

The Retention Effects of an Adult's Emotional Displays on Infant Behavior

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The goal of this investigation was to study the regulatory retention effects of an adult's emotional displays on infant behavior. In Study 1, 11- and 14-month-old infants were tested in a social-referencing-like paradigm in which a 1-hr delay was imposed between the exposure trials and the test trial. In Study 2, 11-month-olds were tested in the same paradigm, but the delay between the exposure trials and the test trial was only 3 min. Study 1 revealed that 14-month-olds, but not 11-month-olds, demonstrated behavior regulatory effects toward the target object linked to the adult's emotional displays. Study 2 indicated that 11-month-olds were affected by the emotional displays if the delay between exposure and test trials was brief enough.

In the last quarter of the first year, infants undergo a major developmental reorganization in which they become capable of partaking in two-person communication about third events (Campos, 1983; Carpenter, Nagel, & Tomasello, 1998; Klinnert, Campos, Sorce, Emde, & Svejda, 1983; Walker-Andrews, 1997). This shift leads to both an expansion and a deepening of infants' emotional lives. In this period, infants begin to engage for the first time in three important triadic emotional interactions: (a) affective sharing (bringing to the mother's attention the infant's emotions about particular environmental situations or objects; Conrad, 1994; Striano & Rochat, 1999), (b) social referencing (disambiguating the emotional meaning of objects in the environment by the infant's actively seeking out emotional information from significant others), and (c) emotional imputation (the infant's reacting in an emotionally appropriate manner to objects or persons the mother or experimenter is emoting about).

The primary purpose of the present studies was to investigate the carryover effects on infant behavior of the third of these triadic interactions by presenting two emotional displays differing in affective valence. The present studies were also designed to investigate infants' understanding of referential specificity and

the matching of the hedonic tone of the infants' emotional expressions to those of the adult, both at the time of exposure and after a delay.

The findings concerning the regulatory effects of a variety of positive and negative emotions on infant behavior in all three of these triadic contexts have been extraordinarily consistent (Feinman, Roberts, & Hsieh, 1992; Saarni, Mumme, & Campos, 1998). Four general conclusions emerge from the literature. First, the positive and negative expressions of others appropriately elicit approach and withdrawal behaviors in a variety of settings. Second, vocal expressions alone, and together with the face, regulate infants' behaviors more powerfully than facial expressions alone (Barrett, Campos, & Emde, 1996; Mumme & Fernald, 1996). Third, negative emotional displays elicit withdrawal from objects more readily than displays of joy elicit approach (Boccia & Campos, 1983; Mumme & Fernald, 1996; Svejda & Campos, 1982). Finally, infants regulate their behavior in accordance with emotional displays from either the mother or a familiar experimenter (Klinnert, Emde, Butterfield, & Campos, 1986).

Although it is clear that emotional expressions of others regulate infants' behavior in the here and now, the retention effects that others' emotional displays have on infant behavior are unclear. Bandura (1992) has referred to such consequences as the "vicarious acquisition function" of social referencing and, by extrapolation, of triadic communications in general.

There are major questions centering on the retention effects of triadic emotional communication: What does it take for adults' emotional displays to have carryover effects on infant behavior? At what ages are the carryover effects first evident? And what are the developmental and psychological properties

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that enable triadic communications to have carry-over effects? These questions are important for several reasons. First, if an infant retains nothing from an important affective communication, the infant would require constant or repeated signaling from the emoting adult for the infant to react appropriately in future encounters with the same or similar event (Bandura, 1992). Second, only if adults' emotional displays have continuing impact can infants become socialized and learn values about the world from others. Third, and possibly most important, the enduring consequences of emotional communication from others may play a role in the development of later appearing emotions such as embarrassment and pride. These so-called self-conscious emotions may develop from the intercoordination of several factors, including a developing sense of self (Lewis, *in press*), an appreciation of affectively mediated approvals and disapprovals of an infant's behavior toward objects, and the internalization and retention of such reflected appraisals of others (Witherington, Campos, & Hertenstein, 2001).

Why has there been so little study of the continuing impact of adults' emotional displays on infant behavior? Perhaps the primary reason is that the behavior regulatory effects and the emotional expressions of infants in studies of triadic communication, though highly consistent, have been moderate to weak in most studies (Feinman, 1992). Despite a few exceptions to this rule (e.g., Feinman & Lewis, 1983; Sorce, Emde, Campos, & Klinnert, 1985; Klinnert et al., 1986), the generally modest effects in studies of emotional communication likely discourage investigations into the retention effects of adults' emotional displays on infants. A second reason is a general disregard of the study of memory for affective experiences of any sort. Not until the past decade have investigators provided data on the intensely stressful experiences produced by medically necessitated painful procedures (Taddio & Shah, 2002). This neglect of memory for affect is as ironic as it is pervasive, in light of the importance of such hypothetical affective memory processes in the initial formulations of psychoanalytic and behaviorist theories of emotion.

There are several factors that likely enter into the development of the continuing impact that adults' emotional displays have on infant behavior. One is the sharp improvement in infants' capacities to encode, store, and retrieve memories of nonemotional environmental events late in the first year of life (Barr & Hayne, 2000). Another is the dramatic change in infants' emotional climates and resulting

socialization that take place between 9 and 15 months of age. For example, beginning in the second half of the first year and continuing into the second year, parents increasingly become more direct in their emotional communication about environmental events (Campos et al., 2000). These changes are thought to come about, at least in part, because of self-produced locomotion (both crawling and walking), which powerfully change the frequency and quality of emotional communications from the parent to the infant—communications that both encourage and discourage interactions of the child with objects in the world. Furthermore, locomotor experience affects memory, enabling infants to tolerate ever-longer delays between hiding and finding a toy (Campos et al., 2000). By extrapolation, the onset of walking at the end of the first year of life may permit even further development of the infant's tolerance of delays as the infant's life space expands and, consequently, the walking infant's goals take longer to reach. Finally, the semantic comprehension of the infant undergoes dramatic development in the last half of the first year of life and beyond (Thomas, Campos, Shucard, Ramsay, & Shucard, 1981). Although infants are sensitive to intonational contours, even in the neonatal period (Mehler, Bertoncini, Barriere, & Jassik-Gerschenfeld, 1978), there may be an increase in responding to pragmatics, specifically paralinguistics, once the infant begins to acquire semantic and syntactic comprehension.

With language comprehension may go an increase in understanding of pragmatics, specifically, paralinguistics. The increase in understanding may facilitate retention of the meaning of affective communication, as it does the retention of nonaffective phenomena (Piaget, 1947/1950). All of these factors independently and in concert with others are likely to affect the responsiveness of the infant to emotional signals in the here and now and in the long term (Campos, Barrett, Lamb, Goldsmith, & Stenberg, 1983).

Only two studies that we are aware of have been specifically designed to investigate the retention effects of an adult's emotional displays on infants' behaviors toward objects in the world. The first study, which will be discussed in detail because it is an unpublished dissertation, was designed to examine the extent to which negative emotional displays function as prohibitions, inhibiting infants' actions toward objects both immediately and 25 min later (Bradshaw, 1986). Ten- and 15-month-old infants were tested separately in a laboratory in which two toys were available to approach. When the infants first reached for one of the objects in this

pretest, the experimenter emoted disgust or anger facially and vocally or, as a control, a bland (neutral) display. After a 3-min period, infants went into a different room with their mothers and experimenter and waited for approximately 25 min. After the delay, the infants returned to the testing room for the posttest and the two toys were reintroduced for an additional 3 min. Inhibition of touching (speed of withdrawing hand, latency to touch, and duration of touching) and infant crying were coded in both 3-min periods.

The results of this study indicated that displays of anger and disgust, as compared with the experimenter's bland displays, resulted in immediate prohibition of touching the objects among the 10- and 15-month-olds. Only infants in the anger condition who did not touch the toy in the exposure period showed retention after the 25-min delay compared with infants in the bland condition (analyses were collapsed across age because few 10-month-olds did not touch the objects in the exposure trial). Infants who touched the toys did not behave differently after the 25-min delay as a function of the emotional display they received.

