

THE EFFECTS OF CONTINGENCY IN PREVIOUS INTERACTIONS ON INFANTS' PREFERENCE FOR SOCIAL PARTNERS

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A short-term longitudinal study with 4- and 5-month-old infants investigated whether infants' prior experience with contingency or noncontingency in social interactions with specific others affects infants' preference for these others in subsequent interactions. On Session 1 infants were simultaneously presented with social interaction from two strangers via video, one was interacting contingently and one was interacting noncontingently (a replay of the stranger interacting with another infant). On Session 2 six days later, the same two strangers were simultaneously presented to the infant again; this time both interacted contingently. The infants attended more to the contingent stranger on Session 1 and to this same stranger on Session 2. The results indicate that infants prefer to attend to people who have been responsive to them in the past compared to those who have not and that 4- and 5-month-olds can maintain expectations for responsiveness based on previous encounters for at least six days.

contingency social interaction attention smiling memory

The formation of infants' early self-knowledge depends on their ability to perceive contingency between their self-actions and external consequences. Such self-knowledge is based on perception and arises prior to representation (Neisser, 1991). By noticing the relation between their own actions and resultant

external changes, infants develop a sense that they are agents of those changes. This sense of self-efficacy develops readily in infants' early social interactions with others. The responses that are most effective in facilitating infants' early self-knowledge are socially contingent, reciprocally reflecting the infants' own behav-

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ior (Rochat, 1995). In naturally occurring interactions between parents and young infants, parental responses are primarily imitations of the infants' actions (Stern, 1985). These imitations are not exact but rather match the infants' actions in intensity, affect, and tempo. Infants may more easily recognize the external effect of their behavior when the actions of others mirror the behavior the infants produce (Gergely & Watson, 1996, 1999).

Although parental responses to infants' actions tend to be imitative, they are not perfectly contingent. Parents respond to behavior they perceive to contain emotional content; the parental responses reflect to the infants the emotional content the parents perceive, mirroring the infants' behavior in a marked but selected manner (Gergely & Watson, 1996, 1999). Parental levels of imperfect contingencies to infant behavior have been shown to be stable within parent-infant pairs but vary across the normal population (Stern, Hofer, Haft, & Dore, 1985). This stability within dyads and variability in the population is believed to be present by the time the infants are 3-months old (Watson, 1985). Infants' sensitivity to social contingency levels in interactions with others is influenced by the level of imperfect contingency present in their early parent-child interactions. Infants tend to be most responsive to social partners whose levels of contingency to them are similar to the levels with which they are familiar in their parental interactions (Bigelow, 1998). Thus, the contingency present in infants' intimate relationships may set the levels at which infants search for evidence of their effectiveness in the world, which, in turn, influences their subsequent developmental processes. Individual differences in parents' contingent responsiveness to their infants are reflected in the quality of infants' attachments (Blehar, Lieberman, & Ainsworth, 1977), in their emotional responsiveness (Field et al., 1988; Stern, 1985), and in their coping strategies and cognitive mastery (Dunham & Dunham, 1990; Lamb & Easterbrooks, 1981).

The imperfect contingency present in early

social exchanges with infants may be key to infants' interest in these interactions. Watson (1979, 1985) found that learning scores of infants controlling visual and auditory displays by their kicks to a motion sensitive pillow were reduced in conditions of noncontingency and perfect contingency and were highest at levels of moderately imperfect contingency. There is cognitive advantage to the reduction of arousal to perfect contingency in that it avoids the unproductive investment of attention and energy to the intrinsic perfect contingencies inherent in actions on the self (e.g., sucking on one's own fingers). Focusing attention on the imperfect contingencies present in the interactive behavior of others rather than on intrinsic sensations is adaptive. Infants' ability to detect differences between perfect contingency, imperfect contingency, and noncontingency is acquired early. Detecting the differences between perfect and imperfect contingency may be one of the first ways infants distinguish self from other, and detecting the differences between imperfect contingency and noncontingency may be one of their early means for distinguishing others who are interacting with them and those who are not.

Infants' contingency preferences in social behavior mirror those Watson found in non-social tasks. There are a series of studies that demonstrate infants' preference for imperfect or social contingency, present in face-to-face interactions, over noncontingency, present in videotaped replays of social partners whose interactions are unrelated to what the infant viewers are currently doing. Murray and Trevarthen (1985) were the first to present infants with contingent and noncontingent social displays. Their procedure was modeled after that used to demonstrate the still-face effect. When adults shift from active face-to-face interaction with infants to being still and expressionless, infants respond with changes in behavior, typically exhibiting reduced attention and less positive affect (Carter, Mayes, & Pajer, 1990; Ellsworth, Muir, & Hains, 1993; Field, 1981; Field, Yega-Lahr, Scafidi, & Goldstein, 1986; Fogel, Diamond, Lang-

horst, & Demos, 1982; Gusella, Muir, & Tronick, 1988; Mayes & Carter, 1990; Murray & Trevarthen, 1985; Stoller & Field, 1982; Tronick, Als, Adamson, Wise, & Brazelton, 1978). Such changes in the infants' behavior indicate that they have noticed the changes in the adults' behavior, yet the still-face effect confounds the adults' changes in contingency with the adults' changes in affectivity. That is, studies of the still-face effect remove the adults' contingent responsiveness to the infants' behavior along with the adults' exaggerated facial expressions and vocal tones characteristic of infant-directed interaction. In order to examine more specifically the effect of contingency *per se* on infants' behavior, Murray and Trevarthen replaced the still-face episodes with video replays of adults interacting with infants. They had mothers and infants interacting via video so that each partner saw and heard the other on video monitors. Then the mothers' tapes were quickly rewound and played back to the infants. In the replay the mothers' facial expressions and vocalizations were exactly as they were moments before except that the mothers' actions were unrelated to what the infants were currently doing, *i.e.*, the contingency was missing. Murray and Trevarthen reported that for the four two-month-olds tested, the response to the replay was a marked loss of positive affect and attention, much like the still-face effect.

