Published in final edited form as:

Autism. 2015 November ; 19(8): 915–924. doi:10.1177/1362361314555146.

Social Engagement with Parents in 11-Month-Old Siblings at High and Low Genetic Risk for Autism Spectrum Disorder

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Abstract

Infant siblings of children with an autism spectrum disorder (ASD) are at heightened genetic risk to develop ASD. We observed high risk (HR, $n=35$) and low risk (LR, $n=27$) infants at 11 months during free play with a parent. Children were assessed for ASD in toddlerhood. HR infants with a later diagnosis ($n=10$) were less socially engaged with their parents than were LR infants. Parent behavior during play did not vary by group. Within the HR group, ratings of social reciprocity at 11 months predicted Autism Diagnostic Observation Schedule (ADOS) severity scores at follow-up, suggesting that systematic observations of parent-infant play may be a useful addition to early assessments of emerging ASD.

Keywords

Autism Spectrum Disorder; high risk infant siblings; parent-child interaction; social engagement

Introduction

Recent prospective studies have examined the early development of younger siblings of children with autism spectrum disorder (ASD) who are themselves at elevated genetic risk to develop ASD (Ozonoff et al., 2011; Yirmiya and Charman, 2010; Zwaigenbaum et al., 2007). Indeed, Ozonoff et al. (2011) recently reported a recurrence rate of 18.7% in a large sample of high risk infant siblings followed until 36 months. One primary goal of high risk (HR) infant sibling studies is to identify early signs of ASD prior to the age at which a reliable diagnosis is feasible, thereby facilitating earlier diagnosis and intervention at a time of heightened neural plasticity (Dawson, 2008; Rogers, 2009; Zwaigenbaum, Bryson, and Garon, 2013).

Studies of HR infant siblings have focused on impairments in a range of social and communicative behaviors that emerge during the first year of life in typical development and also map onto the defining characteristics of ASD (Rogers, 2009; Zwaigenbaum et al., 2013). Importantly, infant social engagement with parents has been well-characterized in studies of typical development (e.g., Feldman, Greenbaum, and Yirmiya, 1999; Tamis-

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A preliminary version of these data was presented at the Society for Research in Child Development, Montreal, Canada, March 2011.

LaMonda, Bornstein, and Baumwell, 2001), thereby providing a logical focus for possible early markers of autism in high risk infant siblings. Research on parent-infant interaction demonstrates that typically-developing children engage enthusiastically with their parents during shared play activities, both initiating interaction and responding to parents' scaffolding and teaching (e.g., Bigelow et al., 2010; Bornstein, Tamis-LaMonda, Hahn, and Haynes, 2008; Mendive, Bornstein, and Sebastian, 2013). In contrast, lower levels of social interest, social engagement, and the use of communicative gestures have been identified in retrospective studies of infants who later received an autism diagnosis (Osterling, Dawson, and Munson, 2002; Werner, Dawson, Munson, and Osterling, 2005), underscoring the importance of prospective studies of early social engagement in HR infant siblings.

Several recent studies have begun to delineate differences in social interaction between HR infant siblings with a later diagnosis and low risk (LR) comparison infants at the end of the first year and beginning of the second year of life. Rogza et al. (2011) assessed infant social engagement during a face-to-face interaction with mother at 6 months and joint attention to an examiner at 12 months during structured tasks. At 6 months, HR infants with a later ASD (HR-ASD) diagnosis did not differ from either LR infants or HR infants without a later diagnosis on gaze to faces, social smiles or vocalizations directed to mother. By 12 months, however, the HR-ASD group showed lower rates of both responding to and initiating joint attention to the examiner than either the LR or the HR no diagnosis groups. Studying an overlapping sample, Ozonoff et al. (2010) coded social engagement with an examiner during the administration of the Mullen Scales of Early Learning at 6, 12, 18, 24, and 36 months. HR-ASD infants were compared to LR controls on the same social behaviors as noted above. Consistent with Rogza et al. (2011), no differences were evident at 6 months, but by 12 months differences between HR-ASD and LR infants began to emerge, and they became more pronounced over time, reflecting declines in social interest and engagement between 12 and 18 months in the HR-ASD infants. Finally, Nichols, Ibañez, Foss-Feig, and Stone (2013) recently reported that HR infants with a later diagnosis or with subclinical symptoms of ASD engaged in less social smiling (smiling plus eye contact) with an examiner when assessed between 12 and 23 months than LR control infants. This pattern of no observed differences in social engagement at 6 months, but differences or declines in social interest between the end of the first year and the beginning of the second year of life is also consistent with other studies (e.g., Brian et al., 2008; Bryson et al., 2007; Yirmiya et al., 2006).

