ARE YOUNG INFANTS SENSITIVE TO INTERPERSONAL CONTINGENCY?

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Murray and Trevarthen (1985) provided what seemed to be strong evidence that 2-month old infants can discriminate a view of their mother interacting with them via TV either live or in a replay. This study has been widely cited as having important implications for early social development and the development of the self. Here we report two attempts to replicate it with additional controls. The first experiment, which used a larger group of infants and controlled for the order of conditions, found no hint of Murray and Trevarthen's effect. The second experiment included 2 and 4 month-old infants. In an effort to increase attention to the mother, they were presented with a "still-face" episode just before the critical live or taped segment. At both ages infants responded with reliably less gazing and smiling during the still-face, but did not respond differentially in the live and tape conditions.

Interpersonal contingency social sensitivity early social development

Much has been written on young infants' attunement to their social environment (Stern, 1985), and on the close relationship that infants 6 months and younger develop with their care-takers (Fogel, 1993). By the second month, infants demonstrate socially elicited smiling (Spitz & Wolf, 1946) and pay close attention to others (Adamson, 1995), reflecting what Colwyn Trevarthen (1979) called "primary intersubjectivity." Microanalyses of mother-infant interaction have been said to reveal behavioral reciprocity that includes movement synchrony with adult speech (Condon & Sander, 1974). There are invariant temporal patterns in face-to-face interactions (Stern, 1971), as well as evidence of turn taking in emotional expression (Trevarthen, 1977; Tronick, Als, & Brazelton, 1977). Early on, infants manifest marked behavioral disengagement and distress when mothers or any other

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adult partners suddenly adopt a still face in an on-going playful face-to-face interaction (Toda & Fogel, 1993; Tronick, Als, Adamson, Wise, & Brazelton, 1978). The still-face phenomenon is robust from the second month and suggests that young infants are already attuned to the responsiveness of their social partner, which normally includes the on-line monitoring of the baby's gaze, limb movements, and emotional expressions. Infants react to the sudden still-face of the mother with avoiding gaze and negative affect, perhaps because they sense that her behavior is now devoid of interpersonal contingency. However, this interpretation of the still-face phenomenon is yet to be supported by direct evidence (but see Muir & Hains, 1993).

Murray and Trevarthen (1985) introduced a novel experimental paradigm designed to test young infants' ability to discriminate between reciprocal (contingent) and non contingent interaction with their mothers. In this widely cited study, 4 infants between 6 and 12 weeks of age interacted with their mothers through a closed-circuit TV set-up. In the *Live* condition, the interaction was on-line in real time; in the *Tape* condition, they were presented with a videotape of the mother. Murray and Trevarthen reported that the infants were highly interactive and content during the Live condition, but showed distress and discomfort during the Tape condition (see Table 1).

This finding has important implications for theories of early social development and the development of the self in infancy (Rochat, 1995). It suggests that by the second month, infants are interactive agents and behave as differentiated entities in relation to others. They seem to be able to discriminate between the presence and absence of reciprocity in their mothers' behavior, i.e. of ongoing interpersonal contingency. Such an ability would suggest that by two months infants already have a sense of what Neisser (1991, 1995) calls an interpersonal self.

A closer look at the Murray and Trevarthen (1985) experiment suggests some degree of caution in interpreting its results. Only 4 subjects were tested, at least some of them more than once (there were 18 sessions in all). Moreover, the design made no attempt to control for order: data from the Tape condition were always compared to a Live presentation that had occurred earlier. No successful replications of the experiment with 2 month-olds have yet been published. Muir and Hains (1993) failed to replicate the phenomenon at 2 or 5 months of age when infants interacted with their own mothers, but found a decrease in smiling in the Tape compared to the Live condition by 5-month-old infants when interacting with a female stranger. Bigelow, MacLean, and MacDonald (1995) reported a linear decrease in attention over time, and a change in facial affect (happy, neutral, sad) across Live and Tape conditions in 4-, 6-, and 8-month-olds. Note that all these studies used video arrangement different from that used by Murray and Trevarthen, allowing for much less eye contact between the infant and the mother.

