Infants' Responses to Facial and Vocal Emotional Signals in a Social Referencing Paradigm

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MUMME, DONNA L.; FERNALD, ANNE; and HERRERA, CARLA. Infants' Responses to Facial and Vocal Emotional Signals in a Social Referencing Paradigm. CHILD DEVELOPMENT, 1996, 67, 3219–3237. The independent effects of facial and vocal emotional signals and of positive and negative signals on infant behavior were investigated in a novel toy social referencing paradigm. 90 12-month-old infants and their mothers were assigned to an expression condition (neutral, happy, or fear) nested within a modality condition (face-only or voice-only). Each infant participated in 3 trials: a baseline trial, an expression trial, and a final positive trial. We found that fearful vocal emotional signals, when presented without facial signals, were sufficient to elicit appropriate behavior regulation. Infants in the fear-voice condition looked at their mothers longer, showed less toy proximity, and tended to show more negative affect than infants in the neutral-voice condition. Happy vocal signals did not elicit differential responding. The infants' sex was a factor in the few effects that were found for infants' responses to facial emotional signals.

The goal of the first infant social referencing studies was to investigate how infants use others' emotional signals to regulate their own behavior (Campos, 1983; Campos & Stenberg, 1981; Klinnert, 1984; Klinnert, Campos, Sorce, Emde, & Svejda, 1985). This approach generated considerable interest because it promised to go beyond studies of infants' ability to discriminate emotional expressions and to address questions about infants' ability to interpret emotional expressions. In the typical social referencing study, infants are presented with an ambiguous situation to which they respond by looking toward the caregiver. The prediction is that infants' affect and behavior will vary in appropriate ways with different emotional signals displayed by the caregiver. Findings from such studies have lent support to the notion that 12-month-old infants can use emotional signals to regulate their behavior. However, as discussed in several recent papers, these findings also raise many questions for further research (e.g., Baldwin & Moses, 1994, 1995; Campos, Mumme, Kermaian, & Campos, 1994; Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992; Mumme, 1993). For example, when do infants begin to understand that others are important sources of emotional information? In what contexts are infants likely to regulate their behavior in response to others' emotional signals? To which particular features of emotional signals are infants responsive? The goal of the current study was to investigate this last question by examining the independent effects of facial and vocal emotional signals and of positive and negative signals on 12-month-old infants' behavior in a standard social referencing paradigm.

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The study that has probably contributed most to the impression that social referencing is a powerful regulator of infant behavior is the visual cliff study by Sorce et al. (1985), which used an ecologically significant uncertain event—an apparent 12-inch drop-off. When infants approached the edge of the cliff, looked at the mother, and saw a fear face, none of the 17 infants crossed. In contrast, when they looked at the mother and saw a happy face, 14 of the 19 infants crossed over the drop-off. The findings from the visual cliff study supported the proposition that infant behavior could be influenced differentially and appropriately by changes in facial expression.

Following Klinnert (1984), the majority of social referencing studies have used a novel toy rather than a visual cliff to create the ambiguous situation. In the novel toy procedure, the infant is at play in a laboratory room with an adult (e.g., the mother, a day-care provider, or a female experimenter) when an unusual toy appears. The prediction is that infants who reference someone expressing positive affect toward the novel toy will approach the toy, whereas infants who reference someone expressing negative affect will avoid the toy. In an attempt to replicate Klinnert’s original study, Mumme (1993) tested 56 12-month-old infants in a novel toy procedure in which parents displayed facial expressions of happy, fearful, or neutral affect. Contrary to predictions, there was no evidence that infant behavior was influenced by facial expressions alone. Although infants looked longer at their mothers’ fear faces than happy faces, they did not show greater behavioral inhibition in response to the fear faces.

Closer examination of previous novel toy studies reveals that they too have failed to find consistent evidence for differential responding to positive and negative facial expressions (e.g., Klinnert, 1984; Zarbatany & Lamb, 1985). In her original study, Klinnert (1984) had mothers of 12- and 18-month-old infants pose happy, fearful, and neutral facial expressions over the course of three trials. Although infants tended to approach the toy more often and more quickly during the happy trial than the fear trial and at an intermediate level during the neutral trial, these differences were not significant. Facial expressions did have a significant effect on infants’ proximity to their mothers, but only in the third trial. In the third trial, infants moved closest to mother when she displayed fear, moved to an intermediate distance when she displayed neutral affect, and moved farthest away when she displayed happiness. One interpretation of this pattern of results, as suggested by Gunnar and Stone (1984, p. 1236) regarding their own similar findings, is that mothers’ emotional displays may serve more to regulate attachment behavior than to influence infants’ appraisals of novel toys.

However, in two subsequent novel toy studies, researchers did find that facial signals alone influenced infants behavior toward a toy (Camras & Sachs, 1991; Klinnert, Emde, Butterfield, & Campos, 1986). In both studies, a female adult, but not the infant’s mother, displayed the emotional signals. These studies found that infants in the happy-face condition approached the toy more quickly or more closely than did infants in the fear-face condition. However, Zarbatany and Lamb (1985), using a fairly similar procedure, did not find differences between infants in the happy and fear conditions. Given these mixed findings from the face-only novel toy studies, it is perhaps not surprising that Mumme (1993) also failed to find the predicted pattern of behavior regulation in response to changes in maternal facial expressions.

In contrast to these inconsistencies, novel toy studies in which mothers displayed both facial and vocal emotion have more consistently found the predicted signaling effects. For example, three face-plus-voice studies found that 1-year-old infants showed less toy proximity in response to negative facial and vocal signals than in response to positive facial and vocal signals (Hirshberg & Svejda, 1990; Hornik, Riesenhoover, & Gunnar, 1987; Rosen, Adams, & Bakeman, 1992). Infants around 1 year of age have also shown appropriate responding to multimodal signals on other measures of behavior toward the stimulus toy, such as reaching and touching (Hornik et al., 1987; Walden & Baxter, 1989; Walden & Ogan, 1988).

The regulatory effects of facial plus vocal signals in novel toy studies appear to be more reliable than the effects of facial signals alone. However, because the emotional signals consist of the face and voice together, we do not know whether the combination of the face and voice is necessary or whether the voice alone would also yield positive effects. Only one study, an unpublished dis-
sertation by Svejda (1981), has examined the effects of voice alone. She found that fearful and angry vocal signals were more likely to disrupt infants' behavior toward novel toys than were happy vocal signals, suggesting that the voice alone may be sufficient. Unfortunately, her study did not include a face-only group in the same procedure for comparison. An important next step in investigating infants' responsiveness to emotional signals is to examine the independent contributions of facial and vocal signals in a standard social referencing procedure.

Although it may seem surprising that the social regulatory effects of vocalized emotion have not been thoroughly explored in the social referencing literature, this is consistent with the lack of psychological research on vocal emotion in general (cf. Fernald, 1992; Scherer, 1986; Walker-Andrews, 1988). While the research of Ekman and Friesen (1975) and of Izard (1971) has provided detailed information on how emotion is expressed on the face, quantitative research on vocal expressions of emotion is less extensive and less precise (Dolgin & Azmitia, 1983; Nelson, 1987; Scherer, 1986). Only recently have researchers begun to investigate systematically infants' responses to vocally expressed emotion (e.g., Caron, Caron, & MacLean, 1988; Fernald, 1993; Walker-Andrews & Gronlick, 1983; Walker-Andrews & Lennon, 1991). These studies have shown, for example, that 5-month-old infants can discriminate happy and sad vocalizations (Walker-Andrews & Gronlick, 1983) and that 7-month-old infants can categorize happy and angry dynamic facial plus vocal expressions (Caron et al., 1988). In addition, 5-month-olds show more positive attention and smiling when they hear infant-directed approval vocalizations as compared to prohibition vocalizations, even in unfamiliar languages (Fernald, 1993). The current study extends these findings by using a social referencing paradigm to consider more carefully the role of vocal affect in the regulation of infant behavior.