Murray and Trevarthen's original design of this simple yet clever means of isolating infants' response to social contingency had some methodological problems. Specifically, the order of contingent and noncontingent presentations confounded changes in contingency with changes due to time; that is, the infants' behavioral change may have been due to fatigue or declining interest in watching the same person over time rather than the lack of contingency. In recent years several researchers have attempted to replicate the effect found by Murray and Trevarthen using various methodologies and age ranges (Bigelow, MacLean, & MacDonald, 1996; Hains & Muir, 1996; Muir & Hains, 1993; Nadel, 1996; Nadel & Tremblay-Le-

veau, 1999; Rochat, Neisser, & Marian, 1998). Familiarity of the adult may affect whether infants show the contingency effect. When infants interact with strangers the effect is evident (Hains & Muir, 1996). But when infants interact with mothers, some researchers have not found the effect (Hains & Muir, 1996) while others, using different procedures, have (Bigelow *et al.*, 1996). There is also debate about whether infants as young as two months show the contingency effect. Through the use of different methodologies, some researchers have replicated the findings of Murray and Trevarthen (1985) with infants this young (Nadel, 1996; Nadel & Tremblay-Leveau, 1999) and others have not (Rochat *et al.*, 1998). By four months of age, however, infants, when interacting with strangers, readily respond with reduced attention and less positive affect to the noncontingent replay condition compared to the live contingent condition.

Although most studies examining infants' reaction to contingency have presented them with sequential displays, some researchers have used simultaneous displays (Bigelow, 1996; Muir, Hains, Cao, & D'Entremont, 1996). In these studies infants were seated in front of two video monitors, on one monitor an adult responded contingently to them and on the other monitor an adult responded noncontingently to them. The noncontingent adult was a tape of an adult interacting with another infant, therefore, both adults displayed infant-directed facial and vocal expressions. Although this context is more unusual for infants, 3- to 5-month-olds were more attentive to the contingent adult than to the noncontingent adult, demonstrating that even under conditions of competing stimulation infants in the second quarter of their first year discriminate and prefer contingency present in social interaction to noncontingency present in the replay.

The concern of the present study is whether infants' prior experience of contingency or noncontingency with specific others affects their response to these others in future interactions with them. Dunham, Dunham, Hurshman, and Alexander (1989) were one of the first to dem-

onstrate that infants' experience with noncontingent social behavior had a negative carryover effect on subsequent contingent tasks. In a contingent condition, 3-month-old infants' vocal responses were socially reinforced in face-to-face interactions by an experimenter smiling, touching, and vocalizing to them. In a noncontingent condition the experimenter's social stimulation was independent of the infants' actions. Through a yoked control each infant in the noncontingent condition received the same adult social stimulation that was given to a previously tested infant in the contingent condition. Then the infants in both conditions were seated in front of a visual-auditory display that was activated only when the infants fixated on it. Infants in the noncontingent condition showed suppressed responding to the visual-auditory display, suggesting that the infants' previous experience with noncontingency in the social task had a negative carryover effect to the nonsocial task. Following Dunham et al. (1989), a number of studies have manipulated contingency in social interaction through immediate feedback and replay and found that 4- to 6-month-old infants show short-term carryover effects of noncontingency in subsequent socially contingent interactions (Bigelow et al., 1996; Hains & Muir, 1996; Muir & Hains, 1993). After infants are presented with noncontingent interaction through replay, they are less attentive to the immediately following contingent episodes with the same person, suggesting that infants form expectations about future interactions with particular others based on past interactions. These carryover effects are presumed to be short lived, effecting only the immediately following contingent interactions with the same partner. Yet studies manipulating the contingent responsiveness of nonsocial events have demonstrated that infants' expectations of contingency based on prior experience with specific objects are retained over longer periods of time.

Studies of early infant memory capacities by Rovee-Collier and colleagues indicate that infants are capable of forming expectations of contingency based on past experience in nonsocial contingent tasks (for review, see Rovee-Collier & Hayne, 1987). In these studies 2- to

6-month-old infants were trained to kick to activate a mobile suspended over their crib and connected to their ankle with a ribbon such that any movement of their foot produced a corresponding degree of movement in the overhead mobile. Retention was then assessed after delays of several days to several weeks. Three-month-old infants exhibited retention for 6 to 8 days (Sullivan, Rovee-Collier, & Tynes, 1979). This period of retention could be prolonged to two to four weeks if the infants were shown the mobile, moving at the rate it was during their original learning session, 24 hours prior to the test for long term retention (Fagen & Rovee-Collier, 1983; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Sullivan, 1982). If the infants were shown a stationary mobile, however, retention was not prolonged, indicating that it was the recognition of the dynamic action of the mobile, rather than simply what the mobile looked like, which activated the memory (Hayne & Rovee-Collier, 1995). Moreover, the infants appeared to associate the relation between their kicking and the corresponding movement of the mobile only with the mobile with which they were trained. If the test mobile contained more than one novel object compared to the original mobile, the infants did not demonstrate retention (Rovee-Collier, Patterson, & Hayne, 1985). Thus, memory was for a specific mobile that moved in a familiar way.