The general aim of the present research was to examine Murray and Trevarthen's phenomenon with a larger number of infants, controlling for order of conditions, in a set-up that permitted direct eye-contact between mother and infant. The design of Experiment 1 provided both a replication of the original study ($N = 5$) and an attempt to obtain the same effect with order controlled and a larger sample size ($N = 10$). The results were negative: The infants did not discriminate between Live and Tape conditions, regardless of order. Experiment 2 provided additional data on same age and older infants, using a different procedure that included a "still-face" episode between the two conditions. This manipulation was an attempt to increase the infant's need for contact with the mother prior to the second (Live or Tape) condition. But although all infants reacted to the still-face episode, there was again no evidence of a discrimination between Live and Tape conditions.

EXPERIMENT 1

Method

Apparatus

A double closed-circuit color television system was built similar to the one employed by Murray and Trevarthen (1985). The apparatus was set up in two adjacent rooms (see Figure 1). In both rooms, a metal frame structure supported a TV monitor facing down. The image from the TV was reflected in a one-way mirror, placed diagonally in the metal frame structure, facing the participant's seat. A video recorder was placed behind the one-way mirror. The video camera from the infant's room

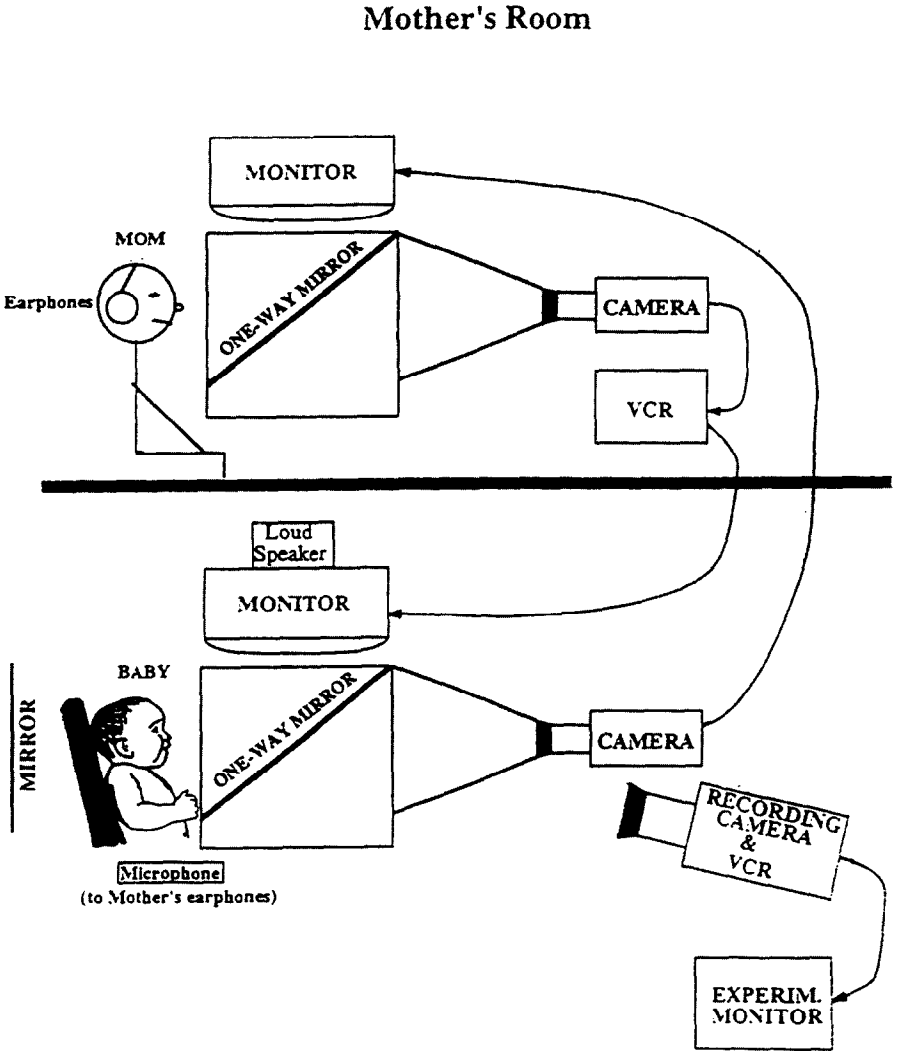

FIGURE 1
Apparatus

transmitted the image of the baby to the mother's TV monitor. Similarly, the camera in the mother's room transmitted her image to the baby's monitor. This latter transmission went via a videocassette recorder, which recorded a tape of the mother that was subsequently presented in the Tape condition. Sound from the infant's room was picked up by a microphone and transmitted to the mother's earphones. Sound from the mother's room was picked up by a tie microphone, run through the VCR, and transmitted through the TV speaker in the infant's room.

