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Intentions make a difference: Infant responses to still-face and modified still-face conditions

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Abstract

In two studies, 3-, 6- and 9-month-old infants interacted with their mothers during natural, still-face, and modified still-face (i.e., mothers wearing a mask, or drinking from bottle) conditions. Infants were also presented with matching doll conditions to control for the possibility that their responses might be due to changes in superficial perceptual features. Regardless of age, infants displayed negative affect to the still-face, but, in contrast to recent reports, not to the modified still-face conditions. However, whereas infants' positive affect also depended on their mothers' communicative intentions, these responses changed with cognitive maturation. As expected, infant responses to their mothers were significantly different from those to the doll. The implications of these findings for theories of communication are discussed.

Keywords: Intentions; Communication; Modified Still-face

From early on, infants appear motivated to interact with social agents. They communicate their emotions reciprocally, showing a strong desire to connect with the social world (Stern, 1985; Trevarthen, 1977, 1979). Although much work has focused on determining when human infants come to perceive people's communicative behavior as meaningful, many questions remain about the developmental path of this ability.

Various theorists argue that infants cannot engage in meaningful communication until many months after birth, because such exchange is dependent on cognitive abilities which become available only with the onset of triadic interactions (Lewis & Carpendale, 2002; Piaget, 1952). A key characteristic of triadic interactions such as gaze following and declarative pointing is that both partners share an interest in an object and both are aware of the other (Legerstee & Barillas, 2003). Accordingly, prior to perceiving people as communicative partners, infants are said to respond to perceptual features of people (i.e., gaze direction, faces and vocalizations, contingent movement, etc.), or respond in particular ways because they have been conditioned to do so (Corkum & Moore, 1998).

However, as Hobson (2007, p. 8) proposes "if infants from around 9 months are identifying with the attitudes of others towards a shared world, then might much younger infants also be identifying with at least some of the attitudes of those with whom they are engaged, even if these do not have an external, shared focus". A theoretical approach that predicts a different ontogenetic path in the development of communication is proposed by those who argue that this ability is embedded in interpersonal experience (Draghi-Lorenz, Reddy, & Costal, 2001; Fogel & Garvey, 2007; Hobson, 2007; Legerstee & Varghese, 2001; Reddy & Trevarthen, 2004). For instance, it is argued that very young

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infants perceive their interactions with adults as a mutually regulated system, where each participant engages in affective exchanges, and during which the emotional meaning of the other's expressive behavior is appreciated (Markova & Legerstee, 2006). "Prima facie, they appear to relate to that other embodied person as the source of the special, sharing form of experience" (Hobson, 2007 p. 8).

Such an interpretation of the available empirical evidence is plausible when considering research showing that 2–3-month-old infants become upset when adults in face-to-face interactions suddenly stop communicating with them for no apparent reason. This condition is called the still-face, and is part of a paradigm in which infants are studied in three conditions: a face-to-face interaction with their mothers, a still-face condition during which mothers assume a passive, unresponsive face, and a so-called reunion episode during which mothers and infants engage again in face-to-face interaction (Toda & Fogel, 1993; Weinberg & Tronick, 1996). Infants' reactions to this experimental manipulation are one of the most robust phenomena in infancy research, suggesting that infants have particular expectations of adults when engaging in communicative exchanges with them.

The still-face paradigm inspired much research in order to determine which features of the communicative partner are responsible for the still-face response (for a comprehensive review see Adamson & Frick, 2003). This research focused on infant sensitivity to various perceptual features, such as the face, voice, or numerous combinations of face, gaze and voice. It was shown that infants were mostly perturbed when their mothers' face was motionless, even though she retained eye contact and continued to interact vocally (Gusella, Muir, & Tronick, 1988). However, by manipulating the face, voice, or gaze, such studies modified the interactive format within which infants' communicative competence is being investigated, thereby not revealing the process underlying infants' differential responsiveness. Specifically, Reddy and Trevarthen (2004) argue that "emotional acts need emotional perception and one cannot do this easily without emotional engagement" (p. 14), thus emphasizing the importance of socially interactive experimental structures in order to gauge the social significance of infants' responses.

Addressing this methodological problem, Murray and Trevarthen (1985) presented 2–3-month-old infants with three conditions: a face-to-face interaction, a still-face condition, and a condition during which mothers tried to communicate with their infants, but for some obvious reason (i.e., a third person interrupted the mother) were not able to continue to do so. The authors found that infants displayed more negative affect and withdrawal during the still-face than during the interrupted episode:

> "(. . .) sneering grimaces of the mouth, increased handling of the clothes, touching the face, sucking the fingers, and frowning, the whole sequence being toned with negative affect and accompanied by active gesturing of the limbs. The initial reaction gave the impression of protesting . . . this phase was followed by withdrawal; the infant inverted its gazes downward from the mother's face looking to her overall only 34% of the time. This profile was quite different from the quiet interest seen during the interruption." (p. 186)

Because infants responded as if they were evaluating the reason why contact was broken, they must have been aware of the intentions of others. However, these findings have not been replicated. Delgado, Messinger, and Yale (2002) found that 6-month-old infants reduced smiles and positive vocalizations, and increased negative affect in the still-face episode, but failed to discriminate between a still-face condition where adults gazed *at* the infants and a modified still-face condition where adults gazed *above* the infants' eyes. It is possible that 6-month-old infants do not follow vertical gaze shifts until much later (Butterworth, 1991), and, consequently, may not have noticed the difference in eye orientation. Additionally, Delgado et al. (2002) argued that the lack of discrimination could be attributed to the absence of affective stimulation in both situations, which resulted in emotional distress in infants, and therefore interfered with their evaluation why contact was broken.

If this hypothesis is correct, then studies that examine infant awareness of the reason why contact is broken should refrain from presenting infants exclusively with conditions that lack affective stimulation. Presenting infants with interactions where the communicative partner's intention to communicate is manipulated may provide a more accurate test of the way infants experience the changes in adult communication. Consequently, we conducted two studies to test these ideas. In the first study, we examined the hypothesized importance of an interactive face for an awareness of communicative motives (Gusella et al., 1988) by presenting 3-, 6- and 9-month-old infants with their mothers who interacted with them in face-to-face, still-face, and a modified still-face condition during which mothers wore a mask. In the second study, we tested the hypothesized importance of affective stimulation for an awareness of the reason contact is broken by presenting 3- and 6-month-old infants with the face-to-face and still-face conditions, however, this time during the modified condition mothers appeared to drink from a bottle. In both studies, mothers maintained eye contact with their infants during all conditions (Hains & Muir, 1996). Additionally, in study 1 they continued to speak with an interactive voice during the face-to-face and mask conditions; in study 2 they maintained a motionless face and did not speak during both the still-face and the bottle conditions.

The mask condition is an especially interesting phenomenon. When Sroufe and Wunsch (1972; see also Sroufe, 1996; Sroufe, Waters, & Matas, 1974) presented infants between 4 and 10 months of age with people wearing a mask, infants recognized their mothers, as indicated by their smiling, but expressed fear toward strangers. The authors argued that infant smiling indicated that infants tried to maintain an approach orientation toward their mothers, in order to evaluate the meaning of mothers' actions (Sroufe et al., 1974). On the other hand, Gusella et al. (1988) found that infants produced a still-face response when presented with their mothers' televised, motionless face, even though mothers retained eye contact and their interactive voices played from behind them. It is possible that infants responded differently in the two studies as a result of infant awareness of their mothers' intentions (i.e., the reason why they did not produce emotional facial expressions). In the live mask condition infants were given a *cue* why their mothers' face was motionless (i.e., their faces were covered), whereas in the televised condition they were not. Alternatively, it is possible that the televised condition did not fulfill infant expectations that in human speech both the auditory and visual properties are part of the vocal act (Kuhl & Meltzoff, 1982; Legerstee, 1991; Massaro, 1987; McGurk & MacDonald, 1976).

Although it is theoretically important to determine whether infant responses indicate that they distinguish between the various communicative conditions as a function of the different intentions of their communicative partner, despite possible perceptual similarities, there remains the methodological problem that, in order to do so, it is necessary to manipulate certain features that differentiate these intentions. Thus, infants are not only reacting to the changing motives of their mothers (i.e., unwilling to talk, drinking something, etc.), but also to perceptual features (i.e., eye contact, affective stimulation, mask, bottle, etc.). In order to control for such an interpretation we included interactions with a non-social object that matched the conditions of the social object. In the face-to-face condition a large doll with facial features made sounds and moved contingently as soon as the infant fixated the doll's face, and in the still-face condition the doll remained immobile. In the mask condition the doll wore the same mask as the mother, and in the bottle condition the bottle was positioned similarly to where the mother held her bottle.

