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How Do You Feel? Preverbal Infants Match Negative Emotions to Events

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There is extensive disagreement as to whether preverbal infants have conceptual categories for different emotions (e.g., anger vs. disgust). In addition, few studies have examined whether infants have conceptual categories of emotions *within* the same dimension of valence and arousal (e.g., high arousal, negative emotions). The current experiments explore one aspect of infants' ability to form conceptual categories of emotions: event-emotion matching. Three experiments investigated whether infants match different negative emotions to specific events. In Experiment 1, 14- and 18-month-olds were randomly assigned to 1 of 3 negative emotion conditions (*Anger, Fear,* or *Disgust).* Infants were familiarized with an Emoter interacting with objects in an anger-eliciting event (*Unmet Goal*) and a disgust-eliciting event (*New Food*). After each event, the Emoter expressed an emotion that was either congruent or incongruent with the event. Infants matched unmet goals to the expression of anger. However, neither age matched the expression of disgust to an event involving exposure to new food. To probe whether this was a design artifact, a revised *New Food* event and a fear-congruent event (*Strange Toy*) were created for Experiment 2. Infants matched the expression of disgust to the new food event, but they did not match fear to an event involving an unfamiliar object. Experiment 3 replicated the disgust findings from Experiment 2 in a sample of 14-month-olds. However, the anger findings from Experiment 1 did not replicate. Taken together, these results suggest that preverbal infants are beginning to form specific matches between some negative emotional expressions and events.

Keywords: infancy, events, emotional expressions, social cognition

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In the past several decades, there has been a growing interest in exploring the nature of infants' emotion concepts, or "conceptual categories." Conceptual emotion categories are a collection of expressive behaviors, causal events, consequences, emotion labels, and appropriate behavioral responses that are considered to relate to specific emotions (Fehr & Russell, 1984; Walle & Campos, 2012; Widen & Russell, 2011). For instance, eating spoiled food can elicit a facial expression with a scrunched nose and gaping mouth, which adults tend to label as "disgust." An appropriate behavioral response for an observer of this expression would be to avoid eating the spoiled food. Several studies have provided evidence that, by the end of the first year of life, infants form conceptual categories of emotions *across* the broad domains of valence (i.e., positive vs. negative) and arousal (i.e., high vs. low; e.g., Martin, Maza, McGrath, & Phelps, 2014; Martin, Witherington, & Edwards, 2008; Sorce, Emde, Campos, & Klinnert, 1985). However, much less is known about whether infants also form conceptual categories of emotions *within* the same dimension of valence and arousal (e.g., anger vs. fear). In particular, some researchers have argued that preverbal infants are unable to form conceptual categories of within-valence emotions (Lindquist & Gendron, 2013; Widen, 2013). The current experiments examine one aspect of infants' ability to form conceptual categories of emotions: event-emotion matching. Specifically, we explored whether infants match different high arousal, negative emotions (i.e., anger, fear, disgust) to specific eliciting events.

The Development of Conceptual Emotion Categories

Initially, infants' emotion categories are likely perceptual in nature, based on specific facial features (Quinn et al., 2011). For example, prototypical disgust faces have scrunched noses, whereas prototypical anger faces have furrowed brows (Ekman & Friesen, 1978). Several studies have found that infants can use this featural information to form perceptual categories for a range of emotional facial expressions—happiness, sadness, anger, fear, and disgust—by 7 to 12 months of age (e.g., Kotsoni, de Haan, & Johnson, 2001; Nelson, Morse, & Leavitt, 1979; Ruba, Johnson, Harris, & Wilbourn, 2017; Safar & Moulson, 2017). To form a perceptual emotion category, infants need only perceive that multiple people are displaying the same expression by attending to a shared facial feature (e.g., scrunched noses on disgust expressions;

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Ruba et al., 2017). Thus, these perceptual categorization tasks cannot speak to the nature of infants' *conceptual* emotion categories. Instead, these perceptual categories are thought to undergo a process of "enrichment," through language and experience (Eimas, 1994; Gelman & Markman, 1986; Mandler & McDonough, 1993; Quinn & Eimas, 1997), whereby they transform into conceptual emotion categories (i.e., based on affective meaning).

