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Infants' Understanding of the Link Between Visual Perception and Emotion: "If She Can't See Me Doing It, She Won't Get Angry"

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Abstract

Two experiments investigated 18-month-olds' understanding of the link between visual perception and emotion. Infants watched an adult perform actions on objects. An Emoter then expressed Anger or Neutral affect toward the adult in response to her actions. Subsequently, infants were given 20 s to interact with each object. In Experiment 1, the Emoter faced infants with a neutral expression during each 20-s response period, but either looked at a magazine or the infant. In Experiment 2, the Emoter faced infants with a neutral expression and her eyes were either open or closed. When the Emoter visually monitored infants' actions, they regulated their object-directed behavior based on their memory of her affect. However, if the previously angry Emoter read a magazine (Exp. 1) or closed her eyes (Exp. 2), infants were not governed by her prior emotion. Infants behaved as if they expected the Emoter to get angry only if she could see them performing the actions. These findings suggest that infants appreciate how people's visual experiences influence their emotions and use this information to regulate their own behavior.

Keywords

social cognition; social referencing; gaze following; imitation; self-regulation

Infants live in a social world filled with emotional, communicative, and referential information. This includes simple acts like pointing or turning-to-look at objects as well as complex multimodal emotional expressions and gestures. Over time, infants become increasingly adept not only in decoding these messages but also at using this information to *regulate their own actions*. Here we test infants' conjoint use of another person's visual experience and emotional reactions to make choices about their own behavior, with implications for infants' emerging self-control.

By 12 months of age, infants will selectively look where another person is looking – gaze following (Brooks & Meltzoff, 2002; Carpenter, Nagel, & Tomasello, 1998; Moore & Dunham, 1995). They also use other people's emotional expressions to determine whether to approach or avoid a novel object – social referencing (Klinnert, Emde, Butterfield, & Campos, 1986; Walden & Ogan, 1988). In adults, the perceptual and emotional understandings that underlie these behaviors are linked in complex ways that enable predictions to be made about other people's future behavior. There is evidence that infants begin to appreciate some of these connections in the second year of life. For example, around 12−14 months of age, infants can use gaze direction to identify the specific item a person is emoting about (Moses, Baldwin, Rosicky & Tidball, 2001; Repacholi, 1998). Beyond this, there has been little research focused

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on infants' ability to link people's visual perception and their emotional behaviors and whether they use this to regulate their own actions.

Infants' Use of Other People's Emotional Signals to Regulate Their Own Behavior

Infants can discriminate between various emotional expressions, facial and/or vocal, in the early months of life (see Walker-Andrews, 1997 for a review). However, there is a significant advance in their ability to recognize and interpret emotional displays when they begin to engage in social referencing. At about one year of age, infants seek out emotional information from other people to resolve their uncertainty about an event and then regulate their behavior on the basis of that information. In laboratory studies, infants are presented with an ambiguous object and an adult produces an emotional response. Infants usually approach and play with the object when a positive expression is posed but exhibit avoidance (e.g., delayed or reduced object contact) if fear is conveyed. When the adult communicates other negative emotions, such as disgust (e.g., Repacholi, 1998) or anger (e.g., Sorce, Emde, Campos, & Klinnert, 1985), infant avoidance has also been observed. When neutral expressions are employed (e.g., Hornik, Risenhoover, & Gunnar, 1987; Mumme, Herrera, & Fernald, 1996), infants' responses often resemble those of infants exposed to positive messages.

In standard social referencing studies, emotional information is directly communicated to infants by a social partner. In the real-world, however, this is not always the case; infants often see and overhear emotional exchanges between other people (e.g., between spouses or a parent and a sibling). Can they learn from emotional reactions that are not directed towards them by 'eavesdropping' on other people's interactions? Repacholi and Meltzoff (2007) developed the 'Emotion-Imitation' paradigm to explore such eavesdropping situations. This paradigm extends the social referencing procedure in a novel way. It capitalizes on the fact that infants are adept and motivated imitators (for a discussion of the nature, scope, and motivation of infant imitation, see Meltzoff, 2007). Thus, infants' imitative responses, not simply their overall approach-avoidance behavior, are used to assess how infants use others' emotional displays to regulate their own subsequent actions.

In Repacholi and Meltzoff's (2007) Emotion-Imitation procedure, 18-month-old infants watched an adult (the Emoter) express Anger or Neutral affect toward an Experimenter in response to her action on an object. Infants were then presented with the object. During this response period, the Emoter was silent and adopted a pleasant neutral expression as she faced the infant. Infants regulated their interaction with the object based on their memory of the Emoter's prior emotional display. In particular, infants were less likely to perform the target act if the Emoter had previously been angry at the Experimenter as opposed to when her prior emotional reaction was neutral. Thus, by 18 months of age, infants can regulate their own actions in response to indirect emotional information – emotional communications that are directed at someone else and not themselves. After watching the Emoter express anger in response to the Experimenter's actions, infants may have expected her to become angry at them as well if they performed the target acts. Consequently, infants were loathe to reproduce those specific actions.

Infants' Responsiveness to Visual Perceptual Cues

Infants also change their behavior based on people's line of visual regard. By 6 months or earlier, infants will look in the same general direction indicated by another person's turning head and eyes (Butterworth & Cochran, 1980; Flom, Lee, & Muir, 2007). Over the next year or so, infants are increasingly likely to spontaneously follow another person's gaze. In addition, they become proficient at locating the correct target and selective as to the cue that elicits gaze following (head direction versus gaze direction). For example, prior to 12 months, infants look in the direction of the adult's turn, but they tend to fixate on the first object encountered along the scan path, even though the adult is looking at a more distant object (Butterworth & Cochran, 1980). After about 12 months of age, infants become more adept at following a person's gaze to a target that is outside their current visual field (Butterworth & Jarrett, 1991; Moll & Tomasello, 2004). At around one year of age or slightly before, infants also begin to use people's eyes (not just head orientation or body posture) as the basis for their gaze following. Brooks and Meltzoff (2002, 2005) presented 9- to 18-month-old infants with an experimenter whose eyes were either open or closed as she turned her head toward a target object. Nine-month-old infants followed the adult's head movement even when her eyes were closed. The older infants, on the other hand, differentiated between the two conditions, following the adult's head turn significantly more when her eyes were open than when they were closed. Thus, by 10 months of age, infants monitor and follow the adult's *gaze* to a target, not just the adult's bodily orientation. They appreciate the importance of eyes as the organ for visual perception.

Linking Visual Perception and Emotion

Infants ultimately need to be able to link emotion and visual perception in order to effectively use these social cues to interpret and predict other people's behavior in the real world. For instance, emotions are often expressed in response to or are ‘about’ an object or event. Cues such as eye direction, a head turn, or a pointing gesture can all be used to determine which object among many in the environment a person is visually attending to and thus emoting about. Infants as young as 12−14 months of age are able to identify the specific target of another person's emotional expression (e.g., Hertenstein & Campos, 2004; Repacholi, 1998). Moreover, Moses et al. (2001) have demonstrated that these young infants can use visual perceptual cues to do so. In their social referencing study, infants were presented with two novel objects, one of which was the target of an adult's affective display. Infants regulated their behavior toward whichever object the adult had been looking at when she delivered the emotional message.

The Moses et al. (2001) findings do not mean, however, that infants’ understanding of the link between visual perception and emotion is complete. A mature understanding of the way in which these are related would include being able to predict how people's visual experiences – what they can see – might influence their future emotional reactions. For instance, an infant might play with his mother's lipstick and discover that this elicits maternal anger. What happens later on, however, when his mother is engrossed in a magazine or is sleeping in her chair, and no longer looking at what he is doing? Does the infant appreciate that mom is likely to become angry only if she *sees* him playing with the lipstick? If so, he might take advantage of this situation and engage in the forbidden activity.

Whether infants can use information about people's visual experiences to predict their future emotions has not been addressed in the existing literature. There is some suggestion, however, that infants are able to use a person's gaze direction as a cue to their future instrumental behavior. Phillips, Wellman, and Spelke (2002) habituated infants to an event in which an adult looked at and expressed positive affect about one of two objects. Infants were then exposed to an inconsistent event in which the adult grasped the ignored object, and a consistent event in which she grasped the object that had previously been the focus of her attention. Both 12-and 14-month-old infants looked longer at the inconsistent than the consistent event, whereas 8-month-olds looked equally at the two. Thus, older infants have learned the regularity that when people attend to and emote positively about an object, they are more likely to grasp that specific object and not another one.