Infants may have a more generalized expectation for contingency in social interactions than in interactions with objects. Indeed, Watson (1985) proposes that infants' interest in contingency with nonsocial objects is due to their experience with contingency in social interactions. That is, infants notice contingency in nonsocial events because they have learned that they can be effective in producing changes in a partner's responses during social interaction, and this sense of personal efficacy is generalized to the nonsocial world. Yet, infants do not experience all people as contingently responsive to them. As a result, infants may be more attentive to specific others who in the past have been contingently responsive to them. Indeed, it would be adap-

tive for them to do so. The present study examines infants' ability to retain their initial preference for a contingent partner over a non-contingent partner when, six days later, the same partners are presented again and both are contingent.

Method

Participants

The participants were 40 4- and 5-month-old infants (23 females and 17 males). Nine of the infants were excluded from the study: two due to excessive crying, two due to inability to return for the second session, one because the stranger did not follow instructions, and four due to equipment failure. The mean age of the remaining 31 infants was 147 days ($SD = 21$ days) at the beginning of the study. The infants were from a university town and surrounding area in Eastern Canada. They were located through newspaper birth announcements.

Socioeconomic status of the infants' families was measured by a Canadian index (Blisshen, Carroll, & Moore, 1987) based primarily on education, income, and to a lesser extent, occupational prestige. In the index, occupations are divided into 514 groups, ranging from SES scores of 17.81 to 101.75 ($M = 42.74$, $SD = 13.28$). The scores of the higher status parent in the participants' families yielded a SES mean of 46.34 ($SD = 13.87$). The percentage of the parents with a college degree or more was 38%; 41% had some college education; 15% had only a high school degree; 6% were without a high school diploma. The racial/ethnic composition of the infants' families was 94% Non-Hispanic White, 3% Asian, and 3% Native American.

Materials and Procedure

The study took place in two sessions in a large laboratory room. In Session 1, a female experimenter took demographic information from the mother and explained the procedure

to her. When the mother appeared comfortable and the infant was quiet and alert, the infant was seated on the mother's lap in front of two video monitors in a three-sided booth made from room dividers. The infant was centered in front of the two video monitors so that each monitor was 1 m from the infant and at an angle of approximately 20 degrees. A camera, positioned between the two monitors, videotaped the infant and relayed a full body view of the infant to a female stranger seated behind the room dividers in front of a third video monitor. A camera, positioned above the stranger's monitor, relayed the stranger's image (life-size, frontal head and shoulders) to one of the monitors in front of the infant. The distance at which the stranger was positioned from the video camera (approximately 2.2 m) allowed her image to be perceived to be making eye contact from the infant's perspective. During the first minute the stranger displayed a still, expressionless face (Still-Face Phase). Immediately following the Still-Face Phase, a 5 min Interactive Phase began. During this phase, the stranger interacted normally with the infant when the infant was attending to her. When the infant was not attending, the stranger resumed a still-face. On the infant's second monitor was a replay of a different female stranger interacting with another infant participant. Thus, the infant was presented simultaneously with the images of two strangers, one on each monitor. Both strangers presented an initial Still-Face Phase, then during the following Interactive Phase one of the strangers interacted contingently with the infant and the other's behavior was noncontingent (i.e., she demonstrated infant-directed facial expressions and vocalizations but they were not contingent on what the infant was currently doing). The particular monitor that showed the contingent stranger was randomized over participants.

Approximately six days later ($M = 6.3$ days, $SD = 1.0$ days), the infants returned for Session 2. The same two female strangers were again shown simultaneously, except on this session there was live feedback from both

the strangers. The strangers were hidden from the infant and each other by room dividers. Each stranger was seated in front of a video monitor displaying a full body image of the infant (see Figure 1 for the layout of the experimental room). For the first minute the strangers remained still and expressionless for a Still-Face Phase and then a 5 min Interactive Phase began. In this phase both strangers interacted normally with the infant when the infant was attending to their particular monitor. When the infant was not attending to their monitor, they resumed a still-face. Thus, on Session 2 both strangers interacted contingently with the infant during the Interactive Phase.

For half of the infants the strangers appeared on the same monitor in Session 2 that they were on in Session 1 and for half the strangers appeared on the opposite monitor. In both sessions the strangers wore white lab coats and were seated in front of a uniform dark blue background.

Fourteen adult females served as strangers for the study. The number of strangers used ruled out the possibility that the infants' performance was due to the interaction styles of particular adults. The majority of the strangers served as both contingent and noncontingent strangers through the course of the study.

Because the strangers who were contingent were in the same room as the infants, there was the possibility that the infants might hear the voices of the strangers from the video monitors and the strangers' actual location. The strangers were seated behind the monitors on which their voices were played in order to reduce the potential confusion about where the voices originated. The room dividers that separated the strangers from the infant (and each other in Session 2) were padded to mute the sound of the strangers' voices from their locations. In addition, the sound from the monitors was turned up so that the volume on both monitors appeared equal and dominated over the voices outside of the infant's booth. This was done on both sessions, although the possibility of the infant hearing the voice from the monitor and

from the stranger's actual location was of particular concern in Session 1. In this session it was possible that the infant might hear voices from both monitors at the same time. If the infant was looking at the monitor of the contingent stranger, that stranger could be speaking to the infant when the voice from the replay was on. It was important that the voices from both monitors be similar in quality (i.e., the infant not hear a double voice from one monitor and a single voice from the other, which in itself might draw the infant's attention to one monitor over the other). In Session 2 the infant only heard one stranger at a time because the strangers interacted with the infant only if the infant was attending to their monitor. Nevertheless, the sound from the monitors was turned up in Session 2, as it was in Session 1, in order that the infants would hear the voices coming only from the monitors.