However, there has been considerable disagreement as to the nature of infants' conceptual emotion categories and when this perceptual to conceptual shift might occur. In particular, some researchers have argued that infants form conceptual categories for different emotions, like happiness, anger, and disgust, in the first year of life (e.g., Izard, 1994; Nelson, 1987; Walker-Andrews, 1997). However, other researchers have argued that preverbal infants only form broad, valence- and arousal-based conceptual categories (Barrett, 2017; Barrett, Lindquist, & Gendron, 2007). These broad emotion categories (e.g., positive vs. negative emotions) are thought to gradually transform into narrower categories (e.g., anger vs. disgust) over the first decade of life (Widen, 2013). The acquisition of emotion labels (e.g., "happy," "sad") is thought to play a fundamental role in this process (Barrett, 2017; Lindquist & Gendron, 2013). However, in the developmental psychology literature, it is unclear whether preverbal infants only have broad conceptual categories of emotions (i.e., based on valence and arousal) or whether they are also beginning to form more narrow emotion categories (i.e., based on different emotions).

One major limitation of the existent research on infants' conceptual emotion categories has been the nature of the emotional stimuli presented to infants. According to the circumplex model of affect (Russell, 1980), emotions can be categorized along two broad dimensions of valence (positive vs. negative) and arousal (high vs. low). For instance, with respect to Ekman's (1972) "basic emotions," happiness is positive and high arousal; sadness is negative and low arousal; surprise is neutral and high arousal; and anger, fear, and disgust are negative and high arousal. Specifically, when viewed on the circumplex model, anger, fear, and disgust are all located in the same quadrant, although the relative ratings of each emotion slightly differ (e.g., anger is more negatively valenced than fear, whereas fear is higher in arousal than anger; Widen & Russell, 2008). The vast majority of infancy studies compare emotions *across valence and/or arousal*—for instance, comparing happiness with disgust or sadness to anger (for a review, see Vaish, Grossmann, & Woodward, 2008). However, very few studies have examined whether infants can form conceptual categories for emotions *within valence and arousal* (e.g., comparing anger, fear, and disgust). It is necessary to compare emotions within these dimensions to determine whether infants can form narrower conceptual categories based on different emotions.

Social Referencing and Infants' Conceptual Emotion Categories

Until fairly recently, most research exploring infants' conceptual emotion categories has focused on social referencing. Social referencing is the process by which infants use another person's emotional expression to regulate their own behavior (e.g., Klinnert, Emde, Butterfield, & Campos, 1986; Sorce et al., 1985; Walden & Ogan, 1988). Multiple studies have reported that by 12 months of age, infants will approach an ambiguous object that is the target of a happy (or neutral) expression, but will avoid an ambiguous object that is the target of a negative emotional expression (e.g., disgust; Hertenstein & Campos, 2004; Moses, Baldwin, Rosicky, & Tidball, 2001; Repacholi, 1998). However, these studies do not disentangle whether infants' behavioral responses reflect broad (e.g., positive vs. negative) or more narrow (e.g., happiness vs. disgust) conceptual emotion categories.

To date, only three social referencing studies have examined infants' responses to emotions within the same dimension of valence and arousal. In a classic study, 12-month-old infants were equally hesitant to cross a visual cliff when their mothers posed anger or fear expressions (Sorce et al., 1985). Consistent with this finding, Martin and colleagues (2014) reported that even 18-month-old infants did not differentially respond to these two negative emotions. Instead, infants were equally likely to avoid playing with a novel toy that had been the target of an adult's anger or fear expression. However, these results are not surprising given that, in the context of an ambiguous object or situation, expressions of anger, fear, and disgust all communicate threat and danger (Shariff & Tracy, 2011). As a consequence, in these contexts, behavioral avoidance is an appropriate response to all three emotions (Walle & Campos, 2012).