Current experiments

The primary goal of this research was to explore 18-month-old infants' understanding of the link between visual perception and emotion. More specifically, we were interested in whether infants can use information about a person's visual experience to predict their subsequent emotions and then use that prediction to regulate their own behavior. Repacholi and Meltzoff (2007) reported that 18-month-old infants are able to predict when they might be the target of another person's angry outburst. Infants apparently used their memory of how an Emoter responded to another person's actions to predict her likely reaction to their own actions.

We modified the Emotion-Imitation procedure by systematically manipulating the Emoter's looking behavior. In Experiment 1, the Emoter expressed either neutral affect or anger toward the Experimenter. She then faced the infants with a neutral expression during the response period. The experimental manipulation was whether her eye gaze was directed down toward a magazine (Anger-distracted) or toward the infant (Anger-attentive; Neutral-attentive). In the response period for Experiment 2, the Emoter faced the infants with a neutral expression, but her eyes were now either closed (Anger/Eyes-closed) or remained open (Anger/Eyes-open; Neutral/Eyes-open). We predicted that infants would take into account both the Emoter's emotional reactions and her looking behavior. Thus, after witnessing the Emoter expressing anger toward the Experimenter, we expected that infants would be less willing to perform the target acts than those infants who previously observed the Emoter expressing neutral affect. Based on developmental advances in infants' gaze-following skills in the second year of life, we also hypothesized that infants might take into account where the Emoter is looking during the time that they have access to the object. If so, infants should be more likely to perform the target act when the previously angry adult can*not* see them, in comparison to when she can.

Experiment 1

Method

Participants—The participants were 72 (36 male) 18-month-old infants (*M* = 18.03 months; *SD* = 4.86 days; range = 17.72 − 18.33 months). Infants were recruited from a computerized database of parents who had expressed interest in volunteering for infant studies being conducted at the University of Washington. To be included in the study, infants had to be full term (37−43 weeks) with normal birth weight (2.5−4.5kg) and have no known physical, sensory, or mental handicap. The racial composition of the sample was 80% Caucasian, 3% Asian, 14% other (e.g., mixed race), and 3% unknown (i.e., the parents did not wish to provide this information). Infants were from middle- to upper-class families. Additional infants were excluded due to extreme infant fussiness/inattention (*n* = 6), parent interference (*n* = 1), and procedural problems (*n* = 1).

Design—Each infant was randomly assigned to one of three conditions (*n* = 24 in each): Anger-attentive, Neutral-attentive, or Anger-distracted. Equal numbers of boys and girls were assigned to each condition. Infants participated in three trials, each involving a different test object. There were six possible orders for presenting the test objects. Object order was counterbalanced within and between conditions.

Materials

Test objects: Three novel test objects were used. These were duplicates of those originally used by Meltzoff (1988) and were also employed by Repacholi and Meltzoff (2007). One object was a collapsible plastic cup, made of a series of graded rings. The action demonstrated by the Experimenter was to collapse the cup by pushing down on the top with the palm of the hand. This action produced a scraping sound as the rings slid down to the base of the cup. Another

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object was a black box with a recessed button on the top surface and a wooden stick. The demonstrated action was to press the button with the stick, thereby creating a buzzing sound. The dumbbell object consisted of two wooden cubes, each with a piece of white plastic tube extending from it. The demonstrated action was to grasp the wooden cubes on each end of the dumbbell and pull outward, such that the object came apart and made a popping sound.

Emotional stimuli: In the Anger-attentive and Anger-distracted conditions, the Emoter based her facial expression on Ekman and Friesen (1975). Her eyebrows were lowered and drawn together, there was a narrowing of her eyes, and her cheeks were elevated. When she was not speaking, her lips were pressed firmly together. When the Emoter vocalized, her tone of voice was angry. In addition, emotion words were included in the verbal script because this helped the Emoter produce a consistent and convincing anger expression. Other social referencing studies have likewise employed this strategy (e.g., Mumme et al., 1996). Because our focus was infants' responses to emotional rather than linguistic information, we chose emotion words that 18-month-old-infants would not typically comprehend.[1] Thus, we expected that infants would respond to the Emoter's angry tone of voice and facial expression. A different verbal script was employed in each trial, but the scripts were carefully designed to be structurally similar and identical in syllable length. The set of scripts were identical in the Anger-attentive and Anger-distracted conditions. Each script involved a dialogue between the Emoter and the Experimenter that was composed of three parts. The Experimenter always maintained a neutral facial expression and used a neutral tone of voice when speaking to the Emoter, but the Emoter varied her emotion, by experimental design. An example of a three-part Anger script is as follows: (a) Emoter (in an angry tone) - "That's infuriating! That's so irritating!" (b) Experimenter (in a neutral tone) - "Oh, I'm sorry you feel that way about it." and (c) Emoter (in an angry tone) - "Well, you should be sorry! It's infuriating!" The emotional exchange between the Emoter and the Experimenter (the expression period) lasted an average of 7.14 s (*SD* = .53).

In the Neutral-attentive condition, the Emoter's facial expression was pleasant and involved a relaxed mouth, a smooth forehead and minimal facial movement. She spoke in a matter of fact fashion with a relatively uniform tone of voice. Her tone of voice suggested that she was mildly interested in the Experimenter's actions. The Neutral scripts were similar in sentence structure and identical in syllable length to the Anger scripts. These emotion words were likewise selected to be beyond infants' comprehension. An example of a three-part Neutral script, which again unfolded as a dialogue between the Emoter and Experimenter, is as follows: (a) Emoter (in a neutral tone) – "That's entertaining. That's so enticing." (b) Experimenter (in a neutral tone) – "Oh, I thought it might have been too distracting." and (c) Emoter (in a neutral tone) – "Well, you could be right. But it is entertaining." [2]

Equipment: The experiment was conducted in a laboratory room equipped with three digital video-cameras. One video-camera recorded the infant (head, torso, hands) and part of the table surface in front of the infant. Infants' instrumental behavior was coded from this record. Another camera provided a wide-angle view of the Experimenter and Emoter. This record was used to code the Emoter's affective displays. A third camera provided a close-up view of infants' faces for coding their facial expressions and looking behavior.

Procedure—Infants sat in their parent's lap at a table, with a female Experimenter seated on the opposite side. Parents were instructed to: (a) remain silent and neutral, (b) look away if

[1]We used words such as 'aggravating' and 'annoying' (seeA Repacholi & Meltzoff, 2007), which do not appear on any language measures as 'words comprehended' at this age. We cannot rule out the possibility that individual infants understood some of the emotion words.
[2]It was difficult to find neutral words that approximated the structure of the words in the Anger scripts, so words with a relatively positive meaning were used instead.

their infant tried to make eye contact or otherwise engage with them, and (c) avoid any form of interaction with their infant (e.g., comforting touches). If parents did not comply with these instructions, the infant was dropped from the sample.[3] Only one infant was excluded on these grounds. Each test session began with a brief warm-up to familiarize infants with the Experimenter and testing room. In each of the experimental trials, the Experimenter initially demonstrated the target action twice on the test object. In between the demonstrations, the object was placed under the table, and out of infants' view, in preparation for the next demonstration. The Experimenter was carefully trained so that she did not express any specific emotion before, during, or after performing the target act (i.e., she was affectively neutral about the object and the action).[4] After the second demonstration, an unfamiliar female adult (the Emoter) entered the room. The Experimenter introduced the Emoter by stating, in a friendly voice, "This is Nina. Nina is going to sit here and read a magazine." The Emoter seated herself on the Experimenter's right, at the corner of the table, about 76 cm away from the infant. She briefly read a magazine. The Experimenter then elicited the Emoter's attention ("Nina, look at this") and demonstrated the action a third and final time. The demonstration period for each object (encompassing the three target acts) lasted an average of 31.72 s (*SD* = 1.10).

Upon completion of the third demonstration, the Emoter immediately expressed an emotion, according to the randomly assigned experimental condition. That is, she displayed either Anger (Anger-attentive and Anger-distracted conditions) or Neutral affect (Neutral-attentive condition) toward the Experimenter. The Experimenter responded in a neutral fashion and the Emoter then expressed further Anger or Neutral affect (see 'Emotional Stimuli').