To date, most studies of the social behavior of HR infants have relied on structured activities with an examiner, but observations with a familiar caregiver should provide complementary information about spontaneous social behavior in a more naturalistic context. Several studies have examined brief periods of face-to-face interaction with mothers in the first 4 to 6 months of life, but results have been inconsistent, generally suggesting either no differences or subtle differences which vary across studies and are difficult to interpret (e.g., Rozga et al., 2011; Yirmiya et al., 2006). However, studies of unstructured parent-child interaction conducted somewhat later, that is at the end of the first year of life, may shed further light on emerging social impairments among infants who go on to receive a diagnosis. By the end of the first year, typically-developing infants are active participants in social interaction with parents, whereas HR infants, especially those who go on to receive an ASD diagnosis, would

be expected to be less socially engaged with parents during play. For example, in one recent study, Winder, Wozniak, Paradé, and Iverson (2013) reported that HR infants observed interacting with their mothers at home at 13 and 18 months initiated less spontaneous communication, including fewer vocalizations and gestures than did LR infants. Some, but not all, of these differences were accounted for by the three infants in their sample who later received a diagnosis. Wan et al. (2012) observed HR and LR infants during free play with their mothers at 6 and 12 months. At 6 months, HR infants as a group were rated as less active than LR infants; at 12 months, HR-ASD infants were less positive and attentive to their mothers during play than LR infants. These two studies suggest that HR infants who later receive an ASD diagnosis are not only less engaged with an unfamiliar examiner, but also show less spontaneous interest in their mothers in unstructured contexts. In the current study, we examine infant social behavior during free play with a parent and compare 11-month-old HR infants with and without a later diagnosis to LR infants.

Comparisons between LR infants and HR infants who do not receive a later diagnosis are also of interest because evidence indicates that some older siblings of children with autism show subclinical impairments in social and communicative behavior reflecting the broader autism phenotype (Bolton et al., 1994). More recent studies using HR infant sibling designs and comparing HR infants without a diagnosis to LR controls have yielded inconsistent results. Some studies suggest that HR infants who do not receive a diagnosis show less social interest and engagement than control infants (e.g., Brian et al., 2008; Nichols et al., 2013) when observed with an examiner during structured tasks. Likewise, Winder et al. (2013) reported lower levels of social communication with mothers among HR infants without a diagnosis compared to LR infants. In contrast, other studies have not found differences in social interaction at 12 months between HR infants without a diagnosis and LR infants (e.g., Rozga et al., 2011; Wan et al., 2012). For example in the Wan et al. study, HR infants without a diagnosis did not differ from LR infants on ratings of positive affect or attention to parents during play at 12 months. However, in a recent paper, Ozonoff and colleagues (2014) reported that HR infants with subclinical impairments at 36 months showed less social engagement with an examiner beginning at 12, but not at 6 months, suggesting that signs of the broader autism phenotype may be evident at the end of the first year. These inconsistencies across studies likely reflect differences in the context of assessment, infant age, and interactive partner. In the current study, we expected the HR siblings without a diagnosis to fall between the LR infants and the HR infants with a diagnosis when observed during free play with a parent.

Only a few studies of parent-infant interaction have also included observations of parental behavior. In the Wan et al. (2012) study, mothers of infants who received an ASD diagnosis at 36 months were rated as more directive at both 6 and 12 months than mothers of LR infants, although ratings of sensitive responsiveness did not vary by group. At 12 months, ratings of dyadic mutuality and intensity of engagement were lower among mothers whose child received a later diagnosis, but mothers of HR infants without a diagnosis did not differ from mothers of LR infants. The authors suggest that less active and engaged infants may elicit more direction from parents. Baker, Messinger, Lyons, and Grantz (2010) observed mother-infant dyads during play at 18 months and compared the HR infants with a later diagnosis to a combined group of HR and LR infants without a later diagnosis; there were

no group differences in ratings of maternal sensitivity, a composite that included age-appropriate scaffolding and emotional support. In the current study, we examine both specific parent behaviors and ratings of sensitivity and scaffolding of play with 11-month-old HR and LR infant siblings, and we compare parents of HR infants with and without a later diagnosis to parents of LR infants.