The Current Study

The primary goal of the current research was to investigate whether either facial or vocal expressions alone are sufficient to influence infant behavior in an ambiguous situation. We know from previous social referencing research that when mothers' responses are relatively unconstrained, they are likely to use both facial and vocal signals and, if allowed, behavioral modeling to influence their infants' behaviors (e.g., Hornik & Gunnar, 1988; Rosen et al., 1992). Are all three cues necessary for infants to respond appropriately? Hornik and Gunnar (1988) found that only with the addition of behavioral modeling were infants likely to pet a live rabbit. However, findings from studies using the novel toy paradigm suggest that facial plus vocal cues, even in the absence of behavioral modeling, are sufficient to influence infant behavior. There are fewer data on the social regulatory effects of unimodal emotional signals. The findings from social referencing studies testing the influence of facial expressions alone are inconclusive, and at this time there is no published research on the influence of the voice alone.

A second goal of the current research was to test whether positive and negative emotional signals are equally effective in influencing infant behavior. With the exceptions of Hornik et al. (1987) and Gunnar and Stone (1984), all previous infant social referencing novel toy studies have made a direct comparison between responses to positive signals and responses to negative signals without a neutral or baseline response measure. However, the finding that infants respond differently to positive and negative signals does not justify the conclusion that infants are responding appropriately to both (see Feinman et al., 1992, for a similar point). It is possible that only one type of signal has a systematic influence on infant behavior and accounts for the significant differences. In support of this hypothesis, Hornik et al. (1987) found more differences between the neutral and negative conditions than between the neutral and positive conditions, suggesting that infants responded more immediately to negative than to positive multimodal signals. In order to provide an adequate test of infants' appropriate responding to unimodal emotional signals, it was important to extend the logic of Hornik et al.'s design to the current study.

At the level of methodology, a third goal was to follow as closely as possible the procedures used in previous novel toy studies in order to provide data that would be comparable to other findings in the social referencing literature (e.g., Hornik et al., 1987; Klinnert, 1984; Walden & Ogan, 1988). As in previous studies, mothers and infants were seated apart from each other in a laboratory room; a novel, noise-making toy appeared in the room; mothers looked at the toy and delivered an emotional signal; and infants were free to explore the room, while moth-
ers remained seated. Although there are limitations to the novel toy procedure (e.g., it lacks ecological validity in that mothers are not allowed to bring the toy to the infant or to command the infant), it has the advantages of providing the infant with behaviorally meaningful response options and of being a standard paradigm in the literature.

In addition to the basic similarities described above, the design of the study differed in several important ways from earlier research:

1. Most recent social referencing studies have used multimodal expressions. Because our objective was to assess the separate contributions of the face and voice to infant behavior regulation, facial and vocal expressions were manipulated independently. Based on the inconclusive results of previous novel toy studies using only facial signals, we predicted that facial signals alone would not be effective. Based on research showing infants’ early responsiveness to vocal signals (e.g., Fernald, 1993; Svejda, 1981; Walker-Andrews, 1988), we predicted that vocal signals alone would be sufficient to influence infant behavior.

2. In most novel toy studies, with the exception of Svejda (1981), vocal signals have been added without the same systematic control and attention given to facial signals. For example, for facial expression training, parents are typically shown Izard’s (1971) or Ekman and Friesen’s (1975) photographs of people posing happy and fearful facial expressions and are instructed how to imitate them. For vocal expression training, parents are sometimes given an example of a verbal message they might use, such as “Oh, look at that scary toy!” and are allowed to deviate from the example (e.g., Walden & Ogan, 1988). The design of this study required similar levels of control for the delivery of facial and vocal signals, so mothers were allowed to use only standardized vocal phrases at specified intervals.

3. Most social referencing studies using multimodal expressions have used vocal signals with words that are potentially meaningful to 12-month-old infants. For example, parents have been instructed to say “Oh, no!” or “That’s yucky!” when expressing negative affect and “Nice toy!” when expressing positive affect (e.g., Hirshberg & Svejda, 1990; Hornik et al., 1987; Walden & Ogan, 1988). Because the intent of this study was to examine the effects of affective prosody independent of semantic information, vocalizations consisted of words that were meaningless to 1-year-old infants.

4. Most previous social referencing studies have directly compared responses to positive signals with responses to negative signals. In order to determine whether infants respond appropriately to both positive and negative emotional signals, we included a control group that had a second neutral trial as its expression trial. Infants in the neutral control group served as the comparison group. Such comparisons provide a better test of the direction and magnitude of the influence of positive and negative signals.

**Method**

**Subjects**

The subjects were 90 full-term, healthy infants (46 girls and 44 boys) and their mothers, recruited from a middle-class population through county birth records in the San Francisco Bay Area. The sample was 81% Caucasian, 8% Asian, 5.5% African-American, and 5.5% Hispanic. The infants were between 12 and 13 months old (M = 54 weeks), with 15 infants (seven or eight girls) in each expression condition within each modality. Thirty-five additional subjects participated in the study but were excluded from the final sample. Nine girls and six boys were excluded because they became fussy during or immediately after the first trial. Only one infant was excluded for not looking to his mother in the face-only condition. There were 13 subjects excluded either because their parent did not follow instructions (six) or because of experimenter error or equipment failure (seven). As a result of the manipulation checks, six subjects (two girls and four boys) were dropped after the study was completed.

**Experimental Set-Up**

The experiment was conducted in a 3.7 m × 4.0-m carpeted room with one-way mirrors on two walls and a 1.5-m tall partition on one side. A brightly colored cardboard box, which concealed the stimulus toy, was placed in front of the partition. As shown in Figure 1, the infant, the mother, and the toy were positioned in a triangle. The infants’ starting position for each trial was on the opposite side of the room, approximately 1.8 m from the toy, with the mother positioned about 1.2 m from the toy and about 1.8 m from the infant. This configuration differs from that of previous novel toy social referencing studies, in which the mother and infant are typically positioned side by side opposite the novel toy (e.g., Klinnert, 1984).
The primary reason for placing the mother midway between the infant and the toy was to ensure that the infant did not have easy access to the mother’s face in the voice-only condition. Although mothers were seated in the same place in the room for both the face-only and the voice-only conditions, they oriented their bodies and faces differently. In the voice-only condition, the mother faced the partition with her back to the infant. In the face-only condition, the mother’s left shoulder was to the infant and her right shoulder was to the toy. Thus, in the voice-only condition, the infant had access to the mother’s face only when the mother looked over her shoulder or when the infant was in front of her. In the face-only condition, the mother could look easily toward the infant and the toy, so the infant typically had continuous access to the mother’s full face or at least her profile.