In the most comprehensive social referencing study to date, Walle, Reschke, Camras, and Campos (2017) presented 16-, 19-, and 24-month-olds with an Emoter who expressed one of five emotions (i.e., happiness, sadness, anger, fear, disgust) in two contexts (i.e., finding a novel toy, discovering that a toy was broken). Despite using a detailed coding system that focused on the underlying function (or goal) of infants' behaviors, few differences were found in infants' responses to anger, fear, and disgust. The main finding was that 24-month-olds showed greater avoidance of the Emoter when she displayed anger, compared with disgust and fear. Thus, by 24 months, infants seem to understand something about the "social nature" of the threat conveyed by anger expressions relative to other high arousal, negative emotions. There was also some (albeit more limited) evidence that younger infants were beginning to differentiate between some of these emotions. Specifically, 19-month-olds (but not 16- or 24-month-olds) demonstrated more "information seeking" (e.g., alternating their gaze between the object and the Emoter) in response to disgust than anger. However, this finding is tempered by the fact that infants in the fear condition engaged in similar amounts of information seeking relative to those in *both* the disgust and the anger conditions. Thus, the evidence for differential responding to negative, high arousal emotions was less clear-cut at this age and the pattern of responding is difficult to interpret. Moreover, it is unclear why this difference in information seeking was evident at 19 but not 24 months of age.

In summary, the social referencing literature suggests that it is not until 19 to 24 months of age that infants begin to show different functional behaviors in response to different negative, high arousal emotions (i.e., "functional affective responding"; Walle et al., 2017). However, this does not necessarily mean that infants younger than 19 months of age do not have narrower conceptual categories of emotions. Instead, it is likely that these categories are not fully formed at this point in development. Research suggests that verbal children gradually add different components (e.g., facial/vocal expressions, causes, consequences,

etc.) to their conceptual emotion categories over the first decade of life (Widen, 2013). In a similar vein, it might be the case that infants' narrow conceptual emotion categories do not yet include information about functional affective responding.

Event-Emotion Matching and Infants' Conceptual Emotion Categories

Recently, researchers have begun to explore whether infants are able match emotions to eliciting events. This research has the potential to shed new light on the nature of infants' conceptual emotion categories. Most of these studies have used variants of the violation-of-expectation (VOE) procedure (Baillargeon, Spelke, & Wasserman, 1985). Infants are shown an event (e.g., a broken toy) followed by an Emoter responding with a congruent emotional expression (e.g., sadness) or an incongruent emotional expression (e.g., happiness). Infants' visual attention (Chiarella & Poulin-Dubois, 2013; Reschke, Walle, Flom, & Guenther, 2017; Skerry & Spelke, 2014) or pupil dilation (Hepach & Westermann, 2013) is then measured to infer their expectations about the Emoter's emotional expression. For example, if infants match a broken-toy event to the emotion of sadness, they should look longer at an emotional expression that is incongruent with that event (e.g., happiness) compared with a congruent, sad expression.

These VOE studies suggest that, late in the first year of life, infants match positive events to positive emotions rather than negative emotions. Specifically, 10-month-olds expect an agent/Emoter to express happiness after completing a goal (Skerry & Spelke, 2014) or when petting a stuffed animal (Hepach & Westermann, 2013). However, in these studies, infants did not match negative events (e.g., failing to complete a goal) to negative emotions (e.g., sadness) rather than positive emotions. In contrast, by 12 months of age, infants expect an Emoter to express *either* sadness or anger, but not happiness, after fighting over a toy with another person (Reschke et al., 2017). In addition, when the incongruent emotion is happiness, 14-month-olds expect an Emoter to express anger when hitting a stuffed animal (Hepach & Westermann, 2013), and 18-month-olds (but not 15-month-olds) expect an Emoter to express sadness after having an object taken away (Chiarella & Poulin-Dubois, 2013). These studies suggest that infants begin to match negative emotions to negative events and positive emotions to positive events sometime in the second year of life.