In summary, only a few studies have examined parent-infant interaction during unstructured play among HR infant siblings at the end of the first year of life, when signs of emerging ASD may be evident in spontaneous social interaction with parents. The current paper includes ratings of infant and parent engagement and frequencies of specific social and communicative behaviors which were selected because they characterize social communication in typical development and also because delays or deficits in these same behaviors have been identified as possible early signs of ASD (Wetherby et al., 2004). HR and LR infant siblings were observed with their parents during free play at 11 months and then assessed for ASD in toddlerhood. We expected HR children with a later diagnosis (HR-ASD) to evidence less social engagement during play, as reflected specifically in lower ratings of social reciprocity, fewer communicative gestures and vocalizations directed to the parent, and less shared positive affect than LR infants or HR infants without a diagnosis (HR-noASD) at follow-up. Because the literature is inconsistent on this point, we did not have specific hypotheses about differences between LR and HR-noASD infants. However, we expected that HR-noASD infants would fall somewhere between HR-ASD and LR infants on measures of social behavior given that some children in the HR-noASD group may be less socially engaged, reflecting the broader autism phenotype. In addition, we examined parent behavior during play in an exploratory manner, including the provision of both structure and support. Finally, we investigated the degree to which measures of infant social engagement at 11 months predicted symptom severity at follow-up within the HR group, as this is one key goal of high risk infant sibling studies.

Method

Participants

Infants and their parents are participants in a prospective study of infants with an older sibling with autism spectrum disorder and comparison infants with a typically developing older sibling. The 62 [35 HR (21 boys), 27 LR (14 boys)] infants included in this report were seen at 11 months ($M = 11.65$, $SD = 0.59$) and returned for diagnostic evaluations, most at 36 months, ($M = 34.71$, $SD = 4.95$). Three HR and three LR children were seen for follow-up at 24 months.

High risk infants were recruited through the Autism Center at the University of Pittsburgh. To be eligible for inclusion in the HR group, children had to be born full-term after an uncomplicated pregnancy and delivery, and have an older sibling diagnosed with an autism spectrum disorder. The older sibling's diagnosis was confirmed by research reliable staff at the Autism Center who administered the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, and Risi, 2007), under the supervision of a licensed psychologist, prior to the infant's enrollment in the study. Infants whose older siblings had known genetic

or other anomalies, such as Fragile X, were excluded. Two HR infants were half-siblings of the child with ASD.

Control participants were recruited from the local obstetrics hospital and pediatric offices; they were also screened at the Autism Center to establish eligibility for participation. The LR group is comprised of full-term healthy infants who have a typically developing older sibling and negative family history of ASD in first and second degree relatives. In addition, parents completed the Social Communication Questionnaire (Rutter, Bailey, and Lord, 2003) on the older sibling; all scored well below the ASD cut-off of 15.

Participating children are predominantly Caucasian and non-Hispanic (92%) and mostly from two-parent families. Two African American and three Hispanic families participated. All participating parents are the biological parents of study children, including 58 mothers and four fathers. Although the majority of parents in both the HR and LR groups had at least a college degree, parents in the LR group were more highly educated (see below). Parents signed informed consents prior to participation; the research protocol was approved by the University of Pittsburgh Institutional Review Board.

Procedure

To assess infant social engagement and parent scaffolding of infant play, the infant and parent were observed during an unstructured free play interaction at 11 months. Parents were asked to play with their child as they normally would for four minutes, using a standard set of age-appropriate toys. These included large stacking rings, a toy telephone, a pull toy that was also an animal puzzle, and a picture book about animals. All sessions were saved onto DVDs for later coding. Separate teams of observers, blind to infant risk status and later diagnosis, coded infant and parent behavior. Observers were trained to reliability before coding independently and reliability was monitored throughout the study. Inter-observer reliability was determined on roughly 50% of the tapes using intraclass correlations (ICC). Disagreements between coders were resolved by consensus.

Measures

Infant behavior—One set of observers coded the frequencies of specific infant social behaviors including shared positive affect, give toy, showing and giving toys, and pointing to request/share interest with the parent. Giving and showing were combined in the analyses as they are both social communicative gestures that involve sharing a toy with a parent. Pointing occurred too infrequently to be considered further. Socially-directed vocalizations were also coded and were defined as co-occurring infant vocalizations and looks, overlapping in time or occurring within 2-seconds of each other. Reliability coefficients (ICCs), based on 30 subjects, ranged from .83 for shared positive affect to .95 for give toy ($M = .89$).

To capture more qualitative aspects of infant behavior, in addition to the frequencies described above, a second set of observers rated the degree of infant reciprocity with the parent during play using a 4-point scale (4= highly engaged to 1= not at all engaged in reciprocal interaction). This scale assesses the extent to which the infant appears socially

connected and responsive to the parent as opposed to passive and/or disengaged (NICHD Early Child Care Research Network [ECCRN], 1999). The ICC for the reciprocity rating was .73.

