British Journal of Developmental Psychology (2009), 27, 649–667
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Linking actions and emotions: Evidence from 15- and 18-month-old infants

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This study investigated 15- and 18-month-olds' understanding of the link between actions and emotions. Infants watched a videotape in which three adult models performed an action on an object. Each adult expressed the same emotion (positive, negative, or neutral affect) on completion of the action. Infants were subsequently given 20 seconds to interact with the object. Infants were less likely to perform the target action after the models' expressed negative as opposed to positive or neutral affect. Although infants' imitative behaviour was influenced by the models' emotional displays, this social referencing effect was not apparent in their more general object-directed behaviour. For instance, infants in the negative emotion condition were just as quick to touch the object and spent the same amount of time touching the object as did infants in the neutral and positive emotion conditions. These findings suggest that infants understood that the models' negative affect was in response to the action, rather than the object itself. Infants apparently used this negative emotional information to appraise the action as one that was 'undesirable' or 'bad'. Consequently, infants were now loath to reproduce the action themselves.

Infants' emerging understanding of the world is highly reliant on the meanings provided by the behaviour of other people (Feinman, 1992). For example, infants can potentially learn about objects and events by noticing how other people emotionally react to these stimuli. They may then be able to relate this information to themselves, drawing inferences about how they should emotionally respond and/or what actions they should undertake. Indeed, there is a large body of research (see Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992, for a review) indicating that infants not only seek out and attend to other people's emotional displays, but can also use this information to guide their own behaviour – a phenomenon referred to as 'social referencing'. For instance, by 12 months of age, infants will readily approach and touch a novel object if an adult produces a positive expression while gazing at this stimulus, but exhibit avoidance (e.g. delayed and/or reduced object contact) if negative affect is conveyed

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DOI:10.1348/02615100 8X354564

(Klinnert, 1984; Walden & Ogan, 1988). In these situations, infants tend to respond to the emotion as if it were a communication about the nature of the object. In other words, they appear to appreciate how objects impact another person's emotions. To date, however, the social referencing research has not clarified whether infants also appreciate the link between actions and emotions; in particular, how actions on objects can lead to an emotional response. The primary goal of the study reported here was to investigate this issue with 15- and 18-month-old infants.

Social referencing – an overview

In the majority of social referencing studies, infants are presented with an ambiguous object (e.g. a moving, noise-making toy robot). Infants' mothers are then instructed to produce either a happy or negative (typically fear or disgust) emotional display in response to seeing this stimulus. The mother does not show or directly tell the child what to do nor does she ever touch the object – instead, infants must rely on the emotional information conveyed in their mother's face and voice to determine how to proceed. In most social referencing studies, objects have been used as the ambiguous stimuli. However, live animals (e.g. Hornik & Gunnar, 1988), human strangers (e.g. Feinman & Lewis, 1983), and the 'visual cliff' (e.g. Sorce, Emde, Campos, & Klinnert, 1985) have also been successfully employed. And, more recently, researchers (e.g. Mumme & Fernald, 2003) have demonstrated that infants will respond appropriately even when the object is novel but non-threatening in its appearance. Thus, the social referencing effect is not dependent on the infant initially being wary or fearful. Nor is this effect restricted to maternal emotional expressions. Behavioural regulation has also been reported in response to affective signals provided by infants' father (Hirshberg & Svejda, 1990), their day-care provider (Camras & Sachs, 1991), a live adult stranger (Klinnert, Emde, Butterfield, & Campos, 1986), and a videotaped stranger (Mumme & Fernald, 2003). Thus, even though mothers might be a frequent source of these emotional communications in the first 2 years of life, a variety of other individuals can also elicit behavioural regulation.

When neutral expressions have been incorporated into social referencing studies (e.g. Hornik, Risenhoover, & Gunnar, 1987; Mumme, Fernald, & Herrera, 1996), infants' responses typically resemble those of infants exposed to positive messages. It is only when comparisons are made with the negative message condition that differences are reliably observed in infants' behaviour. That is, infants exposed to negative signals are significantly less engaged with the object than those in either the neutral or positive condition. This pattern of results suggests that positive signals do not increase infants' object-directed behaviour and that any regulatory effect is largely a function of the negative display (Blackford & Walden, 1998).

Social referencing has often been characterized as a social-cognitive or interpretive process. For example, Feinman (1982) defines social referencing as a process whereby an individual uses '. . . one's perception of the other person's interpretations of the situation to form one's own understanding of that situation' (p. 445). Thus, when the adult displays negative affect, infants might interpret the object as 'bad' and regulate their behaviour accordingly. However, a simpler mechanism may be operating; one that does not require any appraisal process on the part of the infant. If infants' affect is directly modified by the other person's emotional expression, this affective change could then impact their instrumental behaviour. Consistent with the emotion contagion hypothesis, there is some (albeit inconsistent) evidence that more negative affect is

displayed by infants in response to fearful than to happy or neutral displays, and more positive affect is elicited by happiness in comparison to fear (e.g. Hirshberg & Svejda, 1990; Klinnert *et al.*, 1986; Mumme *et al.*, 1996). Interestingly, when other negative emotions (e.g. disgust, anger, sadness) are compared to positive and neutral displays, affective differences are usually not evident (e.g. Hertenstein & Campos, 2004; Hornik *et al.*, 1987; Sorce *et al.*, 1985). It may be that some emotions have physical elements that make it more or less likely for contagion to occur. In addition, even when infants have an affective response to the other person's emotional signal, this does not rule out an appraisal process. Infants might use the emotional information to interpret the stimulus and this in itself could change their affective state. For example, a negative expression might lead an infant to view the stimulus as 'dangerous' and this appraisal could then elicit negative affect in the infant.