Two wall-mounted cameras recorded onto a split screen. One camera filmed a close-up of the mother’s face, and the other filmed a wide-angle view of the room. A third camera in the observation room was used to film the session through the one-way mirror. This camera recorded onto a separate full screen and captured close-up shots of the infant as he or she moved about the room. The experimental room also contained an earphone for the mother and, behind the partition, an earphone for the experimenter’s assistant. The toys were a 28-cm tall gold robot (“Magic Mike”), a 25-cm long white and black cow (“Roly-Poly”), and a 25-cm tall yellow bear (“Teddy, the Cheer Leader”). All three of the toys were battery operated, made noise, and moved. The robot and cow served as “ambiguous” toys, because similar toys have been used in previous novel toy studies (e.g., Hirshberg & Svejda, 1990; Hornik et al., 1987; Rosen et al., 1992) and in our own pilot testing they tended to elicit hesitation and mixed responses. The bear served as a “positive” toy, because in pilot testing it tended to elicit smiles and approach. At the beginning of each trial, one of the stimulus toys was hidden under the colorful box.

**Procedure**

Infants were randomly assigned to either a face-only or a voice-only condition. Each infant participated in three 75-sec trials. During the first, or “baseline,” trial, the mother expressed neutral affect toward one of the potentially ambiguous toys (i.e., the robot or cow). During the second, or “expression,” trial, she expressed neutral, happy, or fearful affect toward the other potentially ambiguous toy. During the third trial, the mother expressed happy affect toward the bear. The final happy trial was included so that infants in all conditions would end their session on a positive note. The data from this final trial will not be discussed. Thus, the study included three between-subject expression conditions, according to the affect expressed during the second trial: neutral, happy, and fear. The expression conditions were nested within the two modality conditions: face-only and voice-only.

**Experimental session.**—Following a 5-min warm-up period, the experimenter ex-
plained the procedure to the mother while the assistant played with the infant. When the infant appeared comfortable, the experimenter escorted the mother to an adjacent room where mothers in the face-only condition were trained how to make the appropriate facial expressions and mothers in the voice-only condition were trained how to make the appropriate vocal expressions. After practicing each expression a few times, the mother returned to the experimental room.

Before each trial, the experimenter asked the mother to place her infant in the starting square and then to position herself appropriately in her own square. The toy was hidden underneath the box and activated remotely by the assistant concealed behind the partition. The box was then slowly raised to reveal the toy. During the first 15 sec, the toy moved and made noise; for the final 60 sec, the toy was motionless and silent. During each trial, the mother stayed in her position, and the infant was free to move throughout the room. The experimenter announced when the 75 sec had passed, the box was lowered, and the mother was allowed to talk and play with her infant again until it was time for the next trial to begin. The majority of trials lasted 75 sec. The period in between trials was typically around 1 min long, but it ranged from approximately 30 sec to 3 min 30 sec, depending on how long it took the mother to get her infant seated in the starting square.

Training on facial expressions.—For the face-only group, the experimenter described the critical features of the relevant expressions, demonstrated the faces, and showed pictures of a woman and a man making the faces (from Ekman & Friesen, 1975, pp. 62 and 112). The fear face consisted of eyebrows raised and drawn together, upper eyelids raised to expose the sclera, and an open mouth with the lips tensed and drawn back. The happy face consisted of the corners of the lips drawn back and up, exposed teeth, raised cheeks, and "bright eyes." The neutral face was described as a plain face, not expressing any emotion. The experimenter instructed mothers to make the expression as soon as the toy appeared and to hold it throughout the trial. Mothers were also instructed to look back and forth between the infant and the toy.

A manipulation check was performed to ensure that the faces displayed by mothers in the face-only condition expressed the appropriate affect. Mothers' faces were rated only during those intervals in which the infant had been scored as looking at the mother. At the end of the study, two raters, blind to experimental condition, categorized each facial expression as being neutral, happy, surprised, fearful, angry, or sad and also rated the hedonic tone of each expression on a five-point scale ranging from very negative (-2) to very positive (+2). From the neutral baseline trial, 195 facial expressions were coded, and all but two were categorized as neutral. The two exceptions were categorized as happy and given hedonic tone ratings of +2; these subjects, one assigned to the neutral condition and the other to the happy condition, were dropped. The mean hedonic tone rating for neutral expressions was +0.22. From the neutral test trial, 58 facial expressions were coded, and all were categorized as neutral. The mean rating was +0.08. From the happy test trial, 76 facial expressions were coded, and all were categorized as happy. The mean rating was +1.90. From the fear test trial, one parent made surprise faces throughout the trial, so this subject was dropped. Of the remaining 75 facial expressions categorized in the fear trial, 71 were scored as fear, one expression was scored as a surprise-fear blend, and three were scored as a neutral-fear blend. All of these facial expressions were rated as negative in hedonic tone, and the mean rating for the fear trial was -1.44. Thus, the majority of parents' facial expression ratings were acceptable, and only three subjects were dropped as a result of this manipulation check.

Training on vocal expressions.—For mothers in the voice-only condition, the experimenter explained which features were critical and had the mother practice each vocalization. Standard phrases were used for each vocal affect condition. The phrases were designed to be similar in length and phonetic structure across the three emotions and to contain words that were meaningless to 1-year-old infants but meaningful to the speaker: Oh, how delightful! in the happy condition; Oh, how frightful! in the fear condition; and Oh, how insightful! in the neutral condition. The fear and happy vocalizations incorporated acoustic properties that Scherer (1986) has described as characteristic of vocal affect signals (see also Hirshberg & Svejda, 1990). For the happy vocalizations, the Oh was high-pitched, smooth, and somewhat drawn out, and the how delightful was spoken with a relaxed voice that dramat-
ically rose and then fell in pitch. Mothers were told to sound as if they were very enthusiastic about the toy. For the fear vocalizations, the Oh was a gasping inhalation and the how frightful was spoken rapidly with a tense voice that was sharp and slightly high in pitch. Mothers were told to sound as if their baby were about to do something dangerous or they had just witnessed something shocking. The neutral vocalizations were spoken in a monotone voice, with minimal inflection and in a matter-of-fact fashion. Because the fear and happy vocalizations were exaggerated expressions of emotion, they were typically louder than the neutral vocalizations.

In order to ensure that infants in the voice-only condition would be exposed to approximately the same amount of emotional information as infants in the face-only condition, the timing and frequency of the vocalizations were controlled by the experimenter. Data on the frequency of infant looks to the mother in an earlier study using facial signals (Mumme, 1993) were used to determine the rate of delivery of vocalizations. The median number of looks to mother per trial in that study was 3.5, so mothers were directed to give four vocalizations per trial. The median time from the start of the trial to the first look to mother was 9 sec, so mothers delivered the first vocalization about 9 sec after the toy was activated. The remaining three vocalizations were delivered approximately 25 sec, 40 sec, and 55 sec into the trial and were not contingent on the infants' behavior. Before each vocalization, the experimenter cued the mother, who was wearing an earphone, by modeling the vocalization with the appropriate intonation. The mother then looked at the toy and vocalized.