Parent behavior during play—Frequencies of specific parent behaviors were coded during the play. These included scaffold play, initiate/direct play, and praise. Scaffolding was coded when the parent's behavior supported the infant's ongoing activities and followed the infant's lead. In contrast, direct play was coded when the parent initiated an activity by introducing a toy or changing the ongoing activity. These two codes were mutually exclusive. Positive statements about the child or child's behavior or play activities were coded as praise. Inter-observer reliability (ICC) was calculated on over half the tapes ($n=35$) which were coded independently by two coders over the course of the study. Inter-observer agreement was satisfactory: scaffold (.87), direct play (.88), and praise (.73).

Qualitative ratings were also obtained (4= highly characteristic to 1= not characteristic) on parental warmth, sensitivity, stimulates cognitive development, and intrusiveness using scales developed by the NICHD ECCRN (1999). Warmth reflected affectionate behavior and enjoyment of the interaction. Ratings of sensitivity assessed the degree to which the parent followed the child's lead and was tuned into the child's interests. Teaching and scaffolding play were captured by "stimulates cognitive development." Finally, intrusiveness measured the degree to which parents directed or controlled the interaction, following their own agenda rather than the child's lead. ICCs were calculated on 51 tapes that were coded independently. Given the relatively limited variability on these ratings (i.e., most parents were rated as high on warmth and sensitivity and low on intrusiveness), ICC's were only modest (warmth = .69, sensitivity = .75, intrusiveness .56, stimulates development = .87). These coefficients, however, underestimate the level of agreement because of the limited range of scores. Indeed, exact agreement was quite high and all disagreements were within 1 point. Exact agreements prior to consensus coding were as follows: warmth (90%), sensitivity (88%), intrusiveness (78%), stimulates cognitive development (82%).

Developmental Assessments—The Mullen Scales of Early Learning (MSEL; Mullen, 1995), a standardized measure of cognitive development, was administered at 11 months and at subsequent follow-up visits by examiners not involved in the laboratory visits. The Early Learning Composite (ELC) score was calculated by combining T-scores on the Receptive Language, Expressive Language, Fine Motor, and Visual Reception subscales.

Evaluations for Autism—Both HR and LR infants were evaluated for an ASD diagnosis at follow-up, using the Autism Diagnostic Observation Schedule (ADOS, Lord et al., 2007). The ADOS is a semi-structured observational assessment used to assess ASD. It includes play-based activities that are meant to elicit reciprocal social interaction, communication, and stereotyped behaviors, and it provides scoring rules for a diagnosis of ASD. All children received either ADOS Module 1 or 2. Evaluations were conducted by a research-reliable tester from the Autism Center under the supervision of a licensed psychologist; no one involved in the diagnostic assessments conducted the laboratory visits. A diagnosis of ASD was based on the 36 month (or later, $n= 1$) assessment for all but three HR children in the sample. One of the three HR toddlers with 24 month outcome data received an ADOS score

of 0 and is included in the HR-noASD group (see below), and two HR toddlers with elevated ADOS scores (9, 14, Module 1) are included in the HR-ASD group. Although 36 month outcome data are preferred, data suggest that when diagnoses are clear-cut at 24 months, they are likely to be stable (Chawarska, Klin, Paul, Macari, and Volkmar, 2009).

Children were classified as ASD if they met cut-off scores on the ADOS (Lord et al., 2007) and also met DSM-IV criteria for an autism spectrum disorder (American Psychiatric Association, 2000), as determined by a licensed psychologist with extensive clinical experience with young children with ASD. In addition, parents of children with elevated ADOS scores and/or serious clinical concerns were administered the Autism Diagnostic Interview-Revised (ADI-R, Lord, Rutter, and Le Couteur, 1994) to provide further information, prior to a final diagnosis. Final diagnoses, therefore, were based on a combination of structured diagnostic measures, DSM-IV criteria, and clinical judgment; 10 of 35 (28.5%) HR infants received a diagnosis of ASD (7 boys); no LR infants received a diagnosis.

In addition to a diagnosis, ADOS scores were converted to severity scores using the algorithm presented by Gotham, Pickles, and Lord (2009) to provide comparability across age; severity scores are summarized in Table 1. As expected, there was a main effect of group status, $F(2, 58) = 37.53, p < .001$. The children with a diagnosis had substantially higher severity scores than the LR infants ($p < .001$) and the HR infants ($p < .001$) without a diagnosis (HR-noASD), who did not differ from one another.