Current Studies

Although there is evidence that infants can make valence-based matches between emotional expressions and events, it is not known whether infants can also match different negative emotional expressions to specific negative events. The current studies are the first to our knowledge to explore this research question by comparing emotional expressions *within the same dimension of valence and arousal*.[1] Specifically, we used events that are typically associated with anger, disgust, and fear, all of which are high-arousal, negatively valenced emotions (Russell, 1980). If preverbal infants' conceptual emotion categories are broad, they might match a negative event, such as eating unpleasant food, to any negative, high arousal emotion (e.g., disgust, anger, or fear), rather than a specific negative, high arousal emotion (e.g., disgust). On the other hand, if infants have conceptual categories for different negative emotions, then they should match a particular event (e.g., eating unpleasant food) to a specific negative, high arousal emotion (e.g., disgust), but not other negative, high arousal emotions (e.g., anger and fear).

We tested both 14- and 18-month-old infants given that previous research suggests that infants are able to form negative event-emotion matches sometime during this developmental window (Chiarella & Poulin-Dubois, 2013; Hepach & Westermann, 2013). However, we did not have specific hypotheses with respect to age. Experiment 1 tested infants' ability to match emotional expressions to anger- and disgust-eliciting events. Experiment 2 tested infants' ability to match emotional expressions to a revised disgust-eliciting event and a fear-eliciting event. Experiment 3 aimed to replicate the significant effects that were obtained in the first two experiments.

Experiment 1

The first experiment examined infants' ability to match different negative emotions to events in which the Emoter: (a) tried but failed to obtain an out-of-reach object (*Unmet Goal* event), and (b) tasted a novel food (*New Food* event). After each event, infants saw the Emoter produce either a congruent or an incongruent emotional expression. For example, after viewing the *Unmet Goal* event, infants in the *Anger* condition saw a congruent emotional expression at test, while infants in the *Disgust* and *Fear* conditions saw an incongruent emotional expression. Infants' looking time to the emotional expression was recorded for each event, with the hypothesis that infants would attend longer to the incongruent emotional expressions.

Method

Participants. A power analysis indicated that a sample size of 144 infants (24 for each age/condition) would be sufficient to detect reliable differences, assuming a medium effect size ($f = .25$) at the .05 alpha level with a power of .80. This was preselected as the stopping rule for the study. The final sample consisted of 72 (36 girls) 14-month-old ($M = 14.07$ months, $SD = .16$, range = 13.74–14.47) and 72 (36 girls) 18-month-old infants ($M = 18.05$ months, $SD = .22$, range = 17.62–18.48). The study was conducted following American Psychological Association (APA) ethical standards and with the approval of the Institutional Review Board (IRB) at the University of Washington (Approval Number: 50,377, Protocol Title: "Emotion Categories Study"). Infants were recruited from a university database of parents who expressed interest in participating in research studies. All infants were healthy, full-term, and normal birth weight. Parents primarily identified their infants as Caucasian (79%) or multiracial (15%). Approximately 8% of infants were identified as Hispanic or Latino. An additional nine infants (six 14-month-olds, three 18-month-olds) were tested but excluded from the final analyses for the following reasons: failure to complete the procedure ($n = 4$;

[1] Wu, Muentener, and Schulz (2017) recently examined 12- to 23-month-olds' expectation about which *positive,* within-valence emotional vocalizations (e.g., "sympathy," "excitement") are associated with certain stimuli (e.g., a crying infant, a light-up toy).

three 14-month-olds), fussiness that led to difficulties with accurate coding ($n = 3$; two 14-month-olds), or computer error ($n = 2$; one 14-month-old).