Although the contagion hypothesis can not be completely dismissed, there is reason to believe that other people's emotional communications do indeed influence infants' instrumental behaviour via some appraisal process. For example, if infants were merely 'catching' the other person's emotion, then they should regulate their behaviour regardless of the extent to which the experimental stimulus is ambiguous or novel. However, there is evidence that as stimulus ambiguity increases, infants become more motivated to seek out another's opinion and more receptive to the emotional information (Feinman, 1982; Gunnar & Stone, 1984; Sorce *et al.*, 1985; Tamis-LeMonda *et al.*, 2008). On the other hand, when the experimental stimuli are easily appraised, the emotional message has little or no impact. Consistent with this, when adults are faced with uncertainty or ambiguity, they are also more susceptible to the influence of others' attitudes (Asch, 1955; Sherif, 1937).

In summary, there is some general consensus among social referencing researchers that infants use other people's emotional expressions to interpret novel objects (e.g. Campos & Stenberg, 1981; Camras & Sachs, 1991; Feinman *et al.*, 1992; Klinnert, Campos, Sorce, Emde, & Svejda, 1983). Infants then apply that information to their own object-directed behaviour. However, another person's emotional display can provide other types of information that are also potentially relevant to the self. Imagine that your friend has just bought a cappuccino machine and you are watching as she makes her first cup of coffee. She quickly works out that she needs to push a red disc on the machine in order to obtain a shot of espresso. Pleased with her initial success, she then tries to steam the milk by rotating the red disc. Her smile is quickly replaced by frustration and anger. Unbeknownst to you, this action has released dirty water into the pitcher of milk. In the absence of any other information, it is likely that you would assume that something about the act of rotating the red disc led to your friend's angry outburst. In addition, you would appreciate the personal relevance of this emotional information. You would probably assume that while it is okay to press the red disc, it would be very unwise for you to rotate it.

Whether infants have a similar capacity to link actions and emotions has yet to be established, although there is some recent research that is relevant to this question. Repacholi and colleagues (Repacholi & Meltzoff, 2007; Repacholi, Meltzoff, & Olsen, 2008) employed a modified social-referencing procedure to explore how infants respond when they see and overhear an emotional exchange between two other people (i.e. indirect emotional communications). In their studies, 18-month-old infants watched an adult (the Emoter) express anger or neutral affect towards an experimenter in response to her action on a novel object. Thus, the emotional communication was directed at someone else (not the infant) and was in response to that person having

performed an action on an object. Infants were then given an opportunity to interact with the object. Infants were initially hesitant to touch the object and were less likely to imitate the target act if the Emoter had previously expressed anger than neutral affect towards the experimenter. Because the indirect emotion effect was not limited to infants' imitative responses, it is unclear whether infants appreciated that the Emoter's anger was a response to the action that had been performed on the object. Instead, infants may have linked the Emoter's anger to the object (e.g. 'It's a bad object'), such that they were now hesitant to approach it. It could then be argued that they had lower imitation scores by default. The delay in making contact with the object could have resulted in there being insufficient time remaining in the response period for infants to then perform the target act. Thus, it can not be determined whether infants were linking the emotion to the action ('I can touch the object but I should not perform that action') or the object itself ('I should not touch that object').

Current study

The main question of interest was whether another person's emotional communication can influence infants' interpretation of 'what to do' with an object. More specifically, when another person emotes about an action that they have just performed on an object, do infants then use that information to determine whether they themselves should perform that action? If infants can regulate their behaviour in this way, it would indicate a more sophisticated ability to read and respond to others' emotional communications than has been previously demonstrated. For instance, it would suggest that infants appreciate that actions can give rise to emotions. In order to explore infants' ability to link actions and emotions, they were presented with emotional signals in the context of a modified imitation procedure. Infants watched a model demonstrating an action on a novel object. Immediately upon completing the action, the model produced an emotional response. Thus, the current research differed from the standard social referencing paradigm in that the emotion was expressed in response to an action being performed on an object, as opposed to being a reaction to simply seeing an object. Moreover, unlike the previous studies of Repacholi and colleagues, the emotional response was generated by the person who performed the action (the model), as opposed to an observer. In addition, after completing the action, the model looked towards the infant as she expressed the emotion, thereby indicating that the intended recipient of the message was the infant. In this respect then, the procedure was akin to the standard social referencing paradigm in which infants are presented with direct (as opposed to indirect) emotional information.

Although many social referencing studies have employed fear or disgust, anger was employed as the negative emotion in the current study. Because the experimental procedure was designed to communicate that the adult's emotion is in response to having performed an action on a novel object, as opposed to having merely encountered that object, anger was more appropriate than these other basic emotions. These latter emotions are often expressed in response to objects (e.g. a scary snake, a disgusting slug). Although people and objects (e.g. cars, computers) can elicit anger, this emotion is often related to actions and their outcomes. In particular, anger is frequently expressed in situations where goal directed behaviour is blocked, thwarted or interrupted (Lewis, Alessandri, & Sullivan, 1990; Stenberg & Campos, 1990). Thus, in the current study, the adults could be viewed as having expressed anger because their

actions did not fulfil their goals. It was also assumed that the use of this ecologically valid emotion might help infants link the action to the affective display.