A manipulation check was performed to ensure that the stimulus vocalizations produced by mothers expressed the appropriate affect. The vocalizations were dubbed from the videotapes onto audiotapes so that manipulation checks could be done with the rater blind to experimental condition and to infants' responses. Vocalizations were low-pass filtered at 400 hertz, using a Krohn-Hite filter to remove segmental content and render them unintelligible, while preserving their prosodic characteristics. Vocalizations were categorized as neutral, happy, surprised, fearful, angry, or sad; hedonic tone was rated on a five-point scale ranging from very negative (-2) to very positive (+2). From the neutral baseline trial, 98.9% of the filtered vocalizations were categorized as neutral, two were categorized as sad, and the mean rating was -0.12. The two "sad" vocalizations were not problematic, because the other three vocalizations for those two subjects were rated as neutral and because, in their unfiltered form, the vocalizations sounded neutral. All vocalizations from the neutral test trial were categorized as neutral, and the mean rating was -0.14. From the happy test trial, 67% of the vocalizations were categorized as happy, 33% were categorized as surprised, and all vocalizations received hedonic tone ratings of +1 or +2, resulting in a mean rating of +1.32. From the fear test trial, 95.1% of the vocalizations were categorized as fearful, two were categorized as angry, and one was categorized as neutral, but negative. All fear vocalizations received hedonic tone ratings of -1 or -2, resulting in a mean rating of -1.17. Although some of the filtered happy and fear vocalizations were not categorized correctly, the hedonic tone ratings were all in the right direction, so the vocalizations were acceptable. No subjects were dropped as a result of this manipulation check.

Each mother in the voice-only condition was also instructed about how to control her facial expressions. She was told that her face would naturally tend to reflect the same emotion expressed in her voice and that this was why she was to sit with her back to the infant. The mother looked at the toy when she vocalized, to ensure that her face was turned away from the infant. Only when she felt that her face was relaxed again and neutral was the mother allowed to look over her shoulder at her infant and to look back and forth between the infant and the toy, as in the face-only condition. The experimenter reminded mothers in both modality conditions not to use any other nonverbal cues, such as pointing, and not to talk during the

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1 In the final sample of the current study, the median number of looks to mother per trial in the face-only condition was also 3.5; the mean was 4.61. The means for the individual trials were 4.62 for the neutral baseline trials, 3.80 for the neutral expression trial, 4.73 for the happy expression trial, and 5.27 for the fear expression trial.

2 There were only two instances in the voice-only condition in which the mother failed to deliver all four vocalizations. In the happy-voice condition, two mothers delivered only three neutral vocalizations during the neutral baseline trial.
trials. Six infants were excluded from the study, because their mothers did not follow these instructions.

After the study was completed, two coders rated the facial expressions of the mothers in the voice-only condition, to ensure that they did not convey too much facial emotional information. Mothers' faces were rated only during those intervals in which the infant had been scored as looking at mother. If the mother's back was to the infant, her face was not rated. Three subjects, one in each condition, were dropped because the mother smiled directly at the infant two or more times during the neutral baseline trial. No mothers in the neutral condition smiled during the neutral test trial. Only one mother in the fear condition made a fearful face in the second trial, but this was the same mother dropped for smiling during the neutral baseline trial. During the happy expression trial, several mothers found it difficult to make the happy vocalizations without smiling, and smiles were likely to linger on their faces. Four mothers in the happy condition smiled at least twice during the happy trial. Rather than eliminate all these subjects, their data were retained, and any results in the happy-voice condition will be qualified by this finding that vocal expressions of happiness "leaked" onto the face.

**Coding of Infant Measures**

Coders scored infant looks to mother, proximity, and affect from the full-screen, close-up recording of the infant. This enabled the coders to be blind to condition, because the mothers' face was not visible from this view. In addition, all coding of infant affect and proximity to toy and mother was done without sound, to ensure that raters were blind to condition in the voice-only procedure. The trials were broken down into 5-sec intervals, starting with the onset of the infant's first look to mother for the face-only condition or with the onset of the mother's first vocalization for the voice-only condition. This served as the starting point for all of the variables coded, because the goal of this study was to test whether parents' emotional signals influence infant behavior, and only after the infant saw the mother's face or heard her vocalization was this information available. These variables were scored for at most 60 sec. In the face-only condition, some infants did not look to mother until late in the trial, so there was not a full 60 sec remaining to code. Additionally, in both modality conditions, some trials were cut short, because the infant became fussy or because the mother spoke or gestured just before the end of the trial. In the face-only condition, 78% of the trials lasted the full 60 sec, and the mean trial length was 56.8 sec. In the voice-only condition, 95% of the trials lasted the full 60 sec and the mean trial length was 59.6 sec. In both modality conditions, all trials lasted at least 30 sec.

Four research assistants and the experimenter (DLM) served as coders. For all measures, six infants from the face-only condition and six infants from the voice-only condition were scored independently to check observer agreement. Intraclass correlation coefficients were calculated on the summary scores for each measure.

**Looks to mother.**—We have decided to call this measure looks to mother rather than references, because looks to mother more accurately reflects the measure and does not imply anything more. Typically, referencing implies that the infant is intentionally seeking information about a particular event. We did not attempt to make distinctions among types of looks that have been noted in other studies, such as referencing, affect sharing, orienting toward the voice, or bids for attention (see Clyman, Emde, Kempe, & Harmon, 1986; Hornik & Gunnar, 1988). Furthermore, when infants in the voice-only condition looked to their mother, they often saw the back of her head, and when they did see her face, the facial expression did not match the vocal expression. Thus, every look in the direction of the mother's head (≥0.3 sec) was simply scored as a "look to mother." The duration of each look was coded to 0.10 sec, and durations were then summed to yield a single score for each trial. The intraclass correlation coefficient for rater agreement was .92. We also counted the frequency of looks to mother in each trial. Observer agreement (A/(A + D)) for the occurrence of a look to mother was .93.

**Proximity to toy.**—Toy proximity was coded on a four-point scale for every 5-sec interval. A 0 indicated that during the entire 5-sec interval, the infant did not move in the direction of the toy, that the infant turned away from the toy, or that the infant backed at least 1 m away from the toy. If the infant was faced toward the toy and made any movement in the direction of the toy, the coders recorded a 1 in that interval. Once the infant was within 0.5 m of the toy, a 2 was scored for toy proximity. This was easily measured by whether or not the infant crossed a white boundary line drawn on the floor. A 3 was scored any time the infant...
touched the toy with his or her hand. The summary measure of proximity to toy was calculated by first totaling the infant's score for each 5-sec interval after the infant's first look to mother or the mother's first vocalization and until 60 sec had passed. A mean score was then calculated by dividing the total score by the number of 5-sec intervals (typically 12 intervals) remaining after the first look or first vocalization. The intraclass correlation coefficient for rater agreement was .99.

Proximity to mother.—The scoring criteria for proximity to mother were similar to the proximity to toy scale. A 0 was scored for no movement toward mother or movement away from her. A 1 was scored when the infant was faced toward the mother and made any movement in her direction, and a 2 was scored when the infant moved within arm's reach (the infant's arm) of the mother. Physical contact with mother was scored as 3 for any type of physical contact. The mean score for mother proximity was calculated in the same manner as the mean score for toy proximity. Rater agreement for mother proximity was .99.

