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Infant Twins' Social Interactions with Caregivers and Same-Age Siblings

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Abstract

The study of twin behavior offers the opportunity to study differential patterns of social and communicative interactions in a context where the adult partner and same-age peer are equally familiar. We investigated the development of social engagement, communicative gestures, and imitation in 7- to 25-month-old twins. Twin dyads ($N = 20$ pairs) participated in ten-minute, semi-structured play sessions, with the mother seated in a chair completing paperwork for half the session, and on the floor with her children for the other half. Overall, twins engaged more with their mothers than with their siblings: they showed objects and imitated speech and object use more frequently when interacting with their mothers than with their siblings. When the mother was otherwise engaged, the twins played with toys separately, observed each other's toy play, or were unengaged. These results demonstrate that adult scaffolding of social interactions supports

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increased communicative bids even in a context where both familiar peers and adults are available as communicative partners.

Keywords

joint attention; gesture; imitation; twins; infancy

Twins develop in a social environment unique from that of singletons: As infants they spend most of their waking hours together, and thus have countless opportunities to interact with a same-age peer as well as with caregivers (Thorpe, Rutter, & Greenwood, 2003; Vandell, Owen, Wilson, & Henderson, 1988). Studies of singleton infants and their caregivers have suggested that caregivers' contingent responsiveness to infants' communicative bids serves to impart knowledge of the reciprocal dynamics of conversational speech while encouraging infant vocalization (Goldstein, King, & West, 2003; Goldstein & Schwade, 2008; Pereira, Smith, & Yu, 2008). Less is known, however, about the development of infant social-communicative skills in interactions among infant twins and their caregivers. We examined the development of social interaction among 7- to 25-month-old twins and their mothers, focusing on differential patterns of infant engagement, gestural communication, and imitation as a function of communicative partner, while varying the amount of maternal involvement in the interactions.

Development of Social Engagement in Infancy

Over the first years of life, infants develop the ability to shift their attention flexibly in accordance with situational demands, and become more capable of maintaining their focus of attention on objects, people, and events of interest (Hanania & Smith, 2010; Ruff & Rothbart, 1996). As voluntary control of attention develops, infants initially learn how to sustain dyadic, face-to-face interactions with caregivers, and later become able to respond to caregivers' communicative bids in supported joint engagement where, for example, the caregiver might offer an object of interest to the infant as a means of fostering engagement. Dyadic face-to-face interactions and supported joint engagement provide the foundation for the emergence of coordinated joint engagement—also referred to as joint attention or the infant's ability to coordinate their attention toward an object or event of interest with another individual (e.g., Rochat, 2004; Striano & Reid, 2006). Coordinated joint engagement, which typically emerges between 9 and 13 months, is considered by many to be a critical milestone for the development of referential communication skills, through which infants learn to recognize others' communicative intentions and convey their own using gestures and speech (e.g., Adamson, 1995; Baldwin & Moses, 2001; Eilan, Hoerl, McCormack, & Roessler, 2005; Moore & Dunham, 1995).

Early Communicative Gestures

Infants begin producing a variety of gestures towards the end of their first year of life. Two gestures, *pointing* and *showing*, have received considerable attention in infancy research due to their apparent links with coordinated joint engagement and language development (Brooks & Meltzoff, 2008; Butterworth, 2003; Colonnese, Stams, Koster, & Noom, 2010;

Lock, 1978; Tomasello, Carpenter, & Liszkowski, 2007). These gestures increase in frequency around 8 to 10 months of age (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979), and are more likely to occur when infants are involved in episodes of supported or coordinated joint engagement (Bakeman & Adamson, 1986).

Imitation

Imitation of another person's actions or vocalizations emerges in infancy (e.g., Meltzoff, 1990; Nadel-Brulfert & Baudonniere, 1982; Piaget, 1962; Užgiris, 1981), and like coordinated joint engagement, begins to occur with substantial frequency around the age of 9 months (Bruner, 1983; Ratner & Bruner, 1978), and increases over the next two years (Carpenter, Call, & Tomasello, 2005; Carpenter, Nagell, & Tomasello, 1998; Meltzoff, 1995). Joint attention during social interaction enhances infants' abilities to imitate their social partners (Brugger, Lariviere, Mumme, & Bushnell, 2007; Carpenter et al., 1998), and through imitation infants expand their behavioral and communicative repertoires, and facilitate communication.

Early Studies of Partner Effects in Infant Social Interaction

With few exceptions (e.g., Bakeman & Adamson, 1984; 1986), the literature on early social interaction has focused almost exclusively on interactions between singleton infants and their caregivers (e.g., Adamson & Bakeman, 1984; Soderstrom, 2007). Bakeman and Adamson (1984) videotaped infants at 3-month intervals between the ages of 6 and 18 months while they were interacting during two free-play conditions, one with their mother and one with a familiar peer. Videotaped sessions were coded for several distinct engagement states: person engagement (dyadic, face-to-face interaction), passive joint engagement (later renamed supported joint engagement [Adamson, Bakeman & Deckner, 2004]), coordinated joint engagement (joint attention), object engagement, onlooking, and unengaged behavior. Overall, person engagement and unengaged behavior decreased with age, and coordinated joint engagement increased with age. More importantly for our purposes, infants spent more time involved in coordinated and supported joint engagement with their mothers than with their peers across all ages. Similarly, Bakeman and Adamson (1986) found that infants' communicative gestures and speech were more often directed toward their mothers than their peers across all ages (see also Ninio, 2015). Eckerman and colleagues observed that peer interactions lagged months behind similar interactions involving caregivers, with imitation preceding other kinds of coordinated joint engagement and communication between unfamiliar peers (Eckerman, Davis, & Didow, 1989; Eckerman & Didow, 1996; Eckerman & Stein, 1990).

Regarding partner effects on imitation, Zmyj and colleagues found that 14-month-old infants were more likely to imitate novel actions performed by an adult model than those performed by a same-age peer or older child, but were more likely to imitate familiar actions performed by a peer than those performed by an older child or adult (Zmyj, Aschersleben, Prinz, & Daum, 2012; Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2012). These results suggested that infants encountering novel situations may prefer to interact with an adult, who is presumably a more knowledgeable and reliable model, and thus in this context imitation

served the cognitive function of helping the infant to acquire new skills. With familiar actions, imitation appeared instead to serve a social function of joining in and sharing an experience with a peer (Zmyj & Seehagen, 2013).