In all three emotion conditions, the Emoter adopted a silent, neutral facial expression at the conclusion of her interaction with the Experimenter. The Emoter then attracted infants' attention by standing up and sitting down again, as if to adjust her seating posture (pilot work indicated that this was a natural way to attract infants' attention without implying that the Emoter was making a bid for communication). Once seated, the Emoter oriented her body toward the infant and held an open magazine in a reading posture at chest-height. The Emoter's face was visible but her eyes were either looking toward the infant (Anger-attentive and Neutral-attentive) or the magazine (Anger-distracted). The Emoter did not make direct eye contact with infants in the attentive conditions because, in pilot testing, we found that this upset some infants. Instead, she looked toward the infant's lower chest, just above the table surface. Thus, her gaze direction in the attentive conditions gave the impression that she was monitoring what infants were doing with the object. When looking at the magazine in the distracted condition, the Emoter's head was tilted slightly downward. This head position was selected (after extensive pilot testing) to minimize the difference between the attentive and distracted conditions, while at the same time ensuring that there would be little ambiguity as to where the Emoter was looking. In summary, the Emoter's silent, neutral gaze was designed to create the impression that she was looking at the infants' actions with friendly interest or reading the magazine with equal interest.

[3]To minimize parental influence, parents were not given information about the experimental hypotheses until after the testing was completed. Parental behavior was examined in all of the videotapes. If parents provided help, encouraged or discouraged their infants, or gave feedback about behavior, the infant was excluded. Likewise, infants were excluded if haptic cues were detected (e.g., if the parent caressed the infant), however, the presence of more subtle cues, cannot be completely ruled out. Anecdotally, parents were not visibly tense during the Anger displays; indeed, many parents later reported that they were amused by the procedures. Thus, if haptic cues had been detected by infants, it is possible that these cues would have encouraged infants to interact with the object in the Anger conditions, thereby weakening our findings.

[4]In each experiment, 25% of the sample was examined by the same two naïve coders. The coders observed the Experimenter during the entire testing session and were asked to note any instances in which her facial and/or vocal expression was either positive (e.g., a smile, a laughter, a smile) or negative (e.g., a frown). There was 100% agreement across the two coders and no instances of positive or negative affect were detected.

In each condition, once the Emoter had assumed the correct position, the Experimenter placed the test object on the table, directly in front of the infant, and said “Here” in a neutral tone of voice. A 20-s response period was timed from when the object was positioned on the table. During this time, the Experimenter looked down at a timer in her lap, and maintained a neutral facial expression. At the end of the response period, the Experimenter retrieved the object, and the Emoter left the room. As the door was closing, the Experimenter stated, in a friendly tone of voice, “Nina's gone. Nina's gone bye-bye” and also produced a waving gesture.

The next two trials followed an identical procedure except the Experimenter did not reintroduce the Emoter on her return; only her departure continued to be noted in each trial. Different objects and actions were presented in each trial (see ‘Test Objects’). In addition, different verbal scripts were used in each trial but these were all similar in sentence structure and identical in number of syllables (see Repacholi & Meltzoff, 2007, for the complete set of scripts).

Scoring

Emoter's expressions: A manipulation check was performed to ensure that the Emoter had conveyed the appropriate affect in each experimental condition. Two naïve coders used a 5-point scale to assign an overall rating for the hedonic tone of the Emoter's facial expressions during the expression period when she interacted with the Experimenter (−2: very negative to +2: very positive). These ratings were performed without sound so that the coders would only use the Emoter's face to make these judgments. The coders also indicated which discrete emotion was predominant in the Emoter's facial expression during this time, based on the following list: happiness, interest, neutral affect, surprise, sadness, anger, disgust, and fear. The Emoter's facial expression was coded in the same manner during each response period. Inter-rater agreement for hedonic tone during the expression and the response periods (based on 33% of the data set) was high, $r = .95$. Cohen's Kappa for the predominant emotion classifications was .98.

A check was also performed on the Emoter's vocalizations in the expression period. These expressions were low-pass filtered at 475 Hz, to make the lexical content unintelligible. Two naïve coders rated the hedonic tone (ranging from −2 to +2) of these filtered vocal expressions. The coders were not able to identify any of the words uttered by the Emoter, and good inter-rater agreement (based on 33% of the data set) was obtained, $r = .87$.

Infant attention during the stimulus-presentation period: Infant attention was coded from video records in which the Emoter's face was not visible and the sound was turned off. Thus, coders were not aware of the emotion being displayed. In each trial, two naïve coders recorded the onset and offset of each look toward the demonstration of the target action. The durations of infants’ looks were summed and a proportion score calculated for each trial (to take into account any slight differences in demonstration length). Infants’ looks to the Emoter's face during her vocalizations were also recorded. The durations of these looks were summed and a proportion score was calculated for each trial. Inter-coder agreement, based on 33% of the sample, was high for both measures (demonstration: $r = .98$; emotion: $r = .96$).

Infant object-directed behavior: Infants’ object-directed behaviors were coded from edited video records that only included the three response periods from each infant, thereby ensuring that coders were not aware of infants’ experimental condition. Infants’ performance of the modeled (or target) action was scored in each response period using a dichotomous (yes/no) measure and Meltzoff's (1988) scoring definitions. A ‘yes’ was scored for the dumbbell if the infant pulled it apart. The cup was scored as a ‘yes’ if it was fully or partially collapsed without being thrown or banged. For the buzzer, a ‘yes’ was scored if the infant used the stick to push the button and the buzzing sound was then heard. These scores were summed across the three trials to yield a single imitation score for each infant reflecting the total number of target acts produced (range of 0–3).

Latency to first touch of the object and duration of object contact were also examined to determine whether the regulatory effect of the emotional displays was specific to infants' performance of the target act or influenced their object-directed behavior more generally. Latency to first touch was defined as the time (in seconds) from when the test object was placed on the table to the time the infant first made contact with it (or 20 s if the infant did not touch the object). This measured infants' initial hesitancy to make contact with the object.

The duration of object contact in each trial was defined as the total amount of time (in seconds) that infants spent touching the object during the response period. This measured the extent to which infants were interested in the object. A second coder examined these three measures in 33% of the data set. There were no disagreements on the imitation score. Inter-coder agreement for the latency and duration measures was high (both *r*s = .98).

Infant looks during the response period: The durations of infants' looks toward the Emoter, Parent, Experimenter, and Object were recorded in the response period by two naïve coders. The durations for these individual looks were then summed to yield four total duration scores. Inter-coder agreement (based on 33% of the dataset) was high, $r = .90 - .99$.

Infant affect: Infants' facial expressions were measured by two coders. The close-up video records of infants' faces were examined without sound to ensure that the coders were uninformed as to the experimental condition. Infants' facial expressions were rated every 2 s during both the expression period (i.e., the emotional exchange between the Emoter and the Experimenter) and the response period. Coders used separate 3-point scales for positive and negative hedonic tone (derived from Hirshberg & Svejda, 1990). A score of 2 on the negative affect scale indicated the presence of a cry-face, big frowns, grimaces, or scowls. A 1 was assigned for mild frowning/furrowing of the brows or slight wariness/worried expression. A score of 0 indicated the absence of any negative affect. On the positive affect scale, a score of 2 was given for a broad smile or laugh-face; a score of 1 was for a slight smile; and a 0 was given when there were no signs of positive affect. Mean positive and negative affect scores were then calculated for both the emotional expression periods and the response periods because the number of coded intervals varied slightly for each infant (e.g., no score could be assigned if the infant turned away from the camera). Inter-coder agreement (based on 33% of the data) were high for both the positive ($r = .95$) and the negative ($r = .90$) affect scores.

Results

Manipulation Check

The results of the manipulation check indicate that the Emoter accurately followed the procedure. The Emoter was rated as more negative in her facial expression in the Anger conditions ($M = -1.95$, $SD = .08$) than in the Neutral condition ($M = .24$, $SD = .25$), $p < .001$. There was no significant difference between the Anger-attentive ($M = -1.95$, $SD = .09$) and the Anger-distracted ($M = -1.94$, $SD = .08$) conditions. All of the Emoter's negative facial displays were correctly classified as 'anger' for predominant emotion. About 75% of the neutral facial displays were classified as 'neutral' and the remainder as 'interest' for predominant emotion.

The manipulation check confirmed that the filtered vocalizations in the Anger conditions ($M = -1.48$, $SD = .41$) were significantly more negative than those in the Neutral condition ($M = .62$, $SD = .44$), $p < .001$. There was no significant difference between the Anger-attentive ($M = -1.52$, $SD = .37$) and Anger-distracted ($M = -1.45$, $SD = .44$) conditions. The majority (97%)

of the anger vocalizations were rated as negative in hedonic tone and the remainder were assigned a score of 0. About 62% of the neutral vocalizations were rated as mildly positive in hedonic tone (i.e., a score of +1), and the remainder were assigned a score of 0 (i.e., neutral).