There were two difficulties that limit the conclusions of this study. First, the female experimenter emoted toward infants when they reached toward one of the two objects. In this paradigm, it is impossible for infants to know if the experimenter's emotional display is targeted toward their reaching behavior or toward the object itself. Thus, the 15-month-old infants in the anger condition may not have touched the target in the posttest because their previous behavior was prohibited in the pretest, not because the toys were the object of the prohibiting emotion. Because the infant is likely to engage in reaching much more often than to touching the target objects, reaches will be linked subsequently to other emotions, or to no emotions, more than the specific toys. If so, Bradshaw's (1986) method leads to a systematic underestimate of the capacity of infants to demonstrate the retention effects of emotional communication.

A second limitation is that the study was not designed to address the issue of referential specificity. This type of specificity concerns whether infants link others' emotional displays with an appropriate event—the target of the other's expression. That is, do infants regulate their behavior to objects in general, or do they regulate their behavior to the specific object to which the adult emotes? Infants' ability to correctly link adults' emotional displays with the objects to which adults are actually referring is crucial if one is interested in triadic emotional commu-

nication. If after a delay infants were incapable of referential specificity, they may generalize an adult's emotional displays to inappropriate objects in the environment. In addition, without the capacity to link an appropriate referent with an adult's emotional displays, the infant may perceive that an adult's emotional displays may be directed at the self rather than at an environmental object. For these reasons, it is important for infants to have the capacity to correctly link specific environmental objects with specific emotional displays.

The other study dealing with the retention effects of others' emotional displays on infants' behaviors was conducted with a much shorter delay between the pretest and posttest periods, and was not designed to investigate referential specificity (Hornik, Risenhoover, & Gunnar, 1987). In the pretest, 12-month-old infants were randomly assigned to one of three conditions in which their mothers exhibited either positive, negative (disgust), or neutral emotional displays. Mothers' emotional displays were directed in the pretest toward three stimulus toys that were presented serially to all of the infants. The infants were allowed to play with the toys if they wished to do so. After a 3-min delay, the posttest began in which the three stimulus toys were presented among several other toys to infants that were assigned to the positive and negative conditions (infants in the neutral condition were not tested after the delay).

Hornik et al. (1987) found that infants receiving negative emotional displays in the pretest played less with the stimulus toys in the posttest compared with infants who received positive emotional displays in the pretest. However, both groups of infants played equally as much with the distracter toys during the posttest, indicating that the infants understood the referential intent of their mothers' emotional displays. This conclusion, however, has been challenged on several grounds (see Saarni et al., 1998). In sum, what little work has been done on the carryover effects of triadic emotional communication has potentially not permitted the retention effects of emotional signals to be evident, or has drawn inappropriate inferences.

Study 1

Study 1 was designed to address one overarching question and two subsidiary questions. Its most important objective was to provide evidence on the retention effects of an adult's emotional displays on infant behavior. As a first step in mapping the relation between emotional communication and its carryover effects, infants were given minimal exposure

to emotion directed at one of two objects. The delay period used was 1 hr.

The first subsidiary question addressed in the study was whether infants regulate their behavior to the target of the experimenter's emotional displays or instead generalize their behavior to an object that was not the target. The second subsidiary question was whether the adult's expressive displays affect infants' emotional displays 1 hr later. That is, do infants express more negative emotions when the experimenter exhibited disgust and more positive emotions when the experimenter behaved positively? Although, as noted earlier, emotional expressions of others consistently have been reported to influence infants' instrumental behaviors toward objects and persons, such expressions have not always affected the infants' own expressions. The present study adds to the literature and in so doing may help sort out the mixed results.

Eleven- and 14-month-old infants were randomly assigned to one of two emotion conditions (joy or disgust). In the exposure phase of the study, the infants were given two procedurally identical trials and presented simultaneously with two objects while the experimenter pointed to and gazed at one of the objects (the target object) at the same time as he displayed one of the emotions. In the postdelay period 1 hr later, the two objects were presented to the infants again, but this time the objects were within their reach and the experimenter was out of the infants' sight.

Eleven-month-old infants were chosen in the present study because this age represents the lower end of the range at which triadic emotional communication is typically found. (It is uncertain whether infants younger than 10 months show an effect of triadic emotional communication. Walden and Ogan, 1988, did not report positive findings, although Svejda, 1981, did.) Fourteen-month-olds were chosen because they have had several months experience using others' emotional displays to regulate their behavior toward events in the environment. Infants at this age also have undergone the major transitions in two of the factors—the onsets of walking and the onset of receptive as well as productive language—that we believe play a role in the ontogeny of the retention of the emotional quality of triadic affective communications.

Method

Participants

Sixty-four healthy 11- and 14-month-old infants and their mothers were recruited in the San Francisco Bay area and constituted the final sample. Data

from 9 other infants (4 eleven-month-olds and 5 fourteen-month-olds) were excluded from the analyses because: the mother did not follow directions (3), excessive fussiness (5), and experimenter error (1). Exclusion of participants was approximately the same across experimental participants. There were 32 infants in each of the age groups: 11-month-olds ($M = 334$ days, $SD = 7$ days) and 14-month-olds ($M = 426$ days, $SD = 8$ days). Within each age group, half of the infants were assigned to the positive emotion condition and half to the negative emotion condition. Females and males were equally represented across groups. The ethnic composition of the sample was 59.0% Caucasian, 3.6% Asian, 5.6% Hispanic, and 31.8% other (e.g., mixed race). The infants were from middle- to upper-class families as indexed by their income and the highest level of education obtained.

Apparatus

The apparatus in this study included an infant high chair with an oversized table attached to it, two objects, a mechanical device to present the objects to the infants, and two video recording devices. Infants sat in a high chair with an oversized table (0.81 m × 0.81 m) so that the objects could be presented to the infants out of their reach. Two plastic objects were presented to the infants during the two exposure trials and one test trial: a yellow bird (17 cm × 12 cm) and a blue animal-like object (14 cm × 14 cm) with an extended nose (the visual angle was approximately 20 degrees from the infant's midline and 45 degrees from the experimenter's midline during the exposure trials). These objects were chosen because they elicited neither immediate positive nor negative affective displays from infants during pilot testing and were equally salient. The two objects were presented to the infants via two cables that descended through pulleys at the top of the ceiling. A false ceiling was constructed to conceal the objects from the infants. The entire experimental session, with the exception of the delay, was videotaped using two video cameras. One video camera was aimed toward infants' faces and bodies in the high chair and the other was aimed toward the infants' backs, the mother, and the experimenter's front side. Separate and asynchronous time-date generators were used to superimpose a stopwatch time on each of the video recordings.

Design

The study consisted of four phases. The first two phases were composed of two trials in which infants

were exposed to the experimenter's positive or negative emotional displays (henceforth referred to as Exposure Trial 1 and Exposure Trial 2). The third phase consisted of a 60-min delay, and the fourth phase consisted of the test trial in which infants' behaviors (both expressive and instrumental) were of primary interest to assess the retention effects of the first experimenter's (E1) emotional displays during the two exposure trials. Two independent variables were of chief interest: (a) the age of the infants (11- and 14-months-old) and (b) the emotion to which infants were exposed in the exposure trials (positive or disgust). Within each age, infants were randomly assigned to either the positive or disgust emotional conditions with the constraint that equal numbers of males and females were in each condition. The sides on which the objects were presented (i.e., to the left or right of the infant) were counterbalanced across the exposure trials and the test trial. Thus, the study was conceptualized as a 2 (age: 11- vs. 14-month-olds) \times 2 (emotion: positive vs. disgust) between-participants design.

Setting

A comfortable room was partitioned off by a curtain into an area for play (2.35 m \times 3.85 m) and an area for testing (2.35 m \times 1.7 m). The infant high chair was placed within the testing area with the mechanical device that presented the objects to the infant over the testing table. E1 sat in front of the infant high chair during the two exposure trials and in the play area during the test trial, the second experimenter (E2) operated the video equipment during the exposure trials and the test trial, and the mother was seated approximately 1.5 m away from the infant with her face positioned away from the infant.

Procedure

Each infant was tested separately, and the identical procedure was followed for all experimental conditions. Upon arriving for the experiment, a 10-min warm-up period ensued in which the infants and the mothers interacted with both experimenters. The experimenters played with the infant on the floor and spoke with the mother during the interaction period. Following this period, the mothers were given an overview of the experiment and were given instructions to sit silently near their infants during the two exposure trials and test trial while reading and completing a questionnaire. Though it was impossible for the infants to see their mothers'

faces, the mothers were instructed to concentrate on the questionnaire and to refrain from smiling and looking over their shoulders to watch their infants. This physical arrangement allowed the infants to know that their mothers were present but prevented the mothers from influencing their infant's behaviors.