Taken together, these results suggested that caregiver scaffolding of infant attention assisted infants in coordinating joint attention and resulted in increased communicative bids to the caregiver. In contrast, infants seemed to have difficulty sharing their interest in objects with peers before the middle of the second year. Early social interactions with same-age peers appeared to consist of imitation rather than more sophisticated engagement patterns characterized by joint attention and communicative gesturing. However, the infants in these studies were paired with same-age peers from different families and, thus, the results may have been simply the result of the greater familiarity that the infants had with their mother relative to their same-age peer. Studying twins provides a unique opportunity to examine interactions in a context where both the same-age sibling and caregiver are equally familiar.

Current Focus

Some researchers have suggested that twins exhibit a slower rate of communicative development relative to singletons (Conway, Lytton, & Pysh, 1980; Day, 1932; Savi, 1980); the extent to which this is due to perinatal risks experienced by twins, who are often born preterm, low birth weight, and/or small for gestational age, is unclear (Martin et al., 2010). Preterm infants have been shown to be at risk for delays in joint attention, and have impairments in the rate of acquisition for the use of gesture and imitation, as well as word comprehension and production, relative to full-term controls (e.g., Casiro et al., 1990; De Schuymer, De Groote, Beyers, Striano, & Roeyers, 2011; Garner, Landry, & Richardson, 1991; Landry, 1986, 1995; Rocissano & Yatchmink, 1983; Sansavini et al., 2010; Ulvund & Smith, 1996). Thus, examination of the effects of perinatal risk factors is important when studying twins. On the other hand, the unique social environment in which twins develop may contribute to communication delays. Maternal speech to twins has been observed to be more directive, and less responsive, elaborative, and encouraging than maternal speech to singletons, and differences in the amount of maternal attention and speech directed toward twins might also contribute to language delays (Lytton, Conway, & Suave, 1977; Thorpe et al., 2003). Twins may also participate in fewer bouts of supported and coordinated joint engagement with their caregivers, who must divide their attention between their two infants (Butler, McMahon, & Ungerer, 2003; Stafford, 1987; Tomasello, Mannle, & Barton, 1989; Tomasello, Mannle, & Kruger, 1986).

The current study examines the development of social engagement, gesture use, and imitation in twins over their first two years of life, with a focus on partner effects in two contexts: 1) with the twins allowed time to play with each other, without direct involvement of their mother, and 2) with the mother actively engaged with her infants. We expected coordinated joint engagement, gesture use, and imitation to increase between 7 and 25 months, although the ages at which these skills become well-established might lag somewhat behind those documented by Bakeman and Adamson (1984, 1986), consistent with prior research demonstrating that multiple birth is a risk factor for poor developmental outcome. We hypothesized that perinatal risk factors associated with preterm birth (e.g.,

neurological damage, low birthweight) would be predictive of the infants' early social interactions. Finally, we hypothesized that social engagement would occur mostly between infants and their mothers rather than between siblings, although we expected that the experimental manipulation of maternal availability, which echo real-life limitations, might provide increased opportunities for the twins to interact with one another when the mother was otherwise occupied.

Method

Participants

Twenty twin¹ dyads and their mothers participated in the present study. The twins were a subset of a larger group of infants who were recruited at birth and enrolled in an ongoing longitudinal study of attention and arousal in high-risk NICU graduates. Selection criteria for the larger study included: low birth weight (< 1800 g), small for gestational age (< 10th percentile birth weight for GA), Intrauterine Growth Restriction (IUGR), multiple gestation, evidence of fetal distress with signs of asphyxia at birth (assisted ventilation > 48 hours), persistent apnea or bradycardia, seizures, coma, other signs of intracranial pressure, or abnormal neurological signs; or dysmature (by clinical diagnosis). Exclusion criteria for the larger study were known prenatal exposure to neurotoxic substances (e.g., cocaine, methadone) or diagnosis with a genetically based developmental disability (e.g., Down syndrome). Selection criteria for the present study included twin gestation and English as the primary language in the home. The original sample included 22 sets of twins and their mothers, but data from one pair of twins were excluded after both twins were diagnosed with Autism Spectrum Disorder, and from another set of twins due to experimental error. The 40 remaining twins were evenly divided between girls and boys and were predominately non-Hispanic white (75%), followed by Hispanic white (10%), Hispanic black (5%), non-Hispanic black (5%), and non-Hispanic mixed race (5%), approximating the racial and ethnic demographics of the surrounding area. The education of the mothers in the sample ranged from ten years of formal education (sophomore year in high school) to a graduate school degree (20 years). The average educational experience included some college experience without a bachelor's degree.

The twin dyads participated in semi-structured free-play sessions with their caregiver² at 3-month intervals from 7 to 25 months of age (ages adjusted for degree of prematurity) as a part of the larger study. Due to attrition, missed appointments, and varying ages at the onset of participation, none of the dyads were seen at all of the test ages, however. As a result, six families participated at one test age, seven families across two ages, two families across three ages, three families across four ages, and two families across five ages; no families participated across six or seven ages. Therefore, we report here on a total of 48 sessions (an average of 2.4 sessions per family). These 48 sessions were coded twice, once for each twin, resulting in a dataset of 96 observations. Sample characteristics are shown in Table 1.

¹While the zygosity of the sample is unknown, there were eight pairs of same-sex twins. Thus, not more than eight pairs of twins in the current sample were possibly monozygotic.

²The caregiver was almost always the children's mother, thus we refer to the caregiver as the mother in describing the results.

Although the twins in the present study were all NICU graduates, they appear to be a fairly low-risk group overall, with 83% of the infants having no CNS injury or only mild structural/functional CNS injury, 90% with birthweight > 1500 grams, and 90% with a gestational age of 32 weeks or greater. Only one dyad consisted of a twin with no CNS injury paired with a sibling with moderate-severe injury.

Procedure

Each free-play session took place in a small observation room (1.8m × 2.4m), with a multi-colored, padded play-mat on the floor and a one-way mirror on one side of the room. The room was decorated with colorful pictures and mobiles, and a set of age-appropriate toys on the floor, all selected to increase the likelihood of social interaction between the twins and their mother. Upon entering the room, children were placed within reach of the toys in either a seated or prone position depending on their strength and ability to sit independently. The mother was present with her twins during the entire video recorded 10-minute free-play session. Each observation session consisted of two approximately 5-minute segments: The first five minutes (chair condition) assessed the twins' social interactions while their mother was seated on a chair in the corner of the room, completing a short questionnaire. At the onset of this segment, the mother was instructed not to engage in or initiate any interactions with the twins, although she was told that she could intervene if one or both children became distressed. The second segment (floor condition) evaluated the twins' social interactions while the mother was seated on the floor with the twins. During this segment, the mother was instructed to play with her children as she would at home, while letting the children take the lead as much as possible. To limit potential infant distress as a reaction to their mother detaching from play, the mother on the chair condition occurred first for every family at each observation session. Session lengths ranged from 618 to 881 seconds.