The instructions to the strangers were to interact normally with the infants when, and only when, the infants were looking at them (this was also the case for the noncontingent stranger in the first session because this tape was a replay of the stranger interacting with another infant). These instructions reduced the distractions for the infants due to the simultaneity of the displays and assured that the strangers did not compete for the infants' attention. The experimenter monitored whether the strangers adhered to the instructions. In addition, the following comparisons were done to assure that the strangers did not become more demonstrative in their interactions in Session 2 compared to Session 1 or that other mannerisms of the strangers did not draw the infants' attention to the ConCon stranger (stranger who was contingent in both sessions) rather than to the NonCon stranger (stranger who was noncontingent in Session 1 and contingent in Session 2): (1) ConCon stranger in Session 1 vs. Session 2; (2) NonCon stranger in Session 1 vs. Session 2; (3) ConCon stranger vs. NonCon stranger in Session 1; (4) ConCon stranger vs. NonCon stranger in Session 2. Two adult judges independently examined the videotapes of the strangers shown to 13 of the 31 infants. The

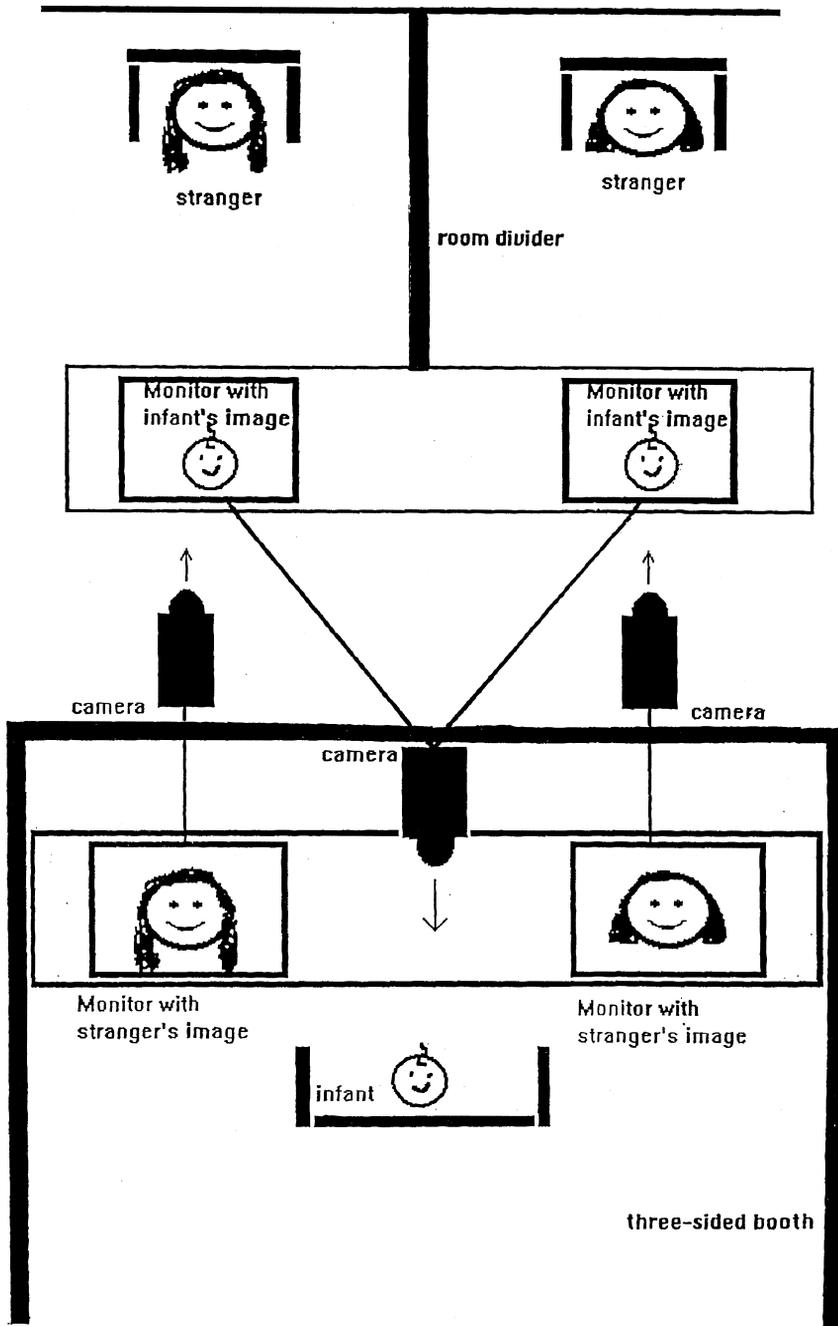


FIGURE 1

Layout of the experimental room. In Session 1 only one stranger was physically present; the presentation of the second stranger was a videotaped replay. In Session 2 both strangers were physically present.

judges, who were blind to the condition and session they were viewing, made choices between the interactions in each pair presented, indicating which was the more compelling for their attention (independent of the amount of time spent interacting which was determined by whether the infant participant was looking at the stranger). Binomial tests (one-tailed) done on the judgements of each of the judges indicated that all the comparisons were non-significant, suggesting the strangers did not differ in the quality of their interaction within or between the two sessions.