In the infant's room an infant seat was placed facing the one-way mirror. A small rectangular mirror was placed on one side behind the infant seat. A camcorder behind the one-way mirror videotaped both the baby and the image of the mother as reflected in the small mirror behind the baby. The camcorder transmitted this image to an auxiliary TV in the infant's room, allowing the experimenter to monitor the infant's responses. The camcorder tape was later used for coding and analysis.

In order to obtain optimal image and acoustics, the mirror, lighting, focus, image size, and sound were adjusted during piloting. Black cardboard was fixed to the frame structure and around the apparatus, and white cardboard and cloth were placed around the infant to prevent possible distractions.

Design

Each infant was presented with three consecutive 60-s test intervals. In two of these intervals the presentation was "Live," i.e., the infant and his or her mother interacted in real time via concomitant video and audio transmission between the two rooms. In the remaining interval the presentation was via "Tape," i.e., the infant saw a videotape of its mother which had been made during the first interval. To enable the making of this tape, the first interval was always Live. The order of conditions in the second and third intervals was counterbalanced across subjects. Thus the overall sequence of conditions was Live-Tape-Live for half the subjects and Live-Live-Tape for the other half. This design allowed for two partially independent analyses. If we consider only the subjects in the Live-Tape-Live sequence, the first two intervals taken alone constitute a replication of Murray and Trevarthen with $N = 5$. Considering all the subjects together, the second and third intervals (Tape-Live or Live-Tape) allowed for an order-controlled analysis with $N = 10$.

Participants

The participants were recruited from a subject pool consisting of infants born in the Atlanta area. Parents were contacted by phone and were invited to participate with their infant. Twelve infants were piloted in the earlier stages of the study in order to adjust optical distance, lighting, sound, and image.

Fourteen mother-infant dyads were recruited for the main study. The data from 4 of them could not be used because of excessive fussiness. The mean age of the remaining 10 infants (3 girls, 7 boys) was 2 months 21 days, ranging from 2 months 12 days to 3 months 00 days (SD = 7.2 days). They were randomly assigned to the two groups. Infants were all healthy with no report of any developmental handicap. Eight of the infants were Caucasian and 2 were African American, all from middle-income families living in the Greater Atlanta area.

Procedure

All mothers were given a detailed description of the live interaction procedure and signed an informed consent form. Mothers were asked to engage their child in an active interaction during the Live intervals.

The infant was placed in an infant seat facing the one-way mirror. One experimenter remained in the same room with the infant, the other experimenter accompanied the mother to an adjacent room. A calibration procedure was used to map the infant's visual response to the screen. During calibration, a toy suspended on

a cardboard arm was moved around the screen and the infant's visual tracking of the toy was videotaped. To keep the infant engaged, a blackboard with a colorful toy (puppet face) was placed between the baby and the video apparatus before and after calibration and between conditions. After calibration was completed, the mother was seated facing the one-way mirror, and the head phones and microphone were adjusted. The live interaction during the first minute was recorded and was used for the tape condition.

Coding

The behaviors chosen for coding were the same as those coded by Murray and Trevarthen, and included gaze to mother, tonguing, mouth wide open, mouth closed, eyebrows raised, smiling, frowning, raised frown, left hand fingers clothes, right hand fingers clothes, left hand touches face, right hand touches face, yawning, grimacing/sneering, and biting/chewing lower lip. Three behaviors (gaze away from mother, mouth relaxed, and eyebrows relaxed) were not coded, due to their reciprocal relation to other behavior(s) (e. g., gaze away from mother is inversely related to gaze to mother). Criteria for each behavior were established, based on Murray and Trevarthen's account.