Data Analysis Plan

Data were analyzed using the IBM Statistical Package for the Social Sciences, (SPSS Version 22.0). Analyses were conducted to compare the 10 infants with a later ASD diagnosis (HR-ASD) to the 25 HR infants without a diagnosis (HR-noASD) and to the 27 LR infants. Because the frequency data were not normally distributed, log transformations were performed prior to analysis. The transformation corrected the skewness in the frequency of socially-directed vocalizations, but not in the frequencies of shared positive affect or give/show toy. Thus, we conducted non-parametric tests on shared positive affect and give/show toy. Socially-directed vocalizations and ratings of infant social reciprocity and parent behavior (frequencies and ratings) were examined with one-way ANOVAs followed by post hoc tests, using Bonferroni corrections for multiple comparisons, with the adjusted alpha set at $p < .05$. Within the HR group, we also examined associations between children's social engagement at 11 months and the ADOS severity score at follow-up to determine the predictive utility of these early social behaviors.

Results

Preliminary analyses

Participant characteristics are summarized in Table 1; all infants were seen within a few weeks of their 11-month birthday ($M = 11.65, SD = 0.59$) with no difference across groups. Although most children scored in the average range on the Mullen ELC at 11 months, the children with an ASD diagnosis at follow-up scored significantly below the other two

groups, $F(2, 59) = 4.67, p = .013$. Follow-up tests indicated that the LR group differed significantly from the HR-ASD group ($p = .01$), with the HR-noASD group falling between but not differing significantly from either the LR or HR-ASD groups.

Groups were also compared on the educational level of the participating parent, scored according to the Hollingshead Scale with higher scores reflecting more education. The main effect of group was significant, $F(2, 59) = 13.64, p < .001$. Follow-up tests indicated that parents of the HR-ASD children were lower in education than the parents of the LR children ($p < .001$) and parents of HR-noASD children ($p < .003$).

In order to determine whether demographic and developmental variables including child gender, parent education, and Mullen ELC needed to be controlled in subsequent analyses, correlations were obtained with the four child variables (shared positive affect, give/show toy, socially-directed vocalizations, reciprocity rating), four parent ratings (warmth, sensitivity, intrusiveness, stimulates cognitive development), and the three parent behaviors (scaffold, direct, praise). Child gender was significantly correlated with the reciprocity ratings, with girls receiving higher ratings than boys, $r(62) = .289, p = .023$, so gender was covaried in the analysis of this variable. The Mullen ELC was significantly correlated with socially-directed vocalizations, $r(62) = .278, p = .03$, and was controlled in the analysis of this measure. No other correlations between these demographic variables and infant behavior were significant.

The qualitative ratings of parent behavior were not significantly correlated with parent education, infant gender, or infant Mullen ELC, so no covariates are included in the group comparisons on these measures. However, parents provided more scaffolding of boys' play than girls' play, $r(62) = -.401, p = .001$ and less educated parents were more likely to initiate or direct play, $r(62) = -.281, p = .027$. Therefore, child gender was controlled in the analysis of scaffold and parent education was controlled in the analysis of initiate/direct. Means and standard deviations of both infant and parent behavior by group are summarized in Table 2. Data on infant behavior are also depicted graphically in Figure 1.

Group Differences in Infant Behavior during Play at 11 months

Kruskal-Wallis non-parametric tests were used to examine group differences in shared positive affect and give/show toy. There was a main effect of group for give/show toy: $\chi^2(2) = 6.26, p = .04$. Follow-up Mann-Whitney U tests indicated that the HR-ASD infants were less likely to give/show a toy to their parent ($U = 84.0, z = -2.05, p = .04$) than the LR infants, with a medium effect size ($r = .34$). There was also a non-significant trend for the HR-noASD infants to engage in these behaviors less often than the LR infants (give/show toy, $U = 252.0, z = -1.85, p = .064, r = .24$). The comparable effect size for the non-significant comparison between the HR-noASD and ASD children was small ($r = .16$). The overall Kruskal-Wallis test did not reveal significant group differences in shared positive affect, $\chi^2(2) = 4.68, p = .096$, so follow-up tests were not conducted.