Coding

Using SubTrak Video Coding Software (Takash, Lindtvedt, & Ragir, 2006), sessions were coded separately for each twin using a three-step process to code for social engagement, gestural communication, and imitation as described below (see Table 2).

Engagement states—We examined infant engagement with people and/or objects using a modification of the coding system developed by Bakeman and Adamson (1984). The following engagement states were identified based on the infant's attentional focus: coordinated joint engagement, dyadic engagement, supported joint engagement, onlooking, object manipulation, and unengaged behavior. The first three of these engagement states involve direct social interaction with another person, while the other three do not since onlooking consists of observation only, not interaction. Only engagement states with a duration of three seconds or longer were coded. Coordinated joint, dyadic, supported joint, and onlooking engagement states were coded for partner (mother, sibling, or both).

Gestural communication—Following Bates et al. (1979), we coded infant pointing and showing gestures. Pointing gestures included the use of an extended arm toward the object of interest even if the child's index finger was not extended. Showing gestures were coded for the infant's partner (mother or sibling), but as points often were not directed toward

another person (e.g., infants often pointed at interesting objects on the wall or ceiling without looking at the mother or sibling) pointing gestures were not coded for partner.

Imitative behaviors—The infant's imitative behaviors were coded following Eckerman (1993). Imitation of vocalizations and object use was defined as behavior that occurred no more than 15 seconds after the initial vocalization or action of the imitated partner. Children were given credit for Vocal Imitation in cases where they approximated their partner's speech. For example, if the mother said, "Where's the hammer?" and the child responded, "hamma", the child was credited for an act of vocal imitation. Imitation of vocalizations and object use were coded for partner (mother or sibling).

Reliability—Intercoder reliability was attained separately for the three coding schemes and was evaluated with kappa coefficients (Cohen, 1960). Reliability for the engagement state coding ($\kappa = .68$) involved the first author and a trained research assistant independently coding 20% of the data set to determine whether they agreed on the onset times (within 3 seconds) for each mutually exclusive engagement state, and whether they agreed on the type of engagement state and associated partner, where appropriate. This level of observer accuracy (~87% according to interpretive suggestions put forth by Bakeman, Quera, McArthur, & Robinson, 1997) is consistent with the level of inter-coder reliability reported by Bakeman and Adamson (1984; with mothers: 85% agreement; with peers: 88% agreement). The reliability procedure for the gesture and imitation coding consisted of the following two-step process. First, the third author and a trained research assistant independently coded each videotaped session and noted when a gesture or imitative act occurred. For the next step, the third author and a different trained research assistant independently coded 20% of the data set for the type of gesture/imitation exhibited and associated partner, where appropriate; gestural communication: $\kappa = .98$ (~99% observer accuracy); imitative behaviors: $\kappa = .97$ (~98.5% observer accuracy). Finally, for each of the coding schemes, all disagreements between the coders were resolved through discussion.

Results

Analysis Plan

Session lengths varied because sessions were sometimes terminated early due to infant fussiness or went longer due to experimenter error; therefore, for all analyses, rates of engagement states, gestures, and imitative behaviors were computed to take into account the true lengths of the sessions. Rates were computed separately for the segment with the mother seated in the chair and the segment with the mother seated on the floor³. This allowed us to conduct comparisons of infant behaviors as a function of maternal position. To examine partner effects, we calculated the rates of coordinated joint engagement, dyadic engagement, supported joint engagement, onlooking states, showing gestures, and imitation of vocalizations and object use for each social partner (mother, sibling) or partners (both mother and sibling for the four listed engagement states only). Given our interest in twins' partner preferences, we chose rates rather than durations of infants' engagement states

³The rates of the different engagement states, gestures, and imitative behaviors were calculated for each five-minute segment using the following formula: frequency of behavior * (300 seconds/ total time of segment in seconds).

because doing so enabled us to examine each attempt at engagement with another person, rather than noting the total amount of time spent engaged in a certain state with the mother or the sibling⁴. The use of rates allowed us to utilize the same unit of measurement across all of our dependent variables (i.e., engagement states, gestural communication, and imitative behaviors). Furthermore, we believed using rates was more consistent with our interest in partner effects because the infant received credit for each act of engagement, regardless of whether or not their expert mother or novice sibling worked towards sustaining that state.

We examined twins' engagement states, communicative gestures, and imitative behaviors in a series of analyses. First, we conducted regression analyses to examine effects of age, gender, perinatal risk, and maternal education on the rates for the entire 10-minute session⁵ for each dependent variable. These analyses utilized generalized estimating equations (GEEs), a form of regression that adjusts for the effects of repeated measurements of individuals (Liang & Zeger, 1986; Zeger & Liang, 1986). Robust estimation of variances and the assumption of a negative binomial distribution were employed due to the non-normal distribution of most of the behavioral measures and to the large number of subjects who did not perform various behaviors at certain ages, which made transformation to normality difficult, if not impossible. We employed a significance criterion of $p < .005$ within each set of GEE analyses in order to take the number of multiple comparisons performed into account.

Second, we examined the overall effects of social partner (mother vs. sibling) across all ages of observation⁶, and investigated age-related changes in the rates per 10-minute session of each behavior with different partners. Third, we looked at the overall effects of maternal position (mother on chair vs. mother on floor), and examined differences in partner preferences (mother vs. sibling) based on rates per 5-minute segment across all ages of observation. Because the rates of these behaviors were non-normally distributed with considerable zero-inflation, we assessed the statistical significance of differences with 2-tailed Wilcoxon signed rank tests. As these three domains of analyses are different in nature, including both fixed (mother's position, test ages) and random (choice of partner) effects, with separate hypotheses, we have analyzed them in separate sets of analyses.

Predictors of Twins' Engagement States, Gestures, and Imitation

We did not find any significant effects of gender, birth weight, gestational age, degree of CNS injury, or level of maternal education on the rates of twins' social engagement, gestural communication, or imitative behaviors, perhaps because the sample as a whole was a fairly low-risk group. Effects of age were examined in GEE models successively adding linear, quadratic, and cubic terms for age to capture the complexity of changes across ages. The

⁴Preliminary calculations revealed substantial relationships between overall frequencies and durations of direct social engagement states (averaged across partners for the entire 10-minute session): coordinated joint engagement ($r = .88$), dyadic engagement ($r = .80$), and supported joint engagement ($r = .82$).

⁵Thus, the rate for the full trial (i.e., rate per 10-minute session) is the sum of the rates for each of the 5-minute segments (chair and floor conditions), expressed as a rate for the nominal duration of the trial (600 seconds).

