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BRIEF REPORTS

Two-Month-Old Infants' Sensitivity to Social Contingency in Mother–Infant and Stranger–Infant Interaction

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Two-month-old infants ($N = 29$) participated in face-to-face interactions with their mothers and with strangers. The contingent responsiveness for smiles and vocalizations, while attending to the partner, was assessed for each partner in both interactions. For smiles and for vocalizations, infants were less responsive to the stranger relative to the mother when the stranger's contingent responsiveness was either more contingent or less contingent than that of the mother. Results are supportive of the hypothesis that young infants develop sensitivities to levels of social contingency present in their maternal interactions, which influence their responsiveness to others.

Infants' early awareness of the contingency between self-actions and external consequences occurs most readily in parent–infant face-to-face social interactions (Neisser, 1991). Parents tend to respond contingently to infants' vocalizations, gestures, and facial affect. For infants under 6 months, parental responses to infant

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behavior are primarily modified imitations of infants' actions that parents perceive to contain emotional content (Stern, 1985; Stern, Hofer, Haft, & Dore, 1985). Individual differences in parental contingent responsiveness to infant behaviors are thought to be stable within mother–infant dyads from the time infants are 2 to 3 months of age, but vary across the population (Stern et al., 1985; Watson, 1985).

Parental responsiveness within parent–infant interactions may create preferred contingency levels through familiarization, which are reflected in infants' responsiveness to new social partners (Bower, 1982; Watson, 1985). Watson (1985) hypothesized that infants will be most responsive to people whose level of contingency is similar to that of their parents. Bigelow (1998) found support for this hypothesis. Four- and 5-month-old infants were most similar in their responsiveness to mothers and strangers when the strangers' contingent responsiveness to them resembled that of their mothers, and infants were less responsive to strangers, relative to their mothers, when strangers' contingent responsiveness was either more contingent or less contingent than that of their mothers.

This study investigated whether 2-month-old infants show this sensitivity to familiar contingency levels. The beginning of bidirectional social exchanges between infants and other people is marked by infants manifesting socially elicited smiles in face-to-face interactions around 2 months of age (Rochat, 2001). These reciprocal exchanges involve attentional, vocal, and postural transactions as well as facial expressions. Infants at 2 months of age are responsive to disruptions in social contingency as evidenced by their reactions to the still-face and replay procedures (Adamson & Frick, 2003; Murray & Trevarthen, 1985; Nadel, Carchon, Kervella, Marcelli, & Réserbat-Plantey, 1999; but see Bigelow & DeCoste, 2003; Rochat, Neisser, & Marian, 1998). Yet how sensitive infants this young are to differences in others' social responsiveness to them remains an open question.

In this study, 2-month-old infants participated in face-to-face interactions with their mothers and with strangers. Contingent responsiveness was assessed for each partner in both interactions. Watson's (1985) hypothesis predicts that infants would be more similar in their contingent responsiveness to mother and stranger when the stranger's contingent responsiveness to the infant resembled the mother's contingent responsiveness to the infant, and infants would be less responsive to the stranger relative to mother when the stranger was either more contingent or less contingent than the mother.

METHOD

Participants

Participants were 29 infants (*M* age = 68 days, *SD* = 9 days; 12 males and 17 females) and their mothers. Five additional infants were excluded, 1 for excessive

crying and 4 for equipment or procedural error. The infants were from a university town and the surrounding area in eastern Canada. They were located through newspaper birth announcements.

Socioeconomic status (SES) of the infants' families was measured by a Canadian index (Blishen, Carroll, & Moore, 1987) based on education, income, and occupational prestige. In the index, occupations are divided into 514 groups, ranging from SES scores of 17.81 to 101.74 ($M = 42.74$, $SD = 13.28$). The scores of the higher status parent in the participants' families yielded an SES mean of 50.50 ($SD = 16.69$). Most of the participants' parents had a college degree or more (47%), 30% had some postsecondary education, 21% had only a high school degree, and 2% had not finished high school. Racial and ethnic composition of the infants' families was 100% non-Hispanic White.

Materials and Procedure

The study took place in a laboratory room. The mother–infant dyads were scheduled in pairs so that the mother of one infant was the stranger to the other infant. A female experimenter took demographic information from the mothers and explained the procedure. Then one infant and one adult were taken to a three-sided booth made from room dividers, while the other infant and adult waited in another room. In the booth, the infant was placed in an infant seat attached to a table (55 cm [H] × 75 cm [W] × 150 cm [L]). A chair for the adult faced the infant seat 1 m away. Three video cameras were used. One, positioned above and to the side of the adult when seated in the chair, recorded the frontal view of the infant. A second, positioned above and to the side of the infant seat, recorded the frontal view of the adult. A third, mounted on the wall, recorded a side view of the dyad. The cameras were connected to a four-way split-screen monitor located outside the booth (the fourth screen was blank).