A one-way ANCOVA on the log-transformed data for socially-directed vocalizations with Mullen ELC controlled was not significant, $F(2, 58) = 1.24, n.s.$, partial $\eta^2 = .04$. The social reciprocity rating, however, differed significantly by group, over and above the control for

child gender, $F(2,58) = 4.45$, $p = .016$, partial $\eta^2 = .13$. The HR-ASD infants received significantly lower reciprocity ratings than the LR infants ($p = .013$). The HR-noASD infants did not differ from either the LR or the HR-ASD groups on this rating.

Group Differences in Parent Behavior during Play at 11 months

One-way ANOVAs conducted on the four parent ratings revealed no differences as a function of children's diagnostic/risk status: warmth, $F(2,59) = 1.58$; sensitivity, $F(2,59) < 1$; stimulates cognitive development, $F(2,59) = 1.22$; intrusive $F(2,59) = 1.96$. As can be seen in Table 2, most parents were rated high on warmth, sensitivity, and stimulates cognitive development and low on intrusiveness. There were likewise no group differences in the frequencies of parental scaffolding (controlling for child gender), $F(2,58) < 1$, praise, $F(2,59) = 1.35$, or initiate/direct play (controlling for parent education), $F(2,58) = 2.15$. The effect sizes for these comparisons were, not surprisingly, consistently small ranging from $\eta^2 = .03$ to $.06$ for the ratings of parent behavior and from $\eta^2 = .02$ to $.06$ for the frequencies of specific behaviors.

Do Infant Behaviors Predict ADOS Severity at Outcome?

In addition to identifying potential early signs of an ASD diagnosis in the HR infants, we examined how well the measures of early social engagement with the parent predicted ADOS severity scores at follow-up within the high risk group as a whole. Both the reciprocity rating and a composite measure of the three social behaviors (log-transformed frequencies of shared positive affect + give/show + socially-directed vocalization, Cronbach's $\alpha = .63$) were examined in relation to ADOS severity. Both were negatively correlated with the ADOS severity score, reciprocity rating, $r(35) = -.402$, $p = .017$, social engagement composite, $r(35) = -.324$, $p = .058$. These two infant measures were also moderately correlated with each other, $r(35) = .585$, $p < .001$. Finally, we entered both the reciprocity rating and the social engagement composite into a stepwise multiple regression to predict the ADOS severity score; not surprisingly given the pattern of correlations just reported, with both variables in the equation, only the 11-month reciprocity rating added unique variance to the prediction of later severity scores among HR infant siblings ($R^2 = .162$, $F(1,33) = 6.36$, $p = .017$). The scatter plot showing the association between ADOS severity and the reciprocity rating is depicted in Figure 2. When the 11-month Mullen ELC was included with the reciprocity rating to predict severity scores, both variables added unique variance (Mullen $B = -.335$, $t = 2.16$, $p = .038$; reciprocity rating $B = -.325$, $t = 2.09$, $p = .044$; $R^2 = .268$, $F(1,32) = 5.86$, $p = .007$). Thus, the combination of social reciprocity and cognitive functioning at 11 months predicted later symptom severity in HR infant siblings, with lower scores on each associated with more ASD symptoms.

Discussion

The present study examined early parent-infant interaction in high and low risk infant siblings during unstructured free play at 11 months to assess social and emotional engagement. Whereas earlier research has demonstrated that HR-ASD infants are less likely than LR infants to engage with an examiner during testing, few studies have examined HR infants during free play with a parent, a context in which HR-ASD infants might be more

comfortable and, hence, more socially engaged. Therefore, this study complements research that has assessed the social engagement of HR infant siblings in more structured interactive contexts with an unfamiliar adult (e.g., Nichols et al., 2013; Ozonoff et al., 2010; Rozga et al., 2011). It also adds to the few studies that have observed parent-infant interaction in HR infants in less structured situations (Wan et al., 2012; Winder et al., 2013) at the end of the first year. Because 28% of our HR group received an ASD diagnosis in toddlerhood, we were able to assess the degree to which the HR-ASD infants differed from LR controls as well as from the HR-noASD infants on early measures of social engagement with parents; observations were conducted close to the first birthday when typically-developing infants are likely to use social communicative gestures and to engage in shared affect when playing cooperatively with parents and when HR infants with emerging autism may show less social engagement even with familiar caregivers.

Results indicated that the HR-ASD infants were less socially engaged with their parents at 11 months than were the LR infants, as reflected in the initiation of fewer spontaneous sharing gestures (give/show toy) and lower ratings of overall social reciprocity. Although group differences in shared positive affect and socially-directed vocalizations were not significant, the pattern was similar, with LR infants more likely to engage in shared positive affect and to vocalize to their parents during play than the HR-ASD infants. Our results add to those of Wan et al. (2012) by demonstrating differences between HR-ASD infants and LR infants in both qualitative ratings of social engagement and in the frequency of specific social-communicative gestures observed during play.