⁶To examine overall partner effects, we compared rates for each partner on each type of interaction, pooling data for all test ages and both conditions (mother on chair, mother on floor).

best-fitting model was chosen according to the Wald χ^2 statistic and the effects of age are described below, with the linear model providing the best fit unless stated otherwise.

Age-related changes in the rates of each of the engagement states are shown in Figure 1. As expected, the rate of supported joint engagement decreased significantly as twins got older ($Wald \chi^2(1) = 91.27, p < .001$) and the rate of coordinated joint engagement increased with age ($Wald \chi^2(1) = 193.92, p < .001$). As shown in Figure 1, the infants' coordinated joint engagement increased between the ages of 10 and 13 months and continued to increase through 25 months of age, with a concurrent decrease in the rate of supported joint engagement; these results suggest that infants took on an increasingly active role in direct social engagement with others as they grew older. The rate of dyadic, face-to-face engagement did not vary with age, nor did the rates of onlooking, object manipulation, and unengaged behavior. Object manipulation was the most frequent state of engagement for twins across all ages, see Figure 1. This matches Bakeman and Adamson's (1984) observation that singletons spent the majority of their time engaged solely with objects (both in sessions with their mother and with a same-age peer).

Age-related changes in the rates of gestural communication and imitation are shown in Figure 2. Rates of pointing and showing gestures increased significantly with age. The cubic model provided the best fit for pointing, supporting the apparent downturn in pointing after 16 months and smaller upturn at 25 months ($Wald \chi^2(3) = 48.90, p < .001$). For showing, the overall model was significant, with the quadratic model providing the best fit to the data ($Wald \chi^2(2) = 131.00, p < .001$). Rates of vocal imitation ($Wald \chi^2(1) = 66.30, p < .001$) and object use imitation also increased with age, with the cubic model providing the best fit for object use imitation ($Wald \chi^2(3) = 14.00, p < .003$). Communicative gestures and imitative behaviors occurred fairly infrequently prior to 13 months of age, but these behaviors began to increase in rate thereafter. The rates of pointing and showing gestures appeared to increase in parallel with one another from 10 to 16 months, after which there was an apparent decline in the rate of pointing and a concurrent increase in the rate of showing, although this inverse relationship was not statistically significant.

Effects of Partner

We investigated differences in social engagement, showing gestures, and imitation as a function of interactive partner (i.e., mother, sibling, or both) through a series of Wilcoxon signed rank tests with the rates per 10-minute session for each behavior collapsed across ages at observation (see Table 3). Engagement states involving the mother and both twins occurred very rarely, and of those interactions involving all three partners only onlooking occurred at a rate sufficient to be included in any of the data analyses. Overall, twins interacted much more with their mothers than they did with their siblings, even though their sibling was available to interact with the entire time, unlike the mother who was occupied with completing the questionnaire for the first half of the session. Twins entered into coordinated joint engagement, dyadic engagement, and supported joint engagement more often with their mothers than with their siblings. In contrast, the siblings rarely watched the mother without engaging (onlooking), unless she was already interacting with the sibling. Twins showed a trend toward monitoring their mother acting alone less often than they

observed their sibling acting alone, and less often than they observed their mother interacting with their sibling ($M = 2.78$, $SD = 2.36$; $Z = -4.98$, $p < .001$). There was no significant difference, however, between the rate of monitoring a sibling acting alone and the rate of monitoring the shared activities of sibling and mother. Overall, twins engaged in significantly more direct social interactions (coordinated joint, dyadic, and supported joint engagement) with their mothers than with their siblings, with only 32% of the interactions with siblings involving direct social engagement, compared to 88% of the interactions with the mothers.

We found a similar pattern in the gesture and imitation data. Overall, infants were more likely to show objects to their mothers, and were more likely to imitate her vocalizations, and object use than those of their sibling, even with a procedure specifically designed to increase the likelihood of interactions between the twins.

Age Comparisons by Partner

The partner effects expressed in the mean rates (for the entire 10-minute session) for engagement states, gestural communication, and imitative behaviors across age are presented in Table 4. GEEs were conducted to examine age-related changes as a function of interactive partner. In interactions with the mother, rates of coordinated joint engagement ($Wald \chi^2(1) = 117.75$, $p < .001$), showing ($Wald \chi^2(1) = 114.06$, $p < .001$), vocal imitation ($Wald \chi^2(1) = 57.95$, $p < .001$), imitation of object use ($Wald \chi^2(1) = 15.04$, $p < .001$) increased significantly with age, while supported joint engagement decreased with age ($Wald \chi^2(1) = 118.30$, $p < .001$). In interactions with the sibling, rates of coordinated joint engagement ($Wald \chi^2(1) = 67.35$, $p < .001$), showing ($Wald \chi^2(1) = 32.43$, $p < .001$) and vocal imitation ($Wald \chi^2(1) = 9.96$, $p = .002$) increased significantly with age, with no significant age-related changes for supported joint engagement or imitation of object use. (Note that the rates of onlooking and dyadic engagement did not change significantly with age for either partner.)

For coordinated joint engagement, showing, and vocal imitation, which increased with age for both mother-infant and twin interactions, we investigated whether these behaviors became well established with the mother at earlier ages than they were between the twins. The changes in the rates of these behaviors over sessions (see Figure 3) revealed seemingly sharp increases at 13 or 16 months for interactions between infants and their mother, with corresponding increases in the rates of these behaviors occurring later for interactions involving the sibling.

Regression discontinuity (RD) analyses were performed to identify ages at which a significant increase occurred in the rates of coordinated joint engagement, showing gestures, and vocal imitation, examining the behaviors separately for each partner. Note that the low rates of these behaviors at some ages resulted in a failure of the RD algorithm to converge; these are indicated by dashes in Table 5. The results of these analyses (see Table 5) indicate that significant increases in coordinated joint engagement and showing gestures occurred in interactions with the mother at the age of 13 months, but the apparent increases in these behaviors with the sibling at 22 months did not approach conventional levels of statistical significance. A significant increase in the rate of imitation of maternal vocalizations

occurred at 16 months, while imitation of the sibling's vocalizations did not increase significantly until 25 months. Thus, twins showed significant lags in engaging in communicative behaviors with their sibling relative to their mothers⁷ and extended the findings of Bakeman and Adamson (1984, 1986) to twins.

Effects of Maternal Position

Wilcoxon signed rank tests were conducted to examine overall differences in the twins' social engagement, gestural communication, and imitative behaviors as a function of the mother's level of attention to the twins reflected in her position, seated on the chair or on the floor (rates per 5-minute segment across all ages of observation; see Table 6). Note that the chair condition always took place before the floor condition (see page 11).