The infants engaged in two 5-min face-to-face interactions with the adults, who were told to interact normally with the infants. In the mother condition, mothers were the social partners. In the stranger condition, mothers of other infant participants were the social partners. The order of the mother and stranger conditions was counterbalanced.

Measures

The videotapes of the mother and stranger conditions were scored for attention, smiles, and vocalizations, using a real-time microcomputer coding program, REAL-TIME, developed by Symons, Acton, and Moran (1990). Attention was scored as the presence or absence of looking at the partner. Smiles were scored as upward lip movements with or without vocalizations or sudden noticeable increases in

such upward lip movements with or without vocalizations. Vocalizations excluded fussing, crying, and digestive sounds (e.g., burps, hiccups). For each 5 min of adult–infant interaction, six passes of the videotape were scored: attention, smiles, and vocalizations for the infant and attention, smiles, and vocalizations for the adult. Behaviors were scored for their onset and offset. After scoring each of the partners, the data files were merged using Symons et al.'s (1990) TMERGE program.

For reliability purposes, two coders independently scored 14% of the adult–infant interactions. The proportion of agreement (Roberts, 2005), within a time tolerance of 1 sec between coders, for infant behaviors was .86 for attention, .74 for smiles, and .75 for vocalizations and for adult behaviors was .95 for attention, .71 for smiles, and .82 for vocalizations.

Smiles that cooccurred with attention and vocalizations that cooccurred with attention were the critical behaviors. Of particular interest was each partner's critical behavior that followed within a 1-sec window the onset of a similar critical behavior by the other partner. A 1-sec window was chosen because, in mother–infant face-to-face interactions, smiling responsiveness tends to occur within 1 sec (Bigelow, 1998; Bloom, Russell, & Wassenberg, 1987; Symons & Moran, 1994), and infants' vocalizations in face-to-face interactions tend to occur most frequently during pauses in adults' speech (Mayer & Tronick, 1985), which last approximately 1 sec (Papousek, Papousek, & Bornstein, 1985). Measures of contingent responsiveness were adjusted residuals (Bakeman & Gottman, 1997) using Watson's (1979, 1985) contingency magnitude scores. Contingency magnitude for each partner's critical behavior was calculated from the merged real-time data as the difference between observed conditional probabilities (e.g., probability of smile onset by partner A follows, within a 1-sec window, smile onset by partner B) and expected unconditional probabilities (e.g., probability of smile onset by partner A).

RESULTS

Four contingent responsiveness scores (adjusted residuals) were calculated for each infant for smiles and vocalizations: mother's contingent responsiveness to infant (Mi), infant's contingent responsiveness to mother (Im), stranger's contingent responsiveness to infant (Si), and infant's contingent responsiveness to stranger (Is). Table 1 shows the means and standard deviations for the contingent responsiveness scores of each of the partners and for the number of smiles and vocalizations by each of the partners. Table 2 shows the correlations among the contingent responsiveness scores, which were all nonsignificant.

Preliminary analyses of variance (ANOVAs) for order effects (mother condition vs. stranger condition first) and sex of infant indicated no significant effects in any of the dependent variables. Thus, order and sex were excluded as variables in subsequent analyses.

TABLE 1
Contingent Vocal and Smiling Responsiveness Scores of Each Partner and Number of Vocalizations and Smiles by Each Partner With Partial Eta Squared for Analyses of Variance

	From or to Mother		*From or to Stranger*		
	M	*SD*	*M*	*SD*	$p\eta^2$
Contingent responsiveness					
Adult to infant					
Smiles	.850[a]	1.862	.316[a]	1.607	.024
Vocalizations[b]	−.272	1.104	−.672[a]	1.436	.057
Infant to adult					
Smiles	.920[a]	1.433	.074[a]	1.190	.251
Vocalizations[b]	−.376	.999	−.145[a]	1.139	.029
Number of behaviors					
Adult to infant					
Smiles	23.9	9.2	22.7	9.8	.012
Vocalizations	132.7	20.0	132.1	27.5	.000
Infant to adult					
Smiles	9.8	8.6	8.8	8.2	.013
Vocalizations	25.5	14.6	21.5	16.3	.050

Note. $N = 29$.