A computer event recorder was used to code the camcorder tape. Coding was done with the sound off. A key was pressed every time the particular behavior occurred. If it was impossible to track the behavior (e.g., the coder could not tell if mouth was open or closed when infant covered the mouth with his/her hand), a "can not tell" key was pressed. Percent of total time the behavior took place was computed (excluding time when the "can not tell" key was pressed). A main coder (VM) coded all infants' behaviors across all three conditions. A secondary coder coded all

TABLE 1
Infants' Behaviors in the Live and Tape Conditions, Expressed as Percent of Total Time

	Murray & Trevarthen (N = 4)			*Replication (N = 5)*			*Counterbalanced Order (N = 10)*		
Infant Behavior	*Live*	*Tape*	*p*	*Live*	*Tape*	*p*	*Live*	*Tape*	*p*
1. *Attention*									
Gaze to mother	89.3	63.4	0.001	73.3	79.8	0.28	75.84	75.25	0.94
2. *Communicative Effort*									
Tounging	29.2	19.5	0.05	9.8	9.4	0.88	14.12	8.96	0.08
Mouth Wide Open	20.4	5	0.001	2.2	2.5	0.77	5.23	4.13	0.44
Mouth Closed	31.3	36.6	0.001	37.1	35.8	0.81	26.09	29.43	0.51
3. *Affect*									
Positive									
Smiling	4.9	1	0.1	5.6	5.4	0.9	0.59	3.33	0.03
Eyebrows Raised	38.3	15.6	0.001	5.5	6.9	0.32	5.77	4.37	0.26
Negative									
distress									
Frowning	0.5	25.4	0.0005	0.9	1.8	0.28	5.63	5.87	0.86
Raised Frown	14.5	20.9	0.02	0.9	1.1	0.26	1.85	1.01	0.4
displacement activity									
Left Hand Finger Clothes	15.9	24.6	0.1	1.4	0.8	0.52	6.72	5.47	0.6
Right Hand Finger Clothes	14.9	34.4	0.001	4	0.2	0.06	4.53	6.08	0.61
Left Hand Touch Face	0	1.5		0.6	2.8	0.42	6.52	6.76	0.95
Right Hand Touch Face	0.3	1.8	0.1	7.2	8.4	0.37	5.32	11.22	0.07
Yawn	0	0.8		0	0		1.32	1.61	0.45
Grimace/Sneer	0.4	7.7	0.001	1.6	1.8	0.86	5.83	3.31	0.51
Bite/Chew lower lip	0.1	1.5	0.1	0.6	0.2		1.01	0.09	0.24