Coordinated joint engagement, supported joint engagement, and object manipulation occurred significantly more often when the mother was on the floor. In contrast, twins became unengaged more often when the mother sat in the chair. The mother's position had no significant effect on dyadic engagement.

Pointing, showing, vocal imitation, and imitation of actions with objects all occurred more often when the mother was on the floor. The higher rate of pointing and showing when the mother was seated on the floor suggests that the mothers' active participation stimulated gesture use.

Effects of Maternal Position on Partner Preferences

We investigated whether partner effects varied with changes in maternal position (mother in chair vs. floor; rates per 5-minute segment by partner averaged across all ages using Wilcoxon signed rank tests (see Table 7). Twins participated in coordinated joint engagement more with their mother than with their sibling when the mother was on the floor. Coordinated joint engagement with the mother decreased when she sat on the chair; however, no significant partner effect emerged. For supported joint engagement, twins engaged more with their mother than with their sibling when the mother was on the floor, and showed a reversal to engage more with their sibling when their mother was preoccupied. Dyadic engagement occurred significantly more often with the mother than with the sibling regardless of maternal position. When the mother was in the chair, twins were more likely to engage in onlooking of their sibling than of their mother, and were more likely to observe their sibling acting alone than to observe their sibling engaged with their mother ($M = .41$, $SD = 1.00$; $Z = 6.84$, $p < .001$). This most likely reflects the reduced opportunities to observe their mother interacting with their sibling when the mothers were occupied with paperwork while seated on the chair. While the mother was on the chair, onlooking of the sibling acting alone occurred nearly three times more often than onlooking of mother alone and mother with sibling combined. In contrast, when the mother was on the floor, there was no significant difference between the rates of twins monitoring their mother or sibling.

⁷The majority of twin pairs were the same at the critical transition periods identified by the regression discontinuity analyses (i.e., between 10 and 13 months for coordinated joint engagement and showing gestures to mother; between 13 and 16 months for vocal imitation of mother). Of the 16 subjects seen at 13 months, ten were seen at 10 months (63%) and of the 14 subjects seen at 16 months, ten of them (71%) were also tested at 13 months.

However, the twins observed their mother and sibling interacting together ($M = 2.37$, $SD = 2.28$) more often than they observed either partner acting alone (mother: $Z = -6.27$, $p < .001$; sibling: $Z = -4.37$, $p < .001$), indicating that during floor time, infants' attention was drawn to occasions when their mother and sibling were interacting together. While the mother was on the floor, more than half of the occurrences of onlooking involved observing the mother and the twin interacting together.

Twins displayed a very strong preference for showing objects to their mother rather than to their sibling, even while the mother sat in the chair. As mentioned above, showing objects to their mother when she was preoccupied with paperwork may have reflected the twins' attempts to re-engage her. The rate of these gestures toward the mother increased when she was on the floor, resulting again in a significant difference between showing to mother and showing to sibling. Maternal position (chair vs. floor) also influenced patterns of imitation. Whereas infants imitated the vocalizations of their mothers more often than those of their siblings, this effect was limited to the context of the mother on the floor. Presumably, this reflects fewer opportunities for twins to imitate maternal speech while their mothers were quietly preoccupied with paperwork. Infants imitated more of their mother's actions when she was on the floor, but more of their sibling's actions when the mother sat preoccupied in the chair. Thus, when both social partners were available, twins preferentially imitated the actions of their mothers; however, in her absence, they followed the lead of their sibling by imitating their use of objects.

In summary, twins tended to engage directly with, gesture toward, and imitate their mother much more often than their sibling, despite a procedure specifically designed to allow the twins uninterrupted time to interact with one another for the first half of the session. Even while the mother was on the chair, twins were much more likely to show objects to their mother than to their sibling, and were more likely to participate in dyadic engagement with her than with their sibling. The rate of unengaged behavior also increased while the mother was on the chair, supporting the idea that early social interactions benefit from the participation of a familiar adult. Interestingly, 66% of the engagement states occurring between the twins solely consisted of watching their twin (onlooking) and did not involve direct social engagement. In contrast, only 12% of the engagement states occurring with their mothers did not involve direct social engagement. Overall, interactions between the twins typically consisted of watching their sibling playing alone or observing their sibling interacting with their mother. With the exception of onlooking, the only interactive routine that occurred repeatedly between siblings was the imitation of actions with objects—and this occurred most often when the mother was disengaged and seated on the chair.

Discussion

This study was designed to accomplish three goals: 1) To document the developmental progression of social interactions among young twins and their caregivers and to consider how these interactions and their age-related changes may differ from those described in the developmental literature between singletons and their mothers; 2) To investigate whether early medical risk factors and maternal education predicted differences in social interactions in our sample of twins and their caregivers; and 3) To determine whether rates of direct

social engagement, gestural communication, and imitative behaviors were higher in twins' interactions with their mothers than with their siblings. Our experimental design included a manipulation of maternal availability, providing increased opportunities for twins to interact with each other for half of the session while their mother was preoccupied with paperwork, but in other respects it was intended to assess social interactions through naturalistic observation.

Development of Social Interaction among Infant Twins and their Caregivers

For the most part, the developmental progression of social engagement states in the twins appeared to be consistent with the timing and patterns observed in studies of typically developing singletons and same-age peers (e.g., Bakeman & Adamson, 1984; Eckerman, 1993; Eckerman & Didow, 1996). As infants grew older, supported joint engagement, which occurred primarily between the mother and her infant, decreased and coordinated joint engagement with the mother increased. Thus, with age, infants showed increased capacities to pay attention to their mothers while engaged with a toy. While coordinated joint engagement with the mother increased significantly between 10 and 13 months, this behavior very rarely occurred between the twins until 22 months. Likewise, significant increases in showing gestures and imitation of vocalizations occurred in interactions with the mother at earlier ages than with the sibling, which matches the findings from earlier studies of close-in-age siblings and same-age peers (e.g., Bakeman & Adamson, 1986; Dunn, 1993; Eckerman & Didow, 1996). The outcomes from this study of twin interactions confirm the interpretation that coordinated joint activity requires the scaffolding of an expert social partner at least until the end of the second year (Eckerman, 1993; Eckerman & Didow, 1996) and the existence of a proclivity to engage with expert partners over novices in joint attention throughout early childhood (Ninio, 2015).

In contrast to Bakeman and Adamson (1984), the rate of dyadic engagement did not decrease significantly with age in our study, and remained relatively stable through 25 months. Note, however, that we are limited in making direct comparisons to Bakeman and Adamson's results, as they focused on the duration rather than rate of observed behavior. The continued dyadic engagement at older ages in our study may reflect infant initiated face-to-face interactions with their mother, in an attempt to get her attention while she was interacting with their sibling, or to disengage her from her paperwork in the first part of the session.