Based on evidence that infants as young as 2 months show an awareness of the other, because they respond to the presence of attunement in face-to-face exchanges (Markova & Legerstee, 2006), we hypothesized that infants are aware of the relational aspects of communication, and thus should respond with more negative affect (sadness, gaze aversions, negative vocalizations) during the still-face condition, where no reason for a break in contact was given, than during the face-to-face, mask and bottle conditions. Second, according to classic still-face studies (Tronick, 1981), we expect infants to reduce their smiles and positive vocalizations from face-to-face to still-face. However, if infants are experiencing the modified still-face conditions as instances where mothers for some apparent reason (i.e., mask, bottle) have different intentions than in the face-to-face or still-face conditions, then we expect more smiles and vocalizations, and also less negative responses in the mask and bottle compared to the still-face condition. Third, according to studies that have examined infant reactions to changing communicative interactions during the first year of life, we expect differential responsiveness as a function of age, due to the infants' maturing socio-cognitive functioning (Cohn & Tronick, 1987; Legerstee, Corter, & Kienapple, 1990; Legerstee, Pomerlau, Malcuit, & Feider, 1987; Toda & Fogel, 1993; Weinberg & Tronick, 1996). Finally, we hypothesized that infants would produce more social responses such as negative and positive affect during the social than during the non-social conditions (see Legerstee, 1992, 2005, for reviews).

1. Study 1

1.1. Method

1.1.1. Participants

Forty-eight infants participated in study 1. Sixteen 3-month-olds ($M = 99$ days, range = 67–117 days; seven females), 16 6-month-olds ($M = 190$ days, range = 181–207 days; nine females), and 16 9-month-olds ($M = 287$ days, range = 267–304 days; eight females). An additional eight infants had been tested, but were not included in the final sample because of fussiness. Infants were recruited from a hospital in the city and through birth lists. Approximately 80% of the infants were Caucasian, and 20% were African American. All infants were healthy at birth and came from lower to middle class families, as determined by parental years of education. Mothers received a small gift for participating in the study.

1.1.2. Materials

Testing took place in a room at the Infancy Centre at York University, Toronto. The laboratory was partially furnished as a child's room. Within the room was a large cubic metal frame which filled two thirds of the space, attached to which were white curtains. This created a 'room within a room', where the infant, mother and experimenter could interact without distraction. Infants sat in a red, foam infant seat that was attached to a chair. Mothers sat in another chair, facing the infant.

The interaction was filmed with two digital video cameras. One was placed behind and to the left of the experimenter's left shoulder, and the other to the far side of the infant's right hand. Images from both cameras were fed into a VCR, which also recorded date and time (in seconds) of the occurrence of the various behaviors. This VCR was equipped with a special-effects generator to obtain a split screen image of the interaction: on the left side of the screen the infant could be seen in full-frontal view, and on the right hand side of the screen the mother's facial expressions could be seen.

The doll used in the experiment was a 60 cm long, stuffed Raggedy Anne doll. The doll was chosen because in pilot work it attracted sustained attention over an interactive puppet.[1] In addition, the head of the Raggedy Ann doll was of a similar size to that of the adult, and thus could wear the face mask. The eyes and smiles of the doll were large and salient, thereby controlling for eye contact and affect. Three little bells were attached to the doll's back, and sounded when the doll was moved.

An expressionless face mask was used for the mask conditions. It covered the complete face of the mother and doll (up to their ears and hair line). There were openings for eyes and lips, allowing for eye contact and sounds to emanate.

In order to familiarize infants with the doll, but not to habituate them, a smaller version of the doll was dropped off at the infants' home for a period of 3 to 4 days. Mothers were asked to play with the doll and the infant, when they had some free time. During testing, none of the infants had a fear response to the moving and sounding doll, and all infants approached the active and passive doll with sustained interest.

1.1.3. Procedure

Upon arrival at the Infancy Centre, mothers and infants were given a few minutes to adjust to their surroundings and infants were familiarized to their infant seat. During this time mothers were informed about the procedure and their written consent was obtained.

Once infants and mothers were familiarized, testing began. All infants were presented with three social (mother) and non-social (doll) conditions: face-to-face (FTF), still-face (SF), and masked still-face (MSF). During the six conditions, infants sat in their seat facing the stimuli at a distance of approximately 25 cm.

In the FTF condition mothers were asked to talk to their infants as they normally would at home. In the corresponding doll condition mothers stood behind the white curtains, and were asked to hold the doll so that it faced the infant and to move it when the infant looked at it. This way mothers moved and jingled the bells that were attached to the doll, thereby mimicking their own communicative attempts with the infants (i.e., "act as if the doll was taking turns and communicating with the baby"). We felt that this was an appropriate control for the mother's behavior during the FTF condition, because when parents interact with infants they naturally respond in a dialogic fashion to infants' actions with movements, vocalizations and gazes (Legerstee et al., 1987; Papousek & Papousek, 1986; Trevarthen, 1977).

In the SF condition, mothers were asked to refrain from talking to their infants, and to keep a neutral facial expression. In the corresponding doll condition, mothers, standing behind the white curtains, held the doll motionless in front of the infants.

In the MSF condition, mothers, while wearing the expressionless face mask, were asked to look at their infants and speak with them. In the corresponding doll condition, the doll wore the same face mask as the mother, and mothers were given the same instructions as in the FTF condition (i.e., "move the doll as if the doll was taking turns and communicating with the baby").

[1] We found that a doll hand puppet, when internally manipulated, changed its facial features from friendly to unfriendly when its mouth was moved. It is possible that for this reason, Ellsworth, Muir and Hains (1993) did not find any smiling to the active puppet, nor any age effects.

Mothers were asked to refrain from touching their infants in all conditions, because it was not possible to control for touch in the doll condition. Each condition lasted 2 min. The sequence of conditions was randomized to control for order effect. If infants became distressed during the sessions they were comforted until they were again in an alert and content state (stage 4; Wolff, 1966) before the session resumed. The number of infants who received such small breaks was less than 18% of the total number of infants.

1.1.4. Measures

Infants' positive (smiles, positive vocalizations) and negative affect (sad facial expressions, negative vocalizations) were coded (see Delgado et al., 2002; Hsu, Fogel, & Messinger, 2001; Legerstee et al., 1987, 1990; Markova & Legerstee, 2006). *Smiles* were defined as facial expressions, with the mouth turned upward, and s*adness* was defined as a negative facial expression (mouth, eye brows and cheeks turned down) and a passive bodily posture. *Positive vocalizations* were defined as sounds containing varied pitch contours, produced relaxed and syllable-like, often called babbling, and containing oral resonance. *Negative vocalizations* were vocal sounds that were produced somewhat forced or with effort, and were often series of vowel-like sounds, somewhat nasal with uniform pitch.

The infants' attention pattern or gaze orientation are also revealing indicators of infant emotions. Infants will look intently at interesting stimuli, but will avert their gazes from people when they stare at the infant impassively (Legerstee et al., 1987; Toda & Fogel, 1993). Consequently, two types of gazes were coded: (1) *gazes at* the stimulus, and (2) *gaze aversions*, which were defined as infants lowering the eyelids, without closing eyes, and a subsequent diversion of gaze.

1.1.5. Reliability

The videotapes were coded at normal speed from a TV monitor with a 53 cm screen. Half of the screen, which showed the stimulus, was covered, so that only the responses of the babies were visible. The time in seconds was recorded on the tape, and allowed frequencies and durations of each behavior to be recorded. The coders were naïve to the experimental hypotheses and could not influence the outcome one way or another. The coders made five passes through the tapes, one for each behavior. Inter-rater agreement on duration and frequencies ranged from $\kappa = .86$ to .91 for all behaviors.

1.2. Results

Data were analyzed with a repeated-measures analysis of variance (ANOVA) for the duration of gazes, gaze aversions, smiles, sad facial expressions, and frequencies of positive and negative vocalizations, with age (3, 6, 9 months) as the between-subjects factor, and stimulus (mother, doll) and condition (FTF, SF, MSF) as the within-subjects factors. There was no main effect of order, nor was this variable involved in interactions with the main factors. Thus, this variable was not included in any follow-up analyses. In all analyses, significant interactions were followed-up by examination of simple effects. Specifically, planned simple effects were computed to compare (1) infant responses to the two stimuli in each condition, and (2) their responses in the three conditions when interacting with their mother.

1.2.1. Negative affect measures

Means and standard deviations for infants' negative affect (sad facial expressions, negative vocalizations, and gaze aversions) are presented in Table 1.

1.2.1.1. Sad facial expressions. Results revealed a significant interaction between stimulus and condition, $F(2, 90) = 30.585$, $p < .001$, $\eta^2 = .405$ (see Fig. 1). Simple effects indicated that infants displayed significantly more sad facial expressions to mother than doll during SF, $F(1, 45) = 28.496$, $p < .001$, $\eta^2 = .388$. Within the social conditions, infants displayed significantly more sad facial expressions during SF compared to MSF, $F(1, 45) = 32.618$, $p < .001$, $\eta^2 = .420$, and least during FTF, $F(1, 45) = 32.265$, $p < .001$, $\eta^2 = .418$.