After the mothers were given instructions, they placed their infants in the high chair and assumed their position near the infants. Mothers were allowed to interact with the infants for a brief time to ensure that the infants were attentive. The curtain was then closed and E1 sat directly in front of the infant. The exposure trials commenced when E2 (who stood on the other side of the partition) lowered the objects from the ceiling at a rate of approximately 10 cm/s. The objects landed approximately 70 cm away from the infant (well out of the infants' reach). Each 15-s exposure trial began when the objects made contact with the table. Immediately upon contact, E1 emoted either negatively or positively while pointing to only one of the objects (the object to which E1 pointed will be referred to as the target and the object to which E1 did not point will be referred to as the distracter). The object to which the experimenter directed his emotional displays was counterbalanced across children. After 15 s, E2 retracted the objects into the false ceiling and the mother was then allowed to interact with her infant while E1 switched the position of the objects. An opaque cloth fabric was hung from the ceiling to prevent the infants from seeing E1 switch the objects. After switching the objects, E1 placed the cloth fabric on top of the mechanical apparatus in the ceiling and instructed the mothers to assume the same position they had in the first exposure trial. The second exposure trial commenced when E2 allowed the objects to descend to the table again. Like the first exposure trial, E1 emoted about the same object, but the object descended on the other side of the infants. After 15 s, E2 retracted the objects into the slits in the false ceiling and the mothers were requested to remove their infants from the high chair and take them to the play area of the room.

Using two exposure trials represents a departure from most studies investigating the regulatory effect of others' emotional displays on infants. This was done for two reasons. First, Feinman (1992) has suggested that infants are often provided with repeated messages about the same object in everyday interactions and this has the likely effect of making the impact of the emotional signals more lasting. Second, two exposure trials were used to ensure that the infants did not use the position of the object as

the referent of the experimenter's display. Using two exposure trials and switching the left-right position of the objects between the trials controls for this possibility.

The 60-min delay (± 3 minutes) was calculated by subtracting the time at which the objects were removed from the table during the second exposure trial from the time at which the toys were presented to the infants during the test trial (11-month-olds in positive emotion condition: $M = 1$ hr, 0 min, $SD = 2.3$ min; 11-month-olds in disgust emotion condition: $M = 1$ hr, 0 min, $SD = 2.4$ min; 14-month-olds in positive emotion condition: $M = 1$ hr, 0 min, $SD = 1.9$ min; 14-month-olds in disgust emotion condition: $M = 1$ hr, 0 min, $SD = 2.1$ min). During the delay, the mothers were asked to continue to fill out the questionnaire for the first fourth of the hour. Subsequently, the infants and mothers were taken outside the building by the experimenters to allow the infants to play in a grassy area. Approximately 10 min before the test trial, the infants and mothers were taken inside the play area of the testing room where the infants were allowed to play with toys. During this period, E1 moved forward the infant's seat so that the objects would descend within the infant's reach during the test trial (the partition was closed to preclude infants from seeing E1 set up the test trial). Approximately 1 min before the test trial, the infants were placed in the high chair by their mothers. As with the exposure trials, the mother sat near the infant silently and directed her visual gaze toward the questionnaire. After the mother assumed her position and the infants were attentive, E1 vacated the testing area and closed the curtain. E2 lowered the objects to the table within the infant's reach (13 cm from the infant's torso) for 1 min. After the infants were allowed to interact with the objects for 1 min, E2 retracted the objects into the false ceiling and the experiment was concluded. The experimental arrangement provided maximum protection against experimenter bias because the experimenter was not within sight of the infant.

Emotional Display Manipulation

A male experimenter (E1) posed all of the emotional displays directed to the infants. The emotional displays were multimodal (facial, vocal, and postural) and endured for 15 s during each exposure trial. In both the positive and negative conditions, the nonsense phrase "tat fobble" was repeated four times during each 15-s exposure trial with each infant's name directly following the second utterance of the nonsense phrase. Joyful facial patterns were

displayed in the positive emotion condition (contraction of the corners of the mouth), and disgust facial patterns were displayed in the negative emotional condition (brows lowered and drawn together, upper lip pulled up and lower lip pulled down and protruded). The repeated vocal displays of emotion occurred in both the utterances of "tat fobble" and other emotionally charged noises ("ahhhh" in the positive condition and "uuuuuh" in the negative condition). By extensively rehearsing the signals, the experimenter made every effort to maintain equal levels of loudness both within and between conditions. Displays of emotion via posture were posed by slightly protruding the neck of the experimenter in the positive condition and slightly retracting the neck in the negative condition.

Manipulation Checks

Two manipulation checks were conducted to ensure the integrity of the procedure. The first manipulation check was conducted to ensure that the experimenter displayed the emotions properly (Bradshaw, 1986). The clarity and intensity of the emotional signals were scored separately for both facial and vocal displays. Two coders independently rated the facial displays, and two different coders independently rated the vocal displays.

The same 9-point Likert scale was used for the facial displays and vocal displays. The scale was anchored according to the following: a 1 indicated that the emotion was barely detectable, a 5 indicated that the emotion was clearly understood, and a 9 indicated the greatest possible indication of the emotion. The raters were told that more than one emotion may be perceptible for each expression. They used the same 9-point Likert scale to make ratings for six emotions: joy, surprise, sadness, fear, disgust, and anger. When raters thought that no specific emotion was present, they were instructed to mark a box next to the emotion indicating that "the emotion was not present."

For each exposure trial, an average was calculated from the two coders' ratings for the face and from the two coders' ratings for the voice. For data to be retained in the final sample, the exposure trials had to be rated a 5 or higher in the intended emotion category, and a 2 or lower in all other emotion categories. If these criteria were not met for both facial and vocal displays, the data were replaced. The manipulation check revealed that all of the experimenter's expressive displays in the exposure trials (both facial and vocal) met or exceeded the preceding criteria. Thus, all data were retained for the final analysis.

A second check was made from the videotapes to determine maternal compliance with instructions. If the mother turned toward the infant (thereby allowing her face to be visible to the infant) or made any sounds in either of the exposure trials or the test trial, the data were discarded from the final analysis. As stated previously, 3 mothers did not comply with the instructions given her.

Coding and Reliability

Research assistants, who were naive to the purpose and hypotheses of the study, coded the test trial on all dependent variables before coding the exposure trials. Three sets of dependent variables were of primary interest: (a) infants' looks in response to emotional displays (i.e., duration of looks toward target, distracter, experimenter, and mother), (b) infants' emotional displays, and (c) infants' instrumental behaviors (i.e., initial object exploration, duration of touching the target and the distracter, latency to touch the target and the distracter, and the percentage of time infants used their whole hand(s) to touch the target and the distracter). It should be noted that most studies falling under the domain of social referencing typically do not include latency to touch and whole-hand touch as dependent variables (e.g., Mumme & Fernald, 1996) and only some studies include initial object exploration (e.g., Repacholi, 1998). We believe that latency and duration can reveal where in the infant's processing of an event the emotion regulation takes place. Latency to touch taps into the initial inclination or inhibition of the child's approach toward a toy; duration of touch, by contrast, can assess whether positive and negative signals continue to operate differentially even after initial hesitation is overcome or approach has begun.

The first two sets of dependent variables were coded for each of the exposure trials, and the last two sets of dependent variables were coded for the test trial. One coder worked independently to code each of the dependent variables, and a second coder coded one third of the final sample. Rater agreement was assessed by calculating intraclass correlations for each of the continuous dependent measures. The coders scored 15 s of data for each exposure trial and 40 s for the test trial. Coding of the exposure trials began when the objects made contact with the table, and coding of the test trial began when the objects were approximately 0.5 m above the surface of the table for the test trial. Coding began at this point for the test trial because some infants were grasping the objects before the objects made contact with the table.

Visual gaze toward target, distracter, experimenter, and mother. The duration of time that infants gazed toward the target, distracter, experimenter, and mother during the exposure trials was coded. Rater agreement was .91 (M difference = .9 s), .92 (M difference = .8 s), .86 (M difference = 1.3 s), and .95 (M difference = .3 s), respectively.