As called for by the experimental design, the Emoter's facial expressions during the response period were assigned a score of 0 for overall hedonic tone in 100% of the trials and were classified as ‘neutral’ for the predominant emotion.

Preliminary analyses

Two sets of analyses were conducted to ensure that any observed differences in infants’ object-directed behavior were not due to differences in their visual attentiveness during the stimulus-presentation period. The proportion scores for infants’ attention to the demonstrations were analyzed in a 3 (condition) × 3 (trial) repeated measures ANOVA. There were no significant effects. Infants in all three conditions were highly attentive and looked at the demonstrations more than 90% of the time ($M = .93$, $SD = .05$). The proportion scores for infants’ looks to the Emoter's face during her affective display were analyzed in the same manner. As might be expected, there was a significant condition effect, $F(2, 69) = 13.03$, $p < .001$. Infants spent more time looking at the Emoter's face as she expressed anger as opposed to neutral affect ($M = .58$, $SD = .22$, both *p*s < .001). There was no difference between the Anger-attentive ($M = .81$, $SD = .13$) and the Anger-distracted conditions ($M = .77$, $SD = .13$).

Latency to First Touch of the Object

Table 1 displays the mean latency to touch the object as a function of condition. A 3 (condition) × 3 (trial) repeated measures analysis of variance (ANOVA) was performed on the latency to touch scores. There was a significant main effect for condition, $F(2, 69) = 3.87$, $p = .03$, η^2_p (partial effect size) = .10; a significant trial effect, $F(2, 138) = 5.46$, $p = .005$, $\eta^2_p = .07$; and a condition × trial interaction, $F(4, 138) = 2.41$, $p = .05$, $\eta^2_p = .07$.

Simple effects analyses were performed to explore the interaction. All post-hoc comparisons in this experiment were conducted using Fisher's least significant difference (LSD) procedure. The source of the interaction was revealed when latency to touch was compared across the three conditions for each trial. There was no condition effect in the first trial, $p > .05$, and in the second trial it only approached significance, $F(2, 69) = 2.67$, $p = .08$. The condition effect was highly significant in the last trial, $F(2, 69) = 5.02$, $p = .009$, $\eta^2_p = .13$. This was due to the fact that infants in the Anger-attentive condition took longer to touch the object ($M = 5.74$ s, $SD = 8.01$) than did infants in either the Neutral-attentive (95% confidence intervals for the difference between the means $CI_d = 1.77, 8.29$) or the Anger-distracted ($CI_d = 0.30, 6.82$) conditions, both *p*s < .05. There was no significant difference between the Neutral-attentive ($M = .71$ s, $SD = 1.18$) and the Anger-distracted conditions ($M = 2.18$ s, $SD = 5.51$).

Duration of Object Contact

Preliminary analyses indicated that there were no significant trial effects for the amount of time that infants spent in contact with the test object. Therefore, a mean duration of contact score was calculated for each infant, based on those trials in which they touched the object (see Table 1). Because the 20 s response period was timed from the moment the object was presented to infants, duration of object contact was highly correlated with the latency to touch measure. Consequently, a one-way ANCOVA was conducted in which mean latency to touch was entered as a covariate. There were no significant effects.

Imitation of the Target Acts

Preliminary analyses showed that infants' imitation scores did not significantly vary as a function of trial. Therefore, infants' total imitation scores (range: 0−3) were analyzed with a one-way ANOVA. As hypothesized, there was a significant condition effect, $F(2, 69) = 4.67$, $p = .01$, $\eta^2_p = .12$ (Figure 1). Infants in the Anger-attentive condition ($M = 1.42$) had significantly lower imitation scores than did infants in either the Neutral-attentive ($M = 2.21$, $CI_d = -1.42, -0.16$) or the Anger-distracted conditions ($M = 2.29$, $CI_d = -1.51, -0.24$), both *p*s < .05. There was no difference between these latter two conditions. The same pattern of results emerged from non-parametric analyses of the data: a Kruskal-Wallis test showed a significant condition effect, $\chi^2(2, N = 72) = 11.74$, $p = .003$, and Mann-Whitney *U*s revealed significantly lower imitation scores in the Anger-attentive condition relative to either of the other conditions, both *p*s < .01.

For completeness, we also conducted a subsidiary analysis using only those trials in which infants had at least a 15-s window, from after they first touched the object, in which to imitate. The majority of infants touched each object within 5 s of it being presented, therefore 91% of the trials could be included in this analysis. Infants were given credit for the proportion of such trials in which they imitated (see other studies for the use of similar scores, e.g., Meltzoff, 1988).[5] Consistent with the analysis based on the entire data set, the ANOVA revealed a significant condition effect, $F(2, 67) = 3.76$, $p = .03$, $\eta^2_p = .10$. Infants were less likely to imitate in the Anger-attentive condition ($M = .51$, $SD = .32$) than in either the Neutral-attentive ($M = .72$, $SD = .40$; $CI_d = -0.42, 0.00$; $p = .05$) or the Anger-distracted conditions ($M = .80$, $SD = .36$; $CI_d = -0.50, -0.07$; $p < .05$). There was no difference between the latter two conditions.

Infant Looking During the Response Period

Preliminary analyses indicated that there were no significant trial effects for the duration of infant looks to the Emoter, Parent, or Experimenter in the response period. Thus, the looking scores were averaged across the three trials (see Table 1). A MANOVA yielded a significant multivariate condition effect, $F(6, 136) = 4.92$, $p < .001$. This effect was examined in more detail using a Roy-Bargmann Stepdown analysis (see Tabachnick & Fidell, 2001), to take into account the correlation between the three looking measures. A Bonferroni corrected alpha level of .017 was used to test the subsequent *F*-values to maintain familywise $\alpha = .05$. Mean duration of looks to the Emoter was examined first because this variable yielded the highest univariate *F* value, $F(2, 69) = 12.35$, $p < .001$, $\eta^2_p = .26$. Infants in the Anger-attentive condition ($M = 4.42$ s) spent more time looking at the Emoter than did those in the Neutral-attentive ($CI_d = 0.65, 2.89$) and the Anger-distracted ($CI_d = 1.64, 3.88$) conditions, both *p*s < .01. There was no difference between the Neutral-attentive ($M = 2.64$ s) and Anger-distracted conditions ($M = 1.66$ s).

Looks to the Experimenter were analyzed next because this measure yielded the next highest univariate *F*-value. A one-way ANCOVA was conducted, with looks to the Emoter entered as a covariate. The condition effect was not significant. There was also no significant condition effect for looks to the Parent, after controlling for looks to Emoter and Experimenter.[6]

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[5]In this subsidiary analysis, the proportion score was based on a 15-s window, from first touch of the object, because several previous studies showed that infants typically imitate within this length of time (e.g., Meltzoff, 1985, 1988). The proportion score was calculated as follows. If the infant was delayed in touching the target object for more than 5 s in a trial, that trial was dropped from the analysis because there was not the required 15-s response period. In this case, the infant's imitation score would be the proportion of the two remaining trials in which the target behavior was produced. For example, if the infant produced the target behavior in one of the two trials, the score would be .50.

[6]When the frequency of looks to the Emoter, the Experimenter, and the Parent were analyzed, the results were identical to those obtained with the duration data.

It is possible that infants in the Anger-attentive condition were more interested in the Emoter than in the Test Object, and if so, this might have contributed to their lower rate of imitation. We explored this possibility by comparing the duration of infant looks to these two stimuli in a 3 (condition) × 2 (stimulus type: Emoter vs. Test Object) repeated measures ANOVA. The data do not support the foregoing notion that infants were more interested in the Emoter. Specifically, there was a main effect of stimulus type, $F(1, 69) = 337.01$, $p < .001$, $\eta^2_p = .83$, such that regardless of condition, infants looked longer at the Test Object than the Emoter.

We also examined whether infants' looks toward the Test Object differed as a function of condition (see Table 1). It was possible, for instance, that infants had lower imitation scores in the Anger-attentive condition because they were less interested in the Test Object than were infants in the other conditions. Mean duration of looks to the Emoter was entered as a covariate, because there was a condition effect (as noted above) and because this measure was correlated with looks to the Test Object. There were no significant condition effects. In summary, infants in the Anger-attentive condition spent most of their time looking at the Test Object during the response period, and did so to the same extent as infants in the other conditions.