1.2.1.2. Negative vocalizations. A significant interaction between stimulus and condition, $F(2, 90) = 23.229$, $p < .001$, $\eta^2 = .340$ (see Fig. 1) and simple effects showed that infants produced significantly more negative vocalizations to mother than doll during SF, $F(1, 45) = 44.515$, $p < .001$, $\eta^2 = .497$. Within the social conditions, infants produced

Table 1
Mean duration of gaze aversions and sadness, and mean frequency of negative vocalizations in the three experimental conditions of study 1 during interactions with mother and doll as a function of age

Age	Mother			Doll		
	FTF	SF	MSF	FTF	SF	MSF
Sad facial expressions						
3 months						
M	0	21.63	.48	0	.44	0
S.D.	0	26.32	1.05	0	1.03	0
6 months						
M	0	11.94	.61	1.31	1.06	1.50
S.D.	0	13.99	.97	3.70	4.25	4.83
9 months						
M	.75	20.19	.88	1.13	2.13	1.81
S.D.	1.73	22.07	1.19	2.09	3.78	4.74
Negative vocalizations						
3 months						
M	4.25	12.44	4.76	1.38	2.88	1.5
S.D.	4.03	8.04	5.97	1.50	3.85	1.32
6 months						
M	2.25	10.25	2.44	1.38	3.13	2.19
S.D.	3.19	9.33	3.44	1.82	4.26	4.69
9 months						
M	.81	7.06	3.19	2.31	3.63	2.75
S.D.	1.05	5.93	4.92	2.50	3.26	6.06
Gaze aversions						
3 months						
M	0	25.06	0	0	0	.38
S.D.	0	14.96	.01	0	0	1.26
6 months						
M	0	15.38	.01	0	0	.50
S.D.	0	16.21	.02	0	0	1.75
9 months						
M	.13	10.19	0	0	0	1.50
S.D.	.50	5.64	0	0	0	4.24

Note. FTF: face-to-face; SF: still-face; MSF: masked still-face.

significantly more negative vocalizations during SF compared to MSF, $F(1, 45) = 37.168$, $p < .001$, $\eta^2 = .452$, and least during FTF, $F(1, 45) = 43.068$, $p < .001$, $\eta^2 = .486$.

1.2.1.3. Gaze aversions. A significant interaction between age, stimulus and condition, $F(4, 90) = 4.762$, $p = .002$, $\eta^2 = .175$ (see Fig. 1) and simple effects revealed that 3-month-old infants produced significantly more gaze aversions to their mothers than the doll during SF, $F(1, 45) = 58$–$.152$, $p < .001$, $\eta^2 = .564$. During the social conditions, 3-month-olds produced significantly more gaze aversions during SF than FTF, $F(1, 45) = 58.118$, $p < .001$, $\eta^2 = .564$, and MSF, $F(1, 45) = 11.541$, $p = .001$, $\eta^2 = .204$. More gaze aversions were also produced during SF than during MSF, $F(1, 45) = 56.435$, $p < .001$, $\eta^2 = .556$.

At 6 months, infants averted their gazes significantly longer toward their mothers compared to the doll during SF, $F(1, 45) = 21.885$, $p < .001$, $\eta^2 = .327$. In the social conditions, infants displayed significantly longer gaze aversions during SF compared to MSF, $F(1, 45) = 21.928$, $p < .001$, $\eta^2 = .328$, and least during FTF, $F(1, 45) = 21.872$, $p < .001$, $\eta^2 = .327$.

At 9 months, infants averted their gazes reliably longer to mother than doll during SF, $F(1, 45) = 9.608$, $p = .003$, $\eta^2 = .176$. Within the social conditions, infants averted their gazes significantly longer during SF than MSF, $F(1, 45) = 10.421$, $p = .002$, $\eta^2 = .188$, and least during FTF, $F(1, 45) = 9.369$, $p = .004$, $\eta^2 = .172$.

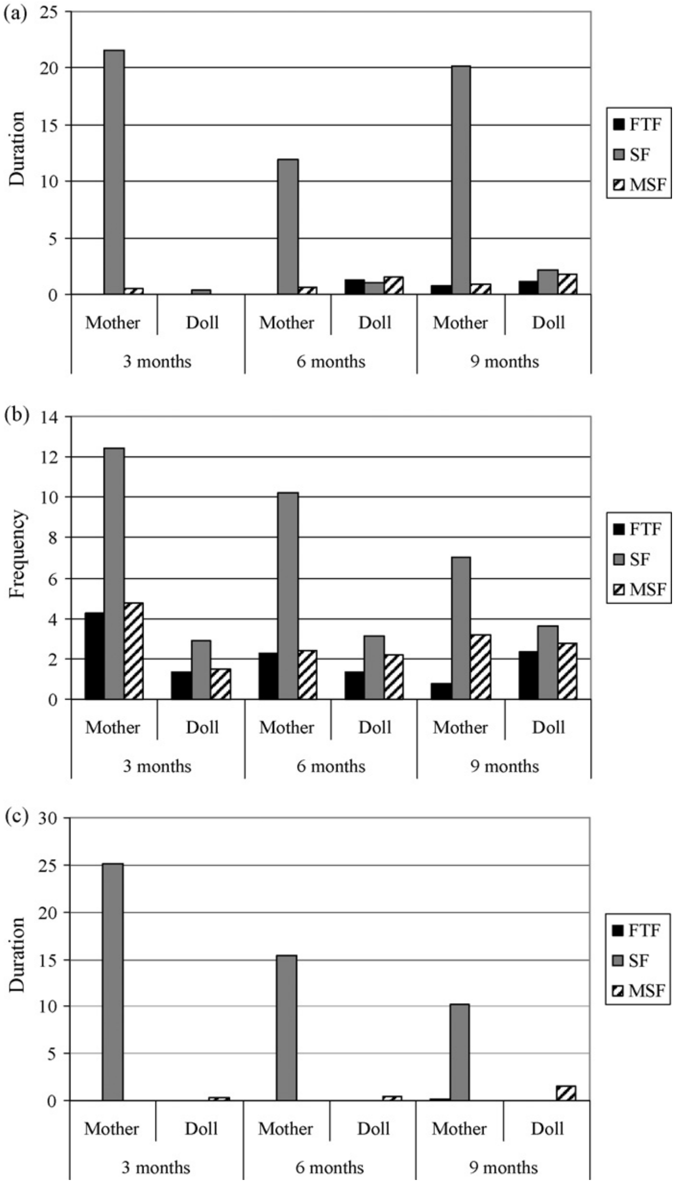

Fig. 1. Infant (a) sad facial expressions, (b) negative vocalizations, and (c) gaze aversions, during FTF, SF and MSF conditions in study 1 with mother and doll as a function of age.

1.2.2. Positive affect measures

The means and standard deviations for infants' positive affect measures (smiles, positive vocalizations, and gazes at stimulus) are shown in Table 2.

1.2.2.1. Smiles. A significant interaction between age, stimulus and condition, $F(4, 90) = 4.971$, $p = .001$, $\eta^2 = .181$ (see Fig. 2), and simple effects revealed that 3-month-old infants smiled significantly more to mother than doll during FTF, $F(1, 45) = 36.035$, $p < .001$, $\eta^2 = .445$. Within the social conditions, 3-month-olds smiled reliably longer during FTF than MSF, $F(1, 45) = 9.160$, $p = .004$, $\eta^2 = .169$, and least during SF, $F(1, 45) = 53.481$, $p < .001$, $\eta^2 = .543$.

At 6 months, infants smiled longer toward mother than doll during FTF, $F(1, 45) = 12.742$, $p = .001$, $\eta^2 = .221$, SF, $F(1, 45) = 13.283$, $p = .001$, $\eta^2 = .228$, and MSF, $F(1, 45) = 8.139$, $p = .007$, $\eta^2 = .153$. Within the social conditions, they

Table 2
Mean duration of smiles and gazes at stimulus, and mean frequency of positive vocalizations in the three experimental conditions in study 1 during interactions with mother and doll as a function of age

Age	Mother			Doll		
	FTF	SF	MSF	FTF	SF	MSF
Smiles						
3 months						
M	41.88	6.50	16.56	6.88	.13	6.50
S.D.	22.30	9.24	6.50	10.01	.34	11.61
6 months						
M	33.88	13.81	28.31	13.06	.56	6.56
S.D.	15.28	12.96	31.49	14.50	1.09	9.28
9 months						
M	26.44	15.50	33.75	23.44	.25	5.56
S.D.	16.46	14.35	34.75	21.79	.45	4.80
Positive vocalizations						
3 months						
M	8.25	1.88	3.94	1.25	.94	1.19
S.D.	6.25	2.28	5.41	1.29	1	1.97
6 months						
M	5	5.50	1.19	.63	1.19	1.06
S.D.	4.1	4.65	1.17	.89	1.28	1.91
9 months						
M	3.81	3.50	1.06	2.38	1.13	.88
S.D.	2.81	3.45	1.29	2.22	1.36	1.46
Gazes at stimulus						
3 months						
M	86.75	33.69	89.81	105.50	88.38	106.88
S.D.	25.52	15.24	36.17	11.31	24.58	11.49
6 months						
M	62.69	35.63	79.94	99.19	65.13	94.06
S.D.	23.88	15.24	26.74	18.28	26.59	23.52
9 months						
M	49.94	41.63	89.94	90	52.44	91.50
S.D.	18.06	18.86	23.83	19.05	27.85	17.02

Note. FTF: face-to-face; SF: still-face; MSF: masked still-face.

smiled less during SF compared to MSF, $F(1, 45) = 4.464$, $p = .040$, $\eta^2 = .090$, and FTF, $F(1, 45) = 17.202$, $p < .001$, $\eta^2 = .277$.