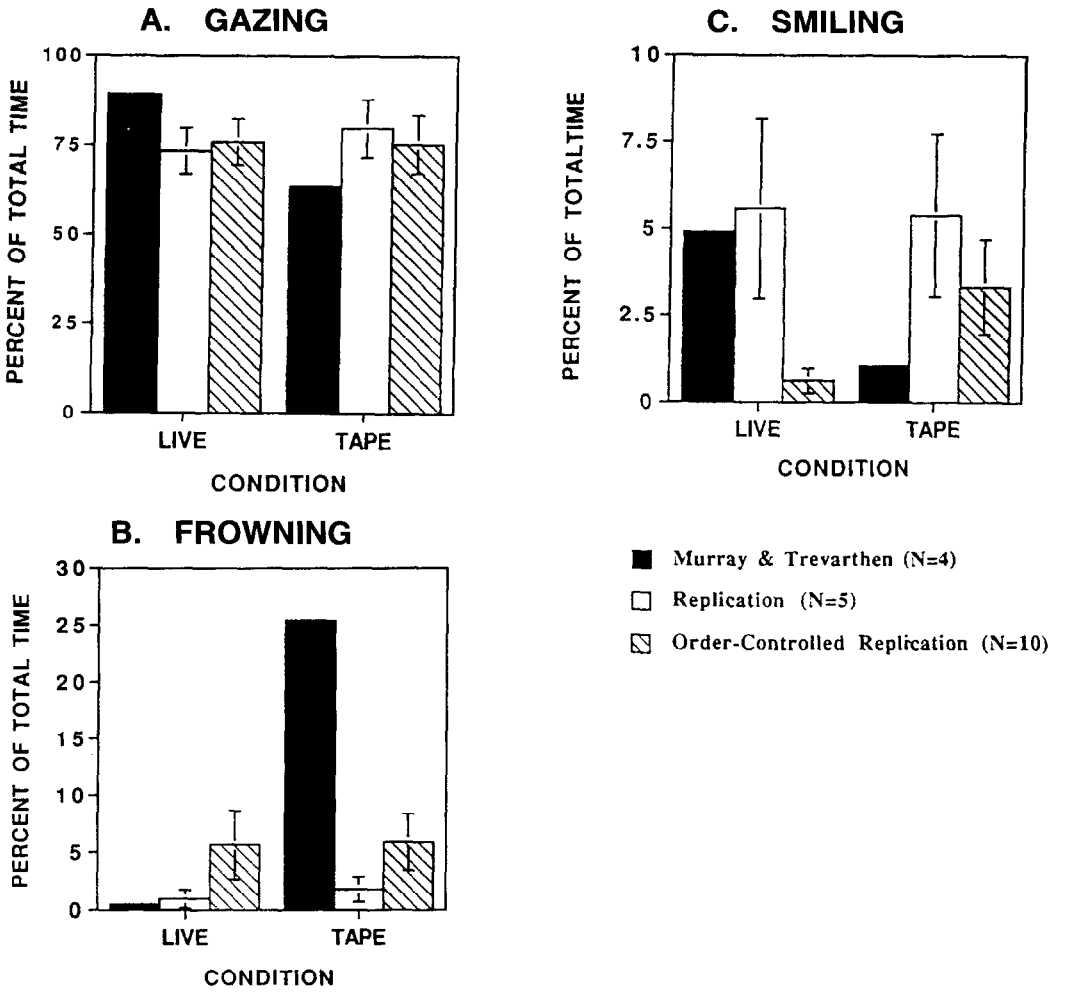

FIGURE 2

Mean percent of time infants Gazed to mother (2A); Frowned (2B); and Smiled (2C); in either the Live or Tape condition in Murray and Trevarthen's original study, our replication with 5 infants, and in our order-controlled replication with 10 infants.

behaviors for four babies. Both were blind to the conditions they were coding. For each of the 15 measures, reliability was computed as follows: in the 12 comparisons (4 randomly chosen babies X 3 intervals) available, the on-time recorded by one coder was divided by that of the other coder (using the higher value as the denominator). For each behavior, the mean of these ratios was over 90%. Pearson r correlations comparing the coders were above .90 for all measures. Reliability of both coders was further examined on a second-by-second basis using Cohen's kappa tests. Kappas averaged .66 across measures, not including intervals where both coders agreed that no behavior occurred (100% agreement, N = 5).

RESULTS AND DISCUSSION

Replication

For the 5 babies in the Live-Tape-Live order, the first two intervals (i.e., Live fol-

lowed by Tape) were analyzed as a replication of Murray and Trevarthen's experiment. ANOVAs were performed on all coded behaviors. No significant differences between conditions were found (see Table 1).

Figure 2 presents the means for Gaze to Mother (2A), Frowning (2B), and Smiling (2C). Overall our results did not replicate any of Murray and Trevarthen' s findings

Order-Controlled Replication

The second and third trial presentations for all 10 infants (5 in Live-*Tape-Live* and 5 in Live-*Live-Tape*) allowed us to counterbalance the order of conditions. ANOVAs were performed on all coded behaviors. The only significant difference between conditions was in smiling (see Table 1 under counterbalanced order column, $p < .03$). However, the direction of the effect was *opposite* to the one reported by Murray & Trevarthen. Overall, there were no noticeable differences in behavior between the Live and Tape conditions when controlling for condition order (see Table 1, counterbalanced order column).

Behaviors by Age

It was suggested by Lynne Murray (personal communication) that this form of attunement to interpersonal contingency may be extremely sensitive to age, occurring only at about ten weeks. Data bearing on this hypothesis are shown in Table 2, in which the participants are ordered by age. No consistent pattern of change emerges.