This research differed from previous social referencing and imitation studies in several other important ways. For instance, in the majority of infant imitation studies (e.g. Barr & Hayne, 1999; Hayne, Boniface, & Barr, 2000; Meltzoff, 1985, 1988) the target action is demonstrated three times by a single model, to provide ample opportunity for infants to encode the information. Three demonstrations of the target action were also employed in the current study, however, there were three models and each model demonstrated the action once only. This modification was essential because infants might begin to doubt the validity of the negative expression if the same person repeatedly engaged in an action that made them unhappy. Thus, infants had to generalize the action *and* the emotion across three different individuals. Adding to the complexity of the task was the fact that the action–emotion sequences were presented in a videotaped format. This presentation format was employed not only to achieve greater control over the emotional expressions but also for practical reasons (the same three models were not available for live participation in every testing session). To date, only two social referencing studies (Friend, 2001; Mumme & Fernald, 2003) have utilized videotaped emotions. In these studies, 12- and 15-month-old infants spent less time touching a novel object when a videotaped adult expressed negative affect in response to seeing a novel object, as opposed to positive or neutral affect. In contrast, it has been reported (e.g. Barr & Hayne, 1999; Meltzoff, 1988) that infants do not reliably imitate the actions of a videotaped model until around 14–15 months of age.[1] Consequently, the youngest participants in the current research were 15-month-old infants. A group of 18-month-old infants was included to explore whether infants' responses to the emotional signals would differ as a function of age and because this age group has previously been found to regulate their behaviour in response to anger (Repacholi & Meltzoff, 2007).

Based on previous social referencing research, the general prediction was that infants would modify their instrumental behaviour in accordance with the models' prior emotional displays. Consequently, after observing the models' positive or neutral reactions, infants should display more object-directed behaviour than when the models expressed anger. If infants read and respond to the emotions as reactions to the modelled action, then the angry display should reduce infants' imitative responses but not their more general interaction with the object. In other words, infants should be willing to touch and explore the object, but will refrain from performing the action demonstrated by the angry models. On the other hand, infants might interpret these emotional signals as information about the object; they might assume that the object itself elicited the emotion. Thus, infants' regulatory responses in the anger condition would not be limited to their imitative behaviour, instead, there would be more general avoidance of the object (e.g. delayed approach and/or reduced contact).

Method

Participants

The final sample consisted of 96 15-month-old ($M = 15.09$ months, $SD = 3.77$, range = 14.78 – 15.32 months) and 96 18-month-old infants ($M = 18.10$ months,

[1] *However, see Barr, Muentener, and Garcia (2007) for recent evidence suggesting that, under certain circumstances, infants as young as 6 months of age can imitate from television.*

SD = 3.89 days, range = 17.75 – 18.44 months), with equal numbers of boys and girls in each age group. Participants were recruited from the University of Washington infant studies participant pool. All infants were full term (37–43 weeks) with normal birth weight (2.5–4.5 kg) and had no known physical, sensory, or mental handicap. The ethnic composition of the sample was 87% Caucasian, 1.6% Asian, 0.5% African-American, and 10.9% other (e.g. mixed race). An additional 29 infants (12 15- and 17 18-month-olds) were excluded from the final sample because of fussiness ($N = 16$), inattention ($N = 10$), or experimenter error ($N = 3$).[2]

Design

The study included age (15- vs. 18-months) and condition (anger, happy, neutral, or control) as between-subjects variables. Twenty-four infants (12 boys and 12 girls) from each age group were randomly assigned to each of the four conditions.

Materials

Test object

Previous research (e.g. Barr & Hayne, 1999) has indicated that 15-month-old infants have difficulty imitating multi-step actions when these are presented in a videotaped format, therefore, a simple one-step action was employed here. The novel test object was a replica of the 'dumbbell' used in Meltzoff's (1988) televised imitation study with this age range. This object was composed of two wooden cubes, with a piece of plastic tubing extending from each cube. One piece of tubing fitted snugly inside the other. The target act was to grasp the wooden cubes and pull outward, thereby separating the two pieces of tubing.

Videotaped displays

Four different videotapes were created, representing the four experimental conditions. In all conditions, three adult females (the 'models') were individually videotaped, from the shoulders up, against an off-white background.[3] The models were always presented in the same order in each condition. In the three modelling conditions, the test object was paired with either a happy, angry, or neutral expression. A control condition was included to provide information about whether infants would spontaneously produce the target act in the absence of any modelling. In this condition, the test object was paired with a neutral expression. The models' facial expressions of happiness and anger were based on the descriptions of Ekman and Friesen (1975). On the other hand, the neutral expression involved little facial movement, a relaxed mouth, and a smooth forehead. During the recording of the videotapes for the neutral and the control conditions, the models were carefully monitored to ensure that there was minimal emotional leakage (e.g. no raised eyebrows or slight smiles).