Hedonic tone. The general hedonic valence of the infant was coded, not displays of discrete emotions, using the same scoring procedure employed in a previous study (Hertenstein & Campos, 2001). Judgments were based on facial, vocal, and gestural displays of emotion. For each exposure trial, ratings were given for two epochs (7.5 s each), and a summary score was computed from the average of these epochs. An overall summary score of the two exposure trials was computed by averaging each exposure trial; this summary score was used for analyses. For the test trial, ratings were given for four epochs (10 s each), and a summary score was computed from the average of these epochs. The instrumental behaviors of the infant were masked on the monitor by placing an opaque cover over the neck and torso of the image of the infants so as not to influence coders' ratings. The highest affective display rating that occurred within each of the epochs was scored. A score of 0 indicated that the infant appeared neutral during the scoring epoch. For the positive emotional display scale, a 1 was scored for a weak smile, operationally defined as slight upturning of the mouth while the mouth was closed and was accompanied by no cheek elevation. A 2 was scored for more intense smiling, operationally defined as a smile with either an open mouth or elevation of the cheeks. A 3 was scored if any of the criteria stipulated in 2 were met, and a positive vocalization (cooing, gurgling, etc.) was present concurrently. For the negative emotional display scale, a 1 was scored when the infant frowned, a 2 was scored when the infant frowned in conjunction with his or her head turning away from the object or the corners of the mouth were pulled back, and a 3 was scored if any of the criteria stipulated in 2 were met and a negative vocalization (grunting, crying, etc.) was present concurrently. Interrater agreement was $K = .72$ for the positive emotional display scale and $K = .74$ for the negative emotional display scale.

Initial object exploration. The object (either the target or distracter) that was touched first by infants was coded. Interrater agreement was $K = 1.00$.

Duration of touching target and distracter. The total time the infants touched the objects was coded. The time they touched the target and distracter were not mutually exclusive; infants could touch either the

target, the distracter, or both. Rater agreement was .90 (M difference = .9 s) for the target object and .91 (M difference = .8 s) for the distracter object.

Latency to contact target and distracter. The time from which the trial began to the time at which the infants first touched the object was coded. Rater agreement was .93 (M difference = .4 s) for the target object and .94 (M difference = .4 s) for the distracter object.

Percentage of whole-hand contact on the target and distracter. The percentage of time the infants touched the objects with their whole hand was coded as an index of the confidence with which the objects were touched. This was coded when one or both of the infants' entire palms touched the object or when all four fingers, irrespective of the thumb, contacted the object. The percentage was calculated by dividing the duration of time the infants touched the object with their whole hands by the duration of total time the infants contacted the object. Rater agreement was .83 (M difference = 3.2%) for the target object and .84 (M difference = 3.1%) for the distracter object.

Preliminary Analyses

All dependent variables presented were checked for normality, skewness, and kurtosis. All dependent variables were within normal limits for these checks. Univariate analyses of variance (ANOVAs) were also conducted on all dependent variables, entering sex as the independent variable. These analyses indicated that this factor was not statistically significant and thus was not entered into the subsequent analyses (all $ps > .05$).

Potential differences between the emotion factor and within each age level were examined in relation to the hypotheses in the present investigation. Four preliminary ANOVAs were conducted to ensure that any observed differences between the 11-month-olds and the 14-month-olds were not due to differences in visual attention during the exposure trials. Four separate factorial ANOVAs were conducted entering age (11- and 14-month-olds) as the factor on each of four dependent variables: (a) visual gaze toward the target, (b) visual gaze toward the distracter, (c) visual gaze toward the experimenter's head, and (d) visual gaze toward infants' mothers. All four analyses revealed no statistically significant effects, allowing confidence that any differences observed between the 11- and 14-month-old infants were not due to differences in visual attention (all $F_s < 1.18$, all $ps > .282$). It should be noted that infants' gaze toward mothers was relatively short ($M = 2.1$ s,

$SD = 1.6$ s), indicating they attended little to their mothers during the study.

Results and Discussion

All of the means and standard deviations are presented in Tables 1 and 2 for each age and emotion condition for all dependent variables. In all of the following analyses, effect-size statistics (eta-squared statistics for ANOVAs and Cohen's w for chi-square analyses) are included for statistically significant findings. An η^2 of .01 and a w of .01 reflect small effect sizes, an η^2 of .06 and a w of 0.3 reflect medium effect sizes, and an η^2 of .14 or larger and a w of 0.5 or higher reflect large effect sizes.

Effects on Infant Behavior During the Test Trial

To address the issue of the retention effects of the emotional communications, two sets of analyses were conducted on the parametric data (see Table 1 for means and standard deviations). First, two Age (11- vs. 14-month-olds) \times Emotion (positive vs. disgust) between-subjects multivariate analyses of

Table 1
Means and Standard Deviations by Emotion Condition for Instrumental and Expressive Infant Behaviors

| | Emotion condition | |
|---|-------------------|---------------|
| | Positive | Disgust |
| 11-month-olds | | |
| Duration of touch (target) ^a | 19.18 (11.74) | 17.56 (10.07) |
| Latency to touch (target) ^a | 8.90 (9.46) | 12.48 (10.89) |
| Whole-hand touch (target) ^b | 58.94 (13.74) | 54.50 (10.20) |
| Duration of touch (distracter) ^a | 15.69 (11.54) | 9.84 (7.12) |
| Latency to touch (distracter) ^a | 16.00 (14.69) | 12.34 (10.80) |
| Whole-hand touch (distracter) ^b | 56.19 (10.34) | 51.13 (9.82) |
| Negative expressive scale ^c | 0.44 (1.02) | 0.61 (1.00) |
| Positive expressive scale ^c | 1.33 (1.06) | 1.25 (1.10) |
| 14-month-olds | | |
| Duration of touch (target) ^a | 19.64 (9.53) | 7.17 (5.46) |
| Latency to touch (target) ^a | 4.10 (3.91) | 17.83 (18.68) |
| Whole-hand touch (target) ^b | 61.88 (10.03) | 51.69 (15.74) |
| Duration of touch (distracter) ^a | 13.18 (10.77) | 13.79 (11.42) |
| Latency to touch (distracter) ^a | 12.77 (13.45) | 14.30 (17.07) |
| Whole-hand touch (distracter) ^b | 59.75 (10.22) | 52.31 (12.00) |
| Negative expressive scale ^c | 0.66 (1.00) | 0.72 (1.19) |
| Positive expressive scale ^c | 1.50 (1.11) | 1.31 (1.31) |

Note. $N = 16$.

^aValues in seconds.

^bValues in percentages.

^cValues on a scale ranging from 0 to 3.

Table 2
Means and Standard Deviations by Emotion Condition for Positive and Negative Expressive Scales During Exposure Trials

| | Emotion condition | |
|---------------------------|-------------------|-------------|
| | Positive | Disgust |
| Positive expressive scale | | |
| 11-month-olds | 1.45 (0.84) | 0.86 (0.91) |
| 14-month-olds | 1.47 (1.00) | 0.93 (0.86) |
| Negative expressive scale | | |
| 11-month-olds | 0.09 (0.22) | 0.02 (0.06) |
| 14-month-olds | 0.34 (0.61) | 0.20 (0.46) |

Note. $N = 16$.

variance (MANOVAs) were conducted. The first included the three behavioral response dependent variables: duration of touching the target, latency to touch the target, and whole-hand touch of the target. Results of this MANOVA revealed a significant effect for emotion, $F(1, 58) = 5.52, p < .01, \eta^2 = .22$, no effect for age, and an Age \times Emotion interaction that approached significance, $F(3, 58) = 2.07, p = .11, \eta^2 = .10$. The second MANOVA included the two emotion dependent variables: the negative expressive scale and the positive expressive scale. Results from this analysis revealed no significant main effects and no interaction. Thus, no further analyses were conducted on these dependent variables. To test the hypotheses directly, two simple effects analyses were conducted within each level of the age factor on each behavioral response dependent variables. These were of primary importance to test the effects of emotion. In addition, a nonparametric test was conducted on the number of infants who touched the target object first. The nonparametric analysis is presented first.

Number of participants touching target object first. As predicted, significantly more 14-month-olds touched the target object first in the positive condition (11 of 16 test trials) and the distracter object first in the disgust condition (11 of 16 test trials), $\chi^2(1) = 4.50, p = .034, w = .80$. By contrast, equal numbers of 11-month-olds touched the target and distracter objects and did so in both conditions, $\chi^2(1) = 2.03, p = .15$.

