dawson, Kelly, Estes, & Webb, 2017; Kasari et al., 2014b; Pickles et al., 2016; Rogers et al., 2014). Social responsiveness and communication strengths or weaknesses among mothers (or other primary caregivers) can have a direct impact on the efficacy of parent-mediated interventions (Parr et al., 2015); however, intervention studies rarely index maternal or parent social responsiveness or communicative competencies (e.g., Kasari et al., 2014a).

To inform parent-mediated interventions this study addressed three aims. The first aim assessed if questionnaire-based ratings of social responsiveness (SRS) or coded social behaviors in context are distinctly different for mothers raising infants at risk for ASD. The second aim focused on maternal behaviors and assessed if these codes were associated with SRS scores or coded infant social behaviors in context at 6, 9, or 12 months of age. The final aim of this study, assessed how maternal and infant behavior may be distinct across infant diagnostic outcome groups at 36 months of age. These aims were informed by two lines of research including: indices of social responsiveness in families raising children with ASD and previous coding-schemes used to index social behaviors in parents raising children with and at risk for ASD.

Maternal Social Responsiveness

Social responsiveness is a key element of positive dyadic interactions and is a known difficulty among family members raising children with ASD. These subclinical social difficulties are often described as elements of the broader autism phenotype (BAP). Validated questionnaires like the Social Responsiveness Scale (SRS) or the Broad Autism Phenotype Questionnaire (BAPQ) are commonly used in family-based research in autism to index the full continuum of social competence (Constantino & Todd, 2003; Constantino, Zhang, Frazier, Abbacchi, & Law, 2010, Feczko, Bliss-Moreau, Walum, Pruett, & Parr, 2016; Schwichtenberg et al., 2010). Elevated scores indicate difficulties with social responsiveness, rigidity, and contextual awareness across a variety of situations. Several studies have demonstrated that families raising children with ASD present with a shifted distribution or more difficulties with social responsiveness and communication (Page et al., 2017; Virkud et al., 2008). However, these findings are less common in mothers and relatively little is known about how high or low scores on these questionnaires relate to behaviors in context. To our knowledge, currently only two ASD-focused studies address how social responsiveness or competence ratings are associated with observed interactive behaviors. First, a study by Jones and colleagues (2017) assessed child social responsiveness (SRS scores) and child gaze behaviors across two contexts (play and conversations). Children with higher SRS scores (more social and communication difficulties) exhibited fewer gaze shifts to the examiner within a conversation context. Second, Parr and colleagues (2015) provided a parent-mediated intervention to mothers of children with ASD exhibiting high ($n = 5$) and low ($n = 9$) levels of the BAP. Mothers presenting with more BAP features, or more social and communication difficulties, exhibited less change in their play behaviors (e.g., praise, turn-taking, imitation) in response to the parentmediated intervention. These preliminary studies highlight the potential utility of indexing social responsiveness and

communication competencies. For example, if a mother receives an elevated SRS score, are her interactions with her infant markedly different than that of a mother with a lower score? If such a connection could be demonstrated then interventionists or clinicians could use questionnaires to identify those who may need more support when implementing a parent-mediated intervention.

Maternal Social Behaviors in Context

When considering maternal behaviors and infant development, an extensive body of research exists that highlights the imperative role of maternal behaviors in language and social development (Bang & Nadig, 2015; Brian et al., 2016; Bottema-Beutel et al., 2014; Chiang, Chue, & Lee, 2016; Green et al., 2017; Gulsrud, Hellemann, Shire, & Kasari, 2016; Kasari, Gulsrud, Paparella, Hellemann, & Berry, 2015; Kim & Mahoney, 2004; Pickles et al., 2016; Tager-Flusberg, 2016; Shire, Gulsrud, & Kasari, 2016; Siller & Sigman, 2002; Siller, Swanson, Gerber, Hutman, & Sigman, 2014). Notably, these studies emphasize the positive role maternal behaviors can have on the development for children with (and without) ASD. Overall, detailing the research on maternal behaviors and early social or language development is beyond the scope of this paper; therefore, the following review focuses only on investigations that utilize an infant sibling design.

Within infant sibling studies, findings regarding maternal behaviors in context are mixed. Three studies have reported mothers of high-risk (HR) siblings displayed lower levels of sensitive responding or higher directedness during play between 6 and 12 months of age when compared to a low risk (LR) group (Harker, Ibañez, Nguyen, Messinger, & Stone, 2016; Wan et al., 2012, 2013). Conversely, an observational study of 11-month-old infant siblings did not find significant HR - LR group differences for parent initiating/directing, praise, scaffolding, warmth, or sensitivity (Campbell, Leezenbaum, Mahoney, Day, & Schmidt, 2015). Similarly, Talbott and colleagues (2015, 2016) reported mothers raising an infant at risk for ASD (HR group) used more gestures and comparable linguistic inputs when compared to their LR counterparts. Comparable maternal responsiveness to infant communicative behaviors were also reported in Leezenbaum and colleagues' (2014) study of HR (n = 12) and LR infants (n = 14).

When considering child diagnosis or developmental concerns, only a few infant sibling studies have directly reported on maternal behaviors across groups (Talbott et al., 2015, 2016; Wan et al., 2013). Talbot and colleagues (2015, 2016) assessed a small cohort of infant siblings and compared maternal vocalizations and gesture use across three groups of children: ASD, LR, and HR (with no ASD diagnosis). Notably, maternal behaviors for the infants diagnosed with ASD were not significantly different. Conversely, Wan and colleagues (2013) used the same groupings and reported higher codes for maternal directiveness when infants were 12 months of age. Within each of these studies, sample sizes were relatively small (less than 60 HR infants) and the mixed findings and attenuated group differences may reflect low power.