The twins in our study displayed relatively high rates of object manipulation, perhaps because they played with the toys while their mother was preoccupied with paperwork or interactions with their sibling. On the other hand, Bakeman and Adamson (1984) also observed singletons to spend considerable amounts of time in object manipulation through 18 months, which suggests that young infants in general are keen to explore objects. The onlooking data provide some information about the activity of a sibling while her/his twin interacted with their mother. When the mother was seated on the floor and available to interact with the twins, most of the occurrences of onlooking involved observing the mother and the sibling interacting with one another.

Interactions consisting of three partners (mother and both twins) were very rare, and when they occurred they were two or three times more likely to consist of one twin observing the other twin interacting with the mother. Although mothers occasionally tried to initiate supported joint engagement with both twins simultaneously, they were far more likely to be involved in supported joint engagement with one twin at a time. Similarly, coordinated joint engagement occurred at least five times more often between the mother and one twin than between the mother and both twins. These results highlight some potential differences in the early social environments of twins, relative to singletons. While mothers are interacting with one twin, the other twin may spend more time exploring objects or observing the interactions between their mother and sibling, raising the question of what effect this might have on their social-communicative development. The more time spent in independent object exploration and observing the interactions of others may offset a reduction in the time spent in coordinated joint engagement with an experienced adult; the reduction in direct social engagement might account for the language delays reported in many twin studies (Conway et al., 1980; Day, 1932; Savi, 1980). On the other hand, it is possible that twins may benefit from the increased opportunities for observational learning through monitoring interactions between their caregiver and sibling. Future research investigating the interactions of twins and their caregivers compared to those of singletons and their caregivers, and including an assessment of language skills among the outcome measures, would address this question.

Perinatal Risk and Social Interaction in Twins

Although we expected that our perinatal risk indicators (birthweight, gestational age, degree of perinatal CNS injury) would predict differences in the rates of social engagement, gestural communication, and imitative behaviors, we did not find any significant relationships between perinatal risk and subsequent social interactions, perhaps because the sample was a fairly homogeneous low-risk group without much variability in the degree of perinatal risk, particularly in comparison to the overall sample of NICU infants in the larger study from which this subset of twins was selected.

Partner Effects in Twin Infants' Social Interactions

The present investigation of partner effects in early social interactions among twins and their mothers lends support to a theory of natural pedagogy that posits that young infants would interact more with familiar and trustworthy adults in situations where infants seek or need to evaluate information about their social world (Csibra & Gergely, 2006; Gergely & Csibra, 2006; Gergely, Egyed, & Király, 2007). Overall, we found that the twins interacted much more with their mothers than they did with their siblings during the first two years, despite the fact that the availability of the sibling as an accessible social partner was twice that of the mother over the 10-minute session. As predicted, the twins were more often observed in bouts of direct social engagement (i.e., coordinated joint, dyadic, and supported joint) with their expert mother than with their novice, same-age sibling. Furthermore, we found that the twins participated in face-to-face interactions with, and directed showing gestures toward their mother more often than their sibling, even when the mother was sitting on the chair. In contrast, the interactions between twins could be characterized as less overtly communicative, frequently consisting of onlooking or, less often, imitating the sibling's

actions. Similarly, twins were more likely to produce gestures and imitate vocalizations or activities when their mother was seated on the floor and available for interaction. Consistent with our hypothesis, we found that the twins' showing gestures were almost exclusively directed toward their mothers, even when mothers were preoccupied with paperwork. The twins had ample opportunities to use gestures to communicate with their siblings, but generally chose not to do so.

Twins' showing gestures and coordinated joint engagement seem to become well established months earlier in interactions with their mothers than with their siblings, as indicated by the significant increase in the rates of these behaviors with their mothers at 13 months, compared to the relative infrequency of these behaviors with their siblings. Thus, the twins in the present study engaged in social communicative interactions more often and at earlier ages with their mothers than with their siblings. Changes in the rates of imitation are a little more difficult to interpret, however. There was an increase in the rate of imitation of maternal vocalizations at 13 months, and these vocal imitations continued to increase through 25 months. In contrast, imitation of the sibling's vocalizations was rare until 25 months when it increased significantly, if at a much lower rate than the imitation of maternal vocalizations. It is unclear whether this was simply a reflection of the reduced opportunity to imitate siblings, who presumably are much less verbal than the mothers.

Overall, there were surprisingly few interactions between siblings, even during the first half of the session when the mother's attention was directed away from her infants. While it is possible that the twins rarely interacted with one another while the mother was on the chair because of some behavioral inhibition, due to wariness of the unfamiliar environment or the fact that the segment with the mother on the chair occurred first for all families, the fact that they interacted with one another very rarely throughout the entire 10-minute session suggests otherwise. The low rate of interactions involving both twins and their mother, and the lack of an increase in the rate of twins' interactions with each other when their mother was on the floor suggests that the mothers may not have been trying to facilitate interactions between the twins, but rather they may have alternated attention from one twin to another while interacting with them as individuals. Some forms of social interaction were just beginning to occur between the twins at the endpoint of this study, however. Perhaps if we had followed the twins past 25 months (ages at which the rates of many of our coded behaviors began to increase), we would have been able to observe a higher rate of interactions between the twins themselves.

Limitations and Future Directions

Our results provide support for the idea that young twins interact much more often with their mothers than with one another. However, our findings are somewhat limited in noting the extent to which the rates of interactions with the mother reflected a greater propensity for the mother to initiate exchanges. Nevertheless, the current coding system does shed some light on the complex nature of twin-caregiver social interactions. For instance, we were able to capture twins' bids for coordinated joint and dyadic engagement, which were often indicated by the child's movement towards their mother when their mother was on the chair. Furthermore, showing gestures were a common way for the child to capture their mother's

attention, and would have been coded as an occurrence of coordinated joint engagement if the mother responded by engaging with her child.

We did not code for additional types of interactions characteristic of twins, such as taking a toy from one's twin or engaging in parallel play because these fairly frequent forms of interaction do not necessarily involve eye contact or coordinated joint engagement. Our approach, based on Bakeman & Adamson (1984), may have underestimated the frequency with which twins interact with one another. Thus, future studies of the development of social interaction among young twins and their caregivers may wish to include a broader range of types of social interaction in order to capture different ways that twins might interact with one another, as well as working to capture the dynamics of twin-caregiver engagement by further examining the behaviors of twins when their mother is interacting with their sibling.