Duration of touch. As predicted, the 14-month-old infants touched the target object less in the disgust emotion condition than in the positive emotion condition; this was not the case for the 11-month-olds. In fact, 14-month-old infants touched the target object over 2.5 times more in the positive condition than in the disgust condition. The simple effects analysis for the 14-month-olds revealed a significant effect for emotion, $F(1, 30) = 20.66, p = .000, \eta^2 = .41$,

whereas the simple effects analysis for the 11-month-olds was not significant.

Latency to touch. The 14-month-old infants waited 4 times longer to touch the target object in the disgust emotion condition than in the positive emotion condition; the 11-month-olds showed no such trend. The simple effects analysis for the 14-month-olds revealed a significant effect for emotion, $F(1, 30) = 8.28, p = .007, \eta^2 = .22$, whereas the simple effects analysis for the 11-month-olds was not significant.

Whole-hand touch. Compared with 11-month-olds, the 14-month-old infants touched the target object with their whole hands a greater percentage of time in the positive condition than in the disgust condition (approximately 10% more). The simple effects analysis for the 14-month-olds revealed a significant effect for emotion, $F(1, 30) = 4.77, p = .037, \eta^2 = .14$, but the simple effects analysis for the 11-month-olds was not significant.

Negative and positive expressive scales. As indicated by the MANOVA, the negative and positive expressive displays did not differ as a function of the adult's posed display.

Referential Specificity of the Adult's Expressive Displays: Effects on Infant Behavior

A major question addressed in the present investigation was whether infants regulate their instrumental behaviors only toward the specific referent of the adult's emotional displays or whether they generalize their behavior, thereby treating the target and distracter objects alike. Because the preceding analyses revealed that only the 14-month-old infants regulated their behavior differentially 1 hr later as a function of the adult's emotional displays, data from the 11-month-olds were excluded in the present set of analyses. Based on a limited literature, it was predicted that the 14-month-old infants would demonstrate referential specificity to some degree. In other words, infants in the disgust condition would differentiate between the target and distracter such that they would not avoid both the target and the distracter, but only the target.

An Emotion (positive vs. disgust) \times Object (target vs. distracter) mixed MANOVA with repeated measures on the last factor was conducted on duration of touch, latency to touch, and whole-hand touch. This analysis revealed a significant main effect for emotion, $F(3, 28) = 5.03, p = .006, \eta^2 = .35$, and a significant Emotion \times Object interaction, $F(3, 28) = 4.73, p = .009, \eta^2 = .34$, but no significant effect for object. Two sets of analyses were conducted to address the

hypothesis stated previously (see Table 1 for means and standard deviations). First, two simple effects analyses were conducted within each level of the emotion factor on each of the preceding dependent variables (i.e., comparing target vs. distracter within each level of emotion). Second, a one-way ANOVA with emotion (positive vs. disgust) was conducted on the duration of touch toward the distracter, latency to touch the distracter, and whole-hand touch of the distracter. The prediction stated previously would be supported if (a) the infants differentiated between the target and distracter in the predicted direction in both the positive and disgust conditions, and (b) infants treated the distracter object alike in both the positive and negative emotion conditions (evaluated using the one-way ANOVA). These were a priori analyses and were conducted to test our hypotheses directly.

Duration of touch. As predicted, the 14-month-old infants touched the target object more than the distracter object in the positive condition and touched the target object less than the distracter object in the disgust condition, but touched the distracter object the same amount of time in both emotion conditions. These results confirm that the 14-month-old infants understood the specific referent of the adult's expressive displays. The simple effects analyses revealed a significant effect for object in the positive condition, $F(1, 15) = 5.69, p = .031, \eta^2 = .28$, as well as a significant effect for object in the disgust condition, $F(1, 15) = 9.78, p = .007, \eta^2 = .40$. The one-way ANOVA revealed no significant effect for emotion, indicating that the infants did not touch the distracter object for differential amounts of time in both emotion conditions.

Latency to touch. A slightly different pattern of findings was obtained for latency to touch. The results with latency suggest that infants in the positive condition understood the referent of the adult's expressive displays, but infants in the disgust condition did not. Specifically, 14-month-olds in the positive condition waited less to touch the target object than the distracter. Moreover, they touched the distracter object equal amounts of time in both of the emotion conditions. However, in the disgust condition, infants waited equal amounts of time to touch the target and distracter objects. The simple effects analyses revealed a significant effect for object in the positive condition, $F(1, 15) = 4.90, p = .043, \eta^2 = .25$, but not in the negative condition. The one-way ANOVA using the data on the distracter objects revealed no significant effects for emotion.

Whole-hand touch. Contrary to expectations, the 14-month-old infants touched the target and dis-

tracter objects equally with their whole hands in both the positive and disgust conditions. Also, the infants touched the distracter object equal amounts of time in both emotion conditions. This set of results suggests that infants did not discriminatively touch the target and distracter objects. The simple effects analyses revealed no significant effects for object in both the positive and the disgust conditions. The one-way ANOVA revealed a statistically insignificant effect for emotion, $F(1, 30) = 3.56, p = .069$, indicating that the infants did not touch the distracter object for differential amounts of time in both emotion conditions.

Impact of the Adult's Emotional Displays on Infants During the Exposure Trials

Another question the study addressed was whether the adult's expressive displays had an immediate impact on infants during the exposure trials. As mentioned in the Introduction, no strong prediction was made regarding the outcome of this question given the mixed results in the extant literature. To address the question, an Age (11- vs. 14-month-olds) \times Emotion (positive vs. disgust) between-subjects ANOVA was conducted on the exposure trial ratings on each of the expressive display scales (all means and standard deviations are reported in Table 2).

Positive expressive display scale. Both 11- and 14-month-old infants' emotional displays were differentially affected by the adult's expressive displays in the exposure trials as indexed by the positive expressive display scale. Infants demonstrated more positive displays in the positive emotion condition compared with infants in the disgust emotion condition. The main effect for emotion was significant, $F(1, 60) = 6.36, p = .014, \eta^2 = .10$, but the main effect for age and the interaction were not.

Negative expressive display scale. At neither age did the adult's expressive displays in the exposure trials result in hedonically negative displays. Infants' negative emotional displays were similar in the positive and disgust emotion conditions. The factorial ANOVA yielded a significant main effect for age, $F(1, 60) = 4.81, p = .032, \eta^2 = .07$, but the main effect for emotion and the interaction were not significant.

Summary

Overall, the adult's expressive displays in the exposure trials had retention effects for 14-month-olds', but not for 11-month-olds', instrumental behaviors toward a target object 1 hr later. Fourteen-month-olds

in the positive condition, compared with those in the disgust condition, (a) touched the target object first, (b) touched the target more, and (c) waited less long to touch the target. There were no carryover effects on the infant's positive or negative emotional expressions.

Fourteen-month-olds demonstrated some degree of referential specificity. They touched the target object more than the distracter object in the positive condition and touched the target object less than the distracter object in the disgust condition. Also, they touched the distracter object equally as much in both of the emotion conditions. Moreover, infants in the positive condition waited less long to touch the target than the distracter. These results suggest that infants understood the referent of the adult's expressive displays 1 hr after exposure to the signals. However, the infants touched the target and distracter objects equally as much with their whole hands in the positive and disgust conditions. Taken as a whole, this set of findings indicates that infants differentiated between the target and distracter in terms of how long they touched the objects, but not by the quality with which they touched the objects.

Finally, the data were mixed regarding the immediate impact the adult's emotional displays had on infants during the exposure trials. Both 11- and 14-month-olds exhibited more positive displays in the positive emotion condition compared with infants in the disgust emotion condition.

Study 2

A second study investigated whether 11-month-olds would show differential behavior regulation when the delay between emotional exposure and test trials was very brief. The same experimental paradigm and conditions were employed in Study 2 as were used in Study 1 with the following two exceptions: (a) only 11-month-olds were tested and (b) the delay time between the second exposure trial and the test trial was only 3 min. If the 11-month-olds in Study 2 did in fact regulate their behavior toward the target object in accordance with the adult's expressive displays, this would confirm that 11-month-olds do register the adult's emotional signals and that they are capable of inhibiting their behavior toward the target and distracter objects. Such a confirmation would rule out these two possibilities for the lack of a carryover effect of emotional communication at 11 months of age found in Study 1.