[a]Contingent responsiveness scores require both adult and infant to have performed the critical behavior. Only 28 of the 29 infants performed the critical behavior in these instances. [b]Mean contingent responsiveness scores for vocalizations are negative because they included cases in which vocalizations by the responding partner did not follow within 1 sec the onset of any vocalizations by the other partner, although both partners vocalized. Contingent responsiveness scores for these cases were negative.

TABLE 2
Correlations Among Contingent Responsiveness Scores

	Smiles				*Vocalizations*			
	Mi	*Si*	*Im*	*Is*	*Mi*	*Si*	*Im*	*Is*
Smiles								
Mi								
Si	−.04							
Im	.16	.24						
Is	.00	.01	.31					
Vocalizations								
Mi	−.01	.03	.03	.05				
Si	−.08	−.03	−.25	−.10	.14			
Im	.27	.22	.11	.13	−.28	−.12		
Is	.11	−.08	.15	.09	−.02	−.32	−.03	

Note. Mi = mothers' contingent responsiveness scores to infants; Si = strangers' contingent responsiveness scores to infants; Im = infants' contingent responsiveness scores to mothers; Is = infants' contingent responsiveness scores to strangers.

Repeated measures (adult partners) ANOVAs were conducted on the contingent smiling and vocal responsiveness scores of adults to infants and infants to adults and on the number of smiles and vocalizations made by adults to infants and by infants to adults. As indicated by the partial etas-squared in Table 1, only the contingent responsiveness of infants' smiles to adults' smiles was significant, $F(1, 26) = 8.71$, $p = .007$. Infants, as a group, smiled more contingently to their mothers' smiles than to the strangers' smiles.

Repeated measures ANOVAs comparing mothers' behavior to their own infants and to unfamiliar infants were nonsignificant for number of smiles and vocalizations, and contingency of smiles and vocalizations. Mothers were similarly expressive and contingent in each behavior across infants.

The correlation between mothers' contingent smiling responsiveness and contingent vocal responsiveness was nonsignificant, indicating that mothers' contingency in one behavior was not predictive of their contingency in the other behavior. When mothers' contingent smiling and vocal responsiveness scores were ranked, 24% of the mothers were in the top half of the contingency ranking for both behaviors, 79% were in the top half in at least one of the behaviors, and 21% did not rank in the top half in either of the behaviors.

To measure how similar mothers and strangers were in their contingent responsiveness to infants, strangers' contingent responsiveness scores to infants (Si) were subtracted from the mothers' contingent responsiveness scores to infants (Mi). Likewise, to measure how similar infants were in their contingent responsiveness to mothers and strangers, infants' contingent responsiveness scores to strangers (Is) were subtracted from infants' contingent responsiveness scores to mothers (Im).

Watson's (1985) hypothesis would predict a U-shaped curve when infants' contingent responsiveness to mothers minus infants' contingent responsiveness to strangers (Im–Is) is plotted against mothers' contingent responsiveness to infants minus strangers' contingent responsiveness to infants (Mi–Si). Infants' responsiveness to mother and stranger would be most similar when mother's and stranger's contingent responsiveness to the infant is similar. However, if the mother's and stranger's contingent responsiveness differed in either a positive direction (mother was more contingent than stranger) or a negative direction (stranger was more contingent than mother), infants would be less contingently responsive to strangers than to mothers.

Figure 1 for smiles and Figure 2 for vocalizations show that for such plots the resultant curve is U-shaped, corresponding to a significant quadratic trend. Trend analyses were conducted on the data using a multiple regression approach (Pedhazur, 1982). Arbitrarily Im–Is was used as the dependent variable and the predictors were Mi–Si (linear trend), $(Mi–Si)^2$ (quadratic trend), and $(Mi–Si)^3$ (cubic trend). The linear trend was entered first in the regression equation, followed by the quadratic trend, and then the cubic trend. This procedure allowed an assessment of the percentage of variance accounted for in Im–Is by each trend,