Infant Facial Expressions

Preliminary analyses indicated that there was a significant trial effect for infant positive affect during the expression period (i.e., the emotional exchange between the Emoter and the Experimenter), $F(2, 138) = 4.21$, $p = .02$. Infants were more positive in the first ($M = .11$, $SD = .22$) than in the second trial ($M = .05$, $SD = .16$), $p = .005$. There were no trial effects for infant negative affect. The mean positive and negative affect scores (see Table 1) were then analyzed with a one-way MANOVA. There were no significant condition effects. During the response period, there was also a significant trial effect for infant positive affect, $F(2, 138) = 6.39$, $p = .002$. Infants were more positive in the first trial ($M = .38$, $SD = .44$) than in Trials 2 ($M = .27$, $SD = .38$) or 3 ($M = .34$, $SD = .36$), both *p*s < .01. There were no trial effects for infant negative affect. Mean positive and negative affect scores were once again analyzed using MANOVA and no significant condition effects were obtained.

Discussion

As predicted, infants in the Anger-attentive condition were less likely to imitate the Experimenter's actions than were those infants in the Neutral-attentive condition. In both conditions, the Emoter maintained a neutral expression as she looked toward the infant during the response period. These experimental conditions only differed with respect to the Emoter's prior emotional reaction to the Experimenter's actions. Thus, infants responded to the emotional information, even though they were bystanders, seeing and overhearing an interaction between two other individuals.

This indirect emotion effect was not confined to infants' imitative behavior. Infants in the Anger-attentive condition were also delayed in touching the object in comparison to infants who had previously been exposed to the Emoter's neutral exchange with the Experimenter. However, these infants overcame their initial hesitancy and ultimately spent as much time in contact with the object as did infants in the Neutral condition. Finally, infants in the Anger-attentive condition spent nearly twice as long looking at the Emoter during the response period in comparison to infants in the Neutral condition. These infants may have been checking the Emoter's (now neutral) face for information – perhaps looking for a sign that she might become angry again or how she was appraising their handling of the object.

The findings indicated that infants were not only responsive to the Emoter's prior emotion but also her current looking behavior. When the previously angry adult looked toward a magazine in the Anger-distracted condition, infants' behavior differed in crucial ways from that of infants in the Anger-attentive condition. Both groups of infants had previously witnessed the Emoter's angry emotional display, but those in the condition where the Emoter was now ‘distracted’ were quick to touch the object and were more likely to perform the target act. Indeed, in all respects, their behavior was indistinguishable from that of infants who had watched the Emoter expressing neutral affect toward the Experimenter (the Neutral-attentive condition).

One lean interpretation of these findings is that, as a result of her angry outburst, the Emoter's face became an arousing stimulus, such that when she looked at infants in the response period, they were now more interested in her than the Test Object. Infants in the Anger-attentive condition spent more time looking at the previously angry Emoter in the response period than did infants in the other two conditions. However, the evidence suggests that infants in the Anger-attentive condition retained an interest in the object. First, the majority of these infants touched the object; and infants spent just as much time in contact with the object as did infants in the other two conditions. Second, infants in all three conditions looked longer at the object than at the Emoter during the response period. Third, infants in the Anger-attentive condition spent just as much time looking at the object as did infants in the other conditions. Thus, although infants were checking the previously angry adult's (now neutral) face, she did not capture their attention to such an extent that the object lost its appeal.

Another possibility to consider is whether infants in the Anger-attentive condition had less exposure to the action demonstrations and were therefore uncertain as to what to do with the novel objects. If true, it might explain their hesitancy to touch the objects and lower rates of imitation. However, there were no differences across the three conditions with regard to infants’ attentiveness to the demonstrations. A further issue is whether there was differential exposure to the Emoter's anger in the Anger-attentive versus Anger-distracted conditions. If so, this might account for why infants in the latter condition were more eager to play with the objects than were infants in the former condition. However, there is no support for this option. Infants in the two anger conditions spent equal amounts of time looking at the Emoter's angry face.

Why did infants regulate their behavior in response to the emotional information in one anger condition and discount it in the other? In both the Anger-attentive and the Anger-distracted condition, the Emoter's body was oriented toward the infant and her face was visible. However, in one condition, the Emoter was looking toward a magazine and, in the other, she was looking toward the infant and could monitor the infant's behavior. The gaze following literature provides considerable evidence that infants at this age are skilled at identifying the target of another person's gaze. This information, along with their memory of her prior affect, may have enabled infants to make a prediction about the Emoter's future emotional behavior if the infants themselves performed the act.

Experiment 2

In Experiment 1, the Emoter's visual line of regard could be discerned from two cues: her head orientation and her eye direction. Brooks and Meltzoff (2002, 2005) reported that 10-to 18-month-old infants will gaze-follow if a person's eyes are open as she turns her head in the direction of an object, but not if she turns with eyes closed. This difference suggests that infants appreciate the importance of eyes (not just head position) in providing a bridge between looker and object. Although infants are sensitive to the status of another person's eyes and use eyes to determine which external object to look at, it is unclear whether they can use another's eye status to predict that person's future *emotional* reaction.

We addressed this question in a second experiment in which the Emoter's body, head and eyes were always directed toward the infant while she maintained a neutral expression in the response period. The crucial manipulation involved the Emoter either closing her eyes during this time or keeping her eyes wide open. Are infants more willing to play with the object when the previously angry adult's eyes are closed than when her eyes are open – even though the head position is identical in both cases – perhaps because the adult cannot now see them?

Method

Participants—The participants were 90 (45 males) 18-month-old infants (*M* = 18.01 months; *SD* = 5.37 days; range = 17.62 − 18.36 months). The racial composition of the sample was 76% Caucasian, 2% Asian, 20% mixed race, and 2% unknown. Infants were from middle- to upper-class families. Nine infants were excluded because of parent interjections (*n* = 4), extreme infant fussiness/inattention (*n* = 3), procedural error (*n* = 1), or equipment failure (*n* = 1).

Materials and Design—The Emoter, Experimenter, test room set-up, test objects, and demonstrated actions were identical to those used in Experiment 1.

Equal numbers of boys and girls were randomly assigned to each of the three conditions (*n* = 30): Anger/Eyes-open, Neutral/Eyes-open, or Anger/Eyes-closed. Within each condition, infants participated in three trials, each involving a different test object. The six possible orders for the three test objects were counterbalanced within each condition.

Procedure—The procedure was the same as that employed in Experiment 1 except for the Emoter's looking behavior during the response period. Thus, in each trial, infants were exposed to two demonstrations of the target action prior to the Emoter's entry into the room. After the third demonstration, the Emoter expressed either neutral affect or anger toward the Experimenter. The average length of the emotional exchange between the two adults was 7.00 s (*SD* = .63). In each trial, the three demonstrations of the action lasted an average of 29.99 s (*SD* = 1.31). In all conditions, the Emoter's body, head, and eyes were in an identical physical orientation – directed toward the infant – during the response period. However, the Emoter either closed her eyes (Anger/Eyes-closed) or kept her eyes open (Anger/Eyes-open; Neutral/Eyes-open).[7]

Scoring—The video records were scored in the same manner as in Experiment 1. Inter-rater agreement was high for the imitation score (100%), latency to touch (*r* =.99), duration of object contact (*r* = .98), attention to the demonstrations (*r* = .99), looks to the Emoter's face during her affective display (*r* = .99), infant positive affect (*r* = .92), and infant negative affect (*r* = .88). Agreement for infants' looks to the Emoter, Experimenter, Parent, and Object during the response period ranged from *r* = .97 − .99. As in Experiment 1, a manipulation check was conducted on the Emoter's facial and vocal displays. There was good inter-rater agreement for hedonic tone (face: *r* = .92; voice: *r* = .87). The coders were in 100% agreement as to the predominant emotion classifications for the Emoter's facial expressions.

Results

Manipulation Check

The Emoter's facial expressions were rated as more negative in the Anger conditions (*M* = −1.99, *SD* = .03) than in the Neutral condition (*M* = .00; *SD* = .00), $p < .001$. There was no difference between the Anger/Eyes-open (*M* = −1.99, *SD* = .04) and the Anger/Eyes-closed (*M* = −2.00, *SD* = .00) conditions. All of the Emoter's negative facial displays were classified as ‘anger’ and her neutral faces as ‘neutral’ for predominant emotion. Her vocalizations in the Anger conditions were more negative (*M* = −1.56, *SD* = .19) than those in the Neutral condition

[7]The Anger/Eyes-open and Neutral/Eyes-open conditions (Exp. 2) are virtually identical to the Anger-attentive and Neutral-attentive conditions (Exp. 1). The only difference is that in Experiment 1, the Emoter holds an open magazine as she looks toward the infant.