Notably, the groupings used across infant sibling studies often vary and sometimes include a LR comparison group and two HR groups (e.g., HR ASD group and HR no-ASD group). To

help ground this work within previous studies (e.g., Talbott et al., 2016; Wan et al., 2013), two distinct outcome groupings for HR infants were employed in the current study. The first compares infants solely based on their developmental outcome (ASD, non-TD, and TD) and the second incorporated their risk group status (LR, HR non-ASD, HR ASD).

Measuring Dyadic Behaviors

Assessing mother and infant behaviors during play or other social tasks is common in social science research. Unfortunately, there is little agreement on a gold standard in the field (Halle, Anderson, Blasberg, Chrisier, and Simkin, 2010). Studies like Wan et al. (2012, 2013) use indices that assess global maternal behaviors (i.e., Manchester Assessment of Caregiver-Infant Interaction). For this rating scale and others like it, observers rate an interaction using global ratings that assess the quality and intent of parental behaviors (e.g., scaffolding; Campbell et al., 2015; Freeman & Kasari, 2013). Other approaches in the field assess parental cognitions about their interactions (Ohr, Vidair, Gunlicks-Stoessel, Grove, & La Lima, 2010) or the frequency of positive or negative parenting behaviors per minute of interaction (Cyr, Pasalich, McMahon, & Spieker, 2014). Researchers have also assessed interactions at a more micro-analytic level, assessing core social competencies, vocalizations, or gaze (Lambert-Brown et al., 2015; Leezenbaum, Campbell, Butler, & Iverson, 2014; Warlaumont, Richards, Gilkerson, & Oller, 2014). The latter approach may reduce rater bias and capture elements of an interaction not readily apparent in real-time or when making more global judgments. For example, in Green et al. (2017), the parent-mediated intervention included two validated behavioral coding schemes for characterizing dyadic interactions (i.e., global ratings and event coding) and observed more instances of behavioral change using the event coding scheme.

The present study uses a micro-analytic approach to take a detailed look at maternal and infant behaviors during dyadic play in order to reduce value interpretations and other rater biases. The coded behaviors pull from previous studies and focus on behaviors that have been highlighted as influential in ASD risk or development including: gaze, vocalizations, affect, and multimodal social behaviors like social smiling (Ozonoff et al., 2010; Gangi et al., 2017; Yirmiya et al., 2006; Filliter et al., 2015; Nichols, Ibañez, Foss-Feig, & Stone, 2014; Talbott et al., 2015; 2016). With these micro-analytic codes, parent-mediated interventions may be informed by identifying potential maternal ‘promoter’ behaviors. For example, in families raising infants at risk for ASD, more maternal positive affect may be associated with more infant prosocial behaviors.

Current Study

To inform parent-mediated interventions, the current study focuses on maternal social responsiveness and social behaviors within context but does also include infant social behaviors to provide information on both members of the dyad. Assessing maternal behaviors specifically will help the field move forward in two ways. First, it will add to the growing body of literature assessing maternal dyadic behaviors in HR siblings with the largest sample to date. With this, it has the potential to inform discrepant findings. Second, it will provide insights into the application of questionnairebased indices of social

communicative behaviors to explore if they are useful in identifying mothers that may need more support within parent-mediated interventions.

Method

Participants

One hundred and fifty-two families participated in this study. Infant siblings were recruited from families with at least one older child diagnosed with ASD (n = 90) or at least one typically developing older child and no history of ASD in 1st, 2nd, and 3rd degree relatives (n = 62). The older HR siblings (called proband siblings) were diagnosed with *DSM-IV* Autistic Disorder, Asperger Disorder, or Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS). Proband diagnostic status was confirmed with the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002). Family demographic information stratified by risk group is provided in Table 1.

At the 36-month visit, infants were classified into 1 of 3 algorithmically defined outcome groups: Typical Development (TD), Non-Typical Development (Non-TD), and ASD. The grouping criteria were developed by the Baby Siblings Research Consortium, a network of researchers studying autism identification in infants (for details see Ozonoff et al., 2014). Within the HR group most of the infants were categorized as TD (n = 58, 64%), followed by Non-TD (n = 16, 18%), and ASD (n = 16, 18%). In the LR group infants were categorized as TD (n = 59, 95%), Non-TD (n = 2, 3%), and ASD (n = 1, 2%). To provide a direct comparison for previous studies (e.g., Talbott et al., 2016; Wan et al., 2013), a second grouping pattern was also employed which incorporated both risk group status and infant diagnostic outcomes. These groups included a LR comparison group (n = 59) and the high-risk group was split into those with ASD (HR ASD, n = 16) and without ASD (HR no-ASD, n = 74).

Measures

Play Behaviors.—As part of a longitudinal prospective study, mother-infant interactions were videotaped and coded during a play task when infants were 6, 9, and 12 months of age. Dyads were asked to play as they typically do at home and a standardized bin of toys was provided. The toys included a doll, bottle, small blanket, car, shape sorter, ball, rattle, and a pair of toy phones. From this play session, maternal and infant gaze, affect, and vocalizations, respectively, were coded for 3 minutes. The selected video segment included the first few minutes of active play once the examiner left the room. Initial toy setup and exploration were not coded.

For the present study, mother and infant behaviors were coded independently for frequencies of *look face, positive affect,* and *vocalizations*, which could occur in isolation or combination (i.e., multimodal responses/bids). Three multimodal codes were generated and summed: *look face and positive affect*, *look face and vocalization*, and *vocalization and positive affect*. Detailed coding rules were established in a previous study (removed for review). For example, positive affect included hearing the infant/mother laugh, seeing at least one corner of the infant's/mother's mouth up-turn, and/or flexed orbicularis oculi

muscles which raise the cheeks and form 'crow's feet' around the eyes. Coders were asked to identify when positive affect began (*on*) and ended (*off*). For each *on* and *off* code of positive affect a frequency count of 1 was given. For smiles or laughs that were in close succession, a break of at least one second was required to count them as two separate positive affect expressions. For additional code descriptions see (removed for review) and Table 2.