Conclusions

At the outset of the study, we hypothesized that the twins would interact in bouts of social engagement more often with their mother than with their same-age sibling, presumably due to prior experiences of active scaffolding of social exchanges by expert caregivers. Twins did indeed directly engage (i.e., coordinated joint, dyadic, and supported joint) more often with their mother than with their same-age sibling, while engagement states between siblings consisted of less overtly social behavior. The only engagement state that occurred substantially between twins was onlooking in the form of monitoring the activity of the sibling acting alone, or the mother and sibling interacting together. Taken together, our results provide support for the critical role of scaffolding of infant attention by caregivers in the development of coordinated joint engagement, communicative gestures, and imitation, with twins only gradually extending their communicative skills in interactions with their siblings towards the end of the second year.

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Highlights

- Development of twins' social engagement is consistent with singletons'
- Infant-mother social interactions are more sophisticated than between twin siblings
- Engagement states between twin siblings consist of less overtly social behavior
- Twins socially interact more with expert partners over equally familiar novices
- Coordinated joint activity requires an expert partner's scaffolding through 2nd year

Figure 1.
Developmental progression of twins' engagement states (average rates per 10-minute session by age at observation; error bars represent standard errors)

Figure 2. Developmental progression of twins' gestural communication and imitation (average rates per 10-minute session by age at observation; error bars represent standard errors)

Figure 3.

Differences in the developmental progressions of coordinated joint engagement, showing gestures, and vocal imitation as a function of social partner (average rates for the entire 10-minute session by partner and age at observation; error bars represent standard errors)

Table 1

Demographic Information by Age

		Participants by Age (months)									
		Full sample		7	10	16	16	16	16	16	16
	<i>n</i>	40	10	10	10	16	16	16	16	16	16
Female	Count	20	6	8	8	7	7	6	7	6	6
	%	50.0%	60.0%	50.0%	50.0%	43.8%	43.8%	42.9%	50.0%	50.0%	42.9%
Gestational Age (weeks)	Mean (SD)	33.8 (2.2)	34.9 (1.4)	34.0 (2.4)	35.1 (1.9)	34.1 (1.9)	33.5 (3.2)	33.4 (2.5)	33.5 (3.2)	33.4 (2.5)	33.5 (2.1)
	Range	29–38	33–37	29–37	32–38	32–37	29–38	30–38	29–38	30–38	32–38
Birth Weight (g)	Mean (SD)	1984 (435)	2208 (449)	2073 (504)	2166 (398)	2021 (383)	1946 (492)	1904 (305)	1946 (492)	1904 (305)	1776 (309)
	Range	992–3005	1644–3005	1219–3005	1673–3005	1644–3005	1219–3005	1588–2608	1219–3005	1588–2608	992–2211
Maternal (years)	Mean (SD)	15.0 (2.8)	16.4 (1.6)	16.8 (1.8)	16.2 (2.5)	16.1 (2.4)	13.9 (2.6)	12.1 (2.0)	13.9 (2.6)	12.1 (2.0)	14.4 (2.7)
	Range	10–20	14–18	14–20	11–20	11–18	10–16	10–16	10–16	10–16	11–18
CNS Injury	None (%)	14 (35.0%)	3 (30.0%)	5 (31.3%)	6 (37.5%)	3 (21.4%)	5 (35.7%)	5 (41.7%)	5 (35.7%)	5 (41.7%)	5 (35.7%)
	Mild (%)	19 (47.5%)	5 (50.0%)	8 (50.0%)	10 (62.5%)	10 (71.4%)	6 (42.9%)	5 (41.7%)	6 (42.9%)	5 (41.7%)	7 (50.0%)
	Moderate Severe	7 (17.5%)	2 (20.0%)	3 (18.8%)	0 (0.0%)	1 (7.1%)	3 (21.4%)	2 (16.7%)	3 (21.4%)	2 (16.7%)	2 (14.3%)

Note. Central Nervous System (CNS) Damage Classification: *None*: no detectable abnormality on auditory brainstem evoked response (ABR) or cranial ultrasound (CUS); *Mild*: abnormality on ABR and/or slight abnormality on CUS; or *Moderate-Severe*: detectable abnormality on ABR and CUS with evidence of intraventricular hemorrhage with or without cysts or ventriculomegaly > 5mm

Table 2
Coding Schemes Outlining Categories of Social Engagement, Gestural Communication, and Imitation

Coding Scheme	Description
Direct Social Engagement States	Standard: duration greater than 3 seconds
<i>Coordinated Joint Engagement</i>	Engagement with another person involving an object, with attention to both the object and the other person (joint attention)
<i>Dyadic Engagement</i>	Face-to-face mutual gaze; engagement with a person without objects
<i>Supported Joint Engagement</i>	Child responds to object introduced by another person with no attention to the person
Other Engagement States	
<i>Onlooking</i>	Child observes another person's activity but does not take part in the activity
<i>Object Manipulation</i>	Solitary object play
<i>Unengaged</i>	Child does not engage with or look at a person or object
Gestural Communication	
<i>Pointing</i>	Child extends arm, hand, and/or finger to coordinate their own or another's attention towards an object
<i>Showing</i>	Child presents an object to another person by raising the object upward and motionless for longer than one second
Imitative Behaviors	Standard: initial behavior and act of imitation within 15 seconds of one another
<i>Vocal Imitation</i>	Child imitates speech sounds, words, or utterances of another person
<i>Object Use Imitation</i>	Child imitates the use of an object demonstrated by another person

Table 3
Mean Rates per 10-minute Session of Twins' Social Interactions by Partner (standard
deviations in parentheses; n = 96)

Infant Behavior	Partner		Z (p-value)
	Sibling	Mother	
Coordinated Joint Engagement	.81 (1.63)	3.69 (3.44)	6.92 ($< .001$)
Dyadic Engagement	.37 (.67)	2.88 (2.55)	7.33 ($< .001$)
Supported Joint Engagement	.62 (1.01)	3.42 (3.17)	6.08 ($< .001$)
Onlooking	3.79 (3.17)	1.40 (1.55)	-2.06 (.04)
Showing	.33 (1.10)	3.71 (5.17)	6.83 ($< .001$)
Vocal Imitation	.29 (.84)	1.96 (3.29)	5.83 ($< .001$)
Object Use Imitation	1.17 (2.16)	1.58 (2.17)	2.80 (.005)

Mean Rates per 10-minute Session of Twins' Social Interactions by Partner and Age at Observation (standard deviations in parentheses)