Design. Equal numbers of male and female infants were randomly assigned to one of three emotion conditions (between-subjects): *Anger*, *Fear*, or *Disgust* ($n = 48$ per condition, 24 per age). Each infant watched two different videotaped events of an Emoter interacting with objects (within-subjects): the *Unmet Goal* event and the *New Food* event. Infants were first presented with two familiarization trials of one of these events (e.g., *Unmet Goal*). This was followed by a test trial in which the Emoter produced an emotional expression (e.g., anger in the *Anger* condition), and looking time was assessed. Following this test trial, infants were then presented with two familiarization trials of the other event (e.g., *New Food*), followed by a test trial of the same emotional expression (e.g., anger; Figure 1). The order in which the two events were presented was counterbalanced across participants.

This design differs from that employed in classic VOE studies in which infants are familiarized (or habituated) to an event and then, at test, are sequentially presented with a congruent and an incongruent outcome (in a counterbalanced order). A pilot study using that design found significant order effects, whereby infants consistently looked longer to whichever emotion was presented second. In an effort to avoid these emotion order effects, the Emoter's emotional expression was held constant for the two event test trials in the current studies. In the pilot study for the current design, no order effects (i.e., *New Food* first vs. *Unmet Goal* first) were evident.

Stimuli.

Familiarization trials. The familiarization trials consisted of the two videotaped events in which an adult, female Emoter interacted with objects. Both events began with the Emoter sitting at a table, facing the camera. The Emoter introduced herself by looking at the camera and saying "Hi baby" in a pleasant tone of voice. Following this introduction, the Emoter interacted with different objects in one of two events. Each event was approximately 30 s in length (Figure 1).

In the *New Food* event, the Emoter placed a bowl, spoon, and cereal box on top of the table. She looked at the camera and said,