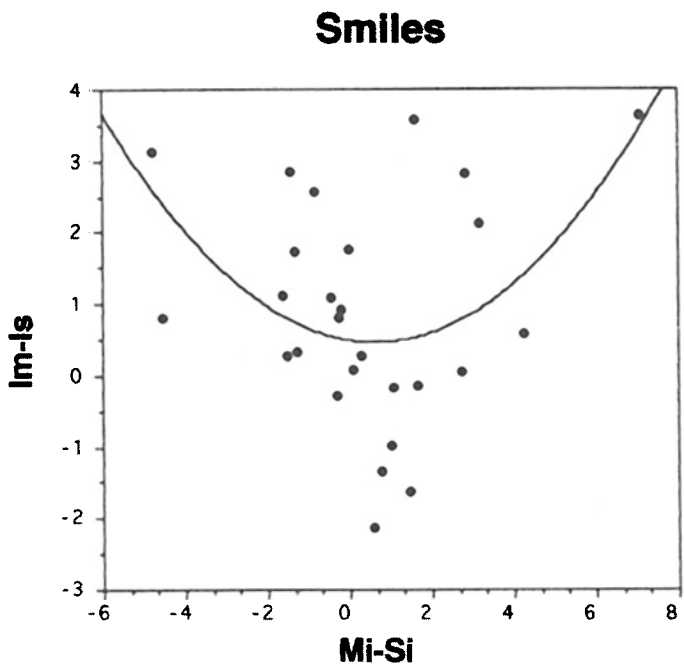

FIGURE 1 The relational plot of the difference between the infants' contingent smiling responsiveness to mothers and strangers (Im–Is) and the difference between mothers' and strangers' contingent smiling responsiveness to the infants (Mi–Si).

over and above the contribution of the previously entered trends. Table 3 shows the R^2 for the linear trend and the changes in R^2 for the quadratic and cubic trends from the previous trend(s) for smiles and vocalizations. Only the quadratic trends were significant. For smiles, the quadratic trend, $F(1, 24) = 6.94$, $p < .025$, accounted for 22% of the variance in Im–Is. For vocalizations, the quadratic trend, $F(1, 25) = 4.80$, $p < .05$, accounted for 15% of the variance in Im–Is.[1]

[1]To determine whether the significant quadratic trends were driven by a few participants, trend analyses (Pedhazur, 1982) were conducted on the smiling data without the four cases with Mi–Si scores greater than 4 absolute and on the vocalizations data without the two cases with Mi–Si scores greater than 2 *SDs* from the mean. For smiling, only the quadratic trend was significant, $F(1, 20) = 6.11$, $p < .025$, accounting for 23% of the variance in Im–Is when the linear trend was partialed out. R^2 was .004 for the linear trend; changes in R^2 from the previous trends were .233 for the quadratic trend and .038 for the cubic trend. For vocalizations, only the quadratic trend was significant, $F(1, 23) = 5.66$, $p < .05$, accounting for 19% of the variance in Im–Is when the linear trend was partialed out. R^2 was .017 for the linear trend; changes in R^2 from the previous trends were .194 for the quadratic trend and .051 for the cubic trend.

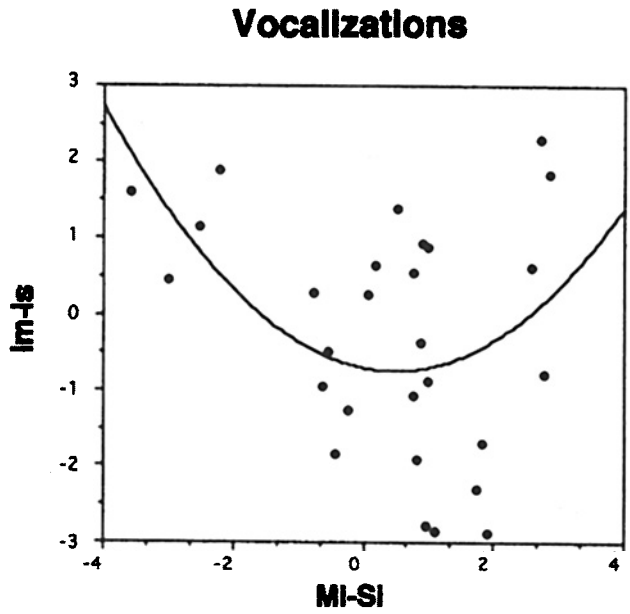

FIGURE 2 The relational plot of the difference between the infants' contingent vocal responsiveness to mothers and strangers (Im–Is) and the difference between mothers' and strangers' contingent vocal responsiveness to the infants (Mi–Si).