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[2] *Three other trials were subsequently administered to infants during the testing session as part of a preliminary study exploring order effects in social referencing. An additional six 15-month-old and eight 18-month-old infants completed the test trial for the current study, but did not finish the other three trials due to fussiness or inattention. By excluding these infants from the final sample, a balanced experimental design was maintained with respect to the gender and age of infants in each of the four conditions described here. It is important to note, however, that the exclusion of these infants did not change the findings reported here.*

[3] *The three models differed in terms of their clothing and the colour, length, and/or style of their hair.*

Each facial expression was accompanied by a verbal script that differed primarily in its intonation. Different verbal scripts were employed in each of the four conditions but these were similar in their structure and the syllable length was identical. Like some other social referencing studies (e.g. Mumme *et al.*, 1996), emotion words were used in the scripts rather than nonsense words, because this helped the models produce convincing expressions. These specific emotion words do not appear on any language measures as being comprehended by 15- to 18-month-old infants. Thus, it was assumed that infants would simply respond to the models' tone of voice in combination with their facial expressions. The scripts were as follows: 'Oh! How aggravating!' (anger); 'Oh! How fascinating!' (happy); 'Oh. How stimulating' (neutral);[4] and 'Oh. How validating' (control).

In the anger condition, the first model began with a neutral facial expression and demonstrated the target action with the test object (see Figure 1). Upon completion of the action, she looked in the direction of the infant and immediately expressed anger, both facially and vocally. The model continued to show anger in her facial expression and look out towards the infant for a few more seconds after vocalizing. As illustrated in Figure 1, a second model performed the same action and expressed the same emotion, followed by the third model. The models always produced their facial and vocal expressions immediately after the action was completed, so as not to distract infants while the action was being demonstrated. The happy and neutral conditions (see Figure 2a and 2b, respectively) were identical to the anger one, except for the emotion that was expressed after completing the target action. In the control condition (see Figure 2c), the models picked up and looked at the test object but did not demonstrate the target action. On returning the object to the table, each model expressed neutral affect as she looked towards the infant. The neutral facial expression was maintained for a few seconds after the vocalization. Each of the four video presentations lasted 48 seconds.

Apparatus (based on Mumme & Fernald, 2003). Infants were seated at one end of a long (120 cm) and narrow (76 cm) table, facing a 20 in. (50.8 cm) colour TV. A smaller (51 cm long × 76 cm wide) table was placed on each side of the long table to provide a wider play surface for the infant. All three tables were 70 cm high. The TV was placed on a 98 cm high audio-visual (AV) cart that was positioned at the other end of the long table. Curtains were hung from the ceiling and surrounded the TV in order to conceal a research assistant. This assistant controlled the presentation of the videotapes and the test object from behind the curtains.

A fringed plastic curtain was attached to the AV cart and hung down so that it just barely touched the surface of the table. This small curtain concealed the hands of the assistant as she placed objects on a tray and pushed them out to the infant (using a long handle attached to the end of the tray). The tray (46 cm wide × 61 cm long) was fitted inside a pair of plastic runners attached to the surface of the table. These runners allowed the assistant to push the tray along the table, stopping 2.5 cm from the end of the table.

Each testing session was recorded with two video-cameras. One camera was positioned so that it recorded the infant and part of the table surface in front of the infant. Infants' instrumental behaviours were coded from this video record. A second

[4] *It was difficult to find neutral words that matched the length and structure of the happy and the anger words, so a word with a somewhat positive meaning was used instead.*

Figure 1. The three models from the anger condition, in order of presentation on the videotape.

camera (mounted on top of the TV) provided a close-up view of infants' faces so that coders could examine their facial expressions and looking behaviour.

Procedure

The accompanying parent (usually the mother) seated the infant in a high chair in the testing room. The high chair was positioned at one end of the long table and faced the TV screen. The parent then encouraged the infant to play at the table with a toy. Once the child was comfortable, the experimenter seated the parent on the right hand side of

Figure 2. The first videotaped model in each of the other conditions. (a) Happy, (b) Neutral, and (c) Control.

the TV. Parents sat with their back to the infant and pretended to read a magazine. About 15% ($N = 28$) of the infants were tested in the parent's lap because they refused to remain seated in the high chair. Regardless of the seating arrangement, parents were instructed not to interact with, look at, or speak to their infants during the testing.

After a few more minutes of free-play at the table, infants received a warm-up trial to familiarize them with the apparatus and the testing procedure. The concealed assistant placed a small colourful box on the tray. She pushed the tray out from behind the fringed curtain until the box was positioned directly beneath the TV. The experimenter turned on the TV (using the remote control) and the assistant played a videotape in which an adult female removed the lid from a box, identical to the one on the tray, and proceeded to retrieve a small block from inside it. The real box was visible during this time in an attempt to highlight its connection with the videotaped image (Troseth, 2003; Troseth & DeLoache, 1998). At the conclusion of the videotape, the experimenter turned off the TV (via the remote control) and the assistant pushed the tray to the end of the table. Infants were given 30 seocnds in which to play with the box.

The test trial was then administered. This trial was composed of a demonstration period in which one of the videotapes was played, followed by a response period in which infants were given access to the test object. During the entire test trial, the experimenter was seated behind and slightly to the left of the child. From this position, she remotely controlled the TV and also timed the response period. An open magazine lay on the experimenter's lap so that if the infant turned to look at her, she could quickly look down and pretend to read. At the start of the test trial, the concealed assistant positioned the test object on the tray so that when it was pushed out, it would be directly beneath the TV screen during the demonstration period. At the conclusion of the videotape, the TV was turned off and the concealed assistant gently pushed the tray to the end of the table, thereby delivering the test object to the infant. Infants were then given 20 seconds in which to play with the object. The timing of the response period typically began when the tray reached the end of the table. However, if the infant touched the object before the tray stopped moving, the timing began at the moment the infant made contact with the object.