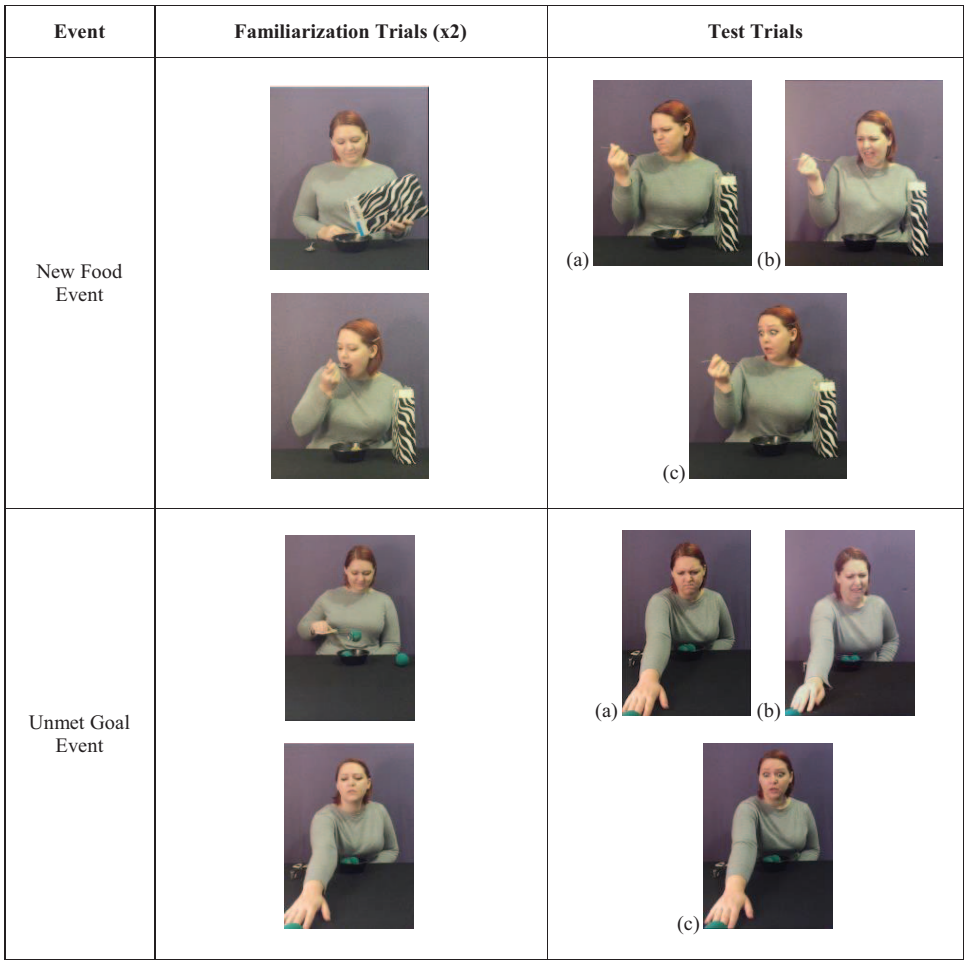

Figure 1. Experiment 1 design. Test trials are depicted for each condition: (a) anger, (b) disgust, and (c) fear. The individual whose face appears here gave signed consent for her likeness to be published in this article. See the online article for the color version of this figure.

pleasantly to the infant, "I'm going to put some food in my bowl." The Emoter picked up the box and poured some nondescript food into her bowl. She returned to looking at the camera, and said, "I'm going to take a bite." The event ended after she dipped her spoon into the bowl and took a bite of food.

In the *Unmet Goal* event, the Emoter placed a bowl, three balls, and tongs on top of the table. She looked at the camera and said, pleasantly to the infant, "I'm going to put some balls in my bowl." The Emoter picked up the tongs and used them to put two of the balls in the bowl. When she reached for the third ball, she "accidentally" knocked the ball out of reach toward the infant/camera. The Emoter leaned across the table and tried to reach the third ball, saying to the camera, with a neutral facial expression, "I can't reach it." Previous research suggests that young infants understand the goals of an individual who attempts to obtain an out-of-reach object and other unmet goals (Hamlin, Wynn, & Bloom, 2007; Meltzoff, 1995; Warneken & Tomasello, 2007; Woodward, 1998).

Test trials. The test trials were videotapes of the Emoter's emotional expression after each event, which consisted of a facial expression and appropriate vocalization. The onset of the expression occurred after the Emoter ate the food (*New Food*) or after the Emoter unsuccessfully reached for the third ball (*Unmet Goal*). Facial expressions followed the criteria outlined by Ekman and Friesen (1978). *Anger* was expressed with furrowed eyebrows and a tight mouth, *disgust* was expressed with a protruding tongue and scrunched nose, and *fear* was expressed with raised eyebrows and an open mouth. During the expression, the Emoter maintained her gaze on the spoon (which was pulled away from her mouth) or the ball (which was at the edge of the table). Vocal expressions began with an emotional utterance (e.g., a guttural "ugh" for *anger*, "ewww" for *disgust*, or a sharp "ah" for *fear*) followed by, "That's blicketing. That's so blicketing," spoken in an angry/disgusted/fearful tone. Nonsense words were used to minimize infants' reliance on the lexical content of the vocalization. Thus, it was assumed that infants would rely on the affective tone of the facial and vocal expressions to determine the conveyed emotion, not the semantics of the (nonsense) words. After the Emoter finished her script (approximately 5 s), she maintained her facial expression. The video was frozen at this point, to provide a still-frame of the Emoter's emotional expression. This still-frame was shown for a maximum of 60 s, during which infants' looking behavior was recorded (see Scoring). Full videos can be accessed here: https://osf.io/eyujq/?view_only=90be6da30b2842a4b02824bfe47d6cfc. See the online supplemental materials for validation information.