Two additional questions were of interest in Study 2. First, if the 11-month-olds do differentially regulate their behavior toward the target object under

conditions of a short delay between exposure and test trials, do they do so in a referentially specific manner, or do they generalize the adult's emotional displays to both the target and the distracter objects? Only two published studies (Moses, Baldwin, Rosicky, & Tidball, 2001; Repacholi, 1998) have directly tested the infants' capacities to link the target of one's live emotional displays with a given object in the environment (although see Mumme & Fernald, 2003, in which televised stimuli were used). Both of these studies were conducted in the context of emotional imputation and were conducted in the here and now (i.e., with no delays). One study suggests that 14-month-olds (Repacholi, 1998) and the other study suggests that 12- and 18-month-olds (Moses et al., 2001) link the specific referent of the others' emotional displays. The present study potentially extends their findings of referential specificity to a younger age.

Finally, Study 2 addressed (as did Study 1) whether the adult's expressive displays had an immediate impact on the infant during the exposure trials.

Method

Participants

Thirty-two healthy 11-month-old infants ($M = 334$ days, $SD = 8$ days) and their mothers were recruited in the San Francisco Bay area and constituted the final sample. Data from 4 other infants were excluded from the analyses because: the mother did not follow directions (2), excessive fussiness (1), and experimenter error (1). Exclusion of participants was approximately the same across experimental participants. Within each age group, half of the infants were assigned to the positive emotion condition and half to the negative emotion condition. Females and males were equally represented across groups. The ethnic composition of the sample was 64.0% Caucasian, 2.3% Asian, 4.8% Hispanic, and 28.9% other (e.g., mixed race). The infants were from middle- to upper-class families.

Apparatus

The apparatus was identical to those used in Study 1.

Design

The study consisted of four phases. The first two phases were composed of two separate trials in which infants were exposed to the experimenter's

display of positive or negative emotion (Exposure Trial 1 and Exposure Trial 2). The third phase consisted of a 3-min delay, and the fourth phase consisted of the test trial in which infants' behaviors (both emotional and instrumental) were of primary interest to assess the retention effects of E1's emotional displays during the two exposure trials. The independent variable of chief interest was the emotion to which infants were exposed in the exposure trials (positive or disgust). Infants were randomly assigned to either the positive or disgust emotional conditions with the constraint that equal numbers of males and females were in each condition. The sides on which the objects were presented (i.e., to the left or right of the infant) were counterbalanced across the exposure trials and the test trial. Thus, the study was conceptualized as a between-subjects design with one factor (emotion: positive vs. disgust).

Procedure

The setting and procedure were similar to those of Study 1 with one exception: The delay period was approximately 3 min. The 3-min delay (positive emotion condition: $M = 3$ min, 17 s, $SD = 45$ s; disgust emotion condition: $M = 3$ min, 27 s, $SD = 46$ s) was calculated by subtracting the time at which the objects were removed from the table during the second exposure trial from the time at which the toys were presented to the infants during the test trial. During the delay, the mothers and E2 played with the infants on the floor and introduced toys to the infants. Every infant played with toys during this period.

Manipulation Checks

The same manipulation checks used in Study 1 were used in Study 2. Recall that the first manipulation check used a 9-point scale to ensure that the experimenter displayed the emotions properly. The manipulation check revealed that all of the experimenter's expressive displays in the exposure trials (both facial and vocal) met or exceeded the criteria stated in Study 1. Thus, all data were retained for the final analysis.

Recall that the second check was made from the videotapes to determine maternal compliance with instructions. As stated previously, 2 mothers did not comply with the instructions given her.

Coding and Reliability

The same coding and reliability procedures used in Study 1 were used in Study 2. For sake of brevity,

therefore, we report the following reliability coefficients (and kappa when appropriate) and mean differences (when appropriate): (a) visual gaze toward target, .88 (M difference = .9 s); (b) visual gaze toward distracter, .92 (M difference = 1.0 s); (c) visual gaze toward experimenter, .86 (M difference = 1.3 s); (d) visual gaze toward mother, .95 (M difference = .3 s); (e) positive emotional display scale, $K = .73$; (f) negative emotional displays scale, $K = .71$; (g) initial object exploration, $K = 1.00$; (h) duration of touching target, .89 (M difference = 1.0 s); (i) duration of touching distracter, .90 (M difference = .9 s); (j) latency to contact target, .94 (M difference = .3 s); (k) latency to contact distracter, .92 (M difference = .4 s); (l) percentage of whole-hand contact on the target, .82 (M difference = 3.6%); and (m) percentage of whole-hand contact on the distracter, .78 (M difference = 3.7%).

Preliminary Analyses

All data presented were checked for normality, skewness, and kurtosis. All data used in the study were within normal limits for these checks. Univariate ANOVAs were also conducted on all dependent variables entering sex as the independent variable. These analyses indicated that this factor was not statistically significant and thus it was not entered into the subsequent analyses (all $ps > .05$). Like Study 1, infants gazed little toward their mothers ($M = 2.5$ s, $SD = 1.8$ s).

Results and Discussion

All of the means and standard deviations are presented in Tables 3 and 4 for each age and emotion condition for all dependent variables. In all of the following analyses, effect-size statistics (eta-squared statistics for ANOVAs and Cohen's d for chi-square analyses) are included for every statistically significant finding.

Effects on Infant Behavior During the Test Trial

The primary purpose of Study 2 was to investigate whether 11-month-olds could demonstrate behavior regulatory effects when the delay period is much shorter than it was in Study 1. This was indeed the case. As in Study 1, preliminary MANOVAs were conducted on the behavioral (duration of touch to target, latency to touch target, whole-hand touch of target) and emotion (negative and positive emotion scales) dependent variables, entering emotion as the independent variable. For the behavioral responses,

Table 3
Means and Standard Deviations by Emotion Condition for Instrumental and Expressive Infant Behaviors

| | Emotion condition | |
|---|-------------------|---------------|
| | Positive | Disgust |
| 11 month-olds | | |
| Duration of touch (target) ^a | 21.59 (16.11) | 11.28 (11.93) |
| Latency to touch (target) ^a | 9.06 (9.27) | 16.83 (11.21) |
| Whole-hand touch (target) ^b | 57.88 (10.03) | 50.44 (10.17) |
| Duration of touch (distracter) ^a | 16.13 (11.28) | 16.32 (12.19) |
| Latency to touch (distracter) ^a | 9.42 (10.21) | 6.57 (5.66) |
| Whole-hand touch (distracter) ^b | 53.44 (11.31) | 54.06 (10.67) |
| Negative expressive scale ^c | 0.41 (0.66) | 0.72 (0.66) |
| Positive expressive scale ^c | 0.63 (0.75) | 0.42 (0.67) |

Note. N = 16.

^aValues in seconds.

^bValues in percentages.

^cValues on a scale ranging from 0 to 3.

the MANOVA revealed a significant effect for emotion, $F(3, 28) = 3.32, p = .03, \eta^2 = .26$. The MANOVA revealed no significant effect for emotion on the expressive responses; thus, no further analyses were carried out on these measures. To test the hypotheses directly, univariate analyses were carried out on each of the behavioral responses, entering emotion as the independent variable.

Number of participants touching target object first. Eleven-month-old infants touched the target object first in significantly more cases in the positive condition (10 of 16 test trials) and the distracter object in significantly more cases in the disgust condition (12 of 16 test trials), $\chi^2(1) = 4.57, p = .033, w = .81$.

Duration of touch. Eleven-month-olds in the disgust condition touched the target object in the disgust condition approximately half the time they did in the positive condition, $F(1, 30) = 4.24, p = .048, \eta^2 = .12$.

Latency to touch. The infants in this study waited to touch the target object longer in the disgust emotion condition than in the positive emotion condition, $F(1, 30) = 4.57, p = .041, \eta^2 = .13$.

Table 4
Means and Standard Deviations by Emotion Condition for Positive and Negative Expressive Scales During Exposure Trials

| | Emotion condition | |
|---------------------------|-------------------|-------------|
| | Positive | Disgust |
| Positive expressive scale | 1.02 (0.83) | 0.45 (0.62) |
| Negative expressive scale | 0.03 (0.09) | 0.16 (0.26) |

Note. N = 16.