Coders were unaware of risk status or outcome group. For training, each coder read the coding manual, shadowed a master coder for the coding of 1 to 4 play sessions and then coded 4 to 8 play sessions independently. After this initial independent coding, preliminary intra-class correlation coefficients (ICCs) were calculated and feedback was provided for areas of discrepancy (if needed). Then the coder completed an established reliability set of 6 play sessions (alpha set). If all coded behaviors (i.e., gaze, positive affect, and vocalizations) did not achieve ICCs at or above .70, additional feedback was provided and then the coder completed a second reliability series (beta set). All independent coders achieved our reliability standard (ICCs at or above .70) on the alpha or beta coding sets. If ICCs at or above .70 were not achieved, then the coder did not move into independent coding. Independent coders had an ICC range of .70 to .99 (M = .88). Mother and infant means are depicted in Figure 1.

Social Responsiveness.—Partner ratings of mothers on the Social Responsiveness Scale (SRS) were used to index social responsiveness. The SRS is a 65-item informant-report questionnaire which assesses social interactions, relationships, and communication skills. Items are rated on a 4-point scale of (1) not true, (2) sometimes true, (3) often true, and (4) almost always true. Studies using the SRS report high reliability (Constantino & Todd, 2005; Constantino et al., 2009) and discriminant validity, differentiating well between typically developing, at-risk, and ASD populations (Constantino, Hudziak, & Todd, 2003; Constantino, Przybeck, Friesen, & Todd, 2000; Reiersen, Constantino, Volk, & Todd, 2007). Partner-reported SRS scores have been validated (Constantino & Gruber, 2012) and are often included in familybased studies (Lyall et al., 2014; Schwichtenberg, Young, Sigman, Hutman, & Ozonoff, 2010; Virkud, Todd, Abbacchi, Zhang, & Constantino, 2008). SRS total T scores may fall within the normal (T score ≤ 59), mild to moderate (T scores 60–75), or severe range (T score ≥ 76). Descriptive SRS statistics stratified by risk group are provided in Table 1.

Autism Diagnostic Observation Schedule.—The ADOS (Lord et al., 2000) is a semi-structured standardized interaction and observation that measures symptoms of autism. It has two empirically derived cutoffs, one for ASD and one for Autistic Disorder. It was administered to the proband at the initial visit to confirm inclusion and to the infant siblings at 36 months of age as part of outcome classification. Each administrator completed an initial ADOS training and maintained 80% or greater agreement with a reliable trainer across all items.

Mullen Scales of Early Learning.—The MSEL (Mullen, 1995) is a standardized developmental test for children ages birth to 68 months. The subscales administered

included gross and fine motor, visual reception, and expressive and receptive language. This measure was used in the outcome definition, as described above.

Procedure

This study was conducted under the approval of [removed for review] Institutional Review Board. The study was explained to parents orally and in writing, all their questions were answered, and consent was obtained before conducting assessments. The SRS was completed at time of enrollment. Mother-infant play interactions were completed at 6, 9, and 12 months as part of a larger experimental battery. Infant outcome classification was determined following a laboratory visit at 36 months of age.

Results

All data were checked for normality, multicollinearity, and homoscedasticity prior to model estimation using IBM Statistical Package for the Social Sciences (SPSS) version 23. Our research questions of interest were assessed using general linear models with terms for infant sex and family income when mother-infant data were included. For the mother-infant data, separate models were specified for 6, 9, and 12 months to maximize the observations that could be incorporated. Group differences were interpreted if $p < .05$. To aid in the interpretation of our findings, a series of posthoc power analyses were also conducted.

Maternal Social Responsiveness

To address our first research aim, we compared the maternal SRS scores across the HR and LR groups. As illustrated in Figure 2, maternal SRS T scores were not significantly different across the two groups, $F(1, 151) = .70$, $p = .40$. In both groups, a majority of the scores fell within the normal range of reciprocal social behavior (T scores < 60). Within the LR group only one mother scored in the Mild range and none were in the Moderate or Severe ranges. Within the HR group, only two mothers scored within the Mild range (T scores 60–65), one within the Moderate range (T scores 66–75) and none in the Severe range. These findings replicate two previous studies (e.g., De la Marche et al., 2012; Schwichtenberg et al., 2010) which have reported that mothers of children with ASD do not, at a group level, exhibit more social responsiveness difficulties (i.e., elevated SRS scores) as indexed by partner or self- report questionnaires.

Maternal Social Behaviors in Context

General linear models were used to assess group differences in maternal social behaviors during play, with infant sex and family income as covariates. Mothers in the HR group did not present with significantly lower levels of *look face, positive affect,* or *vocalizations* when their infant was 6, 9, or 12 months of age (Table 3). Mothers in the HR group used slightly fewer multimodal bids or responses at 9 and 12 months; however, these differences were not statistically significant (adjusted for multiple comparisons) and, given the size of the effects, are unlikely to be functionally meaningful. With respect to infant sex and family income, mothers in both groups displayed similar patterns. When infants were 6 months of age, mothers used more multimodal bids with boys, and mothers who reported a higher family income tended to use more multimodal bids. Similarly, at 12 months of age mothers

vocalized more to boys, and mothers who reported a higher family income tended to vocalize more.

Maternal Social Behaviors in Context with Social Responsiveness

To assess if partner ratings of social responsiveness were associated with maternal social behaviors in context, general linear models were specified with terms for infant sex and family income. These models were specified with all available data (including all dyads regardless of risk group status or infant outcome). Partner ratings of social responsiveness (SRS scores) were not associated with maternal behaviors during play at 6, 9, or 12 months of age (p range .05 to .99). Of the models specified, only one reached our interpretation threshold of $p < .05$. For this model, maternal vocalizations when infants were 12 months of age were more frequent for interactions with boys. Maternal SRS scores were not a significant predictor.