TABLE 3
R^2 for Linear Trend and Changes in R^2 for Quadratic and Cubic Trends From Previous Trend(s) for Smiles and Vocalizations

	Mi–Si Trend		
	Linear	*Quadratic*	*Cubic*
Smiles	.001	.224	.011
Vocalizations	.062	.151	.078

Note. Mi–Si = mothers' contingent responsiveness to infants minus strangers' contingent responsiveness to infants.

DISCUSSION

By 2 months of age, infants' responsiveness to new partners is influenced by how similar those partners' contingency levels are to the contingency levels with which the infants are most familiar. The quadratic trends depicted for smiling contingency in Figure 1 and for vocal contingency in Figure 2 indicate that infants are less

responsive to strangers relative to mothers when strangers' contingency levels were either more contingent or less contingent than those of mothers, supporting Watson's (1985) hypothesis that infants become sensitive to the contingency levels experienced in maternal social interactions.

The similarities and differences, shown in Table 4, between the performance of 2-month-old infants and their adult partners in this study and the performance of 4- to 5-month-old infants and their partners in Bigelow's (1998) study reveal developments in infants' sensitivity to familiar contingency levels. Familiar contingency levels are embedded in mother–infant routines in face-to-face interactions that become established over the infants' first months of life, particularly between 2 months, when infants' interest in face-to-face interactions emerges (Rochat, 2001), and 4 to 5 months, when their interest in face-to-face interactions is at its height (Lamb, Morrison, & Malkin, 1987). Both younger and older infants smiled and vocalized as much to strangers as to mothers. Yet the older infants smiled and vocalized more contingently to mothers than to strangers; the younger infants were more contingent to mothers than to strangers only with their smiles. Infants may become more contingently responsive to mothers than to strangers across different modalities as their experience with mother–infant interactions increases. The younger infants and their adult partners had higher numbers of smiles and vocalizations but lower contingent responsiveness scores in smiles and vocalizations than the older infants and their adult partners, indicating that at 2 months the dyads were expressive but the interactions were less reciprocal and responsive than at 4 to 5 months. Indeed, in Bigelow's (1998) study, strangers smiled more often than did mothers, which was interpreted as strangers' attempts to engage infants in the absence of established reciprocal mother–infant routines.

The younger infants were more variable in their contingent responsiveness difference scores (Im–Is), suggesting that although infants showed sensitivity to familiar contingency levels at 2 months, this sensitivity becomes more stable by 4 to 5 months. The variability in younger infants' contingent responsiveness difference scores was particularly prevalent when mothers' and strangers' contingency levels were similar (when Mi–Si scores clustered around zero). Older infants may be more sensitive to familiar contingency levels, responding to strangers whose contingency levels are familiar as they do in their maternal interactions, whereas younger infants may be reactive to strangers' contingency levels particularly when the levels are dissimilar to those that are becoming familiar, responding to the dissimilarity with less contingency. That some 2-month-old infants were more responsive to mothers than strangers even when mothers' and strangers' contingency levels were similar is not surprising given that mothers' face and voice as well as emerging mother–infant face-to-face routines were more familiar. Yet some young infants were more responsive to strangers than mothers when the adults' contingency levels were similar. In other studies where infants' responsiveness to strangers was greater than to mothers, the strangers were

TABLE 4
Comparisons Between Performance in 2-Month-Old and 4- to 5-Month-Old Infant–Mother and Infant–Stranger Face-to-Face Interactions

Similarities	*Differences*
Adult Behaviors	
Within each age group, mothers and strangers were similar in the number of vocalizations made to infants.	When interacting with older infants, strangers produced more smiles than mothers; with younger infants, strangers and mothers were similar in the number of smiles made to infants.
Within each age group, mothers and strangers were similar in their contingency to infants with both smiles and vocalizations.	Adult partners of younger infants had higher mean number of smiles and vocalizations but lower mean contingent smiling and vocal responsiveness scores than adult partners of older infants.
Mothers' contingent responsiveness in one behavior (vocalizations, smiles) was not predictive of mothers' contingent responsiveness in the other behavior.	
When mothers' contingent smiling and vocal responsiveness scores were ranked, most mothers were in the top half of the contingency ranking in only one of the behaviors.	
Infant Behaviors	
Within each age group, infants did not differ in the number of smiles or number of vocalizations made to mothers and strangers.	Older infants smiled and vocalized more contingently to mothers than to strangers; younger infants smiled more contingently to mothers than to strangers but did not differ in their contingent vocalizations to mothers and strangers.
	Younger infants had higher mean number of smiles and vocalizations but lower mean contingent smiling and vocal responsiveness scores than older infants.
Relation Between Contingent Responsiveness Difference Scores	
For both smiles and vocalizations, significant quadratic trends resulted when Im–Is was plotted against Mi–Si, indicating infants were similar in contingent responsiveness to mothers and strangers when strangers' and mothers' contingent responsiveness scores were similar and infants were less contingently responsive to strangers, relative to mothers,	For both smiles and vocalizations, younger infants' contingent responsiveness difference scores (Im–Is) were more variable than those of older infants, particularly when mothers' and strangers' contingent responsiveness scores were similar (Mi–Si clustered around zero). The variance of Im–Is for the younger infants who interacted with mothers and strangers who were