At 9 months, infants smiled significantly more toward mother than doll during SF, $F(1, 45) = 22.223$, $p < .001$, $\eta^2 = .331$, and MSF, $F(1, 45) = 14.186$, $p < .001$, $\eta^2 = .240$. Within the social condition, they smiled less during SF than FTF, $F(1, 45) = 7.016$, $p = .011$, $\eta^2 = .135$, and MSF, $F(1, 45) = 7.072$, $p = .011$, $\eta^2 = .136$.

1.2.2.2. Positive vocalizations. A significant age, stimulus and condition interaction, $F(4, 90) = 3.715$, $p = .008$, $\eta^2 = .142$ (see Fig. 2), and follow-up analyses revealed that 3-month-old infants produced significantly more positive vocalizations to mother than doll during FTF, $F(1, 45) = 34.130$, $p < .001$, $\eta^2 = .431$, and MSF, $F(1, 45) = 10.778$, $p = .002$, $\eta^2 = .193$. Within the social interactions, they produced more positive vocalizations during FTF than MSF, $F(1, 45) = 11.681$, $p = .001$, $\eta^2 = .206$, and least during SF, $F(1, 45) = 11.378$, $p = .002$, $\eta^2 = .202$.

At 6 months, infants produced significantly more positive vocalizations to mother compared to the doll during FTF, $F(1, 45) = 13.332$, $p = .001$, $\eta^2 = .229$, and during SF, $F(1, 45) = 10.645$, $p = .002$, $\eta^2 = .191$. Within the social interaction, they produced more positive vocalizations during SF than MSF, $F(1, 45) = 9.955$, $p = .003$, $\eta^2 = .181$, and also more during FTF compared to MSF, $F(1, 45) = 7.971$, $p = .007$, $\eta^2 = .150$.

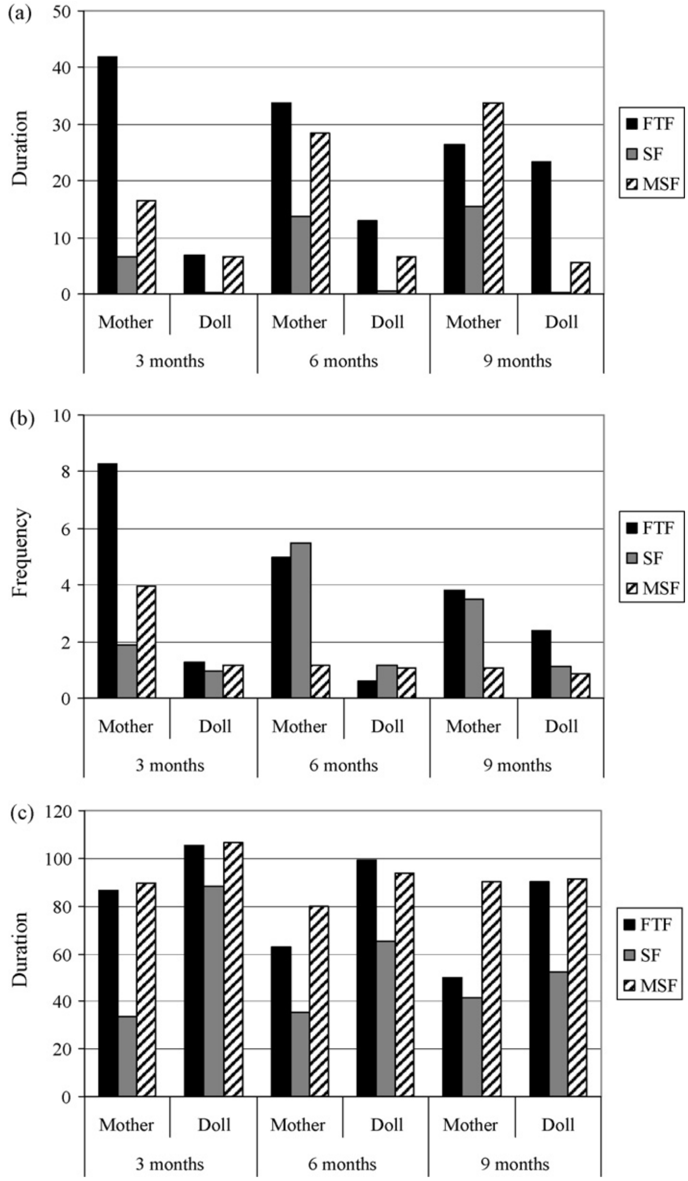

Fig. 2. . Infant (a) smiles, (b) positive vocalizations, and (c) gazes, during FTF, SF and MSF conditions in study 1 with mother and doll as a function of age.

At 9 months, infants produced significantly more positive vocalizations to mother than doll during SF, $F(1, 45) = 4.528$, $p = .039$, $\eta^2 = .091$. Within the social conditions, infants produced more positive vocalizations during SF than MSF, $F(1, 45) = 5.657$, $p = .022$, $\eta^2 = .112$, and also more during FTF compared to MSF, $F(1, 45) = 4.750$, $p = .035$, $\eta^2 = .095$.

1.2.2.3. Gazes at stimulus. There was an age, stimulus and condition interaction, $F(4, 90) = 5.324$, $p = .001$, $\eta^2 = .191$ (see Fig. 2). Analyses of simple effects showed that 3-month-old infants gazed significantly more at the doll than at mother during FTF, $F(1, 45) = 9.298$, $p = .004$, $\eta^2 = .171$, SF, $F(1, 45) = 44.138$, $p < .001$, $\eta^2 = .495$, and MSF, $F(1, 45) = 4.064$, $p = .050$, $\eta^2 = .083$. Within the social conditions, they gazed significantly longer during FTF compared to SF, $F(1, 45) = 54.931$, $p < .001$, $\eta^2 = .550$, and also longer during MSF than SF, $F(1, 45) = 42.988$, $p < .001$, $\eta^2 = .489$.

At 6 months, infants gazed significantly longer at doll than at mother during FTF, $F(1, 45) = 35.234$, $p < .001$, $\eta^2 = .439$, and SF, $F(1, 45) = 12.843$, $p = .001$, $\eta^2 = .222$. Within the social conditions, infants gazed longer during MSF compared to FTF, $F(1, 45) = 4.989$, $p = .031$, $\eta^2 = .100$, and also compared to SF, $F(1, 45) = 26.797$, $p < .001$, $\eta^2 = .373$. Additionally, these infants gazed longer during FTF compared to SF, $F(1, 45) = 14.288$, $p < .001$, $\eta^2 = .241$.

At 9 months infants gazed significantly longer at the doll than at mother during FTF, $F(1, 45) = 42.448$, $p < .001$, $\eta^2 = .485$. Within the social conditions, they gazed longer during MSF than SF, $F(1, 45) = 31.854$, $p < .001$, $\eta^2 = .414$, and FTF, $F(1, 45) = 26.828$, $p < .001$, $\eta^2 = .374$.

1.3. Discussion

Results showed that infants as young as 3 months differentiated with negative and positive affect between the social and non-social stimuli and also between the social conditions, and continued to do so until 9 months. That is, infants produced a classic still-face response during SF but not during MSF when interacting with their mothers. Infants also produced significantly more positive affect during FTF than during MSF and least during SF.

It could be argued that infants differentiate between people and objects, but are responding to modulation of affective stimulation they receive from people (i.e., most in FTF, less in MSF, and least in SF), rather than differences in communicative intentions. To investigate this suggestion, we continued the inquiry by presenting infants with two still-face conditions during which mothers kept eye contact, but presented no affective stimulation. Consequently, mothers displayed a classic still-face and a modified still-face. In the modified still-face condition mothers appeared to drink from a bottle. Because by 9 months there is strong evidence in the literature that infants perceive intentions in people's communicative behavior (see Carpenter, Nagell, & Tomasello, 1998, for a review), in study 2 we focused on the theoretically more important ages by studying infants at 3 and 6 months (Delgado et al., 2002; Ellsworth et al., 1993; Gusella et al., 1988; Murray & Trevarthen, 1985).