One potentially significant consequence of the reduced production of social-communicative bids observed among the HR-ASD infants in the present study is that mothers of HR-ASD infants may have fewer opportunities to provide linguistic input that is specifically tailored to their infants' attentional focus. Prior research on communication development in HR infants suggests that there is a significant relationship between maternal verbal responses to infants' early social communicative bids and infants' subsequent word production (Leezenbaum, Campbell, Butler, and Iverson, 2013). Thus, the delays in early social communication exhibited by HR-ASD infants may have cascading effects on later language development by virtue of alternations in the input that infants may elicit from their caregivers. This is clearly an area for further research with possible implications for intervention.

The HR-noASD children did not differ from either the LR children or the HR-ASD children on any of the observational measures, but they consistently fell between these two more extreme groups in the frequency of social behaviors. Although our relatively small sample limited our ability to detect group differences, the consistent pattern of results depicted in Figure 1 is intriguing and merits additional study in a larger sample, as well as examination of social engagement in this group at later ages. Although a few of the HR-noASD children may be showing subclinical signs of social difficulties, the current sample is too small to allow for further differentiation into subgroups showing typical development and those showing social concerns at follow-up (e.g., Ozonoff et al., 2014). As we accrue a larger sample and more data on social engagement into toddlerhood, we will be in a position to

look more closely at patterns of early social engagement in HR siblings with different outcomes.

In addition to examining infant behavior during play, we coded specific parental behaviors and rated parental warmth, sensitivity, stimulation, and intrusiveness using well-validated scales from the NICHD Study of Early Child Care (NICHD ECCRN, 1999). There were no differences across groups on any of these parent behaviors or ratings. This is important because one might expect that parents who have already raised a child with ASD may feel compelled to provide more stimulation and structure for their younger child, or they may be less engaged because they have lower expectations for appropriate responses from their infant. However, in the current study, blind and independent raters did not identify any differences in parent behavior, despite the fact that the infants with a later diagnosis were less socially engaged. Thus, parents across groups were providing similar levels of sensitive responsiveness, direction, scaffolding, and stimulation despite differences in children's behavior toward them. Wan et al. (2012) also did not find group differences in observed maternal sensitivity at 12 months, although parents of HR-ASD infants provided the most direction during play and they differed from parents of LR infants on this measure. Nevertheless, parents of the HR-ASD infants in our sample appear to be appropriately tuned in to their infants' needs and able to scaffold their play, despite receiving less positive feedback in the form of shared enjoyment and reciprocity.

Since one goal of HR infant sibling research is to predict later outcomes, we also examined whether the frequencies of infant social behavior or the qualitative ratings of social reciprocity predicted ADOS severity scores at follow-up. Both these measures showed modest associations with severity scores, with only the reciprocity rating predicting severity scores uniquely. Thus, infant engagement with the parent during play at 11 months during play forecast the emergence of ASD symptoms as assessed on the ADOS, and this was the case even after controlling for 11 month Mullen Early Learning scores. These results highlight the potential importance of observations of parent-child interaction during unstructured play which may be a useful addition to structured examiner administered tests when attempting to assess early signs of ASD in infancy.

From a clinical perspective, a pattern of low social engagement evident at the end of the first year may be an early sign of emerging autism, and the combination of limited spontaneous engagement not only during structured tasks as identified by others, but also during unstructured parent-child interaction may be significant. As can be seen in Table 1 and consistent with Bryson et al. (2007), the HR-ASD children in our study also showed a clear decline in the MSEL Early Learning Composite score relative to the HR-noASD and LR infants. This combination of low social engagement and declining ELC scores across infancy appears to be a strong predictor of emerging autism in HR infant siblings (Bryson et al., 2007; Rogers, 2009), making this group of children logical targets for early intervention (Dawson, 2008).

The prospective design and careful observations of free play with a parent using age-appropriate toys are strengths of this study. A major weakness, however, is our small sample size which limited our power to detect group differences and did not permit us to further

subdivide our HR-noASD group. The negative correlation between the social reciprocity rating and the ADOS severity scores may well have been driven primarily by the children with a diagnosis. With a larger sample size and longer-term follow-up the meaning of these results may become clearer, especially in regard to the variability in early functioning and later outcomes in those HR infants who do not receive a diagnosis of ASD, but still evidence more subtle signs of social and communicative impairments. In addition, it would have been preferable to assess all HR infants at 36 months, given the possibility that diagnoses made at 24 months may be unstable in some children. We are continuing to recruit high and low risk infants into our study to enlarge our sample and to follow children through toddlerhood to study not only spontaneous social engagement with parents, but also emerging empathy, pretend play, and self-regulation. This will allow us to examine developmental trajectories of social behavior in both high and low risk infants using age-appropriate indicators of skills that emerge in toddlerhood in typically developing children and are likely to be delayed or atypical in HR siblings, especially those with emerging autism.