Maternal and Infant Social Behaviors in Context

To inform how maternal behaviors co-occur with infant behaviors, a series of partial correlations were completed with infant sex and family income as covariates. For all dyads, maternal expressions of *positive affect* and the use of *multimodal* bids or responses were positively associated with infant *positive affect*, *looks to face*, *vocalizations*, and *multimodal* bids or responses (Table 3). Overall, this pattern was most consistent when infants were 12 months of age. For mothers raising infants at risk for ASD (HR group) more maternal *positive affect* was associated with more infant *positive affect*, *vocalizations*, *looks to face*, and *multimodal* bids or responses. Similarly, more maternal *multimodal* bids or responses were associated with more infant *positive affect*, *vocalizations* and *multimodal* bids or responses at 12 months of age. For mothers in the LR group, the overall pattern was similar.

Infant Diagnostic Outcomes and Developmental Concerns

We assessed the relations between infant outcome classifications at 36 months of age and (1) partner reports of maternal social responsiveness, (2) maternal social behaviors (when infants were 6, 9, and 12 months of age) and (3) infant social behaviors. To help compare this study directly with previous research two outcome group classifications were utilized (i.e., ASD, non-TD, and TD; LR, HR non-ASD, HR ASD). Partner ratings of maternal social responsiveness (SRS scores) were comparable across the ASD ($M = 49.86$, $SD = 5.26$), Non-TD ($M = 50.50$, $SD = 5.26$), and TD outcome groups ($M = 48.96$, $SD = 4.22$). Similarly, when considering risk and outcome (LR, HR non-ASD, and HR ASD) no significant differences emerged for maternal social responsiveness. As illustrated in Table 4, maternal social behaviors in context were not significantly different at any age across the three developmental outcome groups. Specifically, mothers of infants within the ASD outcome group ($n = 16$) had comparable frequencies of positive affect, vocalizations, gaze to face, and multimodal bids or responses. When considering LR, HR non-ASD, and HR ASD a similar pattern emerged, with no significant differences in maternal behaviors at 6, 9, or 12 months of age (all $p > .05$).

Although the focus of this research is maternal behaviors, infant behaviors during play were also assessed to provide information on both members of the dyad. Descriptive statistics on

infant behaviors are provided in Tables 4 and 5, and are illustrated in Figure 1. Overall, regardless of outcome at 36 months of age, all infants increased their frequency of *look face*, *positive affect*, *vocalizations*, and *multimodal bids or responses* to their mothers at 6, 9, and 12 months of age (Tables 4 & 5). There were no significant differences in infant behaviors at 6, 9, or 12 months of age across the developmental outcome groups (TD, non-TD, ASD) or the risk and outcome groups (LR, HR non-ASD, HR ASD).

Power Analyses

Post-hoc power analyses completed with G Power verified that our sample sizes were sufficient for detecting medium to large effect sizes. Specifically, analyses comparing risk group (i.e., HR vs. LR) with two covariates and an alpha set at 0.05 revealed that our current sample ($n = 152$) had power above 0.80 to observe a medium ($f^2 = .15$) to large effect ($f^2 = .35$). Additionally, for the outcome group comparisons of TD to ASD ($n = 74$) and TD to Non-TD ($n = 74$) with two covariates, power analyses revealed that the outcome comparison groups sample sizes had a power of 0.78 for a medium effect and 0.99 for a large effect size. Given the lack of significant differences for most of our analyses, these post-hoc power analyses aid in providing a context for our null results.

Discussion

The present study found no significant group-level differences in socialcommunicative behaviors during play or ratings of social responsiveness between mothers of infants at risk for ASD and the comparison group (regardless of infant diagnostic status).

We recognize that our analyses present null findings and that a lack of significant difference is not the same as stating the groups are equivalent. Adequate power was obtained to detect moderate to large differences. However, across three assessment ages and six dimensions of social interaction, marked/significant differences were not apparent. The present investigation echoes findings from previous studies demonstrating that mothers of children with ASD do not exhibit social responsiveness difficulties as indexed by the SRS (De la Marche et al., 2012; Scheeren & Stauder, 2008; Schwichtenberg et al., 2010). In previous research, elevated SRS scores were more commonly reported in fathers and biological siblings of children with ASD than in mothers (Schwichtenberg et al., 2010; Virkud et al., 2008). However, other measures (i.e., BAPQ) have been used to document elevated social difficulties in mothers of children with ASD (Flippin & Watson, 2018; Pruitt, Rhoden, & Ekas, 2018). Additionally, elevated BAP features in mothers have been associated with less optimal developmental progress for children with ASD (Flippin & Watson, 2018).

Our research questions also addressed how scores on a social communication questionnaire (i.e., SRS) relate to maternal behaviors in a social context. In theory, social communitive behaviors indexed via a questionnaire and observation would be related, but in the present study they were not. This may reflect several factors, including questionnaire informant and content, or simply a lack of relationship. The use of partner or father reports is supported by previous studies (Constantino & Gruber, 2012; Lyall et al., 2014; Pearl, Murray, Smith, & Arnold, 2013, Virkud et al., 2008); however, spousal reports may be capturing different or qualitatively distinct behaviors. Statements on the SRS include: *She is able to communicate*

feelings to others, *She is awkward in turn-taking with others*, *Her behavior is socially awkward, even when trying to be polite*. Each of these assess social communicative behaviors but it is understandable how they may not relate to frequencies of gaze to face, vocalizations, or the use of multimodal bids, such as social smiling. Additionally, the SRS has several items that index elements of the broader autism phenotype that may not relate to social communicative behaviors (e.g., *She has repetitive behaviors that others consider odd*, *People think she is interested in too few topics, or that she gets too carried away with those topics*). Finally, the range of SRS scores within this study was truncated and does not reflect the full range of difficulties faced by some individuals. It could be that associations between behaviors in context and SRS scores are only apparent at the higher (more impacted) end of the scale. A small study of children with autism ($n = 20$) supports this notion, with a reported association between SRS scores and child gaze behaviors during conversations (Jones et al., 2017). Similarly, Parr and colleagues (2015) reported more intervention implementation difficulties for mothers with elevated BAP features.