The infants in our study did not react differently when watching the mother on-line than when viewing a videotape of the mother. We believe that this failure to replicate Murray and Trevarthen (1985) results mainly from procedural differences. Murray and Trevarthen typically allowed their babies to remain in the live

TABLE 2
Behaviors of Individual Infants in the First Live Interval
(expressed as percent of total time) as a Function of Infants' Age

Infant's Age	*10w 2d*	*10w 3d*	*10w 4d*	*11w 1d*	*11w 3d*	*11w 5d*	*12w 3d*	*12w 4d*	*12w 5d*	*12w 6d*
1. *Attention*										
Gaze to mother	96.46	46.71	47.85	89.77	71.37	74.61	76.23	91.78	87.44	91.23
2. *Communicative Effort*										
Tounging	11.24	20.5	1.61	7.19	6.96	1.87	27.25	14.76	7.17	12.14
Mouth Wide Open	1.68	40.49	2.38	7	3.81	0	3.09	11.86	0.95	2.08
Mouth Closed	43.21	26.6	58.8	2.96	17.3	58.61	7.58	0	44	0
3. *Affect*										
Positive										
Smiling	7.1	0	0	0	13.8	6.98	0	0	3.36	0
Eyebrows Raised	0.63	1.27	21.28	2.81	2.31	1.66	1.6	1.49	0	1.43
Negative										
distress										
Frowning	0	11.04	0.66	1.66	0	0	4.06	3.6	0	34.29
Raised Frown	0	0.88	2.3	1.91	0	0	2.07	1.38	0	0
displacement activity										
Left Hand Finger Clothes	0	30.03	4.15	0	0	0	3.01	10.67	0	0
Right Hand Finger Clothes	0	0	2.68	0	9.02	4.07	4.17	0	61.34	0
Left Hand Touch Face	0	0	1.88	5.96	0	0	0.96	9.52	15.36	0
Right Hand Touch Face	0	20.11	0	0	0	0	35.79	77.22	0	0
Yawn	0	0	0	0	0	0	0	0	0	0
Grimace/Sneer	0	7.91	0	0	0	0.75	7.13	0	1.15	0
Bite/Chew lower lip	0	1.01	0.63	1.3	0	0	2.54	0	0	0

condition until an active interchange was reached (personal communication). The Tape condition followed. A probable consequence of this procedure is that the subjects were at their peak interactive performance in the Live condition, so that a natural decline from that peak would have produced lower performance in the Tape condition. This decline may have been mistakenly attributed to the change of the experimental conditions. In our experiment, the duration of infants' exposure to each condition was fixed.

It is possible that the double video set-up is not an optimal environment for interpersonal communication in early infancy. It lacks ecological validity in several ways: mothers can not touch or hug their infants, nor can they approach very close and regulate their distance to the infant, as well as track their gaze. All these may be important cues by which infants can detect the mother's attunement to their behavior in face-to-face, play interaction. For this reason, our failure to replicate Murray and Trevarthen's findings does not necessarily mean that infants of two months are not sensitive to interpersonal contingency; the double-TV method may just not be an effective way to demonstrate it.

EXPERIMENT 2

The rationale for this experiment was to assess whether this failure to replicate the results of Murray and Trevarthen may have been due to state or perceptual factors rather than the actual inability of the infants to detect the difference between the Live and Tape conditions. One possibility was that, for unknown reasons, the infants in our setup may not have seen their mothers clearly. Another possibility was that the infants may not have been genuinely motivated to monitor the degree of interpersonal contingency expressed by their mothers. To control for these factors, we modified the procedure by introducing a *still-face episode* just before the last interval. The infants' reaction to the still-face would enable us to determine whether they could perceive their mothers clearly in our setup: if so, there should be a marked drop in attentiveness to the mother during this episode. In addition, exposure to the still-face conditions was expected to put all the subjects into a mildly stressed state prior to the critical last interval, which was a Live presentation for half of them and a Tape presentation for the other half. It seemed plausible that infants who had just been exposed to a still-face episode would be especially attentive to their mothers, and might therefore be especially sensitive to the presence or absence of interpersonal contingency. In addition, two age groups were tested to explore the development of the ability to detect interpersonal contingency.

Method

Apparatus and Design

The apparatus was the same as in Experiment 1. All infants were presented with three consecutive intervals: a Live presentation, then a Still-Face, and finally a Test interval which was Live for half the subjects and Tape for the other half. (Six of the 11 older infants were assigned to Live.) To reduce the possibility of overtaxing the infants, the duration of each condition was shortened to 45 seconds.