2. Study 2

2.1. Method

2.1.1. Participants

Twenty-eight full-term and healthy infants were included in the final sample. They were divided into two age groups, with 14 infants in each group: 3-month-old infants ($M = 101.5$ days, range 81–115 days; eight females), and 6-month-old infants ($M = 186.9$ days, range = 179–201 days; 7 females). An additional seven infants had been tested, but not included in the final sample because of fussiness ($n = 6$) or experimental error ($n = 1$). Infant and mother participants were obtained from a list indicating mothers' interest in participating in research in infant development. Approximately 85% of the infants were Caucasian and 15% were African American. All infants were healthy at birth and came from lower to middle class families, as determined by parental years of education. Mothers received a small gift for participating in the study.

2.1.2. Materials and procedure

The general procedure and materials were similar to study 1, except that in study 2, during the modified still-face condition, mothers appeared to drink from a water bottle she held against her lower lip, while maintaining eye contact and a neutral, unresponsive expression (BSF). The bottle was a small white plastic and see-through water bottle, approximately 12 cm long and 6 cm wide. Again mother and doll conditions were presented in a randomized order and infants were assessed when they were in calm and alert state (stage 4; Wolff, 1966).

2.1.3. Measures and reliability

The same infant behaviors were measured as in study 1. Namely, sad facial expressions, negative vocalizations and gaze aversions were coded as signs of negative affect, while smiles, positive vocalizations and gazes at stimulus were measured as signs of their positive affect. The same coding definitions and procedures were used as in study 1. Inter-rater agreement on duration and frequencies of all measures ranged from $\kappa = .80$ to .86.

Table 3
Mean duration of gaze aversions and sadness, and mean frequency of negative vocalizations in the three experimental conditions of study 2 during interactions with mother and doll as a function of age

Age	Mother			Doll		
	FTF	SF	BSF	FTF	SF	BSF
Sad facial expressions						
3 months						
M	0	4.67	0	0	.07	1
S.D.	0	6.07	0	0	.27	3.46
6 months						
M	0	4.21	0	0	0	0
S.D.	0	5.47	0	0	0	0
Negative vocalizations						
3 months						
M	.01	3.58	0	0	.14	0
S.D.	.02	3.05	0	0	.36	0
6 months						
M	0	3.21	0	0	.07	0
S.D.	0	2.97	0	0	.27	0
Gaze aversions						
3 months						
M	0	17.33	0	0	0	0
S.D.	0	15.82	0	0	0	0
6 months						
M	0	16.43	0	0	0	0
S.D.	0	11.89	0	0	0	0

Note. FTF: face-to-face; SF: still-face; BSF: bottle still-face.

2.2. Results

Preliminary analyses did not show an effect of order, nor was this variable involved in interactions with the main factors. Therefore, this variable was not included in subsequent analyses. Data were analyzed with a repeated-measures ANOVA for the duration of gazes, gaze aversions, smiles, and sad facial expressions, and frequencies of positive and negative vocalizations, with age (3, 6 months) as the between-subjects factor, and stimulus (mother, doll) and condition (FTF, SF, BSF) as the within-subjects factors. Significant interactions were followed-up by analyses of planned simple effects to compare infant responses (1) between mother and doll, and (2) among the three social conditions.

2.2.1. Negative affect measures

Means and standard deviations of infants' negative affect measures (sad facial expressions, negative vocalizations, and gaze aversions) are presented in Table 3.

2.2.1.1. Sad facial expressions. A significant interaction between stimulus and condition was found for the duration of sad facial expressions, $F(2, 52) = 15.960$, $p < .001$, $\eta^2 = .380$ (see Fig. 3). Follow-up analyses revealed that infants produced more sad facial expressions to their mothers than doll during SF, $F(1, 26) = 16.176$, $p < .001$, $\eta^2 = .384$. Within the social conditions, infants produced more sad facial expressions during SF than both FTF, $F(1, 26) = 16.558$, $p < .001$, $\eta^2 = .389$, and BSF, $F(1, 26) = 16.558$, $p < .001$, $\eta^2 = .389$.

2.2.1.2. Negative vocalizations. A significant interaction between stimulus and condition, $F(2, 52) = 30.073$, $p < .001$, $\eta^2 = .574$ (see Fig. 3), and simple effects revealed that infants produced significantly more negative vocalizations to mother than to doll during SF, $F(1, 26) = 35.103$, $p < .001$, $\eta^2 = .574$. Within the social conditions, infants produced

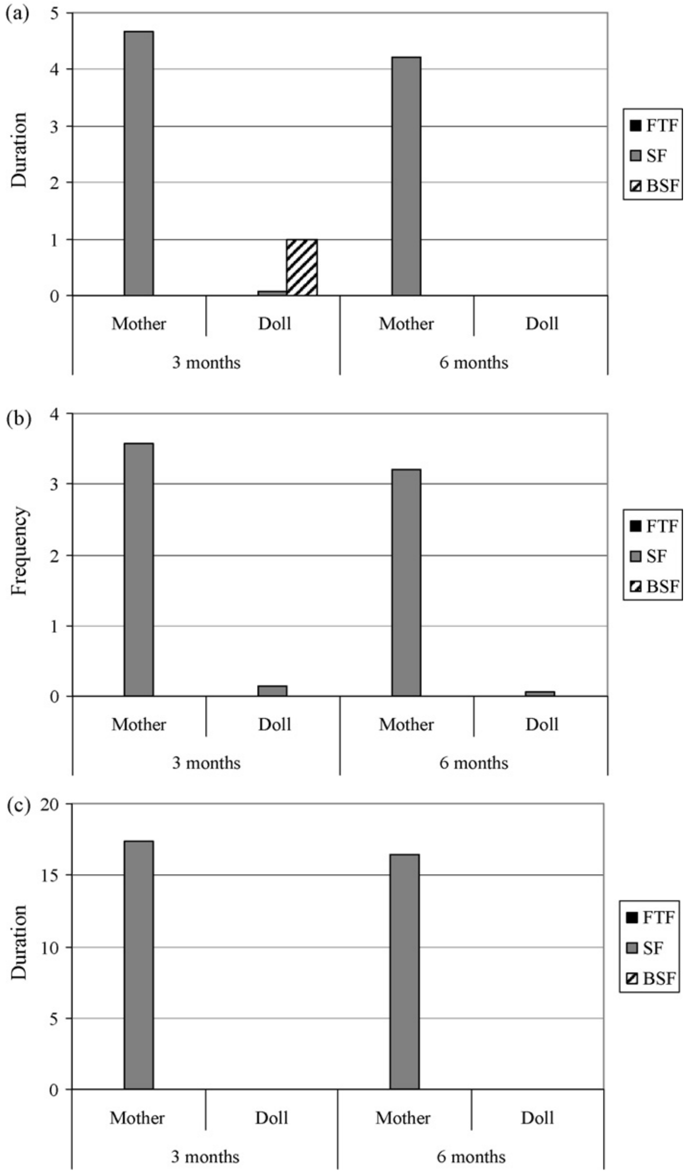

Fig. 3. Infant (a) sad facial expressions, (b) negative vocalizations, and (c) gaze aversions, during FTF, SF and BSF conditions in study 2 with mother and doll as a function of age.

significantly more negative vocalizations during SF compared to FTF, $F(1, 26) = 35.679$, $p < .001$, $\eta^2 = .578$, and BSF, $F(1, 26) = 35.740$, $p < .001$, $\eta^2 = .579$.

2.2.1.3. Gaze aversion. A significant stimulus × condition interaction, $F(2, 52) = 40.756$, $p < .001$, $\eta^2 = .611$ (see Fig. 3), and follow-up analyses showed that infants produced more gaze aversions to mother compared to doll during SF, $F(1, 26) = 40.756$, $p < .001$, $\eta^2 = .611$. Within the social conditions, infants produced more gaze aversions during SF compared to both FTF, $F(1, 26) = 40.756$, $p < .001$, $\eta^2 = .611$, and BSF, $F(1, 26) = 40.756$, $p < .001$, $\eta^2 = .611$.

2.2.2. Positive affect measures

Means and standard deviations of infants' positive affect measures (smiles, positive vocalizations, and gazes at stimulus) are shown in Table 4.