Affect.—The experimenter and an experienced research assistant (CH) coded affect together. Following procedures described by Hirshberg and Svejda (1990) and Fernald (1993), positive and negative affect were coded separately, each on a three-point scale. Judgments were based exclusively on facial expressions of affect, because the volume had to be turned down for raters to remain blind. With this measure, we intended to assess the general hedonic state of the infant and not discrete affect expressions. A facial expression was scored as an affective expression only if the coders agreed on the valence. A score of 0 indicated that the infant looked neutral during the interval. For positive affect, a 1 was scored for slight smiles and raised brows, and a 2 was scored for big smiles. For negative affect, a 1 was scored for slight frowns, furrowed brows, and worried expressions, and a 2 represented crying or big frowns, grimaces, or scowls. Summed scores were divided by the number of codable 5-sec intervals remaining after the infant's first look to mother or after the mother's first vocalization, to yield a mean positive affect score and a mean negative affect score. A second pair of research assistants coded affect together to check reliability. The intraclass correlation coefficients for rater agreement were .90 for positive affect and .85 for negative affect.

Results

Preliminary Analyses and Strategy for Primary Analyses

Time window analyses.—In an earlier study, we found that infants looked at fear faces longer than happy faces, but only in the first half of the 60-sec coding window (Mumme, 1993). The majority of significant order effects found in this earlier study were also only in the first 30 sec. This suggests that a coding window of 60 sec may have been too long. Thus, the analysis of the data from the current study began with a comparison of data averaged over the first half of the 60-sec window (0 sec to 30 sec after the infant's first look to mother or the mother's first vocalization) and data averaged over the second half (31 sec to 60 sec post first look or vocalization). For each modality, the five dependent variables were converted into difference scores by subtracting the baseline trial from the expression trial (trial 2 – trial 1) and were analyzed for expression condition differences in a multivariate analysis of variance. The data from the first half of the coding window yielded one significant multivariate effect and several significant univariate effects for expression (p < .05). The data from the second half of the coding window did not yield any significant effects (p > .10). Thus, by the second half of the 60-sec coding window, the expression condition differences all but disappeared. In addition, in the face-only condition, the majority of looks to mother (63%) occurred in the first 30 sec after the first look. It seems plausible that the situation may have become less ambiguous over the course of the trial, because the toy stopped making noise and moving. Moreover, the impact of the mother's emotional signals may have lessened, because the same signal was repeated and because mothers did nothing else to encourage or discourage their infants. Based on these findings, we decided that a 30-sec coding window was a more appropriate unit of analysis than a 60-sec window. All subsequent analyses are based on the 30-sec coding window.

Missing data.—Because infants sometimes faced away from the cameras, affect was uncodable during approximately 25% of the intervals across the 60-sec coding window. In examining the missing affect data, we found that most of the missing data occurred in the second half of the trial and was accounted for by a few infants who rarely faced the cameras. In the first 30-sec coding window, we found that 10 infants had affect
TABLE 1
INFANT RESPONSES TO MATERNAL VOCAL SIGNALS DURING THE NEUTRAL BASELINE TRIAL

<table>
<thead>
<tr>
<th>Vocal Expression Condition</th>
<th>Girls</th>
<th>Boys</th>
<th>Girls</th>
<th>Boys</th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Looks to mother</td>
<td>1.53 (1.38)</td>
<td>2.60 (2.09)</td>
<td>3.64 (4.76)</td>
<td>1.83 (1.59)</td>
<td>1.84 (1.64)</td>
<td>1.59 (1.14)</td>
</tr>
<tr>
<td>Toy proximity</td>
<td>.71 (.95)</td>
<td>1.69 (1.12)</td>
<td>.98 (1.05)</td>
<td>.77 (.74)</td>
<td>1.50 (1.00)</td>
<td>1.46 (.96)</td>
</tr>
<tr>
<td>Mother proximity</td>
<td>.37 (.69)</td>
<td>.48 (.77)</td>
<td>.71 (.90)</td>
<td>.33 (.51)</td>
<td>.07 (.13)</td>
<td>.10 (.29)</td>
</tr>
<tr>
<td>Positive affect</td>
<td>.36 (.39)</td>
<td>.57 (.39)</td>
<td>.47 (.65)</td>
<td>.39 (.65)</td>
<td>.25 (.33)</td>
<td>.40 (.39)</td>
</tr>
<tr>
<td>Negative affect</td>
<td>.02 (.06)</td>
<td>.10 (.15)</td>
<td>.07 (.15)</td>
<td>.08 (.11)</td>
<td>.11 (.27)</td>
<td>.08 (.15)</td>
</tr>
</tbody>
</table>

Neutral Trial Analyses

Voice-only condition.—The 3 × 2 MANOVAs on infants' behavioral and emotional responses in the neutral trial revealed no significant effects of expression condition or sex and no significant expression × sex interactions (p > .10). See Table 1 for girls' and boys' responses during the neutral trial.

Face-only condition.—The 3 × 2 MANOVA on infants' behavioral responses in the neutral trial revealed no significant effects of expression condition or sex (p > .10). However, there was a marginally significant expression × sex interaction, F(6, 74) = 1.99, p = .08, which appears to be the result of the tests for boys and girls behaving differently on the looks to mother and toy proximity measures during the neutral trial (see Table 2). The 3 × 2 MANOVA on infants' emotional responses in the neutral trial revealed a significant effect of sex, F(2, 34) = 5.56, p < .01. A subsequent univariate analysis revealed that boys and girls differed in their

For the most part, the five dependent measures were not highly correlated. Correlations calculated on the difference scores showed that the highest correlation in the face-only condition was between positive and negative affect (r = .40). The highest correlations in the voice-only condition were between toy proximity and mother proximity (r = -.37) and between durations of looks to mother and negative affect (r = .37). All other correlations were below r = ±.30.
TABLE 2
INFANT RESPONSES TO MATERNAL FACIAL SIGNALS DURING THE NEUTRAL BASELINE TRIAL

<table>
<thead>
<tr>
<th>Facial Expression Condition</th>
<th>Happy</th>
<th>Neutral</th>
<th>Fear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>Looks to mother</td>
<td>2.33 (2.12)</td>
<td>2.99 (2.60)</td>
<td>6.89 (5.83)</td>
</tr>
<tr>
<td>Toy proximity</td>
<td>1.05 (1.01)</td>
<td>1.15 (1.07)</td>
<td>1.10 (.99)</td>
</tr>
<tr>
<td>Mother proximity</td>
<td>.48 (.53)</td>
<td>.21 (.34)</td>
<td>.23 (.31)</td>
</tr>
<tr>
<td>Positive affect</td>
<td>.30 (.30)</td>
<td>1.10 (.60)</td>
<td>.55 (.64)</td>
</tr>
<tr>
<td>Negative affect</td>
<td>.02 (.06)</td>
<td>.00 (.00)</td>
<td>.05 (.13)</td>
</tr>
</tbody>
</table>

NOTE.—Standard deviations are in parentheses.

* Sex effect: positive affect, \( p = .01, df = 1, 35. \)

expressions of positive affect during the neutral trial, \( F(1, 35) = 10.87, p < .01 \) (see Table 2). Boys (\( M = 1.02, SD = 0.53 \)) initially expressed more positive affect than girls (\( M = 0.47, SD = 0.50 \)) across all three facial expression conditions.

Because there was no significant effect of expression condition in the neutral trial in either the voice-only or face-only conditions, the first neutral trial was an appropriate baseline trial for the main set of analyses. Therefore, all of the mean scores reported below the mean difference scores. However, because of the sex differences found in the neutral trial of the face-only condition, we have also included additional analyses of girls’ and boys’ responses.