Measures

The infants were scored for visual attention, facial affect, and vocalizations to each of the strangers. The videotapes of the infants had the running time in seconds inscribed on the tapes. The sessions were divided into 2-s time blocks. The infants were judged to be visually attending to a particular stranger if the infants were looking at that stranger for the majority of the 2-s time block. Thus, the infants may not have been continually attending to that stranger during the time block but any changes were fleeting. The facial affect of the infants in the 2-s time blocks in which they were attending to a stranger was scored for smiles (upward lip movements with or without vocalizations) and grimaces (downward lip movements with or without crying). In the absence of either smiles or grimaces, expressions were judged to be neutral. Vocalizations in the 2-s time blocks in which the infants were attending to a stranger were scored as positive (cooing, gurgling), negative (fussing, crying), or nil. Digestive sounds (burps, hiccups) were excluded. No infant both smiled and grimaced during the same 2-s time block or had both positive and negative vocalizations during the same 2-s time block. For reliability purposes the videotapes of six infants were independently scored by two scorers. The value of kappa was .87 for attention, .97 for smiles, .95 for grimaces, .80 for posi-

tive vocalizations, and .92 for negative vocalizations.

Results

Analyses were conducted on the attention and smiling data. Although facial affect was minimal for most infants, 74% showed some smiling. Grimacing and vocalizations of either a positive or negative nature were infrequent throughout the study.

Preliminary analyses for (1) sex of the infant and (2) whether the stranger who was contingent on Session 1 was shown on the same or opposite monitor on Session 2 yielded nonsignificant results. Thus, both of these variables were eliminated from the following analyses.

For the Still-Face Phase, ANOVAs with two within factors, strangers (ConCon, Non-Con) and sessions, examined the difference between the infants' responses to the two strangers in the two sessions.

For the Interactive Phase, the infants' responses to the strangers were examined separately for each session. ANOVAs with two within factors, strangers (ConCon, NonCon) and minutes, were conducted on Session 1 and on Session 2. Planned comparisons examined the infants' responses to the two strangers during each minute of the interaction in order to determine when in each session the preferences occurred. In addition, nonparametric sign tests (one-tailed) were conducted comparing the number of infants who showed a preference for the ConCon stranger with the number of infants who showed the reverse preference in each minute of the interaction in each session.

Visual Attention

Table 1 shows the mean number of 2-s time blocks (TB) that the infants visually attended to each of the strangers during the Still-Face Phase and during each minute of the Interactive Phase for Sessions 1 and 2. Figure 2 depicts the infants' visual attention

TABLE 1
 Mean Number of 2-s Time Blocks (with Standard Deviations) Infants Spent Visually Attending to the Two Strangers in Each Session

Phases	Sessions					
	1		2		Strangers	
	ConCon	NonCon	ConCon	NonCon	ConCon	NonCon
Still-Face	10.6 (7.3)	9.2 (7.1)	10.6 (7.3)	10.4 (7.7)		
Interactive						
Min 1	14.6 (7.5)	9.6 (6.8)	12.6 (9.4)	10.8 (8.8)		
Min 2	13.5 (8.7)	8.0 (6.3)	12.5 (9.1)	9.6 (8.5)		
Min 3	11.7 (7.4)	9.4 (7.8)	12.8 (7.3)	9.0 (7.3)		
Min 4	12.2 (7.6)	8.2 (6.5)	11.5 (7.8)	6.9 (6.5)		
Min 5	11.1 (7.7)	7.0 (4.7)	10.7 (6.8)	5.7 (4.2)		

to the strangers during the Still-Face Phase and over the 5-min Interactive Phase for each session.

Infants did not differ in their attention to the two strangers on either of the sessions during the Still-Face Phase.

Still-Face Phase. The ANOVA with two within factors, strangers and sessions, yielded nonsignificant results. Thus, the in-

Interactive Phase. On Session 1 the ANOVA with two within factors, strangers and minutes, yielded main effects for strang-

VISUAL ATTENTION

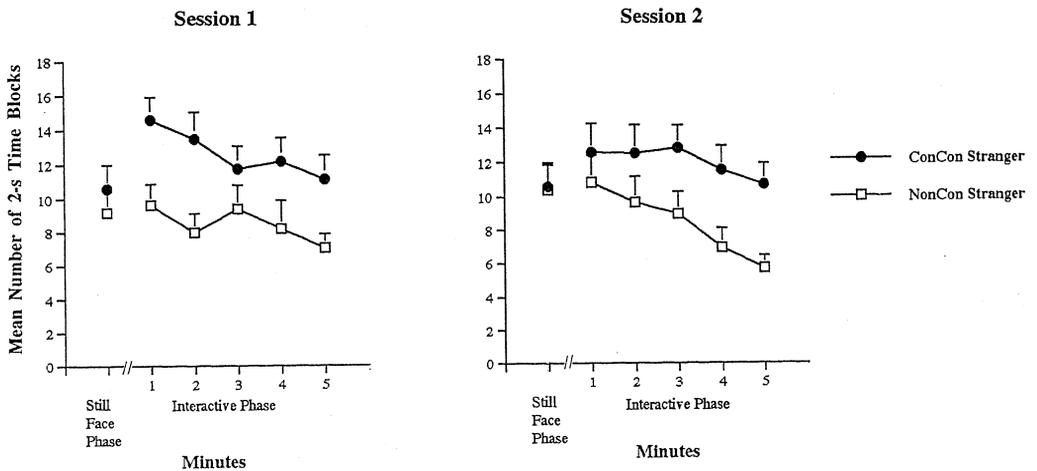


FIGURE 2

Mean number of 2-s time blocks in each minute of the Still-Face and Interactive phases that the infants attended to the strangers in Sessions 1 and 2. Vertical bars represent standard errors.