Table 4

	Age at Observation (months)						
	7 (N = 10)	10 (N = 16)	13 (N = 16)	16 (N = 14)	19 (N = 14)	22 (N = 12)	25 (N = 14)
<i>Engagement States</i>							
Coordinated Joint w/ Mother	.29 (.47)	.51 (.74)	3.00 (3.23)	4.77 (3.05)	6.04 (3.04)	5.33 (3.43)	5.70 (3.02)
Coordinated Joint w/ Sibling	.07 (.23)	.06 (.26)	.12 (.33)	.49 (.90)	.67 (.99)	2.26 (2.15)	2.21 (2.72)
Dyadic w/ Mother	2.07 (2.39)	2.83 (3.11)	2.90 (2.74)	2.64 (2.12)	2.86 (2.33)	3.28 (1.59)	3.43 (3.20)
Dyadic w/ Sibling	.57 (.66)	.16 (.45)	.29 (.67)	.34 (.71)	.42 (.74)	.58 (.80)	.35 (.73)
Supported Joint w/ Mother	5.54 (2.54)	7.48 (3.00)	4.58 (1.85)	2.51 (2.24)	1.98 (1.91)	.96 (1.38)	.40 (.61)
Supported Joint w/ Sibling	.00 (.00)	.00 (.00)	.87 (1.14)	.90 (1.16)	.69 (1.05)	1.45 (1.37)	.42 (.50)
Onlooking of Mother	.77 (.84)	2.26 (2.06)	1.28 (1.57)	1.86 (2.12)	1.26 (.71)	1.02 (.99)	1.03 (1.33)
Onlooking of Sibling	5.55 (4.34)	3.64 (2.67)	4.67 (3.15)	3.67 (3.28)	2.74 (3.08)	3.10 (2.98)	3.48 (2.82)
Onlooking of Mother & Sibling	1.41 (1.45)	3.87 (3.04)	3.33 (2.58)	2.43 (1.97)	2.64 (2.11)	3.18 (2.76)	2.02 (1.43)
<i>Gestural Communication</i>							
Showing to Mother	.00 (.00)	.06 (.25)	1.94 (2.32)	5.51 (5.47)	7.06 (5.62)	6.84 (6.32)	4.69 (6.12)
Showing to Sibling	.00 (.00)	.00 (.00)	.06 (.24)	.42 (.74)	.14 (.36)	1.60 (2.59)	.29 (.73)
<i>Imitative Behaviors</i>							
Vocal Imitation of Mother	.00 (.00)	.58 (1.08)	.00 (.00)	2.32 (2.81)	2.63 (3.67)	3.66 (5.07)	4.69 (3.62)
Vocal Imitation of Sibling	.00 (.00)	.05 (.20)	.00 (.00)	.49 (1.00)	.34 (.47)	.00 (.00)	1.10 (1.68)
Object Imitation of Mother	.62 (.65)	1.16 (.90)	.70 (1.43)	2.19 (2.38)	2.45 (2.88)	1.46 (1.86)	2.40 (3.19)
Object Imitation of Sibling	.83 (1.15)	.89 (1.03)	.43 (.81)	2.65 (3.79)	.94 (2.03)	2.16 (3.02)	.50 (.64)

Table 5
Results of Regression Discontinuity Analyses Indicating at What Ages Twins’
Coordinated Joint Engagement, Showing Gestures, and Vocal Imitation Increased by
Partner (Rates per 10-minute Session)

<i>Age at Observation</i>	Coordinated Joint Engagement		Showing Gesture		Vocal Imitation	
	Mother <i>z</i>	Sibling <i>z</i>	Mother <i>z</i>	Sibling <i>z</i>	Mother <i>z</i>	Sibling <i>z</i>
10 months	--	--	--	--	--	--
13 months	2.68 [*]	--	3.24 ^{**}	--	--	--
16 months	-.33	--	1.02	--	3.70 ^{**}	--
19 months	-.28	--	-.57	--	-1.15	--
22 months	-.96	1.62	-.46	--	.28	--
25 months	.47	-1.11	-.59	-1.85	.00	3.07 [*]

Note.

^{*}
 $p < .01$,

^{**}
 $p < .001$

Table 6
Mean Rates per 5-minute Segment of Twins' Social Interactions (standard deviations in parentheses; n = 96)

Infant Behavior	Position of Mother		Z (P-value)
	Chair	Floor	
<i>Engagement States</i>			
Coordinated Joint Engagement	1.20 (2.07)	3.71 (3.65)	6.27 ($< .001$)
Dyadic Engagement	1.71 (1.79)	1.54 (1.74)	-0.49 (.62)
Supported Joint Engagement	.67 (1.28)	3.66 (3.23)	6.39 ($< .001$)
Onlooking	3.67 (3.21)	4.31 (3.21)	2.35 (.02)
Object Manipulation	7.17 (3.70)	9.31 (3.66)	4.12 ($< .001$)
Unengaged	1.80 (2.63)	.54 (1.20)	-4.55 ($< .001$)
<i>Gestural Communication</i>			
Pointing	.68 (2.36)	1.44 (3.07)	3.59 ($< .001$)
Showing	1.36 (2.44)	2.68 (4.28)	2.95 (.003)
<i>Imitative Behaviors</i>			
Vocal Imitation	.29 (1.02)	1.96 (3.27)	6.08 ($< .001$)
Object Use Imitation	.75 (1.64)	2.01 (2.66)	5.24 ($< .001$)

Table 7
Mean Rates per 5-minute Segment of Twins' Social Interactions by Partner (standard deviations in parentheses; n = 96)

Infant Behavior	Position of Mother					
	Chair			Floor		
	Partner			Partner		
	Sibling	Mother	Z (P-value)	Sibling	Mother	Z (P-value)
<i>Engagement States</i>						
Coordinated Joint Engagement	.64 (1.49)	.53 (1.15)	−0.74 (.46)	.19 (.45)	3.16 (3.12)	7.47 ($< .001$)
Dyadic Engagement	.24 (.51)	1.47 (1.70)	6.08 ($< .001$)	.13 (.38)	1.42 (1.70)	6.70 ($< .001$)
Supported Joint Engagement	.39 (.73)	.26 (1.03)	−2.82 (.005)	.23 (.48)	3.15 (3.19)	7.12 ($< .001$)
Onlooking	2.67 (2.55)	.59 (1.07)	−6.85 ($< .001$)	1.13 (1.47)	.81 (1.22)	−1.25 (.21)
<i>Gestural Communication</i>						
Showing	.24 (.78)	1.12 (2.18)	5.12 ($< .001$)	.10 (.51)	2.58 (4.13)	6.99 ($< .001$)
<i>Imitative Behaviors</i>						
Vocal Imitation	.18 (.63)	.11 (.84)	−2.28 (.02)	.11 (.42)	1.85 (3.22)	6.37 ($< .001$)
Object Use Imitation	.70 (1.63)	.05 (.33)	−4.79 ($< .001$)	.48 (1.12)	1.53 (2.17)	4.85 ($< .001$)