Effects of Vocal Emotional Signals

Instrumental response to vocal signals.—For the voice-only condition, the analysis of infants’ looks to mother and proximity to toy and mother revealed a significant effect of expression, \( F(6, 74) = 2.45, p < .05 \). There was no main effect of sex and no significant expression \( \times \) sex interaction. To determine whether both the happy-voice and fear-voice conditions were contributing to this overall expression effect, two multivariate planned contrasts were run, collapsing across sex. The happy-voice condition did not differ significantly from the neutral-voice condition \( (p > .10) \). The fear-voice condition, however, did differ significantly from the neutral-voice condition, \( F(3, 42) = 3.44, p < .05 \). Subsequent univariate planned contrasts between the fear and neutral conditions revealed significant effects for duration of looks to mother, \( F(1, 44) = 5.85, p < .05 \), and toy proximity, \( F(1, 44) = 5.15, p < .05 \) (see Table 3). From the neutral baseline trial to the expression trial, infants in the fear-voice condition showed an increase in the amount of time they looked at their mothers \( (M = 2.43 \text{ sec}, SD = 2.30) \), while infants in the neutral-voice condition showed a decrease in the amount of time they looked at their mothers \( (M = -0.16 \text{ sec}, SD = 3.12) \). On the measure of toy proximity, infants in the fear-voice condition showed a decrease in their approach to the toy \( (M = -0.54, SD = 0.81) \) from the baseline trial to the expression trial, while infants in the neutral-voice condition showed a slight increase \( (M = 0.18, SD = 0.76) \).

Emotional response to vocal signals.—The analysis of infants’ expression of positive and negative affect revealed no main effects of expression or sex and no significant expression \( \times \) sex interaction \( (p > .10) \). Next, the multivariate planned contrasts were used to test whether the happy or fear condition alone differed significantly from the neutral condition. The happy-voice condition did not differ significantly from the neutral-voice condition \( (p > .10) \). The multivariate effect for the neutral versus fear contrast was marginally significant, \( F(2, 37) = 2.78, p = .07 \). This marginal effect appears to be due to infants in the fear-voice condition \( (M = 0.27, SD = 0.52) \) showing more negative affect than infants in the neutral-voice condition \( (M = -0.02, SD = 0.13) \) (see Table 3).

In summary, in response to fearful vocalizations, infants looked longer at their mothers, approached the toy less, and tended to express more negative affect than did infants in response to neutral vocalizations. On the measures of proximity to mother and positive affect, there were no significant differences between infants in the fear-voice condition and neutral-voice condition. Infants in the happy-voice and neutral-voice conditions did not differ significantly on any of the measures.
<table>
<thead>
<tr>
<th>Vocal Expression Condition</th>
<th>Happy</th>
<th>Neutral</th>
<th>Fear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>Looks to mother*</td>
<td>1.84 (1.00)</td>
<td>1.70 (3.37)</td>
<td>1.33 (3.32)</td>
</tr>
<tr>
<td>Toy proximity*</td>
<td>.48 (1.27)</td>
<td>-.02 (.58)</td>
<td>.31 (.54)</td>
</tr>
<tr>
<td>Mother proximity</td>
<td>-.02 (.92)</td>
<td>-.09 (.32)</td>
<td>.17 (1.52)</td>
</tr>
<tr>
<td>Positive affect</td>
<td>.29 (.43)</td>
<td>-.33 (.41)</td>
<td>.16 (.42)</td>
</tr>
<tr>
<td>Negative affect</td>
<td>-.02 (.06)</td>
<td>.07 (.25)</td>
<td>-.03 (.07)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fear</td>
<td>2.27 (2.68)</td>
<td>2.57 (2.08)</td>
</tr>
</tbody>
</table>

Note.—Numbers represent mean difference scores, calculated by subtracting Trial 1 scores from Trial 2 scores. Standard deviations are in parentheses.

* Fear versus neutral contrasts: looks to mother and toy proximity, p < .05, df = 1, 44.
Effects of Facial Emotional Signals

Instrumental response to facial signals.—For the face-only condition, the analysis of infants’ looks to mother and proximity to toy and mother revealed a marginally significant effect for expression, $F(6, 74) = 1.88, p < .09$, and a significant expression $\times$ sex interaction, $F(6, 74) = 3.08, p < .01$. There was no main effect of sex. Subsequent univariate comparisons indicated that the interaction was significant for both looks to mother, $F(2, 39) = 4.15, p < .05$, and toy proximity, $F(2, 39) = 4.85, p < .01$. Girls and boys in the neutral-face and fear-face conditions appeared to show opposite patterns of responding on these two measures (see Table 4).

In order to provide parallel analyses for both modality conditions, multivariate planned contrasts for the face-only condition were first conducted without considering sex as a factor. The multivariate contrast for the happy-face and neutral-face conditions did not yield a significant effect of expression ($p > .10$). The fear-face condition, however, did differ significantly from the neutral-face condition, $F(3, 42) = 2.84, p < .05$. Subsequent univariate planned contrasts between the fear and neutral conditions revealed a significant effect only for the measure of duration of looks to mother, $F(1, 44) = 3.93, p < .05$ (see Table 4). From the neutral baseline trial to the expression trial, infants in the fear-face condition showed an increase in the amount of time they looked at their mothers ($M = 0.19$ sec, $SD = 4.01$), while infants in the neutral-face condition showed a decrease in the amount of time they looked at their mothers ($M = -2.69$ sec, $SD = 4.63$). However, as discussed below, only girls showed this pattern of looking.

Emotional response to facial signals.—The analysis of infants’ expression of positive and negative affect in the face-only condition revealed only a main effect of sex, $F(2, 34) = 4.34, p < .05$ (see Table 4). There was no main effect of expression and no significant expression $\times$ sex interaction. Subsequent univariate comparisons for the sex main effect were significant for positive affect only, $F(1, 35) = 7.41, p = .01$. In all three expression conditions, boys ($M = -0.51$ sec, $SD = 0.47$) showed less positive affect than girls ($M = -0.13$ sec, $SD = 0.44$). Again, multivariate planned contrasts were conducted without including sex as a factor. Neither the happy-face nor the fear-face conditions differed significantly from the neutral-face condition ($p > .10$).

Differential responding by girls and boys.—Because girls and boys in the face-only condition appeared to differ during the neutral baseline trial on the measures of looks to mother, toy proximity, and positive affect, we ran additional multivariate planned contrasts on the behavioral and emotional response data, this time examining girls’ and boys’ responses separately.

As suggested by Keppel (1991), the kind of baseline-test data examined in the preceding difference score analyses can also be examined using analyses of covariance, in which the baseline trial scores are treated as covariates. For comparison, we ran 3 (expression) $\times$ 2 (sex) ANCOVAs on each of the dependent measures. These were followed by planned contrasts, using the adjusted means. The major findings were the same: the neutral-voice condition differed significantly from the fear-voice condition on the measures of looks to mother, toy proximity, and negative affect ($p < .05$); the neutral-face condition differed from the fear-face condition on the measure of looks to mother ($p < .05$). Interestingly, two (toy proximity and positive affect) of the three sex differences in the face-only condition that were significant using the difference score approach were no longer significant using the ANCOVA approach ($p > .10$). This suggests that these sex differences may have been due to differences between the groups prior to the experimental manipulation.