Whole-hand touch. The infants also touched the target object with their whole hands a greater percentage of time in the positive condition than in the disgust condition (approximately 7% more), $F(1, 30) = 4.34, p = .046, \eta^2 = .13$.

Negative and positive expressive scales. Contrary to expectations, the infants' expressive displays were not differentially regulated by the adult's. The average ratings indicated that infants in both the positive and disgust emotional conditions exhibited negative displays infrequently and weakly. As with the negative expressive measurements, the infants' positive expressive displays were not differentially affected by the emotion displays presented. The average ratings indicated that infants in both the positive and disgust emotional conditions exhibited positive displays infrequently and weakly.

Referential Specificity of the Adult's Expressive Displays: Effects on Infant Behavior

To investigate whether infants link the specific referent (i.e., the target object) to the adult's emotional displays or instead generalize the adult's emotional displays to both the target object and the distracter object, an Emotion (positive vs. disgust) \times Object (target vs. distracter) mixed MANOVA with repeated measures on the last factor was conducted on duration of touch, latency to touch, and whole-hand touch. This analysis revealed no significant main effects. Two sets of analyses were conducted to address referential specificity directly (see Table 3 for means and standard deviations). First, two simple effects analyses were conducted within each level of the emotion factor on each of the preceding dependent variables (i.e., comparing target vs. distracter within each emotion condition). Second, a one-way ANOVA with emotion (positive vs. disgust) was conducted on the duration of touch toward the distracter, latency to touch the distracter, and whole-hand touch of the distracter. Infants' abilities to link a specific referent to the adult's displays would be supported if (a) the infants differentiated between the target and distracter in the predicted direction in both the positive and disgust conditions (evaluated using the simple effects analyses) and (b) infants treated the distracter object alike in both the positive and disgust emotion conditions (evaluated using the one-way ANOVA). These were a priori analyses and were conducted to test our hypotheses directly.

Duration of touch. Infants touched the target and distracter equal amounts of time within each of the emotion conditions. The simple effects analyses

revealed no significant effect for object for either the positive or the disgust condition. The one-way ANOVA revealed a statistically insignificant effect for emotion, indicating that the infants touched the distracter object the same amount of time in both emotion conditions.

Latency to touch. Infants in the disgust emotion condition waited to touch the target object longer than the distracter object. However, infants waited equal amounts of time to touch the target and distracter objects in the positive condition. This set of results suggests that infants in the disgust emotion condition at least to some extent understood the referent of the adult's expressive displays, whereas infants in the positive condition did not (at least as indexed by this dependent variable). The simple effects analyses revealed a significant effect for object in the disgust condition, $F(1, 15) = 9.40$, $p = .008$, $\eta^2 = .39$, whereas it revealed no significant effect for object in the positive condition. The one-way ANOVA revealed a statistically insignificant effect for emotion, indicating that the infants touched the distracter object the same amount of time in both emotion conditions.

Whole-hand touch. Infants touched the target and distracter equal proportions of time within each of the emotion conditions. The simple effects analyses revealed no significant effect for object in either the positive or the disgust condition. The one-way ANOVA revealed a statistically insignificant effect for emotion, indicating that the infants touched the distracter object the same amount of time in both emotion conditions.

Impact of the Adult's Emotional Displays on Infants During the Exposure Trials

The final question the study was designed to address was whether the adult's expressive displays had an impact on infants during the exposure trials. To address this issue, a between-subjects ANOVA entering emotion (positive vs. disgust) as the factor was conducted on the exposure trial ratings on each of the expressive display scales. All data are presented in Table 4.

Positive expressive display scale. The adult's emotional displays appeared to affect differentially infants' displays; infants in the positive emotion condition displayed more frequent and stronger positive emotional displays compared with infants in the disgust emotion condition, $F(1, 30) = 4.72$, $p = .038$, $\eta^2 = .14$.

Negative expressive display scale. By contrast, although there was a trend in the right direction, in-

fants did not differentially manifest emotional displays during the exposure trials as rated on the negative expressive scale, $F(1, 30) = 3.43$, $p = .074$, $\eta^2 = .14$.

Summary

Study 2 showed that the experimenter's emotional communications significantly influenced the instrumental behaviors of 11-month-olds if the delay period is sufficiently short. Clearly, 11-month-olds can register the adult's emotional displays during the exposure trials, and they are capable of inhibiting their reaching behavior during the test trial. In the short delay between emotion imputation and test, 11-month-olds showed some evidence for referential specificity (which infants at this age showed no evidence for at 14 months). Overall, then, 11-month-olds generalized the adult's emotional displays toward both the target and the distracter object. Finally, the data were mixed regarding the real-time consequences that the adult's emotional displays had on infants' expressive behaviors.

General Discussion

Eleven- and 14-month-old infants differed in how long the effects of an adult's emotional displays lasted. Fourteen-month-olds in the positive emotion condition touched the target object over 2.5 times more and waited one fourth the time to touch the target object compared with infants of the same age in the disgust emotion condition. Moreover, 14-month-olds in the positive condition touched the target object a higher proportion of time with their whole hands compared with infants of the same age in the disgust condition; thus, the experimenter's emotional displays regulated both the temporal aspects and the quality of infants' instrumental behaviors toward an object. What is especially noteworthy about these findings is not that 11-month-olds revealed no retention effects but that 14-month-olds did after exposures coming only from a relatively unfamiliar experimenter.

A noteworthy finding in the research described in this report is that the disgust condition may have carried the regulatory effect of the experimenter's emotional expressions. For example, in Study 1, the duration of time the infants touched the objects was approximately the same for all 11-month-olds, as well as for all 14-month-olds in the positive condition. However, 14-month-olds in the disgust condition touched the target significantly less time (and waited longer to touch the target). A similar pattern

of findings was found for the 11-month-olds in Study 2. These findings concur with others in the literature on triadic emotional communication to the effect that negative emotional displays more powerfully regulate infant behavior than do positive emotional displays (Hertenstein & Campos, 2001; Sorce et al., 1985). As Cacioppo and Gardner (1999) pointed out, negative emotions often block action tendencies, whereas positive emotions often maintain (not necessarily increase) them. The results of this study add weight to Cacioppo and Gardner's conclusion.

What Accounts for the Difference in the Retention Effects of Emotional Communication?

The differences in the retention effects of emotional communication found in this study cannot be due to the emotional displays being ineffective at 11 months of age. The findings of Study 2 showed that the emotional displays significantly affected the performance of 11-month-olds so long as the delay was on the order of a few minutes. The same findings rule out the possibility that 11-month-olds simply cannot inhibit their behavior to the toys. They can and do. Hence, some other interpretation of the age differences in the carryover effects of the emotional manipulation is needed. We propose two possible interpretations for the developmental shift in the retention effects of emotional communication found in this research.

Increasing Exposure of Infants to Emotional Signals

One explanation centers on differences in socialization practices of parents of 11- and 14-month-olds. These changes in socialization practices result from parental compensations for infants becoming more "willful" at the beginning of the second year (Biringen, Emde, Campos, & Appelbaum, 1995). Mahler (1968), for example, pointed out that infants at approximately 1 year of age increasingly exercise social autonomy, which results in children's being less compliant with their parents. This autonomy becomes especially marked with the acquisition of walking skills. The child's new autonomy, willfulness, and walking proficiency may lead parents to increase the intensity, frequency, and clarity of their emotional displays to keep the infant in check as well as to foster desired behaviors. They are also more likely to follow up their emotional signals with actions on their part to see that the baby obeys, especially because the child can now locomote well beyond the parent. Can a residue of such salience and impact be that the older infant better under-

stands the meaning of the social signals (i.e., the actions of the parents that follow the emotional signal) and has more opportunity to rehearse what to do on perceiving social signals directed at objects?

Development in General Memory Skills

A second explanation of the findings reported here rests on differences in memory development. Several theoreticians have proposed that a crucial aspect of cognitive development is a steady increase in the memory capacity of the infant (e.g., Case, 1987). Memory is a multicomponential construct composed of several neural systems that serve different functions and operate according to different principles (Barr & Hayne, 2000; Eichenbaum, 1997; Schacter & Tulving, 1994). These components need to be identified, experimentally manipulated, and linked to the age differences in the carryover effects of emotional communication reported here.