To ground our findings pertaining to infant diagnostic and risk groups within previous literature, we will first address how our findings align with previous research on maternal behaviors and child social communicative development in ASD, and second we consider infant sibling study designs in particular.

Previous studies highlight the role maternal gaze patterns, vocalizations, pragmatic language, and responsiveness may play on language and social development in children with ASD (Bang & Nadig, 2015, Bottema-Beutel et al., 2014; Flippin & Watson, 2015; McKean et al., 2017; Northrup & Iverson, 2015; Stern, Maltman, & Roberts, 2017). For example, in a study of 20 children with ASD and a matched group of typically developing children, maternal linguistic input (including number of vocalizations) was associated with later vocabulary growth for both groups of children (Bang & Nadig, 2015). Similarly, Flippin and Watson's (2015) study of children with ASD documented differential growth in language skills based on maternal verbal responsiveness (which included positive affect). In this study, some of these same maternal behaviors early in development were not distinctly different across infant diagnostic or risk groups.

Within studies of infant siblings, a few have documented differences in parenting behaviors in HR samples (Harker et al., 2016; Wan et al., 2012, 2013). Although most studies report a comparable range of maternal behaviors in overall frequency of utterances, dyadic synchrony, responsiveness, and parental warmth to their children (Blacher, Baker, & Kaladjian, 2013; Campbell et al., 2015; Leezenbaum et al., 2014; Talbott et al., 2015, 2016; Siller & Sigman, 2002). Our findings align with a majority of these noting a range of social communicative behaviors in mothers of HR infants that is comparable to that of mothers raising typically developing infants.

Parent-mediated interventions rely heavily on parent behaviors in context to promote infant prosocial behaviors. Within the present study, the behaviors indexed in infants during the first year included looking to their mother's face, expressions of positive affect, vocalizing, and multimodal bids or responses. Each of these behaviors were associated with maternal behaviors. Although the direction of influence cannot be definitively determined, the pattern

of correlations suggest that as infants developed they were more likely to gaze shift to their mother's face, vocalize more, express more positive affect, and use more multimodal bids or responses as mothers expressed more positive affect and used more multimodal bids or responses. These associations were most consistent when infants were 12 months of age, the last age at which behaviors were coded. These associations may reflect maternal mirroring (Bigelow, Power, Bulmer, & Gerrior, 2017) or responsiveness to infant cues (Van Egeren, Barratt, & Roach, 2001). These behaviors provide potential targets for parent-mediated interventions and with replication promotors of parent positive affect and multimodal bids or responses could increase infant prosocial behaviors.

Although not an explicit aim of this study, the lack of association between infant behaviors and diagnostic status warrant discussion. Infants within this study displayed the expected developmental gains in gaze shifting (more looks to his/her mother's face), vocalizations, and multimodal commutative bids/responses. This pattern highlights that our index of social communicative behaviors was sensitive enough to capture expected developmental trends and that our lack of association is not likely a reflection of poor measurement. When considering infant behaviors, this study is not the first to document indistinguishable infant features prior to one year for children with ASD (Beford et al., 2012; Cassel, et al., 2007; Elsabbagh et al., 2013; Ozonoff et al., 2010; Rozga et al., 2011; Wan et al., 2013; Yirmiya et al., 2006; Zwaigenbaum et al., 2005). To the contrary, identifying early behavioral markers before 12 months has been a challenge for the field (see reviews, Elsabbagh & Johnson, 2016; Jones, Gliga, Bedford, Charman, & Johnson, 2014; Szatmari et al., 2016; Zwaigenbaum, Bryson, & Garon, 2013).

Dyadic coding practices in the social sciences are diverse and may include micro-analytic coding for duration and frequency counts, global rating systems, or research specific coding schemes (Halle et al., 2010). These discrepancies in measurement may contribute to mixed representations of behavioral differences across studies, as well as an inability to directly compare findings across studies with similar infant sibling samples (e.g., Wan et al., 2013). Specifically, studies that utilize microanalytic approaches to extract frequency counts (like the present study) document comparable or higher rates of maternal vocalizations, approach behaviors, gestures use, and responsiveness when comparing HR and LR samples (Apicella et al., 2013; Leezenbaum et al., 2013; Talbott et al., 2015; 2016). Conversely, studies that use more global or 'gestalt' coding schemes highlight differences in maternal behaviors including more directiveness during play (Harker et al., 2016, Wan et al., 2012), less sensitive responding (Wan et al., 2013), and qualitative differences in approach behaviors (i.e., more physical contact, more high-intensity behaviors; Doussard-Roosevelt et al., 2003). Overall, global ratings of maternal behaviors have documented more difficulties for mothers of children with ASD. However, ratings of this nature are also more prone to rater bias (for a summary see Yoder & Symons, 2010).

In the future, it may be beneficial to code maternal behaviors for both microanalytic processes (e.g., frequency of gaze shifts) and more globalized ratings (e.g., directiveness during play) to gain a holistic representation of how mothers interact with their infants. For example, Yirmiya and colleagues (2006) found significant group differences between HR and LR siblings for infant led synchronous interactions when the observers coded maternal

and infant behaviors on 10-second intervals and qualitatively rated the intervals on a 6-point Likert scale.