In order to provide parallel information for both modalities, these additional multivariate contrasts, examining the girls’ and boys’ responses separately, were also conducted on the voice-only data, even though there were no initial differences between girls and boys in the voice modality. For boys’ behavioral and emotional responses, neither the neutral-voice versus happy-voice nor the neutral-voice versus fear-voice contrasts were significant ($p > .10$). The neutral-voice versus happy-voice multivariate contrasts conducted on girls’ behavioral and emotional responses were also not significant ($p > .10$). However, even with the reduced sample size, girls in the neutral-voice and fear-voice conditions did differ significantly in both their behavioral responses, $F(3, 19) = 3.54, p < .05$, and their emotional responses, $F(2, 16) = 3.96, p < .05$. Subsequent univariate contrasts between the girls in the fear and neutral conditions revealed significant effects for duration of looks to mother, $F(1, 21) = 6.50, p < .05$, and negative affect, $F(1, 17) = 6.00, p < .05$, but did not reach significance for toy proximity, $F(1, 21) = 2.92, p = .10$. Thus, although boys and girls in the fear-voice condition responded similarly on the measures of duration of looks to mother, proximity to the toy, and negative affect, the effects may have been stronger for girls than for boys.
<table>
<thead>
<tr>
<th>Facial Expression Condition</th>
<th>Happy</th>
<th>Neutral</th>
<th>Fear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>Looks to mother</td>
<td>.67 (.49)</td>
<td>.57 (3.35)</td>
<td>-5.03 (5.02)</td>
</tr>
<tr>
<td>Toy proximity</td>
<td>-.48 (1.28)</td>
<td>-.33 (0.71)</td>
<td>-.81 (.89)</td>
</tr>
<tr>
<td>Mother proximity</td>
<td>.09 (1.19)</td>
<td>.21 (1.03)</td>
<td>.21 (.68)</td>
</tr>
<tr>
<td>Positive affect</td>
<td>.10 (.28)</td>
<td>-.54 (.53)</td>
<td>-.24 (.26)</td>
</tr>
<tr>
<td>Negative affect</td>
<td>-.02 (.06)</td>
<td>.07 (.11)</td>
<td>-.02 (.06)</td>
</tr>
</tbody>
</table>

**Note.**—Numbers represent mean difference scores, calculated by subtracting trial 1 scores from trial 2 scores. Standard deviations are in parentheses.

*Fear versus neutral contrast: looks to mother, $p = .05$, $df = 1, 44$.  
 Expression $\times$ sex effect: looks to mother, $p = .05$, $df = 2, 39$; toy proximity, $p = .01$, $df = 2, 39$.  
 Sex effect: positive affect, $p = .01$, $df = 1, 35$.  

For boys’ behavioral responses, neither the happy-face nor the fear-face conditions differed significantly from the neutral-face condition ($p > .10$). For girls’ behavioral responses, the neutral-face versus happy-face multivariate contrast did not reach significance, $F(3, 20) = 2.37, p = .10$. However, the neutral-face versus fear-face contrast for girls did yield a significant multivariate effect, $F(3, 20) = 7.54, p < .01$. Subsequent univariate planned contrasts between girls in the fear and neutral conditions yielded significant effects for looks to mother, $F(1, 22) = 9.70, p < .01$, and toy proximity, $F(1, 22) = 6.95, p < .05$. Girls looked at their mother more when she displayed a fearful expression during the second trial than when she again displayed a neutral expression (see Table 4). Contrary to prediction, girls in the fear-face condition showed an increase in their proximity to the toy, whereas girls in the neutral-face condition showed a decrease. It is important to note that this increase could be the result of the particularly low toy proximity shown by the girls in the face condition during their neutral baseline trial (see Table 2).

In the neutral trial, boys initially expressed more positive affect than girls across all three facial expression conditions. This possible ceiling effect may be the reason why boys showed a greater decrease in positive affect than did girls from the baseline neutral trial to the expression trial. However, it does not appear that either girls’ or boys’ emotional responses varied systematically with expression condition. The reanalysis of the emotional response data for girls and boys separately did not yield any significant contrast effects ($p > .10$).

In summary, we found that there were few significant differences in infants’ responses to neutral, happy, and fearful facial expressions and that the infant’s sex was a factor in the few differences that were found. Only girls showed differential responses to fearful facial expressions. As compared to girls in the neutral-face condition, girls in the face condition looked longer at their mothers and, surprisingly, approached the toy more when their mothers expressed fear. There were no significant differences between boys in the neutral-face and face-face conditions on these or any other measures. There were also no significant differences between the happy-face and neutral-face conditions on any of the measures, for either girls or boys.

**Discussion**

The current study confirmed several of our predictions for the influence of vocal emotional signals on infant behavior. When infants heard their mothers express fear verbally, they showed a decrease in toy exploration and tended to show an increase in negative affect. These infants also looked longer at their mothers during the expression trial, which suggests that they detected the change from the relatively monotone neutral vocalization to the more highly modulated fearful vocalization. Infants’ proximity to mother and positive affect were not systematically influenced by either negative or positive vocalizations. Infants who heard their mothers express happiness also did not show the predicted increases in toy exploration or positive affect. Thus, in the voice-only condition, infants responded appropriately only to the fearful vocalizations, and they did so even though the vocal expressions were not accompanied by matching facial expressions.

In contrast, infants in the face condition did not show a reliable decrease in proximity to the toy as compared to infants in the neutral-face condition; nor did they show an increase in proximity to mother or in negative affect. One behavior that was affected by changes in facial expression was duration of looks to mother, but only female infants showed the effect. When girls saw their mothers express fear during the expression trial, they looked longer at these new expressions as compared to girls who saw their mothers again looking neutral. The only other significant finding was the unexpected increase in toy proximity by girls in the fear-face condition. The failure of this study, a previous study in our lab (Mumme, 1993), and two other novel toy social referencing studies (Klimnert, 1984; Zarbatany & Lamb, 1985) to find consistent responses to positive and negative facial signals indicates that the face alone may be too weak a social signal to regulate 1-year-olds’ interactions with novel toys.

The finding that facial emotional signals did not elicit the expected behavior in a novel toy paradigm does not mean that the face is never an important regulator of infant behavior. In fact, the weak effects of facial expressions in novel toy studies are in contrast to the dramatic effects of facial expressions found in the original visual cliff study (Sorce et al., 1985). What might account for these discrepant findings? Hirshberg and
Svejda (1990) suggest that the effects obtained in the visual cliff study may be unique to that context. One possibility is that the visual cliff situation may have elicited the optimal level of uncertainty in infants, because the apparatus was unfamiliar and the depth had been carefully calibrated (Hirshberg & Svejda, 1990, p. 1185). It may be only in highly uncertain or potentially dangerous situations that the face alone is likely to be effective as a means of distal communication. In situations that do not appear particularly dangerous, such as the approach of an unusual toy, the face in combination with a more preemptive action, such as a strong vocal signal or physical intervention, might be necessary to disrupt or facilitate the infant’s response. Another possibility is the infant in the visual cliff study might have been particularly aware of the mother’s face, because she was directly in front of the infant and because her face and the edge of the cliff were probably the two most compelling things to look at in this situation. Because there was only one response option in the cliff study (crawling toward the drop-off) the mother’s facial expression also probably appeared more contingent on infant behavior than it did in the current study, in which infants could have been responding in any number of ways (e.g., crawling toward the toy, the mother, the starting square, etc.) when they looked at the mother’s face. A related concern is that the facial expressions may have lacked authenticity in this setting. It is certainly the case that infants are responsive to changes in facial expression in face-to-face interactions (cf. Cohn & Tronick, 1983; Meltzoff & Moore, 1983; Stern, 1985). Whether 12-month-old infants are responsive to facial expressions in distal communications remains unclear and probably depends greatly on context.