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(*M* = .53, *SD* = .30), $p < .001$. There was no difference between the Anger/Eyes-open (*M* = −1.56, *SD* = .20) and Anger/Eyes-closed (*M* = −1.57, *SD* = .18) conditions. In all conditions, the Emoter's facial expressions in the response period were classified as ‘neutral’. Taken together, these findings indicate that the Emoter followed the experimental design.

Preliminary analyses

The proportion of time that infants spent looking at the demonstrations of each action was analyzed using a 3 (condition) × 3 (trial) repeated measures ANOVA. There were no significant effects. Infants in all conditions were highly attentive and, on average, spent 93% (*SD* = 9%) of the time looking at the demonstrations. A similar analysis was conducted on the proportion scores for infant looks to the Emoter's face during her affective display. As expected, infants in the Anger/Eyes-open (*M* = .75, *SD* = .18) and the Anger/Eyes-closed conditions (*M* = .86, *SD* = .09), spent more time looking at the Emoter's face during her outburst than did those in the Neutral/Eyes-open condition (*M* =.50, *SD* = .22), both *ps* < .001. In the first two trials, there was no significant difference between the two anger conditions. However, by the third trial, infants in the Anger/Eyes-closed condition (*M* = .85, *SD* = .15) were more attentive to the Emoter's face than were infants in the Anger/Eyes open condition (*M* = .68, *SD* = .21), $p < .01$.

Latency to Touch the Object

Latency to touch the object was analyzed with a 3 (condition) × 3 (trial) repeated measures ANOVA. There was a significant condition effect, $F(2, 87) = 6.94$, $p = .002$, $\eta^2_p = .14$. Infants in the Anger/Eyes-open condition (*M* = 6.36 s) took longer to touch the objects than did infants in the Neutral/Eyes-open (*M* = 1.37 s, CI_d = 2.23, 7.75) and the Anger/Eyes-closed (*M* = 2.68 s, CI_d = 0.92, 6.44) conditions, both *p*s < .01 (Table 2). There was also a trial main effect, $F(2, 174) = 5.77$, $p = .004$, $\eta^2_p = .06$. Infants were slower to touch the object on the Trials 2 (*M* = 4.15 s, *SD* = 7.17) and 3 (*M* = 3.91 s, *SD* = 7.17), relative to Trial 1 (*M* = 2.35, *SD* = 5.08).

Duration of Object Contact

Preliminary analyses indicated that there were no significant trial effects; therefore the duration of contact scores were averaged across those trials in which infants touched the object (see Table 2). The mean duration of object contact was analyzed, with mean latency to touch entered as a covariate, and there were no significant effects.

Imitation of the Target Acts

Preliminary analyses indicated that there were no trial effects for imitation. A one-way ANOVA on the total imitation scores revealed a significant main effect for condition, $F(2, 87) = 6.38$, $p = .003$, $\eta^2_p = .13$ (see Figure 2). Infants had lower imitation scores in the Anger/Eyes-open condition (*M* = 1.33) than in either the Neutral/Eyes-open (*M* = 2.33, CI_d =−1.56, −0.42) or the Anger/Eyes-closed (*M* = 2.10, CI_d = −1.35, −0.18) conditions, both *p*s < .05. There was no significant difference between the latter two conditions. Non-parametric analyses (Kruskal-Wallis and Mann-Whitney *U*s) yielded an identical pattern of results.

Infant Looking Behavior During the Response Period

Preliminary analyses revealed a significant trial effect for infant looks to the Emoter, $F(2, 174) = 12.85$, $p < .001$. Infants spent more time looking at the Emoter in the first trial than in either of the other two trials, both *p*s < .001 (recall that in all response periods the Emoter is silent and neutral). There were no trial effects for infant looks to the Experimenter or the Parent. Because there were no significant trial × condition effects for any of the looking measures, the scores were averaged across the trials (see Table 2) and analyzed using MANOVA. This analysis revealed a significant multivariate condition effect, $F(2, 172) = 2.45$, $p = .03$. A stepdown analysis was then performed, and a corrected alpha (p = .017) was used to test the subsequent F-values. Duration of looks to the Emoter was examined first, $F(2, 87) = 5.00$, $p = .009$, $\eta^2_p = .10$. Post-hoc comparisons indicated that infants in the Anger/Eyes-closed condition (M = 4.43 s) spent more time looking at the Emoter than did infants in the Neutral/Eyes-open condition (M = 2.49 s), CI_d = 0.72, 3.16, p = .002, but did not spend significantly more time looking at her compared to infants in the Anger/Eyes-open condition (M = 3.32 s), CI_d = −0.12, 2.33. Duration of looks to the Parent was analyzed in the next step. After entering looks to the Emoter as a covariate, there was no significant condition effect. In the final step, duration of looks to the Experimenter was analyzed, with looks to the Emoter and Parent entered as covariates. There was no significant condition effect.[8]

As in Experiment 1, we compared the duration of infant looks to the Emoter versus the Test Object during the response period. Regardless of condition, infants spent significantly more time looking at the Test Object than at the Emoter, $F(1, 87) = 228.91$, $p < .001$, $\eta^2_p = .73$ (see Table 2). We also examined whether infant looks toward the Test Object varied as a function of experimental condition. A one-way ANCOVA was conducted, with mean duration of looks to the Emoter entered as a covariate. There were no differences across conditions in the amount of time that infants spent looking at the Test Object.

Infant Facial Expressions

Infants' mean positive and negative affect scores (see Table 2) in the expression period (i.e., the emotional exchange between the Emoter and Experimenter) were analyzed in a one-way MANOVA. There were no significant condition effects. Infant affect during the subsequent response period (when both adults were silent and neutral) was analyzed in a similar manner, and there were likewise no significant condition effects (see Table 2).

Discussion

The results replicate and extend the findings from Experiment 1. Infants in the Anger/Eyes-open condition imitated fewer target acts than did infants in the Neutral/Eyes-open condition. In addition, infants in the Anger/Eyes-open condition were initially hesitant to touch the object compared to those in the Neutral condition. More important, however, infants' object-directed behavior differed in the two Anger conditions. Infants were eager to touch the object and more likely to perform the target act when the previously angry Emoter's eyes were closed (Anger/Eyes-closed) than when they were open. Thus, infants distinguished between the two anger conditions based on the status of the Emoter's eyes in the response period.

Unlike Experiment 1, there was a difference between the two anger conditions in the last trial with respect to infants' attention to the Emoter's angry facial expression. In this trial, infants spent more time looking at the Emoter's face in the Anger/Eyes-closed than in the Anger/Eyes-open condition. There appears to be a simple account of this. After seeing multiple instances of anger followed by eye closure, infants were now curious about the Emoter and closely monitored her face. However, despite more looking at the Emoter's angry face in this last trial, infants in the eyes-closed condition were still eager to play with the object. For instance, even in the third trial (as in the first two), these infants were significantly more likely to perform the target act than were those infants in the eyes-open condition.

It is also important to note that the adult's eye closure in the response period did not appear to disturb infants. First, infants performed more target acts, not fewer, than the infants in the Anger/Eyes-open condition. Second, there was no difference between the Anger/Eyes-closed

[8]As in Experiment 1, the results for frequency of looks were identical to those obtained with the duration data.

and the Neutral/Eyes-open condition with respect to infants' affect during either the emotional expression or the response periods. Finally, these infants quickly touched the object and were just as likely to perform the target actions as those infants in the Neutral/Eyes-open condition.

General discussion

In two experiments, we found that 18-month-old infants responded to emotional cues that they had encountered in the course of seeing and hearing a social interaction between two other people. After the Emoter expressed anger toward the Experimenter in response to her actions, infants in the Anger-attentive (Exp. 1) and Anger/Eyes-open conditions (Exp. 2) – the two conditions in which the adult visually monitored the infant after expressing anger – were hesitant to touch the object and less likely to reproduce the target acts than were infants exposed to a previously neutral Emoter. Thus, infants' object-directed behavior was influenced by the Emoter's anger even though this emotional communication did not directly involve them. These findings replicate the 'indirect emotion' effects obtained by Repacholi and Meltzoff (2007).