Coding and reliability

The video records of infants' instrumental behaviour were edited so that the coding tapes only included the 20 second response period from each infant. This ensured that the coders were unaware of which videotape infants had watched. In the response period, four behavioural variables were examined to determine whether the emotional signals influenced infants' object-directed behaviour. One of these variables was whether infants touched the object. This behaviour was coded using a dichotomous (yes/no) measure. If infants touched the object, latency to first touch, and total duration of touch were then coded. Latency to first touch was defined as the time (in seconds) from when the test object was positioned in front of the infant to the time the infant first made contact with the object (or 0 seconds if the infant touched the object before the tray reached the end of the table). Duration of object touch was defined as the total amount of time (in seconds) that the infant spent touching the object during the response period and was measured starting from the moment the object was first touched by the infant. Finally, coders determined whether infants performed the target action (i.e. pulled the dumbbell apart). This behaviour was coded using a dichotomous (yes/no) measure. One naïve coder scored the entire data set and a second naïve coder

scored one-third of the data. There were no disagreements as to whether infants touched the object or performed the target act. Intra-class correlation coefficients were high for both latency to touch ($r = .98$) and duration of object contact ($r = .97$).

Infant attention during the demonstration period was measured using the close-up recording of the infant's face. These video records were examined without sound to ensure that coders were not aware of infants' experimental condition. Two naïve coders recorded the duration of every infant look to the television screen during the demonstration period. These looks were then summed to obtain a measure of total looking time. Because some infants occasionally moved off-camera and could not be coded during those moments, proportions were calculated for the attention variable (i.e. total looking time/total coding time). Inter-coder reliability, based on one-third of the sample, was $r = .98$.

Infant affect, indexed by facial expression, was also measured during the demonstration period using the close-up video records (without sound). Infants' facial expressions were rated every 3 seconds, using separate three-point scales for positive and negative hedonic tone (derived from Hirshberg & Svejda, 1990). A score of two on the positive affect scale indicated a broad smile or laugh-face; a score of 1 was assigned for a slight smile, and a 0 indicated the absence of any positive affect. On the negative scale, a score of 2 was given for a cry-face, big frowns, grimaces, or scowls; a score of 1 was for mild frowning/furrowing of the brows or slight wariness/worried expressions, and a score of 0 was given when there were no signs of negative affect. Mean positive and negative affect scores were then calculated, based on the number of intervals that could be coded for that infant (i.e. no score could be assigned if the infant moved off-camera). Another naïve coder rated one-third of the data, and there was excellent agreement between the two coders (positive affect: $r = .94$; negative affect: $r = .96$).

Finally, a manipulation check was performed to ensure that the models had conveyed the appropriate affect. Naïve coders used a five-point scale to assign an overall rating for the hedonic tone of each of the model's facial expressions in the period immediately following the completion of the target action (-2: very negative to $+2$: very positive). These ratings were performed without sound so that the coders would only use the model's face to make their judgments. In addition, the coders indicated which discrete emotion was predominant in the model's facial expression during this time, based on the following list: happiness; interest; neutral; surprise; sadness; anger; disgust; and fear. There was excellent inter-rater agreement for facial hedonic tone, $r = .97$. In addition, the coders were in 100% agreement as to the predominant emotion classifications for these facial expressions.

Because the verbal scripts included emotion words that could bias coders' judgments, the models' vocal expressions were low-pass filtered at 475 Hz, to make the lexical content unintelligible. Two naïve coders listened to the filtered audio-files and, like the facial expressions, rated the hedonic tone of the vocal expressions (ranging from -2 to $+2$). The coders were not able to identify any of the words uttered by the models and good inter-rater agreement was obtained, $r = .95$.

Results

Manipulation check

The models were rated as more negative in their facial expression in the anger condition ($M = -1.67$, $SD = 0.58$) in comparison to the neutral ($M = 0.00$, $SD = 0.00$), control

($M = 0.00$, $SD = 0.00$), and happy ($M = 1.67$, $SD = 0.58$) conditions, all ps $< .01$. And, the models' facial expressions were rated as being significantly more positive in the happy condition than in either the neutral or control conditions, both ps $< .01$. All of the facial expressions were correctly classified for predominant emotion. The manipulation check also confirmed that the vocalizations in the anger condition ($M = -1.67$, $SD = 0.58$) were significantly more negative than those in the neutral, control, and happy conditions, all ps $< .01$. In addition, the happy vocalizations ($M = 1.33$, $SD = 0.58$) were rated more positively than were those in the neutral ($M = 0.00$, $SD = 0.00$) and control ($M = 0.00$, $SD = 0.00$) conditions, both ps $< .05$. Taken together, these results indicate that the models' facial and vocal expressions conformed to the procedural requirements of the study.

Did infants perform the target action?

A preliminary analysis indicated that the 15- and the 18-month-old infants were equally unlikely to spontaneously perform the target action in the control condition. Indeed, the rate was only .04 for each age group (see Figure 3). A logistic regression analysis was carried out, with age and condition entered as independent variables. This analysis revealed a main effect of condition, $\chi^2 = 23.23$, $p < .001$. There were no other significant effects. A more detailed analysis of the condition main effect was then conducted. First, the control condition was compared to each of the other conditions to determine whether imitation had occurred. Infants in the anger condition (.27) were more likely to produce the target action than were those in the control condition, $\chi^2 = 9.56$, $p < .01$. Likewise, a larger proportion of the infants in the happy (.52) and the neutral conditions (.52) performed the target act relative to those in the control condition, both $\chi^2 = 27.26$, $p < .001$. As expected, infants in the anger condition were less likely to imitate than were infants in either the neutral or the happy conditions, both $\chi^2 = 6.27$, $p < .05$.