Not only are there contextual features that may influence the impact of vocal or facial emotional signals, but there are also procedural differences that may have been important in the current study. For example, one procedural difference is that infants in the voice-only condition still had potential access to the mother’s face, even though her facial expression was neutral. Walker-Andrews and Lennon (1991) found that 5-month-old infants discriminated vocal emotional expressions when they were shown a face but not when they were shown a checkerboard pattern, regardless of whether the facial emotion matched the vocal emotion. Although it is not clear why access to an uninformative face should facilitate discrimination of vocal expressions, it is possible that the face engages the infants’ attention more effectively or simply makes the situation less bizarre. In addition, there is an inherent problem with determining whether infants perceived the facial and vocal signals as equally intense or equivalent in scale. Although we instructed mothers to use extremely, exaggerated facial and vocal expressions and although, for both modalities, the happy expressions were all rated as moderately to very positive and the fearful expressions were all rated as moderately to very negative, we lack a strong demonstration of scale equivalence. Thus, in interpreting the results of the current study, it is important to remember that the two modality conditions were not precisely equivalent and that their effectiveness cannot be directly compared.

The problem of determining whether infants perceived the facial and vocal signals as equally intense is also relevant when evaluating the relative effectiveness of positive and negative emotional signals. Positive and negative signals, even when objectively rated by an adult coder as equal in intensity, may not be perceived by the infant as equally intense. Exposure to fearful vocal expressions, as well as fearful facial expressions, may be a relatively rare event in the life of the 1-year-olds in this sample. In contrast, exposure to happy expressions is more likely to be a common, familiar event. If fearful expressions are uncommon, the infant may find even relatively weak fearful expressions unsettling.

As observed in the current study, it was only negative expressions that were associated with changes in infant behavior and affect. Only infants in the fear-voice condition and girls in the fear-face condition showed changes in their behavior during the expression trial. Neither happy vocalizations nor happy faces promoted exploration or increased positive affect in infants. These findings support Hornik et al.’s (1987) suggestion that infants respond more readily to negative than to positive signals. Similar findings have been reported in the adult social psychology literature, suggesting that there is a negative bias in learning and emotion, probably because one cannot risk learning slowly about imminent dangers (e.g., Clore, 1992; Rozin & Nemeroff, 1990) and, as suggested above, perhaps because negative signals are used infrequently.
Another reason why the fearful vocalizations in particular may have had the predicted inhibitory effects is that they may have regulated behavior directly, by eliciting a change in the infant’s emotional state. Even if infants failed to associate the fearful vocalization with the novel toy, the sudden, sharp onset of the fearful vocalization could have elicited the same response, namely, behavioral inhibition. The finding that the condition differences were strongest in the first 30 sec of the trial lends some credence to this interpretation. In addition, the finding that infants in the fear-voice condition showed an increase in expressions of negative affect suggests that a change in infant mood may have occurred. Perhaps in another context, happy vocalizations would have had the corresponding excitatory or positive impact on infants’ exploration of the environment. In many different ways, the social referencing context is an important factor in determining the social regulatory power of positive and negative signals and of facial and vocal emotional signals (see also Walden, 1991).

Differences between Boys and Girls

The majority of infant social referencing studies have not found response differences between boys and girls. In the current research, however, several sex differences emerged. Girls in the neutral-face condition showed the greatest decrease in looks to mother and toy proximity in the neutral expression trial. For girls, having their mothers repeatedly pose a neutral, nonexpressive face may have been more disturbing than having them pose an exaggerated fear face. Malatesta and her colleagues report that mothers of 2-year-olds show greater expressivity to girls than to boys, indicating that girls are exposed to a greater range of emotions (Malatesta, Culver, Tesman, & Shepard, 1989). Perhaps girls in the present study more so than boys expected their mothers to engage in emotional communication and, thus, became disconcerted when their mothers were not emotionally expressive.

Girls in the fear-face condition showed an unexpected increase in toy exploration when their mothers expressed fear. This is probably not due to weaker expressions of fear signaled to girls than to boys. The manipulation checks revealed no differences in mothers’ fearful facial expressions made in the presence of daughters versus sons. The girls’ behavior is surprising, because the typical finding in research on sex differences in emotion understanding is that females tend to be better than males at decoding emotional expressions (e.g., Hall, 1978; Malatesta et al., 1989). Girls at least noticed that their mothers’ facial expression had changed, as suggested by their longer looking to mother in the fear trial. It is possible that girls did decode their mothers’ facial expressions correctly—as “mock” fear expressions, and that is why they ignored or perhaps tested the seriousness of their mothers’ behavior by moving closer to the toy. Walden and Ogan (1988) raise a similar point in their discussion of the behavior of older infants in their study. In the current study, however, there were only eight girls in the fear-face condition, so it seems equally likely that their anomalous behavior was due to sampling error.

Conclusions

The finding that infants responded appropriately only to fearful vocalizations suggests that negative vocalizations are effective social signals in infancy. Does this mean that the 12-month-old infants in this study actually understood that the negative vocalizations signified fear and that they were in reference to the novel toy? One interpretation of the current findings is that the infants did appreciate the meaning of the fearful vocalizations, because they responded appropriately by avoiding the toy that had been the target of their mothers’ fearful reaction. However, there are several reasons why we prefer a more conservative interpretation of the current results.

Fernald (1992) has proposed that vocal expressions may be more potent signals in infancy than facial expressions, because the intrinsic acoustic properties of vocal affective expressions, such as loudness and pitch, may induce emotions directly. In our study, it is quite possible that the fear vocalizations, especially the initial gasp, startled the infant and directly induced a state of wariness in the infant. The same infant responses would have been observed if the vocalization directly induced wariness, whether or not infants understood the meaning of the emotional signal. In other words, infants may have responded with behavioral inhibition and negative affect because they were in a negative mood state and not because they understood that the vocalization signified fear of the novel toy. It is possible that it was simply the sudden onset and intensity of the negative vocal signals, or their unfamiliarity, that elicited behavioral inhibition rather than a fully referential understanding of the emotional signal. In any
study like the current one, in which there is only one salient target object in the room, one cannot assume that a decrease in toy proximity reflects specific avoidance of the novel toy (see Mumme & Fernald, 1995, for a more detailed discussion).

Social referencing research represents one of the most promising approaches to date for investigating early understanding of emotional communication. The goal of the current study was to assess the independent influences of facial and vocal emotional signals and of positive and negative signals on infants' behavior. Even though infants responded appropriately to negative vocal signals, it seems likely that their knowledge of the emotional meaning of vocal signals is still developing during the second year. Infants at this age may just be beginning to learn to use emotional signals as information about how to feel about or respond to external events. While experimental studies such as this one have their advantages, it is also important to devise more natural, ecologically valid procedures to determine what is developing during this period and how infants begin to use many different sources of information. As infants' understanding of other forms of communication becomes more sophisticated over the course of the second year, they may only gradually come to understand that facial and vocal emotional signals reflect internal states with predictable antecedents and consequences. It seems likely that infants' responses to emotional signals will be increasingly mediated by this new knowledge.

References
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