Overall the current study has several strengths including a relatively large sample size, longitudinal data, an observational measure of maternal-infant interactions, and strict inclusion/exclusion criteria, but it is not without limitations. Mother-infant interactions are a dynamic process and each member of the dyad contributes to the overall synchrony or 'flow' of the interaction. This paper's overall focus is on maternal behaviors, yet it is conceptually challenging to disentangle infant and parent behaviors within dyadic interactions. For example, as illustrated in Figure 1, both infant and maternal codes show developmental growth (i.e., as infant vocalizations increase over time, so do maternal vocalizations). One concern, when studying half of a dyad (mothers) in which the other half experiences social difficulties (e.g., developing ASD), is that the infant influence would 'pull' the frequencies of parent social-communication behaviors down. None of our findings support this. Ultimately, the entanglement of parent and infant codes is inherent in any dyadic interaction coding systems.

Another limitation of the present study is the focus on only mother-infant interactions. Father-infant interactions are an understudied area in typical child development and in autism. As mentioned above, previous research has found elevated SRS scores for fathers of children with autism. Although some fathers did participate in our laboratory visits there were too few to include as a separate group in analyses. Future research may address fathers' social responsiveness and paternal behaviors when engaging in a parent-infant interaction with infant siblings of ASD.

Ultimately, the findings of the present study do not support the notion that mothers raising infants at risk for ASD are in some way less competent social interaction partners. This is an important message for clinicians and researchers to reflect on. These null findings also support the application of parent-mediated interventions to target social communication skills and play behaviors in children with ASD (e.g., Green et al., 2017; Kasari et al., 2014; Rogers et al., 2014). Maternal behaviors that were associated with prosocial infant behaviors included positive affect and the use of multimodal bid or responses. Future parent-mediated interventions can build on this to optimize developmental progress for infants/children with and at risk for ASD.

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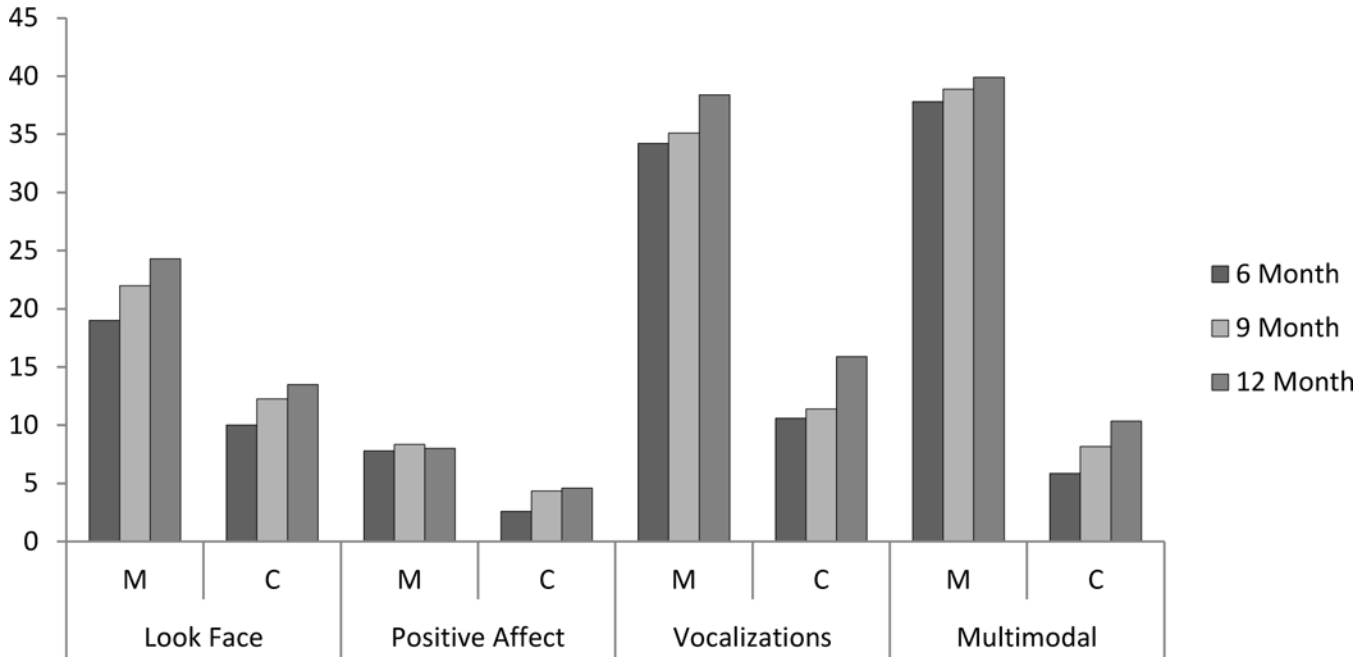

Figure 1.
Mother (M) and child (C) play behaviors when infants were 6, 9, and 12 months of age.