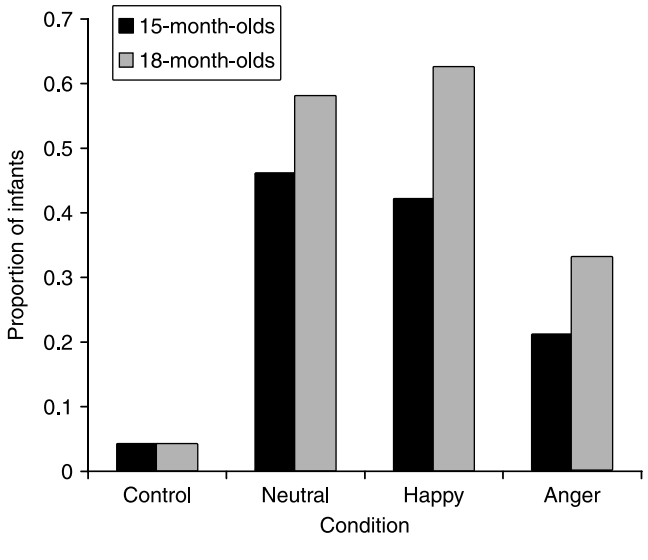

Figure 3. Proportion of infants performing the target action as a function of condition and age.

Did the emotional signals influence infants' general object-directed behaviour?
All infants touched the test object during the response period. Latency to first touch and duration of object contact were then examined to determine whether the effect of the models' affective displays was specific to infants' performance of the target act or influenced their object-directed behaviour more generally. Latency (in seconds) to touch the object (see Table 1) was analysed using a factorial ANOVA, with age and condition as between-subjects variables. There were no significant main effects or interactions. Duration of object contact was likewise analysed using a 4 (condition) × 2 (age) ANOVA. There were no significant main effects or interactions.

Were infants attentive during the demonstration period?
It is possible that infants failed to imitate the target action in the anger condition because they were less attentive to the videotaped stimuli than were infants in the other conditions. In order to address this issue, the proportion of time that infants spent watching the videotape was analysed using a 4 (condition) × 2 (age) ANOVA. This analysis revealed a main effect of age, $F(1, 184) = 4.89, p < .05$. Overall, the 18-month-old infants ($M = 0.84$, $SD = 0.17$) were more attentive during the demonstration period than were the 15-month-olds ($M = 0.79$, $SD = 0.18$). There was also a significant condition main effect $F(3, 184) = 13.03$, $p < .001$. Infants were equally attentive to the videotapes in the anger and the happy conditions (see Table 1). However, infants were more attentive in each of these conditions relative to the neutral and the control conditions, all ps $< .01$. Infants were also more attentive in the neutral than in the control condition, $p = .05$.

Was there evidence of emotional contagion?
Infants' facial expressions were examined to explore whether emotion contagion played any role in guiding their instrumental behaviour. Infants' mean positive and negative facial affect scores (see Table 1) during the demonstration period were analysed in separate 4 (condition) × 2 (age) ANOVA's. There were no significant main effects or interactions for infant negative affect. However, there was a significant condition main effect for infant positive affect, $F(3, 184) = 3.45$, $p < .05$. Follow-up analyses indicated that infants displayed more positive affect in the happy condition ($M = 0.16$, $SD = 0.27$) than in either the anger ($M = 0.05$, $SD = 0.10$), or the control ($M = 0.07$, $SD = 0.09$) conditions, both ps $< .05$. There was no difference between the happy and neutral conditions in the level of positive affect. Finally, infants were no less positive in the anger condition in comparison to either the neutral or the control conditions.

Because there was some evidence that infants' affect was influenced by the models' emotional displays, a series of correlation coefficients were calculated to determine whether the affect scores (positive or negative) during the demonstration period were related to infants' later performance of the target action. In most instances, there was no significant relationship between these variables. However, in the neutral condition, infants who later performed the target act had significantly lower negative affect scores during the demonstration period than did those who failed to imitate, $r = .33$, $p < .05$.

Discussion

At both 15- and 18-months of age, infants were more likely to perform the target action in each of the three modelling conditions (anger, happy, and neutral) than in the control

Table 1. Mean (and *SD*) for infant behaviour and affect as a function of condition and age

	Condition			
	Control ($N = 24$)	Happy ($N = 24$)	Neutral ($N = 24$)	Anger ($N = 24$)
15-month-olds				
Demonstration phase				
Attention to video[a]	0.70 (0.18)	0.87 (0.10)	0.73 (0.22)	0.87 (0.12)
Positive affect[b]	0.09 (0.10)	0.14 (0.29)	0.12 (0.20)	0.02 (0.06)
Negative affect[b]	0.04 (0.17)	0.02 (0.05)	0.03 (0.07)	0.00 (0.01)
Response period				
Latency to touch	0.20 seconds (0.44)	0.21 seconds (0.64)	0.69 seconds (2.80)	0.28 seconds (0.83)
Duration of touch	16.26 seconds (5.09)	17.88 seconds (4.87)	18.01 seconds (4.30)	17.30 seconds (4.83)
18-month-olds				
Demonstration phase				
Attention to video[a]	0.74 (0.21)	0.89 (0.08)	0.83 (0.15)	0.91 (0.15)
Positive affect[b]	0.05 (0.08)	0.17 (0.25)	0.12 (0.22)	0.07 (0.13)
Negative affect[b]	0.01 (0.03)	0.01 (0.04)	0.01 (0.05)	0.03 (0.07)
Response period				
Latency to touch	0.18 seconds (0.37)	0.35 seconds (0.74)	0.49 seconds (1.63)	0.90 seconds (3.41)
Duration of touch	17.18 seconds (4.55)	18.14 seconds (3.12)	17.80 seconds (4.76)	15.93 seconds (5.71)