TABLE 2
Mean Number of 2-s Time Blocks (with Standard Deviations) Infants Spent Smiling to the Two Strangers in Each Session

Phases	Sessions				
	1		2		
	Strangers		Strangers		
	ConCon	NonCon	ConCon	NonCon	NonCon
Still-Face	0.11 (0.42)	0.18 (0.16)	0.50 (1.10)		0.57 (1.55)
Interactive					
Min 1	1.32 (4.35)	0.42 (0.99)	1.71 (4.02)		1.19 (2.52)
Min 2	0.97 (3.28)	0.19 (0.75)	1.19 (3.26)		0.65 (1.89)
Min 3	1.10 (4.00)	0.58 (1.06)	0.94 (2.72)		0.87 (2.20)
Min 4	1.74 (3.84)	0.65 (1.76)	0.55 (1.23)		0.29 (1.10)
Min 5	0.94 (2.80)	0.23 (0.76)	0.55 (1.12)		0.26 (0.68)

ers, $F(1,30) = 5.872$, $p < .05$ [ConCon $M = 12.6$ TB ($SD = 7.8$), NonCon $M = 8.5$ TB ($SD = 6.5$)] and for minutes, $F(4,120) = 6.359$, $p < .0001$ [min 1 $M = 12.1$ TB ($SD = 7.5$), min 2 $M = 10.7$ TB ($SD = 8.1$), min 3 $M = 10.6$ TB ($SD = 7.7$), min 4 $M = 10.2$ TB ($SD = 7.3$), min 5 $M = 9.1$ TB ($SD = 6.6$)], with no significant interaction. Visual attention declined over the session; there was significantly more attention in the first minute than in the following minutes and significantly more attention in the second and third minute than in the final minute. Planned comparisons of the infants' visual attention to the strangers on each minute of the interaction indicate that the infants showed a significant preference for the contingent stranger over the noncontingent stranger on each minute of the interaction except the third minute, suggesting that the infants noticed the difference in the contingency between the strangers' interaction immediately, in the third minute they examined the noncontingent stranger more closely, but they returned to their preference for the contingent stranger in the final minutes. The results of the sign tests indicate that there were significantly more of the infants attending to the contingent stranger than to the noncontingent stranger in minutes 1, 2, 3, and 4 (significance level of minute 5 was .09).

In Session 2 the ANOVA yielded a main effect for minutes, $F(2,120) = 10.676$, $p < .0001$ [min 1 $M = 11.7$ TB ($SD = 9.1$), min 2

$M = 11.1$ TB ($SD = 8.8$), min 3 $M = 10.9$ TB ($SD = 7.5$), min 4 $M = 9.2$ TB ($SD = 7.5$), min 5 $M = 8.2$ TB ($SD = 6.1$)] and a marginal main effect for strangers, $F(1,30) = 3.771$, $p = .06$ [ConCon $M = 12.0$ TB ($SD = 8.1$), NonCon $M = 8.4$ TB ($SD = 7.4$)], with no significant interaction. There was significantly more visual attention in the first three minutes than in the final two minutes of the session. The planned comparisons indicate that the infants visually attended more to the ConCon stranger than to the NonCon stranger in the third, fourth, and fifth minute, suggesting that the infants showed no initial preference for the previously contingent stranger but after the first two minutes of interaction they preferred the previously contingent stranger over the previously noncontingent stranger, even though both strangers were interacting contingently with the infants on this session. The results of the sign tests indicate that there were significantly more infants preferring the ConCon stranger to the NonCon stranger in minutes 4 and 5. Thus, findings from both the sign tests and the planned comparisons show that the infants' visual preference for the previously contingent stranger occurred midway in the session.

Smiling

Table 2 shows the mean number of 2-s time blocks that the infants smiled at each of the

strangers during the Still-Face Phase and during each minute of the Interactive Phase for Sessions 1 and 2. Figure 3 depicts the infants' smiling to the strangers during the Still-Face Phase and over the 5-min Interactive Phase for each session.

Still-Face Phase. The ANOVA with two within factors, strangers and sessions, yielded nonsignificant results indicating that the infants' smiling did not discriminate between the strangers on either session during the Still-Face Phase.

Interactive Phase. In Session 1 the ANOVA with two within factors, strangers and minutes, yielded no significant main effects or interaction, although the effect for strangers showed a trend, $F(1,30) = 2.488, p = .13$ [Con-Con $M = 1.2$ TB ($SD = 3.7$), NonCon $M = .4$ TB ($SD = 1.1$)]. The planned comparisons indicate that the infants smiled more to the contingent stranger than the noncontingent stranger in minutes 1 and 4, with marginal significance in minute 2 ($p = .06$) and 5 ($p = .09$). The results of the sign tests approached significance in minutes 2 ($p = .06$), 4 ($p = .11$), and 5 ($p = .11$), suggesting a trend for more infants to show, through their smiling, a preference for the contingent stranger over the noncontingent stranger.