The fact that the indirect emotion effect was not limited to infants' imitative responses but was also evident in their general object-directed behavior raises an interesting question. Were infants associating the Emoter's anger with the object (e.g., this is a bad object) or the target action (e.g., this is a bad action)? Further research is needed to provide a definitive answer, but any delay in touching the 'forbidden object' would have reduced the amount of time remaining in the response period for infants to perform the target act. Did these infants have lower imitation scores not because they linked the anger with the production of the target act, but because there was insufficient time for them to perform the action? This seems unlikely, however, given that most infants touched the object within 5 s of it being presented to them, and thus had ample time remaining in the response period. In addition, when we analyzed those trials in which infants had at least a 15-s response window following their first touch of the object, infants in the Anger-attentive condition were still less likely to imitate than were infants in the other two conditions.

We favor the hypothesis that infants identified the Experimenter's *action on the object* as the source of the Emoter's emotional reaction. Consistent with this proposal, infants rarely refused to touch the object when the previously angry adult was looking at them. In the Anger-attentive condition, for instance, there were only 10 trials (out of a total of 72 administered) in which infants did not touch the object. And, in the Anger/Eyes-open condition, infants failed to touch the object on only 19 of the 90 trials. Moreover, the experimental procedure itself provided a number of different cues that should have enabled infants to link the Emoter's emotion with the production of the target act. For instance, the Emoter's anger did not occur at the moment she saw the Experimenter touch the object; instead, her anger occurred immediately on completion of the action. In addition, the Experimenter continued to touch the object after being scolded by the Emoter, but she did not produce the target action again.

It is conceivable that, despite having linked the emotion to the production of the action (i.e., this is a 'forbidden act'), infants were nonetheless concerned that other actions on the object might also elicit anger. Consequently, it may have taken a few seconds for infants to overcome their initial doubts about this stranger and begin to play with the object, accounting for their longer latency to touch the object but no significant difference in their overall duration of play with it. Further research is needed to directly test these competing hypotheses.

Regardless of how this issue is ultimately decided, the findings clearly show that infants were able to appropriately modify their actions in response to an emotional communication that was directed toward and intended for another individual. This indirect emotion effect is important because it provides empirical evidence that infants have the ability to learn a great deal simply by observing how *other people emotionally interact with each other*.

What is the nature of this learning? It is possible that the Emoter's anger automatically changed infants' emotional state via some emotion contagion mechanism. Infants may have 'caught' the negative emotion from the adult and their own negative affect then dampened their subsequent exploratory behavior. However, in both experiments, infants in the Anger conditions were no more negative (as indexed by their facial expressions) than were those infants in the Neutral condition. Infants' object-directed behavior is likewise incompatible with this emotional contagion account. If catching the Emoter's negative affect is the whole story, infants should have been hesitant to manipulate the object, regardless of whether the Emoter was looking at them during the time that they had access to the object. This was not the case. In the Anger-distracted condition (Exp.1), the Emoter faced infants and read a magazine, but this did not dampen infants' interaction with the object. And, in Experiment 2, when the previously angry Emoter oriented toward infants with her eyes closed, this likewise did not reduce their object-directed behavior. A contagion account can not explain this pattern of results.

It has often been assumed that social referencing involves some cognitive process whereby infants use the adult's emotional expression to 're-appraise' a novel experimental stimulus. For instance, when their mother displays fear, infants now re-define the object as something bad or dangerous and adjust their behavior accordingly. However, in the typical social referencing study, infants' behavior can be explained equally well by either a cognitive appraisal or an emotional contagion mechanism (see Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992). The findings presented here make an important contribution to the debate about the mechanism (s) underlying infant social referencing. In our experiments, infants actively processed emotional information gleaned from eavesdropping on the Emoter and the Experimenter. Infants used the Emoter's anger to re-appraise the situation (e.g., deciding that this was a bad object or action) and then regulated their object-directed behavior accordingly. They were active rather than passive observers.

What is unique about the current experiments is that infants' object-directed behavior was influenced conjointly by their memory of the Emoter's prior anger *and* by whether the Emoter was looking at them or not. But what meaning did infants ascribe to the Emoter's looking behavior? A lean interpretation is that infants used the Emoter's looking behavior to determine whether she was likely to interact with them during the response period. Infants may have learned that gaze direction and/or eye status are social signals. When the Emoter's eyes were open and directed toward them, infants might have viewed her as 'socially available' and anticipated that any ensuing interaction would be marked by anger. On the other hand, when her eyes were closed or directed toward a magazine, infants may have felt confident that the Emoter was now unavailable – that there would be no interaction, angry or otherwise.

A richer interpretation, and the one favored here, is that infants were making a more psychological attribution about the Emoter. Infants may have been able to use head/eye direction in Experiment 1 and eye status in Experiment 2, to determine whether the Emoter could *see them* during the response period. They then inhibited their play with the objects when their actions could be seen by the previously angry adult.

Several converging lines of evidence suggest that from 12 months on, infants begin to understand something about the act of seeing. For instance, infants will now look at the specific target of another's gaze instead of merely turning to the appropriate side and looking no further than the first object they encounter (Butterworth & Jarrett, 1991). This suggests that infants are now searching for the correct object rather than just any interesting visual event. Consistent with this, Moll and Tomasello (2004) report that 12-month-old infants will follow another's gaze behind a barrier rather than look at the barrier itself. At around this time, infants turn to look in the same direction as an adult who can see an object but not when that person is unable to see it by virtue of having closed eyes (Brooks & Meltzoff, 2005). Finally, at this age, infants begin to use gestures such as pointing to direct another person's attention to a specific event (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004) and seem to do so preferentially when the adult can see them pointing (Brooks & Meltzoff, 2002). Together, these findings support the proposal that an implicit understanding of *seeing* begins to emerge in the second year of life.

However, our research moves beyond the findings in the gaze-following literature. Infants were not only able to identify what the Emoter could see, but could also link it with that person's prior emotional state to predict her future affective behavior. We suggest that infants registered that they were the focus of the Emoter's gaze and appreciated how this visual access to their actions might influence her emotions. Infants may have expected the Emoter to become angry if they repeated the target actions, but *only if she could see them* performing these acts. Infants were then able to regulate their behavior based on this prediction about the Emoter's likely emotional reaction. Infants behaved as if they have some basic understanding of how other people's visual experiences influence their emotions.

Although infants may have been interpreting the Emoter's looking behavior as part of a larger psychological web, their ability to do so is still developing. We are struck by the fact that the infants' responses were quite naïve in many respects. For example, an adult would appreciate that when the Emoter is reading a magazine, she could look up at any time and catch the infant performing the forbidden act. The Emoter's visual access to the infant is not actively blocked by the magazine; she is merely attending to something other than the infant. Infants do not appear to think things through in this manner. Related to this, an adult would also be aware that the sound associated with the target actions might alert the Emoter to what the infant is doing. Yet infants appeared to make no attempt to silence the objects. Thus, 18-month-olds may understand more about visual access than auditory access. This could arise, in part, because they have active experience manipulating their visual perceptions (eye opening/closing), but the ears cannot be actively manipulated in the same way (see Meltzoff, 2007 for more details about the 'Like-Me' mechanism of generalizing from one's own perceptual experience to that of others). We are conservative in that we would attribute to 18-month-old infants a primitive understanding of what the Emoter can *see*, without a full understanding of *attentional* state. The mature adult understanding is that you can see something but not attend to it; and you can attend to something but not see it (e.g., auditory attention). We believe that this "see-attend" distinction develops some time after 18 months of age.

The current findings represent a significant advance in what we know about infants' understanding of other people and how they use that knowledge for self-regulation. In particular, this research provides the first demonstration that infants are able to coordinate two very different sets of social cues to make predictions about another person's emotional reactions. In the Phillips et al. (2002) study, the actor's gaze alone would have been sufficient to make a correct prediction about her future goal-directed actions. In our experiments, infants did not simply respond to the Emoter's gaze alone or prior emotion alone, but conjointly recognized the significance of her current looking behavior plus prior emotional state. Thus, infants integrated two different pieces of social information. This enabled infants to respond flexibly and adaptively to the situation at hand. They were slow to touch the object and loathe to perform the actions when the previously angry adult was looking at them; but when she was not looking at them, or was looking at them but had not previously been angry, they eagerly touched the object and reproduced the actions.

The developmental roots of the capacities described here remain to be explored. Despite having the component skills (gaze following and social referencing), younger infants might require more proficiency in their use of these, along with extensive social experience, before they can use them conjointly to make complex predictions about other people's behavior and to regulate their own actions. It will also be important to determine when and how children's responses change after 18 months of age. For instance, when would children begin to understand that the sound of the target action might alert the Emoter to what they are doing? To date, the research on young children's understanding of other people's perception has focused on vision.