Acknowledgments

We thank Dr. Nancy Minshew, Dr. Mark Strauss, Dr. Carla Mazefsky, Dr. Holly Gastgeb, Ms. Stacey Becker, and the staff at Autism Center of Excellence, University of Pittsburgh for overseeing recruitment and assessment of participating families. The Autism Center of Excellence was supported by award number HD055748 (PI Minshew) from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development. Recruitment was also facilitated by the Clinical and Translational Science Institute, supported by the National Institutes of Health through Grant Numbers UL1 RR024153 and UL1TR000005. We appreciate the financial support of the Central Research Development Fund, University of Pittsburgh and the National Institute of Mental Health R01 MH091036 to Dr. Campbell

Thanks are due to Rosanna Breaux, Kristen Decker, Danielle Filer, Stephanie Fox, Michelle Kwan, Christy Lucas, Brianna Pollock, Dana Rosen, Sarah Silverman, and Maura Vitale for assistance with data collection and coding. Special thanks go to the parents and children who participated in this study.

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Figure 1.

Means of infant behaviors coded as frequencies. HR-ASD = high risk infants with a later ASD diagnosis. HR-noASD = high risk infants with no later ASD diagnosis. LR = low risk control infants. Standard error bars depict ± 1 SE.

Figure 2.
Scatter plot of infant reciprocity ratings and ADOS severity scores at follow-up for all HR children
▣ = multiple children

Table 1

Sample Characteristics

	HR-ASD (n=10)	HR-noASD (n=25)	LR (n=27)
	M (SD)	M (SD)	M (SD)
MSEL ELC ^a at 11 months	90.70 (9.96)	101.68 (15.87)	105.70 (11.51)
MSEL ELC ^a at Outcome	66.11 (11.32)	102.76 (13.95)	120.35 (14.88)
ADOS Severity Score	5.50 (2.22)	1.76 (1.09)	1.50 (0.99)
Male, n (%)	7 (70%)	14 (56%)	14 (51.9%)
Parent Education Level	6.63 (0.56)	6.12 (1.01)	5.00 (1.01)

HR-ASD = high risk infants with a later ASD diagnosis

HR-noASD = high risk infants with no later ASD diagnosis

LR = low risk control infants

^a Mullen Scales of Early Learning, Early Learning Composite Standard Score

Table 2

Means and standard deviations of Infant and Parent Behavior during Play

	HR-ASD (n=10)	HR-noASD (n=25)	LR (n=27)
	M (SD)	M (SD)	M (SD)
Infant Behavior			
Shared Positive Affect ^a	0.40 (0.70)	0.60 (0.76)	1.26 (1.40)
Give/Show ^a	0.10 (0.32) *	0.36 (0.76)	1.59 (2.80) *
Socially-directed Vocalizations ^a	0.60 (0.97)	1.36 (1.93)	1.85 (1.83)
Reciprocity ^b	2.10 (0.57) *	2.60 (0.65)	2.85 (0.66) *
Parent Behavior			
Initiate/Direct ^a	11.10 (11.67)	6.72 (5.10)	9.67 (7.78)
Praise ^a	2.80 (3.97)	1.72 (2.48)	3.11 (3.30)
Scaffold ^a	24.40 (7.82)	25.96 (9.43)	26.33 (11.78)
Warmth ^b	3.70 (0.48)	3.92 (0.40)	3.93 (0.27)
Sensitivity ^b	3.40 (0.84)	3.72 (0.68)	3.70 (0.54)
Stimulate Development ^b	3.20 (0.79)	3.60 (0.65)	3.44 (0.70)
Intrusive ^b	1.60 (0.70)	1.20 (0.41)	1.44 (0.70)

HR-ASD = high risk infants with a later ASD diagnosis

HR-noASD = high risk infants with no later ASD diagnosis

LR = low risk control infants

* significant difference ($p < 0.05$) between HR-ASD and LR^a frequency of observed behavior (4 minutes), including raw scores for socially-directed vocalizations^b rating (1–4) of behavior