In Session 2 the ANOVA yielded only a significant main effect for minutes, $F(4,120) = 4.501, p < .005$ [min 1 $M = 1.4$ TB ($SD = 3.3$), min 2 $M = .9$ TB ($SD = 2.7$), min 3 $M = .9$ TB ($SD = 2.5$), min 4 $M = .4$ TB ($SD = 1.2$), min 5 $M = .4$ TB ($SD = 9$)]. Smiling declined over the session; there was significantly more smiling during the first minute than in the final two minutes. The effect for strangers in this session did not approach significance, $F(1,30) = .562, p < .46$. The paired comparisons showed no significant differences in the smiling to the strangers in any of the minutes of the interaction. The sign tests also showed no significant difference in the number of infants who pre-

ferred the ConCon stranger to the NonCon stranger.

DISCUSSION

Infants' attentiveness to interactions with specific others is influenced by past interactions with these people. Four- to five-month-olds maintain expectations based on previous encounters for at least six days, even when the encounters are as short as 5 minutes. Although infants notice contingency in social interaction when it occurs, they are more attentive to contingent social partners who have been previously responsive to them than to social partners who have been previously noncontingent.

In Session 1 infants demonstrated their attentional preference for contingent interaction over noncontingent social behavior even in a simultaneous display. With few exceptions (Bigelow, 1996; Muir et al., 1996) most studies examining infants' ability to detect contingency in social exchanges have used sequential displays. The stimuli presented in a simultaneous display are potentially more confusing and distracting for infants. Because the strangers interacted with the infants only when the infants were attending to their particular monitor, the stimulation presented on Session 1 was biased against the infants attending to the contingent stranger. In this session when the infants were attending to the noncontingent stranger, the contingent stranger did not compete for the infants' attention and resumed a still-face. However, the interaction of the noncontingent stranger was unrelated to the infants' attentional focus, which meant the interaction from the noncontingent stranger could occur while the infants were attending to the contingent stranger, potentially distracting the infants away from the contingent stranger. Yet the pattern of attention shown on Figure 2 indicates that the infants detected the difference in the contingency the strangers were demonstrating and were more attentive to the contingent stranger from the first minute of the interaction. Contingency in social interactions is powerfully

attractive to infants; they detect it and prefer it to noncontingency even in competing displays.

The infants' performance in Session 2 indicates that their previous experience with social contingency from specific others influences their attentional preference for those others. Initially the infants showed no preference for either partner, both of whom were interacting contingently on this session. After a few minutes, however, the infants were more attentive to the partner who had been previously contingent. Thus, the preference was not immediate but rather it manifested after the infants had time to notice that both partners were socially contingent. Social partners who were contingently interactive with the infants in the past were preferred over social partners who were previously noncontingent, even though the infants' earlier encounters with

these persons were short and separated from the subsequent encounters by delays of 6 days. Infants are not indiscriminately attentive to contingent social partners. They are more attentive to social partners with whom they have a history of contingent interaction, even if this history is brief, compared to social partners with whom they have experienced noncontingency.

Smiling was minimal throughout the sessions. Other studies (Gusella et al., 1988; Hains & Muir, 1996) have shown that infants' smiling is reduced when in social interactions via video compared to interactions with partners who are physically present. The simultaneous nature of the televised display may have further reduced the infants' positive affect because the infants' attention was split between two interactions. Positive vocalization, an additional indicator of positive affect, was very

SMILING

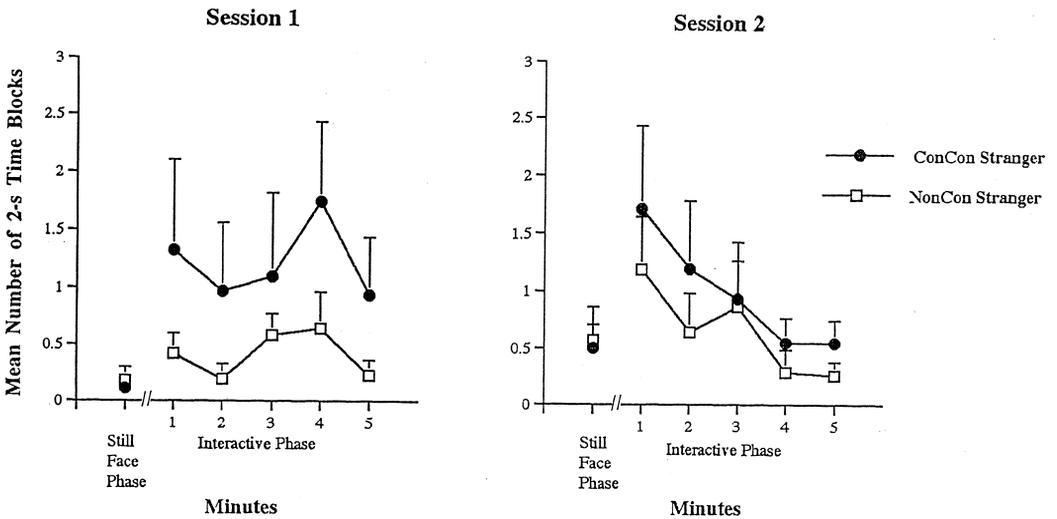


FIGURE 3

Mean number of 2-s time blocks in each minute of the Still-Face and Interactive phases that the infants smiled to the strangers in Sessions 1 and 2. Vertical bars represent standard errors.

infrequent throughout the study, again perhaps because of the nature of the display. Grimacing and negative vocalization were rare during the sessions. The lack of negative affect in infants during face-to-face interactions replicates the findings of others (Ellsworth et al., 1993; Hains & Muir, 1996; Stack & Muir, 1992).