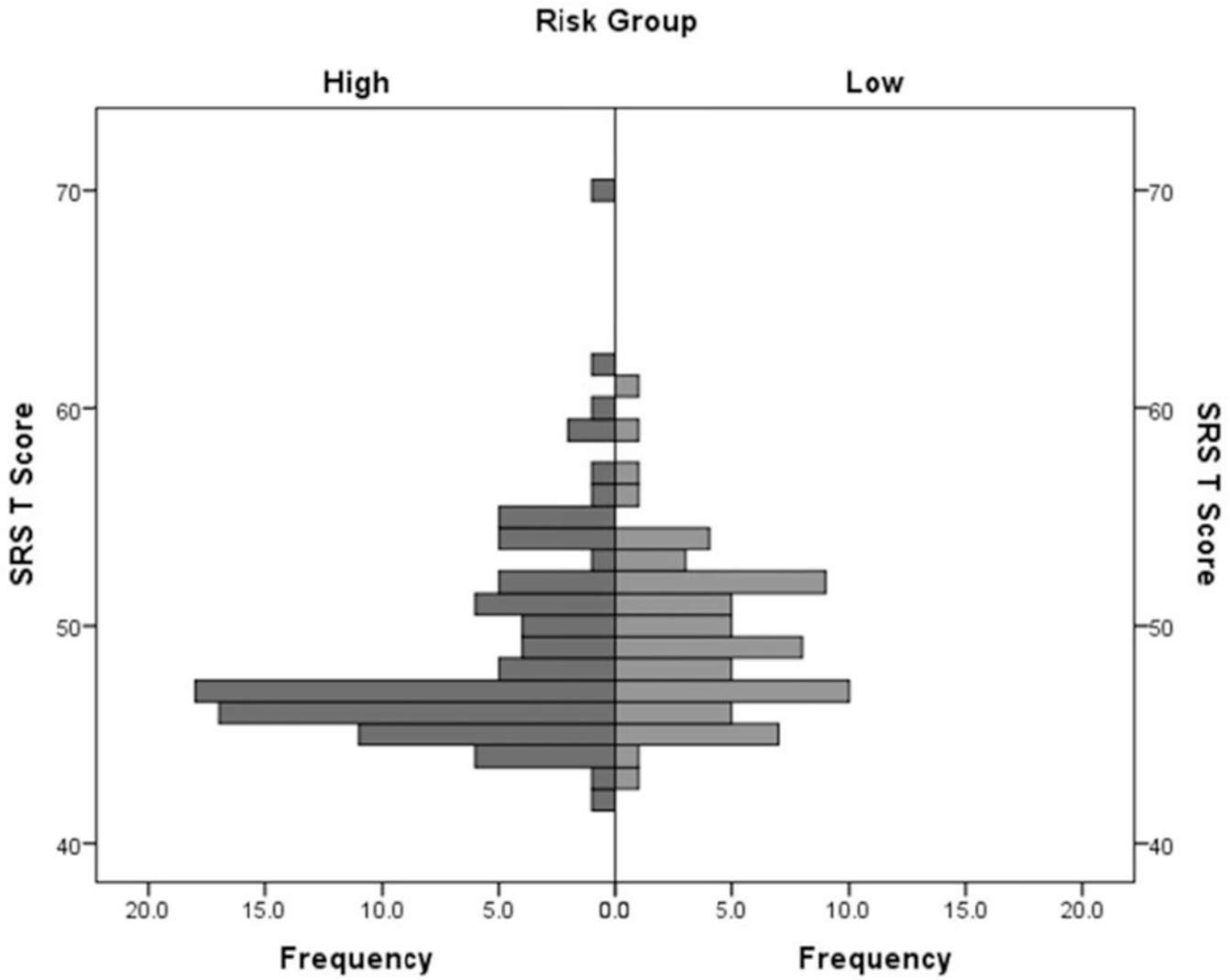

Figure 2.
Maternal SRS T scores by risk group status.

Table 1
Sample demographic characteristics stratified by family risk group

		Risk Group	
		Low	**High**
N		62	90
Maternal age, Range, *M(SD)*		18–44, 32(5)	23–49, 35(5)
Maternal Education, *n*(%)			
	Some High School	2 (3%)	0 (0%)
	High School/GED	11 (18%)	27 (30%)
	College Degree	27 (44%)	39 (43%)
	Graduate Degree	20 (32%)	15 (17%)
	Other	1 (2%)	2 (2%)
	Unreported	1 (2%)	7 (8%)
Marital Status, *n*(% married)		54 (87%)	82 (91%)
Family Income, *n*(%)			
	Below $25,000	2 (3%)	5 (6%)
	$25,000–$49,999	8 (13%)	7 (8%)
	$50,000–74,999	16 (26%)	15 (17%)
	$75,000–$99,999	11 (18%)	19 (21%)
	$100,000–$124,999	9 (15%)	12 (13%)
	$125,000 and above	13 (21%)	24 (27%)
	Unreported	3 (5%)	8 (9%)
Maternal SRS T Scores, Range, *M(SD)*		44–61, 50(4)	43–70, 49(5)
Enrolled Infant, *n*(%)			
	Male	38 (61%)	55 (61%)
	Female	24 (39%)	35 (39%)
Outcome Status, *n*(%)			
	TD	59 (95%)	58 (64%)
	NON-TYP	2 (3%)	16 (18%)
	ASD	1 (2%)	16 (18%)

Table 2

Maternal and Infant behaviors coded during a three minute play episode

Code	Description
Look Face	Gaze is directed towards the face of play partner
Positive Affect	Displays positive affect (i.e., smile, laugh)
Vocalizations	Vocalizes using non-word sounds, words, or phrases
Multimodal	Combines at least two of the behaviors above (i.e., look face and positive affect, look face and vocalization, vocalization and positive affect)

Table 3

Correlations between maternal and infant play behaviors for all dyads and dyads in the high-risk (HR) and low-risk (LR) groups