Table 4
Mean duration of smiles and gazes at stimulus, and mean frequency of positive vocalizations in the three experimental conditions in study 2 during interactions with mother and doll as a function of age

Age	Mother			Doll		
	FTF	SF	BSF	FTF	SF	BSF
Smiles						
3 months						
M	4.93	1.08	.64	.50	.43	.50
S.D.	5.69	1.94	1.15	1.02	.85	1.61
6 months						
M	5.07	2.50	1.62	3.79	.50	.71
S.D.	5.92	3.46	2.17	5.78	1.02	1.86
Positive vocalizations						
3 months						
M	3.31	.33	.43	.07	.14	.36
S.D.	2.09	.60	1.09	.27	.36	.74
6 months						
M	.57	.36	.46	.14	.14	.14
S.D.	.65	.74	.93	.36	.36	.36
Gazes at stimulus						
3 months						
M	35.15	21.83	29.64	51.86	45.43	46.79
S.D.	19.00	14.17	19.33	13.23	12.87	9.09
6 months						
M	27.57	16.00	19.54	56.14	41.86	46.07
S.D.	17.78	13.43	10.85	5.33	12.48	7.96

Note. FTF: face-to-face; SF: still-face; BSF: bottle still-face.

2.2.2.1. Smiles. Main effect of stimulus, $F(1, 26) = 7.654$, $p = .010$, $\eta^2 = .227$, indicated that infant produced more smiles to mother ($M = 2.64$, S.D. = 3.44) than doll ($M = 1.07$, S.D. = 2.34) (see Fig. 4). A main effect of condition, $F(2, 52) = 14.910$, $p < .001$, $\eta^2 = .364$, and post-hoc tests (with Bonferroni correction) showed that infants produced significantly more smiles during FTF ($M = 3.57$, S.D. = 5.05) than SF ($M = 1.13$, S.D. = 1.88, $p = .002$) and BSF ($M = .87$, S.D. = 1.74, $p = .001$).

2.2.2.2. Positive vocalizations. A significant interaction between age, stimulus and condition, $F(2, 52) = 15.320$, $p < .001$, $\eta^2 = .371$, and follow-up analyses of simple effects revealed that 3-month-old infants produced significantly more positive vocalizations to mother than doll during FTF, $F(1, 26) = 61.752$, $p < .001$, $\eta^2 = .704$ (see Fig. 4). Within the social conditions, 3-month-olds produced significantly more positive vocalizations during FTF compared to SF, $F(1, 26) = 52.149$, $p < .001$, $\eta^2 = .667$, and BSF, $F(1, 26) = 26.702$, $p < .001$, $\eta^2 = .507$.

Analyses of simple effects showed that 6-month-old infants did not differentiate with their positive vocalizations between mother and doll in any of the three conditions, and, moreover, did not differentiate between the conditions when interacting with their mothers.

2.2.2.3. Gazes at stimulus. There was a significant age × stimulus interaction, $F(1, 26) = 5.383$, $p = .028$, $\eta^2 = .172$ (see Fig. 4). Both 3- and 6-month-old infants looked longer at the doll than their mothers, $F(1, 26) = 64.224$, $p < .001$, $\eta^2 = .712$, and $F(1, 26) = 127.584$, $p < .001$, $\eta^2 = .831$, respectively. A significant main effect of condition, $F(2, 52) = 8.580$, $p = .001$, $\eta^2 = .248$, indicated that infants gazed significantly more during FTF ($M = 42.68$, S.D. = 14.30) than SF ($M = 31.28$, S.D. = 13.22, $p < .001$).

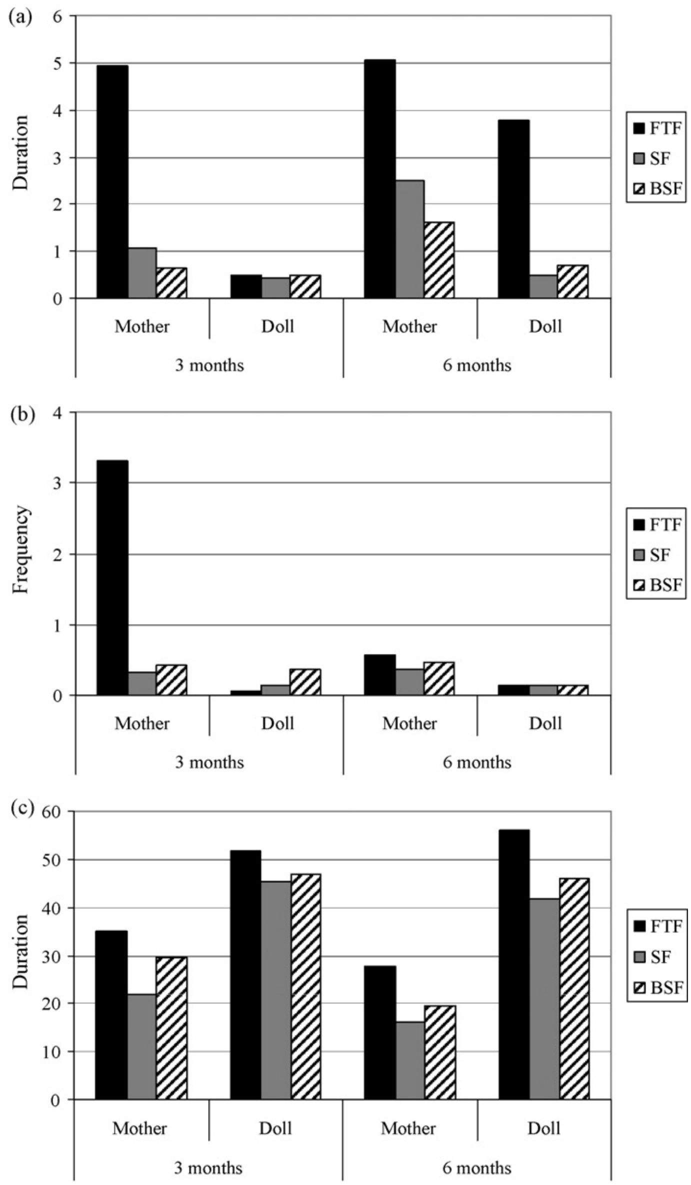

Fig. 4. Infant (a) smiles, (b) positive vocalizations, and (c) gazes, during FTF, SF and BSF conditions in study 2 with mother and doll as a function of age.

2.3. Discussion

The idea that infants in study 1 might not have gotten upset during the modified still-face (mask) compared to the classic still-face condition, because mothers continued to supply infants with affective stimulation rather than a cue why her face remained motionless, was assessed with the BSF (i.e., bottle) condition in study 2. Results of study 2 confirmed those of study 1. That is, whereas infants produced significantly more negative affect during SF than FTF and BSF, they did not use negative affect to differentiate between FTF and BSF. In addition, infants produced more positive affect toward their mother during FTF compared to SF and BSF, but they did not use positive affect to differentiate between SF and BSF. This differential responsiveness could not be a function of the superficial perceptual features such as movement, sound and bottle, because infants discriminated with positive and negative affect between mother and doll. Thus, infants in study 1 did not evaluate the mask condition as similar to the natural interaction, even though in both conditions mothers provided affective stimulation to them. In addition, although the bottle condition in study 2 did not allow mothers to actively engage with their infants (and thus was comparable to the classic still-face), infants did not get upset. These results reveal that across the ages tested infants responded consistently and appropriately to the various social and non-social conditions. They got upset when mothers refrained from communicating with them for no apparent reason (i.e., SF), but not when mothers were occupied (i.e., drinking from a bottle), or were unable to communicate (i.e., they wore a mask). Thus, in both studies infants discriminated between people who did not communicate with them because they had a reason from those who did not.

3. General discussion

The goal of the present inquiry was to determine whether infant responses to still-face and modified still-face conditions during the first year of life were a result solely of changes in maternal perceptual features, or whether her different communicative intentions also may have played a role. To explore these questions, two studies were conducted where the reason contact was broken was manipulated in classical (i.e., unwilling to communicate) and modified still-face procedures (i.e., unable to communicate because of wearing a mask, or drinking from a bottle). To control for changing perceptual features of these various conditions, infant responses during the social interactions were compared to their responses to non-social objects.

Infants responded differentially and appropriately to social and non-social objects when confounding variables such as facial features, movements, and sound had been controlled, and supported our hypothesis that 3-month-old infants should discriminate between the various social and non-social conditions. These findings corroborate results of others with typically developing infants as well as infants with Down syndrome (for reviews see Legerstee, 1992, 2005). Such convergence attests to the robustness of these findings. Thus, the changing perceptual features were not the *only* variables influencing infants' differential responsiveness. Instead, infants seem to be sensitive to something *other* when engaging in communicative exchanges with people that transcends the changing physical parameters.