Nevertheless, the trends present in the infants' smiling behavior showed both similarities to and differences from the findings from their attentional behavior. The similarities are evident in Session 1. In this session the infants smiled more to the contingent stranger than to the noncontingent stranger. This pattern reflects the findings of the attention data. Thus, in the initial session the infants showed tendencies in their affect, as well as their attention, of discriminating between the strangers and preferring the partner who was responsive to them. In Session 2, however, differences between the findings from the infants' attention and affect behavior are apparent. When both strangers are contingent, smiling does not suggest a preference for one stranger over the other. These trends imply that smiling is more influenced by the current interaction than by expectations formed from past interactions which occurred six days earlier. Interestingly, Hains and Muir (1996), who explored infants' responses to sequential displays of contingent and noncontingent interactions that immediately followed each other, also found that, although attention was affected by expectations from previous episodes (i.e., there were carryover effects from noncontingent to immediately following contingent episodes), smiling seemed to be more influenced by the current interaction than by expectations from previous interactions (i.e., smiling showed no carryover effects from noncontingent to contingent episodes). The systems that regulate attention and affect may operate independently during face-to-face interactions. Infants' affective systems may be generally responsive to contingency whenever it occurs, but their attention systems are influenced by the contingency present in past interactions.

An alternative explanation for the infants' performance exists because in Session 1 the contingent and noncontingent stimulation presented to the infants differed in the reinforcement of the infants' eye contact as well as in the contingency of the infants' behavior. The infants may have preferred to look at the contingent stranger in Session 1 because that stranger reinforced the infants' eye contact with social interaction whereas the noncontingent stranger did not. Smiling, although likely to be responded to with a contingent smile if the infants were looking at the stranger, was not reinforced if the infants were looking away from the stranger. Therefore, smiling was less subject to reinforcement than was visual attention. Because the noncontingent stranger was nonreinforcing on the first session, the infants' eye contact to that stranger may have been extinguished. In the second session, once the infants realized the same reinforcing contingency was in place for the previously contingent stranger, they may have preferred that stranger to the previously noncontingent stranger. This is a plausible explanation because in normal face-to-face interaction between infants and adults, the adult would typically try to reengage the infant's attention if the infant looked away whereas in this study the adult in the contingent conditions interacted only when the infant established eye contact. However, such an interpretation is unlikely to fully explain the findings. The infants' performance in Session 1 replicates the findings of a number of studies that indicate infants' preference for a contingent partner over a noncontingent partner (Bigelow et al., 1996; Hains & Muir, 1996; Muir & Hains, 1993; Murray & Trevarthen, 1985; Nadel, 1996; Nadel & Tremblay-Leveau, 1999). These studies presented the contingent and noncontingent conditions successively. Thus, the social behavior by the adult was not restricted to when the infant had eye contact. Nevertheless, the infants readily discriminated and preferred contingent interaction to noncontingent interaction. Furthermore, in Session 2 the infants showed no preference for either stranger in the initial minutes of the

interaction. Given that contingency is so readily noticed by infants of this age, they had time to notice the contingent nature of both strangers on this session. Yet after a few minutes they preferred to look at the previously contingent stranger, even though on this session both strangers were reinforcing the infants' eye contact. Although reinforcement of eye contact may be a factor in Session 1, the infants' visual preference for the same contingent stranger in both sessions indicates that experience with contingent interaction from particular others is a compelling factor for infants' attention even in simultaneous displays and that infants form expectations for social contingency based on previous encounters that can be maintained for at least six days.

The lack of preference, demonstrated by attention or smiling, for either stranger during the Still-Face Phases of the study indicates that (1) in Session 1 the preference for the contingent stranger was a function of the interaction, specifically the contingent interaction, with that stranger and not her physical characteristics, and (2) in Session 2 the preference for the previously contingent stranger was not produced by a still image of that stranger but rather it was instigated by the dynamic interaction with that stranger. It may be that infants initially recognize others by action patterns, both physical and vocal, that are salient to them, particularly action patterns over which the infants have some control. Recognition of the physical features of others may be due to the associations that their physical features have with specific action patterns. Indeed, there is evidence that young infants demonstrate their recognition of others by performing actions previously imitated in their interactions together (Meltzoff & Moore, 1994) and that older infants recognize their own reflections initially because of the control they have over the correspondence between self and image action (Bigelow, 1981; Meltzoff, 1990). It is noteworthy that in studies of infants' memory for contingent actions of non-social objects, Hayne and Rovee-Collier (1995) found that a still mobile did not act as

a reminder to reactivate memory of the relation between self action and the external action of the mobile. Only exposure to a mobile moving at the same rate and frequency that the infants had previously experienced served to reactivate memory of the contingent relationship between their own kicking and the mobile's movement.

Infants' ability to notice contingency in social interactions is acquired early. This ability is adaptive and serves multiple developmental functions. Social contingency involves the partner reflecting back to the infants their own actions in a reciprocal manner. Such contingent social interaction facilitates infants' sense of self-efficacy by allowing them to perceive the effects of their own behavior on the behavior of others; thus, it increases infants' self-knowledge (Neisser, 1991). At the same time, contingent social interaction serves to orient and attract infants to particular people. Whether others respond contingently to infants or not influences infants' expectations in future interactions with them. Contingent interactions with social partners enhance infants' subsequent exchanges with these partners, increasing their interest in them, and thereby facilitating the probability of infants' affiliative behavior and attachment to these particular others. Thus, contingency in social interaction provides infants with the dual benefit of increased knowledge of both self and other.

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