[a] Expressed as a proportion.
[b] Ratings based on a scale from 0 to 2.

condition, in which the action had not been demonstrated. These results are consistent with previous studies (e.g. Barr & Hayne, 1999; Meltzoff, 1988) in which infants as young as 14 months of age have imitated a videotaped model. The current findings build on this past research by demonstrating that infants can generalize a modelled action across different people, and can do so when the actions are presented in a videotaped format. However, what is most important for the purposes of this study is the comparison between the three modelling conditions. All of these conditions were identical except for the emotion that the models expressed upon completing the action. Regardless of age, infants were less likely to imitate in the anger than in the happy or the neutral conditions. In contrast, infants' more general manipulation of the object was not influenced by the models' emotional communications. For example, all of the infants touched the object and there were no differences across conditions in the time taken to do so. In other words, infants were not hesitant to touch the object after observing the models' anger. Thus, it was not the case that infants took longer to initially touch the object and then by default had less time in which to produce the target action. Moreover, these infants were very interested in handling the object and spent as much time in contact with it as did infants in the other three conditions.

It is also noteworthy that there was no difference in the rate of imitation between the happy and the neutral conditions. Thus, it appears to be the case that the models' positive affect did not increase infants' motivation to imitate above and beyond that which was seen in the neutral condition. This is consistent with the few previous social referencing studies (e.g. Hornik *et al.*, 1987; Mumme *et al.*, 1996) that have compared infants' responses to positive versus neutral expressions. In these studies, an adult's positive display failed to increase infants' engagement with an ambiguous object.

Taken together, the current findings suggest that the effect of the models' anger was highly specific. The negative emotional message appeared to discourage infants from imitating the target action, but it did not impact infants' more general object-directed behaviour. For example, unlike Repacholi and Meltzoff (2007), infants exposed to the anger display were not delayed in their initial contact with the object. Moreover, these infants spent as much time touching the object as did those infants exposed to the positive and the neutral models. But maybe infants had less exposure to the action during the demonstration period and consequently did not know what to do with the object. However, infants were extremely attentive during the angry videotape and no less so than those in the happy or neutral conditions. Thus, inattentiveness does not explain the lower rate of imitation in the anger condition.

An explanation that warrants more serious consideration is that the anger expressions interfered with infants' ability to either process the action or hold this information in working memory. This might then account for the low rate of imitation in the anger condition. These infants may simply have been unable to recall what to do with the object. Although this explanation can not be completely ruled out, it seems unlikely given the findings of Repacholi and Meltzoff (2007). In their research, an adult expressed anger towards a model in response to her action on an object. The adult then became silent and neutral during the response period, when infants had access to the object. In one study, the previously angry adult either looked towards or turned away from the infant during the response period. Infants were more likely to perform the target action when the previously angry adult had her back to them. Moreover, infants in this anger condition imitated to the same extent as those infants who had previously been exposed to a neutral adult. These findings suggest that in this study, the adult's anger did not interfere with infants' processing of, or memory for, the modelled action.

A more plausible explanation for the findings presented here is that infants linked the models' emotions to the action that had been performed on the object. How were they able to do so? It is unlikely that infants used semantic cues to make this connection. Even if some of the infants understood the specific emotion words (e.g. 'fascinating'), the models did not directly mention that an action had been performed. Instead, the models' utterances were ambiguous. The models could have been describing either the object or the action. Tomasello and Akhtar (1995) reported that 2-year-olds were able to determine whether a novel word referred to an action or an object by using a diverse array of social-pragmatic cues, such as eye-gaze, intentions, timing of the language relative to the speaker's behaviour, and general event knowledge. It is possible that, when determining what adults are emoting about, toddlers likewise use a combination of available cues to make these inferences. In the current experiment, for instance, the models were silent when they first saw and touched the object. And, the emotional outburst did not occur until immediately after each model had completed the target action. In addition, after emoting, the models did not ever produce the target action again. Together, these cues may have enabled infants to solve the referential puzzle. Further research is required, however, to determine more precisely the types of cues that infants can draw upon to identify the source of another person's emotional reaction.

If infants were linking the emotion to the action, what was the mechanism underlying their behavioural regulation? Why did the models' negative affect influence infants' imitative behaviour? It could be argued that the models' expressions automatically changed infants' emotional state via some emotion contagion mechanism (see Feinman, 1982 for further discussion). Thus, in the anger condition, infants' own negative affect might then have dampened their desire to perform the target act. However, infants in the anger condition were no more negative in their facial expressions than were those infants in the neutral and happy conditions. A contagion mechanism also cannot account for why the effect of the anger was restricted to infants' imitative response. If infants had simply caught the models' negative affect, this should have influenced their instrumental behaviour more generally. For example, infants should have been less interested in making contact with the object and/or maintaining this contact. However, this was not the case.