Participants

Thirty one mother-infant dyads participated in the experiment. The data from 10 of them were not used because of excessive fussiness, sleepiness, or less than 10% gaze to mother in the first condition. The remaining 21 infants (10 girls, 11 boys) were divided into 2 age groups: Ten younger infants, aged 8 weeks to 15 weeks (M = 11.3 weeks, *SD* = 3.5 weeks), and 11 older infants, aged 17 to 25 weeks (M = 20.9 weeks, *SD* = 3.2 weeks). All infants were reported healthy with no developmental handicap. Eighteen were Caucasian and three were

African Americans, all from middle-income families living in the Greater Atlanta area.

Procedure

A calibration procedure was performed before the experiment to map the infant's visual response to the screen. Following the calibration, the mother was asked to interact and engage her infant. After 45 seconds, upon a sign from the experimenter, the mother was instructed to suddenly adopt a neutral still-face, staring emotionless at her infant on the TV. The Still Face condition (SF) lasted for a maximum of 45 seconds, or until the first signs of fussing and clear distress was expressed by the infant. The Experimenter then signaled to the mother to resume her interaction (Live Condition), or played back to the infant the previous interaction (Tape condition). This last condition also lasted 45 seconds. For both measures used in this experiment (gazing and smiling), interobserver reliability was assessed based on the independent coding of two randomly chosen infants. For each measure, both mean percent agreement and Pearson r were above .90. Reliability of both coders was further examined on a second-by-second basis using Cohen's kappa tests. Kappas averaged .82 across measures and participants, not including intervals where both coders agreed that no behavior occurred (100% agreement, $N = 4$).

RESULTS AND DISCUSSION

For this Experiment, only gazing and smiling were coded. These two measures were highly sensitive to the Live/Tape contrast in the original Murray and Trevarthen study, and have been commonly used to assess infants' reaction in still-face experiments and other studies of interpersonal contingency (Muir & Hains, 1993).

Gazing

A 2 (Age: younger or older) x 3(Interval: first, second, or third) x 2 (Condition: test interval Live or Tape) mixed design analysis of variance revealed a highly significant main effect of interval ($F(2,34) = 9.937$, $p = 0.0004$). As expected, infants gazed at their mothers much less during the still-face interval than in either the Live interval which preceded it or the test interval (Live for half the subjects and Tape for the other half) which followed it. Post-hoc Tukey tests showed that these differences were highly significant ($p < 0.001$). There were, however, no significant main effects of age or condition. Moreover there were no significant interactions; thus, the hypothesis that infants would respond differently to the Live and Tape conditions during the third interval (after exposure to the still-face) was not supported. These data are shown in Figure 3.

Smiling

Smiling showed the same pattern of results. Mean values for percent of total time the infants smiled in each condition are shown in Figure 3B. Because only half of the infants manifested smiling at any point of testing, statistical analyses could not be performed. However, Figure 3B shows a comparable pattern of results of smiling compared to gazing responses. Infants tended to smile less in the Still-Face episode and equally in either the Live or the Tape condition, regardless of age or order.

The results of this second experiment demonstrate that the infants were indeed perceiving their mothers: they displayed significantly less Gazing and Smiling during the Still-Face episode. These data corroborate other research documenting the Still-Face phenomenon. Nevertheless, the robust stress caused by the mother's still face did not create any difference in response to the Live or Tape condition following the still face episode, in either age group. No evidence was found of any developing sensitivity to interpersonal contingency between 8 and 25 weeks. Again, we believe that the difference between our findings and those of Murray and Trevarthen is mainly due