(continued)

TABLE 4 *(Continued)*

Similarities	*Differences*
when strangers' contingent responsiveness scores were either more contingent or less contingent than those of mothers.	similar in contingent responsiveness (Mi–Si within .5 SD from the mean) was 2.61 for smiles and 2.03 for vocalizations; for older infants the variance was 1.17 for smiles and .62 for vocalizations.

Note. The performance of the 4- to 5-month-old infants and their adult partners is reported in Bigelow (1998), with the exception of the variance for Im–Is scores of infants whose adult partners' Mi–Si scores were within .5 SD of the mean. Im–Is = infants' contingent responsiveness to mothers minus infants' contingent responsiveness to strangers; Mi–Si = mothers' contingent responsiveness to infants minus strangers' contingent responsiveness to infants.

trained or selected for their sensitivity in interactions with infants. Jaffe, Beebe, Feldstein, Crown, and Jasnow (2001) found vocal interactions between 4-month-old infants and their mothers to be less bidirectionally coordinated than vocal interactions between the infants and strangers who were trained to be responsive and sensitive to infant behavior. When investigating interactions of depressed mothers and their infants, Field (1987) found 3-month-old infants mirrored their mothers' depressed affect, but when paired with nondepressed social partners who were selected for their sensitivity to infant behavior, the infants became more responsive (Field et al., 1988). Interestingly, during the stranger–infant interactions, these infants elicited what appeared to be depressed behavior from their nondepressed partners. Sensitive partners, with or without awareness, may adjust their contingency levels to levels where infants are most engaged, which are the levels with which the infants are most familiar. In this study, strangers were mothers of other infant participants. When the stranger's contingency level was similar to that of the mother, the familiarity of the contingency level coupled with the novelty of the new person may have made the interactions particularly engaging for some young infants. However, when novelty of the stranger was paired with unfamiliar contingency levels, infants were less engaged with strangers than with mothers. Although the novelty of interaction with strangers can be interesting to young infants, infants' experience with maternal contingency levels influences their interactions with new people.

Mothers were similarly expressive with their own and unfamiliar infants, yet the means that they used were individually distinctive, which supports previous findings that mothers have individual patterns in the behaviors they most frequently use to respond to their infants (Bigelow, 1998; Stern et al., 1985) and that these patterns persist across infants (Kaye, 1982). Approximately a quarter of the mothers were high in contingent responsiveness for both smiles and vocalizations but most were only high on one behavior, and 21% were low on both, although

other modes of maternal contingency, such as tactile contingency, were not measured. As in Bigelow's (1998) study, mothers' smiling responsiveness and vocal responsiveness were unrelated. Yet in each behavior, infants were sensitive to the familiar levels of contingency experienced with their mothers.

Limitations to this study are several. The sample was small and homogeneous. Although the significant trends obtained with the small sample suggest the findings are robust, whether infants from diverse populations would demonstrate similar sensitivities to familiar social contingency remains to be tested. The contingency levels were modality specific and, therefore, conservative. Adults may contingently respond to infants' behavior in cross-modal ways, although in the first 6 months of life, adults' responses to infants tend to be imitative of the infants' behavior (Stern, 1985). The data were obtained from interactions in a laboratory setting. Jaffe and colleagues (2001) showed differences in mother–infant and stranger–infant interaction synchrony in laboratory and home environments, indicating that the generalizability from laboratory data may be limited. Nevertheless, the findings suggest that 2-month-old infants are sensitive to familiar contingency levels.

Young infants' intimate relationships impact the levels of engagement they bring to social encounters with others. By 2 months of age, infants' experience with maternal contingency levels affects their responsiveness to others. Although infants' responsiveness to differing contingency levels can expand, particularly as they enlarge their social networks, the ease with which new relationships are formed may be influenced by the similarity between others' interactive contingencies and the contingencies with which infants are most familiar.

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