A rich interpretation of these data is that infants used the emotional information to make an inference about the models' intentions. This would be consistent with, and extend the findings of Carpenter, Akhtar, and Tomasello (1998). In their study, 14- to 18-month-old infants observed an experimenter sequentially perform two actions on an object. One action was vocally marked as intentional ('There!') and the other as accidental ('Woops!'). Infants showed a preference for reproducing the intentional action. It is conceivable that, in the current study, infants viewed the modelled action as unintentional when it was accompanied by a negative emotional outburst. On the other hand, there were various indicators that the action was in fact intentional. For instance, the models deliberately grasped the ends of the dumbbell and firmly pulled on each end. Also, the fact that three different individuals performed this particular action and no other action, implies that 'this is what one does' with the dumbbell object. A more conservative interpretation, and the one favoured here, is that infants perceived the act of pulling on the two ends of the dumbbell as being intentional, but were sensitive to the consequences of this action. For instance, their appraisal of the action may have been influenced by the models' negative emotional reaction. Infants now perceived the action to be 'bad' and something that they should avoid performing themselves. They may even have expected that, like the models, they too would experience negative

affect if they pulled on the dumbbell. Another possibility is that the models' anger influenced infants' interpretation of the physical outcome of the action. They may have concluded that the models were angry because their pulling action led to an unwanted or undesirable outcome – that is, separation of the dumbbell into two pieces.

The findings from previous social referencing studies suggest that infants respond to emotional displays as comments about the nature of an object (e.g. this is a dangerous object). Whether infants understand that affective signals can also convey information or advice about specific actions has, until now, been unknown. That infants can extract this type of information from another person's behaviour is not a trivial matter. By observing and analysing what other people say and do, infants can learn some important lessons about the world. In particular, by attending to the emotions associated with other people's actions, infants can avoid some of the negative consequences that might arise if they were to experiment with the action themselves (e.g. what will happen if *I* rotate the red disc on the cappuccino machine?).

This research is also significant because it provides a potential bridge between the infant imitation literature and the work on observational learning in older children. Whether children take into account the consequences associated with a modelled action and then use this information to regulate their own imitative responses has traditionally been explored in the context of social-learning theory (e.g. Bandura, 1977, 1986). Although this process of vicarious reinforcement has been documented in observational learning studies with preschoolers (e.g. Bandura, 1965), whether a similar process governs imitation in an infant population has never been directly investigated. In one of Bandura's (1965) classic 'Bobo doll' studies, preschoolers watched a televised model perform a series of aggressive acts. Children then saw the model being punished or rewarded for her actions by another adult, or they saw neither type of consequence. In the current studies, the 'consequences' portrayed in the videotapes were not externally imposed by another individual, instead, the models experienced an emotional response to their own actions. Despite this crucial methodological difference, the current infant findings are reminiscent of Bandura's (1965) preschool findings. These preschoolers performed fewer aggressive acts in the punished than the rewarded or no consequences condition. In the current study, infants as young as 15 months of age were likewise responsive to the consequences associated with a modelled action. This research is therefore unique in demonstrating that the emotional consequences of actions can impact infants' propensity to imitate.

One final point to consider is the fact that a videotaped presentation format was employed in the current study, for both methodological and practical reasons. However, this raises some questions about ecological validity. It should be noted, however, that this type of media is commonplace in the lives of even very young infants. For instance, Zimmerman, Christakis, and Meltzoff (2007) reported that, at 3 months of age, 40% of infants regularly watch TV, DVDs, and videos. And, by 24 months of age, 90% of toddlers are doing so and, on average, are watching this type of media for 1.5 hrs/day. Despite such findings, little attention has been paid to how televised media impacts the behaviour of infants and toddlers. Thus, the current study makes an important and unique contribution to this small body of literature. In particular, it indicates that infants can use emotional information obtained from television to determine what they should or should not do with a real world, three-dimensional object. Moreover, given that infants tend to learn more from live than videotaped displays (see Barr & Hayne, 1999 for discussion of this point), it is highly likely that the social referencing effects demonstrated here would be magnified if a live presentation format were to be employed.

In conclusion, this research advances our understanding of infants' ability to analyse other people's behaviour and to extract information that can be applied to their own personal situation. More specifically, this study is the first to demonstrate that, by 15 months of age, infants have some appreciation of how people's actions influence their emotions. In the current experimental context, infants apparently understood that the anger was in response to the specific action of the models. This research also provides new insight into the process of infant imitation. In the 2nd year of life, infants are not only skilled imitators, but are also highly selective; they do not mindlessly imitate every interesting action that they encounter. Although previous research (e.g. Carpenter *et al.*, 1998) has shown that infants preferentially imitate intentional actions, the current study highlights the fact that even when an action is intentional, infants will not always copy it. They are very attuned to the emotions that such actions generate and can use that information to regulate their own imitative responses. What remains to be addressed, however, is precisely when and how these advances in infants' ability to read and respond to other people's emotional signals arise.

Acknowledgements

This research was supported by a grant from the University of Washington Royalty Research Fund (65-2685). I would like to thank Amanda Parsley for testing the participants, as well as the numerous undergraduate research assistants who have helped at every stage of this research.

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Received 30 August 2007; revised version received 29 July 2008