It is not clear which of these components may be entering into play in the phenomena discovered in this study. Locomotor experiences that become possible following the onset of walking may be playing a role here, just as they may in accounting for increasing exposure to social signals. For example, crawling experience is related to the ability of the infant to tolerate longer delays between the hiding of an object and the child's correct search for it—a finding related by Campos et al. (2000) to the growing number of intermediary steps that can intervene (but only for crawling infants) between the initiation of a goal-directed action and the eventual attainment of the goal. Such intermediary steps can create a sense of time between initiation and termination of a task and help structure memory processes as a consequence. Walking makes possible even more concatenations—more strides between initiation of means and attainment of ends—which may mediate the longer periods of retention by the child of transactions with the environment.

Several methods related to the present investigation may be employed to understand better the role that aspects of memory may play. First, environmental parameters of the emotional communication need to be manipulated, including the duration and frequency of exposure to the emotional signals, the length of the delay between exposure and test trials, and the strength of the emotional signals themselves. These parametric manipulations may yield clues as to what exactly makes the effects of an emotional signal lasting.

Besides manipulating environmental factors that may account for the retention effects of emotional signals, one needs to identify and manipulate

individual differences in general memory processes that may precede and account for the lasting impact of triadic emotional communication. If specific memory skills were found to correlate with the carryover effects of emotion, one could infer that the retention effects of emotional signals reported here constitute part of a broader shift in cognitive skills.

Influence of Language Acquisition

A third explanation for the age differences found in this research on the retention effects of emotional displays centers on differences in language development. Both language production and semantic comprehension show step-function improvements between 11 and 14 months of age (Bloom, 1993). Infants begin to produce their first word around 12 months of age, and within 2 months produce, on average, 10 words (Fenson, Dale, Reznick, & Bates, 1994). Infants' semantic comprehension changes even more impressively. Infants understand only a few simple words by the time they are 11 months old but can understand more than 100 words by the time they are 14 months old (Fenson et al., 1994). Neither word production nor comprehension entered into the conduct of this research, given its use of nonsense phrases. However, when infants segregate and identify segments of the speech stream as words, it seems likely that they can also begin to improve their perceptual discrimination and use of paralanguage, particularly facial, vocalic, and action tendency accompaniments of parental speech to the infant. If this line of reasoning is sound, it implies that the acquisition of language may facilitate infants' use of vocalic, facial, and gestural information about emotion in new and better ways. Work with young children supports this contention (Friend, 2003), although work with infants has not been carried out.

In sum, a variety of processes may be at work that factor into the identified developmental difference between 11 and 14 months of age. These processes are not likely to be mutually exclusive, and all are subject to experimental test.

Referential Specificity

Infants' ability to link a specific referent to an adult's emotional displays is a significant issue in infant emotional communication. Without referential specificity, infants may generalize the emotional information from the adult's emotional displays, thereby extending the adult's displays to several objects and events in the environment, rather than to the adult's intended target. In addition, without ref-

erential specificity, the infant may link the adult's emotional display (e.g., disgust) to the self rather than to the intended target object. The paradigm employed in the present investigation allowed examination of infant understanding of referential specificity.

Overall, the results from Study 1 indicate that 14-month-olds successfully linked the experimenter's emotional displays to the referent the experimenter intended. This inference can be drawn because (a) within each of the emotion conditions, infants differentiated between the target and distracter objects, and (b) the duration of time infants touched the distracter, as well as the latency to touch the distracter, was commensurate across both emotion conditions. This pattern of findings indicates that the 14-month-olds in Study 1 did in fact link the target to the adult's emotional displays. It should be noted that infants did not differentiate the target and distracter objects on the percentage of time they touched them with their whole hand. Thus, as mentioned earlier, the findings demonstrated referential specificity in terms of the amount of time they touched the objects, not the quality.

The pattern of results from Study 2 indicates that, on most variables, the 11-month-old infants generalized the adult's emotional displays to both the target and the distracter; infants touched the target and distracter equal amounts of time within each of the emotion conditions. A similar set of findings was evident for the percentage of time infants touched the object with their whole hand in both emotion conditions and the latency to touch the objects among the infants in the positive emotion condition group. However, because 11-month-olds in the disgust emotion condition following the brief delay did wait longer to touch the target than the distracter, it would be a mistake to say that 11-month-olds lacked any evidence for referential specificity. At 11 months of age, the skill may be present, but not for long. By 1 hr after the signal, what minimal evidence for specificity was seen after a short delay had dissipated.

What factors may enter into the development of referential specificity? The most common domain implicated to account for the development of referential specificity is the infant's increasing understanding of the geometry involved in the relation between the position of a communicator's face, eyes, and pointing gesture, on the one hand, and a location in the environment, on the other. It seems likely that this geometrical understanding becomes, with age and experience, increasingly precise, though not perfect. In a related vein, it may not be until 12 months of age or thereafter that infants perceive

emoters' intentions and thereby are capable of true referential understanding (Moses et al., 2001).

Developments in language may also enter into the infants' abilities to use adults' emotional displays in a referentially specific manner. A perennial problem in language development is the problem of reference (Miller, 1991). That is, among all of the many objects to which any word may refer, infants must learn to choose a given word's intended referent. It is extraordinarily difficult for toddlers to link a specific referent to a given word. Nevertheless, toddlers come to appreciate the referential nature of words, and this ability increases as they age (Bloom, 1993). Advances in understanding and producing language sharpen referential specificity, which in turn may generalize to the referent of adults' emotional displays. There may be some transfer of training between language and emotional communication in terms of infants' ability to link a specific referent with a word or emotional display. The potential link between the two domains, however, has yet to be investigated.

Impact of the Adult's Emotional Displays on Infants During the Exposure Trials

Evidence for the real-time consequences of the adult's emotional displays on infants' emotional displays was mixed. Both the 11- and 14-month-olds responded differentially in the positive expressive scale. That is, infants in the positive emotion condition exhibited more frequent and more intense positive emotional displays than infants in the disgust condition. However, there was no evidence that infants in the positive emotion condition differed from infants in the disgust emotion condition on the negative expressive scale. Furthermore, when there was evidence for expressive responding by the infants, it was found during the actual exposure to the adult's display; the responding was not evident if any delay, even a brief one, had taken place.

This finding may well be due to the absence of an attentive audience during the test trial. Emotional expressions are more likely to be evident when they are targeted at a person that is within eyeshot of the child (Striano & Rochat, 1999). Recall that during the test trial there were no experimenters present and infants' mothers were faced away from the infant. The lack of a relevant social context may have short-circuited infants' expressive displays in the test trial.

The results also suggest that the adult's positive emotional displays beget more infant positive emotional displays, whereas the adult's negative emotional displays have no effect on infant negative emotional displays. What might account for this

pattern of results? Some social referencing research suggests that adults' negative emotional displays actually have more impact on infant expressive displays than adults' positive emotional displays (e.g., Hertenstein & Campos, 2001; Mumme & Fernald, 1996). In light of these findings, it is surprising that the disgust condition did not have a more powerful effect on infants' negative emotional displays. However, recall that some social referencing studies indicate that infants mirror the adult's emotional displays (e.g., Boccia & Campos, 1983; Hirshberg & Svejda, 1990; Klinnert et al., 1986), whereas others do not (e.g., Hornik et al., 1987; Walden & Ogan, 1988). Thus, the present investigation, consistent with other studies, did not yield clear-cut results regarding the impact of adults' emotional displays on those of infants in real time.

In sum, this investigation has described a developmental change in the retention effects of emotional communication across a relatively narrow age span. It is interesting that this age span is one that covers a major period of developmental transition, creating an opportunity to understand the potential role of the various processes that develop around the beginning of the second year on what has been described in this report. This investigation is thus but a first step in systematic investigation of affect and memory in triadic emotional communication; of the linkages of psychological, neurophysiological, and ecological changes that make possible the type of affective memory described here; and of the potential role of such affective memory as an organizer of new emotions that begin to be evident shortly after the ages studied in this research. Moreover, the present research is only a first step in understanding how contextual factors in regards to setting and emotional signals affect the retention effects of emotional signaling. For example, retention effects may be very different in the home compared with the lab or when the mother is present compared with her absence. Contextual factors related to the quality and intensity of the emotional signals imposed on the infants may also influence the retention effects of adults' emotional signals. These and other contextual factors likely influence the ways infants use signals to guide future behavior.

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