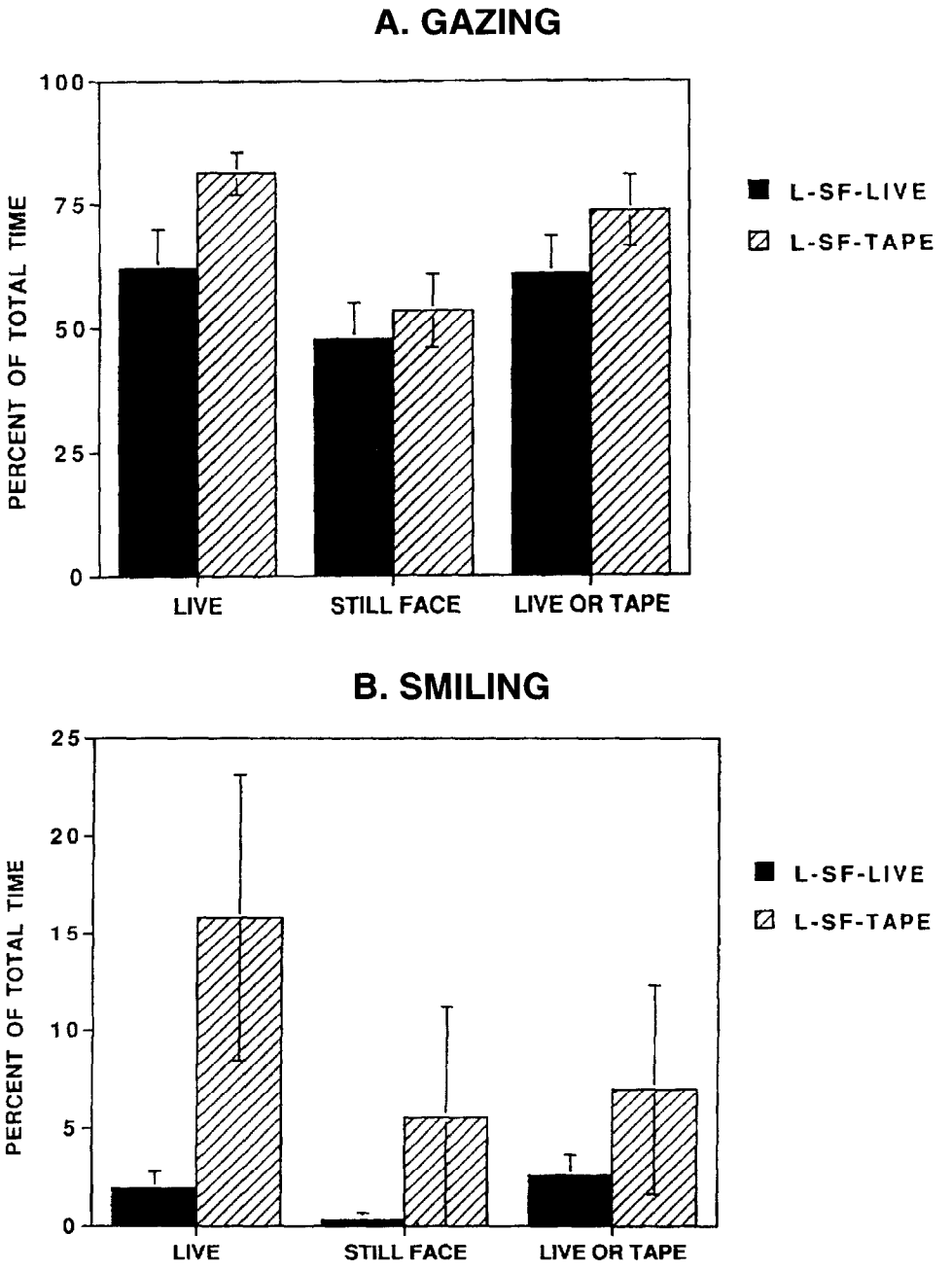

FIGURE 3

Mean percent of time infants gazed to mother in the Live, Still-Face, and the final Live or Tape condition (3A); mean percent of time infants smiled in the Live, Still-Face, and final Live or Tape condition (3B).

to procedural differences (see discussion of Experiment 1).

GENERAL DISCUSSION

Our failure to replicate Murray and Trevarthen's finding does not necessarily mean that young infants are not sensitive to interpersonal contingency. It is quite possible that this sensitivity is present at two months or even earlier, but the double-TV method may not be an effective way to demonstrate it. Video presentation removes important perceptual cues that mothers commonly use to engage their infants in playful face-to-face interactions. Touch is prevented and mothers are unable to modulate the distance that separates them from their infants. In general, mothers reported discomfort in interacting with their infants via the video system and this discomfort might have affected their natural ways of framing the interaction with their infant (Kaye, 1982).

In the present study, however, there is no clear evidence of a discrimination between contingent and non contingent social interactions in early infancy.

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NOTE

1. Neisser and Marian are now at Cornell University.

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