An examination of infants' positive and negative affect in study 1 revealed not only that infants discriminated between mother and doll in the mask condition, but as early as 3 months infants produced more positive affect to their mothers during face-to-face than the mask condition, and less negative affect during the mask than the still-face conditions. In addition, infants in all age groups gazed longest during the mask condition than during all other conditions when interacting with their mothers. Sroufe et al. (1974) suggested that infants continued to maintain attention with their masked mothers, because they were trying to figure out what she was upto. Thus, infants were not interpreting their mothers' lack of emotional facial expressions as a refusal to communicate, but rather perceived what mothers were doing in the mask condition as interesting, and perhaps somewhat surprising. These findings contrast those of Gusella et al. (1988), who found that when infants see a motionless face, but have eye contact and hear their mothers' interactive voice they responded with a decrease in smiling and gazing at their mothers. The authors inferred that infants were upset (produced a classic still-face response). Had Gusella et al. (1988) coded infant negative affect, the results may have necessitated a different interpretation of the 6-month-old's evaluation of the situation.

Infants in study 2 also produced significantly more positive affect during face-to-face than the bottle and least during the still-face condition. If infants relied on perceptual indices only, such as affective stimulation, rather than the reason why contact was broken, then they should have been upset in the bottle condition, because except for the bottle, mother's eye contact, her impassive face and lack of an interactive voice were similar to the still-face condition. Thus, the bottle appeared to provide a salient reason to infants why mothers were not communicating, reasons that were not provided in the classic still-face condition.

To our knowledge, this is the first study that has compared infant responsiveness in the classic still-face paradigm with modified communicative interactions, where mothers retained eye contact and where affective stimulation either remained high (i.e., mask) or was completely absent (i.e., bottle). The similarity of infant responses in the mask and bottle conditions indicates that infants were not simply responding to variations in affective stimulation. In addition, during neither condition did infants get upset, indicating that emotional distress could not have interfered with infants' abilities to evaluate the reason why contact was broken. Overall, our data support the findings of Murray and Trevarthen (1985). That is, infants in the present study showed a strong and consistent still-face response to their unresponsive mother at 3 months, but not during modified still-face conditions, such as the masked or bottle conditions.

Our research provides information about the development of the various responses of infants at 3, 6 and 9 months. The hypothesis that infants should discriminate with appropriate reactions among the three social conditions, but react differently to the non-social conditions, was confirmed. However, there were strong age effects. Whereas 3-month-old infants turned to self-regulatory behaviors, such as head and gaze aversions, in an attempt to reduce the negative affect they experienced during the maternal still-face (see also Field et al., 1988), between 6 and 9 months, infants attempted to regulate the interaction with their mothers and thus showed an increase in vocalizations and smiles when their mothers remained unresponsive during the still-face condition. Often these smiles and vocalizations occurred at the beginning of the session, as a greeting, and re-occurred when mother refrained from communicating, as if to incite her to respond. As a result of the increase in positive affect during greeting and attempted re-engagements in the still-face episode, no reliable differences between the still-face and face-to-face interactions were found for older children. Such developmental changes were expected based on previous extensive empirical evidence (Adamson, 1995; Bruner, 1975; Cohn & Tronick, 1987; Kaye & Fogel, 1980; Legerstee et al., 1987; Messer & Vietze, 1988; Newson & Newson, 1970; Papousek & Papousek, 1986; Trevarthen & Hubley, 1978), and are the result of infants' developing motor and cognitive skills resulting in adaptive interactions and explorations with an expanding environment.

Interestingly, an examination of the video tapes showed that by 6 months infants often began to reach for their mothers' mask, while mothers in turn responded by saying "Peek-a-boo", or "Where is Mommy?", as if they were playing hide and seek. Sroufe et al. (1974) reported similar findings, and suggested that infants' behavior in the mask condition is the result of developing meaning structures that allow for increasingly more complex evaluations of the situation.

The developmental changes in infant social behavior from 3 to 6 and 9 months may be related to an increase in agency (Leslie, 1984), and point to the importance of studying infant socio-cognitive abilities not only over time, but also in paradigms that capture a broad range of infant social behaviors. In particular, the developing independence of the 6- and 9-month-old infants, compared to the 3-month-olds, reveals the significance of studying infant development while using both positive and negative affect measures. Simply measuring a decrease in positive affect and gazing during the still-face condition, as Gusella et al. (1988) did with 6-month-olds, does not capture a classic still-face response. Most studies that have examined infant responses to mothers' still-face have found that infants reduced their smiles and vocalizations, but increased their gaze aversions, negative vocalizations and sad facial expressions (Legerstee et al., 1987, 1990; Papousek, 2007; Toda & Fogel, 1993; Trevarthen, 1977; Tronick, Als, & Adamson, 1979; see also Adamson & Frick, 2003). For instance, a decrease in positive affect in 6-month-olds may indicate a variety of moods and discriminations, such as the onset of boredom with social stimulation during dyadic interactions, or an increasing interest in physical aspects of the environment (i.e., clothing, baby seat, etc.; Legerstee et al., 1987; Toda & Fogel, 1993). A more consistent picture of infant cognitive and social abilities could have been provided by Delgado et al. (2002), if the authors had studied infants at different ages, in conditions that contained eye contact and affective stimulation, and where the reason contact was broken was more salient.

In addition, and consistent with previous research (Ellsworth et al., 1993; Legerstee et al., 1987, 1990; Legerstee, Anderson, & Schaffer, 1998), infants gazed significantly longer at the doll than at their mothers at 3 months. This suggests different bases for infant responses: looking may be a result of novelty and movement, whereas smiles and vocalizations have a potential social significance.

In summary, it appears that from very early on infants do not react merely to the changing perceptual features of people (Wellman, 1990), nor do they show inherent tendencies or deep seated inclinations to communicate with others regardless of whether others intend to communicate with them or not. It would be a mistake to assume that infant behavior is random and functionally meaningless, and it would also be a mistake to assume that in the infant's mind the mother's behavior is random, purposeless and functionally meaningless (Kugiumutzakis & Markodimitraki, personal communication). Rather, during early communicative exchanges infants actively participate in their partners' emotional life, which may motivate them to share their own feelings (Hobson, 2007; see also Kugiumutzakis, Kokkinaki, Markodimitraki, & Vitalaki, 2006). If maternal responses are appropriate, in that they focus on the meaning of the infants' expressions (i.e., thereby matching the child's emotions), infants' signals bring about desired outcomes (Legerstee, 2007). Thus, successful communication depends on reciprocal following and enactment of communicative rules that specify how to interact with a conspecific. If in the mother-infant communicative system this process is engaged in by both partners, then both partners may share not only emotions, actions, motivation, attention and expectations, but intentions as well. The motivation to engage in communication with another person is a necessary condition for meanings to be exchanged (Tronick et al., 1979), and overlooking the role the child plays in this interaction would leave psychological growth unexplained (Trevarthen, 1979). Although, we do not assume that mother-infant communication is intentional by both partners all of the time, but when mutuality appears, intentionality, or as Stern

(1985) proposes inter-intentionality is "there". It is within this framework of mutual activity and sharing of emotions and attention that infants determine why contact is broken. In the mask condition infants may interpret maternal behavior as an interesting modification of her usual communicative actions. Similarly, when mothers are drinking, they are still, in some way, engaged with their infant, demonstrating an act, like they so often do, while maintaining eye contact with their infants. In this case, the infant does not get upset, because the break in affective sharing is caused by a salient reason. In contrast, during the still-face condition mothers establish mutual gaze, a potent communicative signal, and thus indicate that they are willing to engage in communicative exchanges. But the lack of her engagement per se, is responsible for the infant's negative evaluation. Thus, infants' expectations of certain communicative rules are violated in the still-face condition, but not in the modified still-face conditions (i.e., mask, bottle) of the present study.

In summary, through proper controls in the two studies we have ruled out the idea that simple perceptual discrimination of people's communicative acts is the basis for early discrimination among the face-to-face, still-face and modified still-face conditions, and between social and non-social stimuli in young infants. Thus, "we can fool infants into engaging with clever stimuli as if they were humans, of course, just as we can fool adults with holograms, but that does not detract from the fact there is a categorical distinction between person and personal forms of relatedness from early life" (Hobson, 2007, p. 9). But what is the basis for this early differential responsiveness? Assuming that communication is a process in which emotional meanings are exchanged, the caregivers' attunement to the infants' earliest communicative signals serves as a crucial input to change and completes the infant's representations of communication. However, it is the infant's awareness *from the start* of the caregiver's attunement (Legerstee, 2005), that gives infants a sense of connecting or "being with the other", and which allows for the co-creation and regulation of these communicative exchanges, which are then progressively integrated into the infant's internal representations to eventually become explicit.

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References

Adamson, L. B. (1995). *Communication development during infancy*. Madison, WI: Brown & Benchmark.

Adamson, L. B., & Frick, J. E. (2003). The still face: A history of a shared experimental paradigm. *Infancy*, *4*, 451–474.

Bruner, J. (1975). From communication to language: A psychological perspective. *Cognition*, *3*, 255–287.

Butterworth, G. (1991). The ontogeny and phylogeny of joint visual attention. In A. Whiten (Ed.), *Natural theories of mind: Evolution, development, and simulation of everyday mind reading* (pp. 223–232). Cambridge, MA: Basil Blackwell.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63* (4, No. 255).