From around 24 months of age, children are increasingly able to comply with adult prohibitions in the absence of external monitoring (Kopp, 1991). This development in young children's self-control intersects with the Emotion-Imitation procedure in interesting ways. For example, despite understanding the Emoter's visual experience, older children might refrain from playing with the object even if the previously angry adult cannot see them (e.g., if she leaves the room). They may interpret the situation at another level of abstraction having to do with social rules, standards, and what one ‘ought’ to do. There are clearly a broad range of questions about early social cognition and social-emotional development that can be addressed with the Emotion-Imitation procedure.

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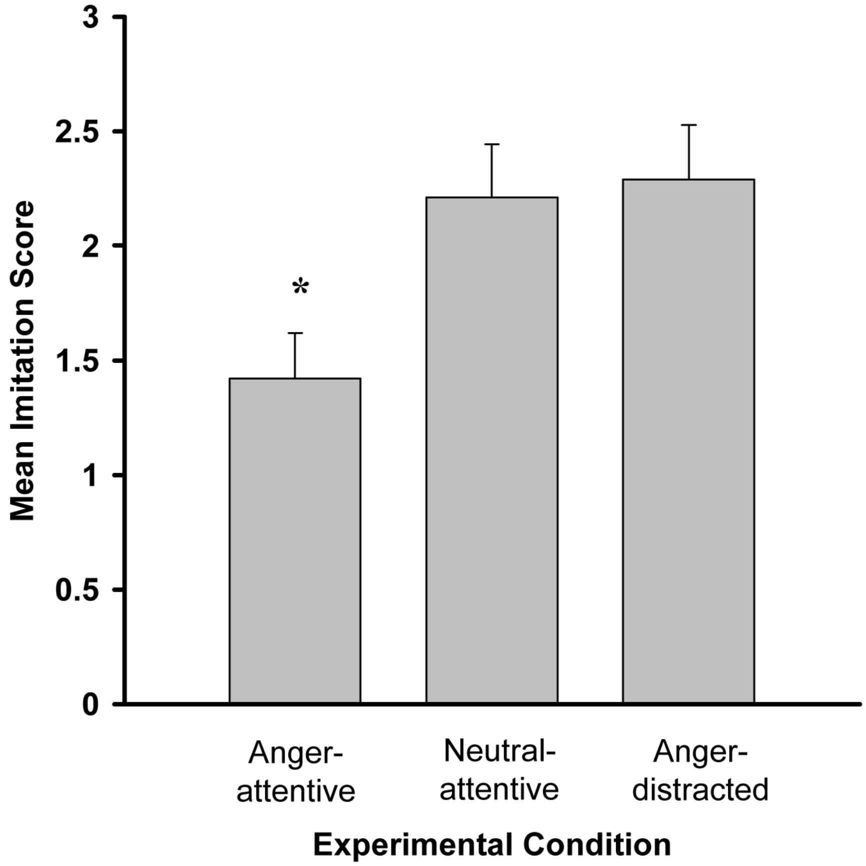

Figure 1.
Mean imitation score (+ 1 *SE*) as a function of experimental condition for Experiment 1. An asterisk indicates that the mean imitation score of an experimental condition is significantly different from that of the other two conditions.

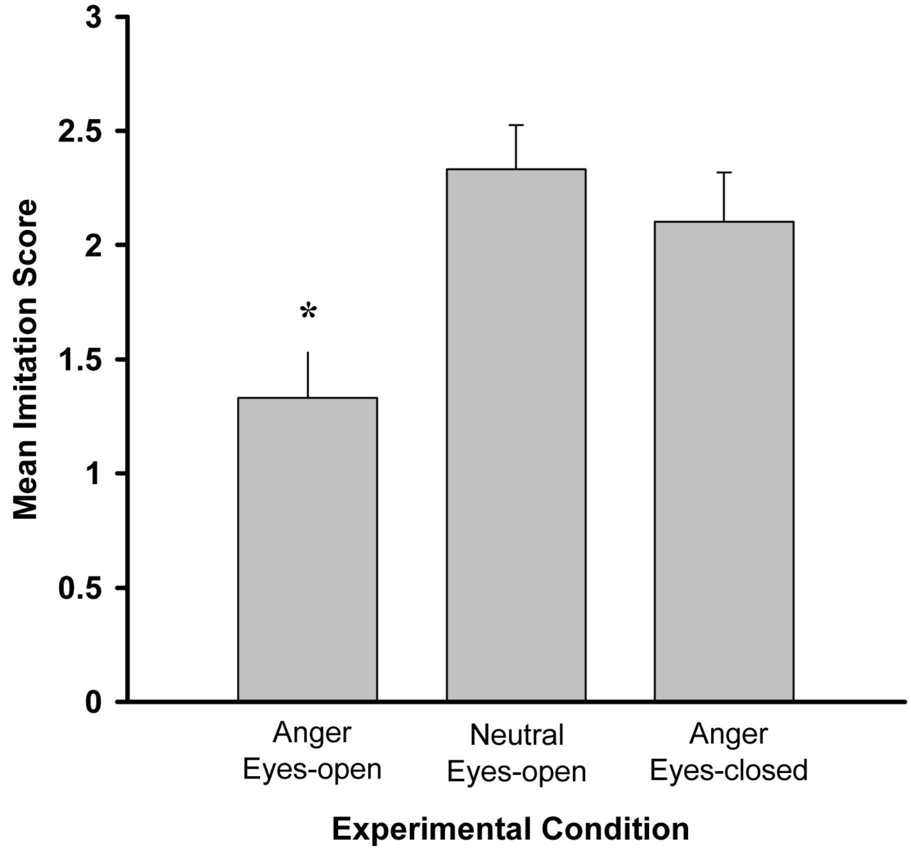

Figure 2.
Mean imitation score (+1 *SE*) as a function of experimental condition for Experiment 2. An asterisk indicates that the mean imitation score of an experimental condition is significantly different from that of the other two conditions.

Table 1

Experiment 1: Infant Behavior as a Function of Experimental Condition

Variable	*Experimental Condition*					
	Anger-attentive		**Neutral-attentive**		**Anger-distracted**	
	M	***SD***	***M***	***SD***	***M***	***SD***
Latency to touch object [a]	4.06	5.29	0.77	1.22	2.02	4.69
Duration of object contact [a,b]	16.97	3.27	17.92	2.57	18.39	1.60
Duration of looks to [a]						
Emoter	4.42[d]	2.13	2.64	2.35	1.66	1.17
Experimenter	2.75	1.01	2.02	1.31	2.86[e]	1.44
Parent	0.33	0.96	0.36	0.66	0.31	.50
Object	10.80	3.37	14.21	3.38	14.06	2.79
Expression period [c]						
Positive affect	0.04	0.07	0.13	0.23	0.06	0.11
Negative affect	0.08	0.18	0.02	0.06	0.03	0.08
Response period [c]						
Positive affect	0.19	0.20	0.36	0.44	0.35	0.33
Negative affect	0.05	0.13	0.02	0.05	0.01	0.04

Note: n = 24 in each experimental condition

[a] Measured in seconds

[b] Only trials in which the object was touched are included

[c] Affect ratings based on a scale from 0−2

[d] Significantly different from the other two conditions

[e] Significantly different from the Neutral-attentive condition

Table 2

Experiment 2: Infant Behavior as a Function of Experimental Condition

	Experimental Condition					
	Anger/Eyes-open		**Neutral/Eyes-open**		**Anger/Eyes-closed**	
Measure	***M***	***SD***	***M***	***SD***	***M***	***SD***
Latency to touch object [a]	6.36[d]	7.09	1.37	3.72	2.68	4.77
Duration of object contact [a,b]	14.32	5.68	18.33	2.19	17.36	4.43
Duration of looks to [a]						
Emoter	3.32	2.53	2.49	1.82	4.43[e]	2.71
Experimenter	2.53	1.84	2.48	1.61	3.04	1.65
Parent	0.10	0.21	0.13	0.41	0.31	0.51
Object	12.18	4.50	14.27	3.04	11.72	4.12
Expression period [c]						
Positive affect	0.03	0.08	0.10	0.18	0.09	0.13
Negative affect	0.32	0.32	0.26	0.31	0.35	0.33
Response period [c]						
Positive affect	0.17	0.23	0.23	0.31	0.24	0.26
Negative affect	0.25	0.32	0.15	0.29	0.20	0.28

Note: $n = 30$ in each experimental condition

[a] Measured in seconds

[b] Only trials in which the object was touched are included

[c] Affect ratings based on a scale from 0−2

[d] Significantly different from the other two conditions

[e] Significantly different from the Neutral-eyes open condition