	Infant Behaviors											
Maternal Behaviors	**6 Months**				**9 Months**				**12 Months**			
	1	2	3	4	1	2	3	4	1	2	3	4
All Dyads												
1. Look Face	.01	−.06	.02	−.03	.10	−.06	.08	−.01	.03	−.07	−.07	−.18
2. Positive Affect	.49***	.45***	.06	.40***	.25**	.28**	.04	.23*	.33***	.42***	.28**	.366***
3. Vocalizations	.09	−.10	−.10	.04	.14	.08	.14	.09	.15	.01	.11	−.04
4. Multimodal	.32**	.21	−.03	.24*	.35***	.26**	.08	.23*	.37***	.29***	.38***	.31***
HR Group												
1. Look Face	.09	−.12	−.09	−.09	.04	−.02	−.01	−.02	−.08	−.08	−.03	−.24
2. Positive Affect	.41**	.30*	.10	.33*	.31**	.32**	.01	.32**	.26*	.48***	.38**	.44***
3. Vocalizations	.21	−.13	−.27	−.02	.18	.01	.11	−.01	−.06	−.04	.15	−.18
4. Multimodal	.38*	.14	−.08	.25	.49***	.14	.03	.42	.23	.31**	.37**	.24*
LR Group												
1. Look Face	−.11	−.08	.16	−.02	.26	−.11	.20	.03	.15	−.10	−.14	−.11
2. Positive Affect	.56***	.61***	.01	.46**	.10	.22	.10	.09	.44**	.33**	.13	.25
3. Vocalizations	−.01	−.07	.08	.16	.04	.17	.19	.22	.44**	.07	.05	.18
4. Multimodal	.22	.28	.05	.21	.16	.36**	.15	.27	.53***	.26	.36*	.40**

^{t}Note. $p < .06$

*$p < .05$

**$p < .01$

***$p < .001$

Table 4

Maternal and Infant Behaviors During Play Across High- and Low-Risk Groups at 6, 9, and 12 Months of Age

Visit Age	6 Months			9 Months			12 Months		
Risk Group	High	Low		High	Low		High	Low	
N	45	41		70	53		71	51	
Estimate	Mean(SE) [a]		*F*	Mean(SE) [a]		*F*	Mean(SE) [a]		*F*
Maternal									
Look Face	19.12(1.60)	19.79(1.67)	.08	22.63(1.20)	22.48(1.38)	.01	24.27(1.20)	24.73(1.40)	.06
Pos. Affect	7.78(0.59)	7.80(0.62)	.01	8.19(0.46)	8.42(0.52)	.11	8.31(0.43)	8.22(0.50)	.02
Vocalizations	33.50(1.43)	34.18(1.49)	.11	34.66(1.26)	36.22(1.45)	.65	37.65(1.20)	39.47(1.39)	.97[gi]
Multimodal	37.55(2.19)	36.30(2.28)	.15[gi]	36.81(1.94)	42.26(2.22)	3.39	38.58(1.72)	41.67(1.99)	1.38
Infant									
Look Face	10.53(0.69)	9.48(0.72)	1.1	12.27(0.72)	12.43(0.83)	0.02	12.38(0.86)	15.28(1.00)	4.83*
Pos. Affect	2.97(0.46)	2.17(0.48)	1.44	4.15(0.42)	5.05(0.48)	1.96	4.69(0.48)	4.68(0.56)	0
Vocalizations	9.08(1.15)	11.30(1.20)	1.78	11.16(0.90)	12.26(1.03)	.66	14.46(1.09)	17.21(1.27)	2.7
Multimodal	6.61(1.20)	4.82(1.24)	1.7	7.43(1.07)	9.98(1.23)	2.45	9.64(1.33)	11.68(1.55)	.99

Note. All models contained infant sex and family income as covariates,

[a] All reported means are adjusted means,

[g] Infant sex was a significant covariate,

[i] Family income was a significant covariate

Table 5

Maternal and Infant Behaviors During Play When Infants Were 6, 9, and 12 Months of Age Across Child Outcome Groups

Visit Age	**6 Months**			**9 Months**			**12 Months**		
Risk Group	TD	Non-TD	ASD	TD	Non-TD	ASD	TD	Non-TD	ASD
N	55	12	8	94	15	11	93	14	10
Estimate		*Mean(SE)* [a]			*Mean(SE)* [a]			*Mean(SE)* [a]	
Maternal									
Look Face	19.25(1.49)	23.75(3.10)	19.44(3.79)	23.03(1.05)	20.60(2.63)	21.72(3.09)	23.15(1.02)	23.52(2.58)	25.77(3.08)
Positive Affect	7.82(.55)	8.16(1.14)	6.85(1.40)	8.31(.38)	7.88(.96)	8.14(1.13)	8.26(.39)	8.52(.99)	9.77(1.18)
Vocalizations[g12]	33.61(1.25)	34.40(2.61)	36.99(3.20)	35.97(1.09)	30.53(2.74)	33.21(3.22)	39.52(1.02)	34.05(2.57)	36.87(3.07)
Multimodal[g6]	36.45(2.06)	39.95(4.30)	37.74(5.27)	40.32(1.64)	31.71(4.12)	33.21(4.85)	41.99(1.51)	36.33(3.82)	40.88(4.56)
Infant									
Look Face [i12]	10.11(.65)	9.88(1.36)	10.63(1.66)	12.61(.59)	10.92(1.47)	11.70(1.73)	14.20(.79)	12.25(2.00)	12.34(2.38)
Positive Affect	2.44(.45)	2.82(.93)	3.86(1.14)	4.42(.35)	3.71(.87)	5.84(1.02)	4.39(.41)	5.03(1.04)	6.21(1.24)
Vocalizations	10.67(1.10)	8.15(2.29)	10.86(2.80)	11.11(.79)	12.22(1.98)	14.43(2.33)	15.83(.89)	12.39(2.25)	14.68(2.69)
Multimodal	5.79(1.17)	7.00(2.44)	7.06(2.99)	8.57(.93)	8.19(2.33)	7.81(2.74)	9.90(1.16)	12.43(2.92)	11.56(3.48)

Note. All models contained infant sex and family income as covariates,

[a]All reported means are adjusted means,

[g12]Infant sex was a significant covariate at 12 months of age,

[g6]Infant sex was a significant covariates at 6 months age.

[i12]Income was a significant covariate at 12 months of age.