Cohn, J., & Tronick, E. Z. (1987). Mother-infant face-to-face interaction: The sequencing of dyadic states at 3,6, and 9 months. *Developmental Psychology*, *23*, 68–77.

Corkum, V., & Moore, C. (1998). The origin of joint visual attention in infants. *Developmental Psychology*, *34*, 28–38.

Delgado, C. E. F., Messinger, D. S., & Yale, M. E. (2002). Infant responses to direction of parental gaze: A comparison of two still-face conditions. *Infant Behavior and Development*, *25*, 311–318.

Draghi-Lorenz, R., Reddy, V., & Costall, A. (2001). Rethinking the development of "Nonbasic" Emotions: A critical review of existing theories. *Developmental Review*, *21*, 263–304.

Ellsworth, C. P., Muir, D., & Hains, S. (1993). Social competence and person-object differentiation: An analysis of the still-face effect. *Developmental Psychology*, *39*, 63–73.

Field, T., Healy, B., Goldstein, S., Perry, S., Bendell, D., Schanberg, S., et al. (1988). Infants of depressed mothers show "depressed" behaviors even with non-depressed adults. *Child Development*, *59*, 1569–1579.

Fogel, A., & Garvey, A. (2007). Alive communication. *Infant Behavior and Development*, *30*, 251–257.

Gusella, J., Muir, D., & Tronick, E. (1988). The effect of manipulating maternal behavior during an interaction on three- and six-month-olds' affect and attention. *Child Development*, *59*, 111–1124.

Hains, S. M. J., & Muir, D. W. (1996). Infants' sensitivity to adult eye direction. *Child Development*, *67*, 1940–1950.

Hobson, P. (2007). Communicative depth: Soundings from developmental psychopathology. *Infant Behavior and evelopment*, *30*, 267–277.

Hsu, H., Fogel, A., & Messinger, D. S. (2001). Infant non-distress vocalization during mother infant face-to-face interaction: Factors associated with quantitative and qualitative differences. *Infant Behavior and Development*, *24*, 107–128.

Kaye, K., & Fogel, A. (1980). The temporal structure of face-to-face communication between mothers and infants. *Developmental Psychology*, *16*, 454–464.

Kugiumutzakis, G., Kokkinaki, T., Markodimitraki, M., & Vitalaki, E. (2006). Emotions in early mimesis. In J. Nadel & D. Muir (Eds.), *Emotional development: Recent research advances*. Oxford: Oxford University Press.

Kugiumutzakis, G., & Markodimitraki, M. (personal communication, January 7, 2007).

Kuhl, P. K., & Meltzoff, A. N. (1982). The bimodal perception of speech in infancy. *Science*, *216*, 1138–1141.

Legerstee, M. (2007). Mental state awareness in infancy and childhood: The role of relationships. In K. H. Brisch & T. Hellbruggge (Eds.), *The infant, Attachment, Neurobiology and Genes*. Stuttgart, Germany: Klett-Cotta.

Legerstee, M. (1991). Changes in the quality of infant sounds as a function of social and nonsocial stimulation. *First Language*, *11*, 327–343.

Legerstee, M. (1992). A review of the animate/inanimate distinction in infancy: Implications for models of social and cognitive knowing. *Early Development and Parenting*, *1*, 59–67.

Legerstee, M. (2005). *Infants' sense of people: Precursors to a theory of mind*. Cambridge: Cambridge University Press.

Legerstee, M., Anderson, D., & Schaffer, M. (1998). Five- and eight-month-old infants recognize their faces and voices as familiar and social stimuli. *Child Development*, *69*, 37–50.

Legerstee, M., & Barillas, Y. (2003). Sharing and pointing to objects at 12 months: is the intentional stance implied? *Cognitive Development*, *18*, 91–110.

Legerstee, M., Corter, C., & Kienapple, K. (1990). Hand, arm and facial actions of young infants to a social and nonsocial stimulus. *Child Development*, *61*, 774–784.

Legerstee, M., Pomerleau, A., Malcuit, G., & Feider, H. (1987). The development of infants' responses to people and a doll: Implications for research in communication. *Infant Behavior and Development*, *10*, 81–95.

Legerstee, M., & Varghese, J. M. (2001). The role of maternal affect mirroring on social expectancies in 3-month-old infants. *Child Development*, *5*, 1301–1313.

Leslie, A. M. (1984). Spatiotemporal continuity and the perception of causality in infants. *Perception*, *13*, 287–305.

Lewis, C., & Carpendale, J. (2002). Social cognition. In P. K. Smith & C. H. Hart (Eds.), *Blackwell handbook of childhood social development* (pp. 376–393). Malden: Blackwell.

Markova, G., & Legerstee, M. (2006). Contingency, imitation, and affect sharing: Foundations of infants' social awareness. *Developmental Psychology*, *42*, 132–141.

Massaro, D. W. (1987). *Speech perception by eye and by ear: A paradigm for psychological inquiry*. London: Lawrence Erlbaum.

McGurk, H., & MacDonald, J. (1976). Hearing lips and seeing voices. *Nature*, *264*, 746–748.

Messer, D. J., & Vietze, P. M. (1988). Does mutual influence occur during mother-infant social gaze? *Infant Behavior and Development*, *11*, 97–110.

Muir, D., & Hains, S. (1993). Infant sensitivity to perturbations in adult facial, vocal, tactile, and contingent stimulation during face-to-face interactions. In B. de Boysson-Bardies, S. de Schonen, P. W. Juszyk, P. McNeilage, & J. Morton (Eds.), *Developmental neurocognition: Speech and face processing in the first year of life* (pp. 171–185). New York: Kluwer Academic/Plenum Publishers.

Murray, L., & Trevarthen, C. (1985). Emotional regulations of interactions between two-month-olds and their mothers. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 177–197). Norwood, NJ: Ablex.

Newson, J., & Newson, E. (1970). On the social origin of symbolic functioning. In V. P. Varma & P. Williams (Eds.), *Piaget, psychology and education*. London: Hodder & Stoughton.

Papousek, M. (2007). Communication in early infancy: an arena of intersubjective learning. *Infant Behavior and Development*, *30*, 258–266.

Papousek, H., & Papousek, M. (1986). Structure and dynamics of human communication at the beginning of life. *European Archives of Psychiatry and Clinical Neuroscience*, *236*, 21–25.

Piaget, J. (1952). *Play, dreams and imitation*. New York: W.W. Norton and Co..

Reddy, V., & Trevarthen, C. (2004). What we learn about babies from engaging with their emotions. *Zero to Three*, *24*, 9–15.

Sroufe, L. A. (1996). *Emotional development: The organization of emotional life in the early years*. New York: Cambridge University Press.

Sroufe, L. A., Waters, E., & Matas, L. (1974). Contextual determinants of infant affective responses. In M. Lewis & L. A. Rosenblum (Eds.), *Origins of fear* (pp. 51–72). New York: Wiley.

Sroufe, L. A., & Wunsch, J. P. (1972). The development of laughter in the first year of life. *Child Development*, *43*, 1326–1344.

Stern, D. N. (1985). *The interpersonal world of the infant*. New York: Basic Books.

Toda, S., & Fogel, A. (1993). Infant response to still-face situation at 3 and 6 months. *Developmental Psychology*, *29*, 532–538.

Trevarthen, C. (1977). Descriptive analyses of infant communicative behavior. In H. R. Schaffer (Ed.), *Studies of mother-infant interaction* (pp. 227–269). London: Academic Press.

Trevarthen, C. (1979). Communication and cooperation on early infancy: A description of primary intersubjectivity. In M. Bullowa (Ed.), *Before speech: The beginning of interpersonal communication* (pp. 321–347). New York: Cambridge University Press.

Trevarthen, C., & Hubley, P. (1978). Secondary intersubjectivity: Confidence, confiding and acts of meaning in the first year. In A. Lock (Ed.), *Action, gesture and symbol* (pp. 183–229). New York: Academic Press.

Tronick, E. Z. (1981). Infant communication intent: The infant's reference to social interaction. In R. E. Stark (Ed.), *Language behavior in infancy and early childhood* (pp. 5–16). New York: Elsevier.

Tronick, E. Z., Als, H., & Adamson, L. (1979). The communicative structure of early face-to-face interactions. In M. Bullowa (Ed.), *Before speech: The beginnings of interpersonal communication* (pp. 349–372). Cambridge, England: Cambridge University Press.

Weinberg, M. K., & Tronick, E. Z. (1996). Infant affective reactions to the resumption of maternal interaction after the still-face. *Child-Development*, *67*, 905–914.

Wellman, H. (1990). *The child's theory of mind*. Cambridge, MA: MIT Press.

Wolff, P. H. (1966). The causes, controls, and organization of behavior in the neonate. *Psychological Issues*, *5* (Monograph No. 1).