Apparatus. Each infant was tested in a small room, divided by an opaque curtain into two sections. In one half of the room, infants sat on their parent's lap approximately 60 cm away from a 48-cm color monitor with audio speakers. A camera was located approximately 10 cm above the monitor, focused on the infant's face to capture their looking behavior. In the other half of the room, behind the curtain, the experimenter operated a laptop computer connected to the test display monitor. A secondary monitor displayed a live feed of the camera focused on the infant's face, from which the experimenter observed infants' looking behavior. Habit 2 software (Oakes, Sperka, & Cantrell, 2015) was used to present the stimuli, record infants' looking times, and calculate the looking time criteria (described in "Procedures" Section).

Procedure. After obtaining parental consent, infants were seated on their parent's lap in the testing room. During the session, parents looked down and were asked not to speak to their infant or point to the screen. Before each familiarization and test trial, an "attention-getter" (a blue flashing, chiming circle) attracted infants' attention to the monitor. The experimenter began each trial when the infant was looking at the monitor. Infants were shown two familiarization trials of the *Unmet Goal* or the *New Food* event (counterbalanced across infants). After two familiarization trials, infants were shown the Emoter's emotional expression, and infants' looking to the still frame of the Emoter's facial expression was recorded. For a look to be counted, infants had to look continuously for at least 2 s. The test trial played until infants looked away for more than two continuous seconds or until the 60 s trial ended. The same procedure was followed for the second event and emotion test trial.

Following the testing session, parents reported whether their infants had the following emotion words in their receptive and productive vocabularies: "anger/mad", "scared/afraid", and "disgusted." Virtually all infants in the sample did not verbally produce these emotion labels (Table 1). A minority of infants were reported to understand the words "anger/mad" (n = 40; 28%), "scared/afraid" (n = 26; 18%), and "disgusted" (n = 9; 6%).

Scoring. Infants' looking behavior was live-coded by a trained research assistant. For each event type, this coding began at the end of the Emoter's vocal expression. Because the

Table 1
Total Number of Infants (and Proportion of Infants in Sample) Who Were Reported to Have the Following Emotion Labels in Their Receptive and Productive Vocabularies

	Experiment 1			Experiment 2			Experiment 3
Variable	14 months	18 months	Total	14 months	18 months	Total	Total (14 months)
Receptive							
"Angry/mad"	14 (.19)	26 (.36)	40 (.28)	16 (.22)	22 (.31)	38 (.26)	9 (.19)
"Scared/afraid"	8 (.11)	18 (.25)	26 (.18)	7 (.10)	11 (.15)	18 (.13)	4 (.08)
"Disgusted"	2 (.03)	7 (.10)	9 (.06)	3 (.04)	2 (.03)	5 (.03)	1 (.02)
Productive							
"Angry/mad"	1 (.01)	1 (.01)	2 (.01)	0 (.00)	1 (.01)	1 (.01)	2 (.03)
"Scared/afraid"	0 (.00)	1 (.01)	1 (.01)	0 (.00)	2 (.03)	2 (.01)	1 (.01)
"Disgusted"	0 (.00)	0 (.00)	00 (.00)	0 (.00)	0 (.00)	0 (.00)	0 (.00)

online coder was aware of the emotion the infant was currently viewing, a second trained research assistant recoded 100% of the videotapes offline, without sound. The coder was kept fully blind as to the participant's experimental condition and which emotion was presented to the infant. Reliability between the live and naïve coder was excellent, $r = .98$, $p < .001$. Identical results were obtained using the online and offline coding (analyses with the offline reliability coding are reported below).

Hypotheses and analysis plan. Between-subjects analyses were planned separately for each event. If infants are able to match different negative emotions to specific events, they should look longer at the expression when it is incongruent with each event, compared with when it is congruent. Thus, after viewing the *Unmet Goal* event, infants should attend longer to the *Disgust* and *Fear* expressions relative to the *Anger* expression. On the other hand, after viewing the *New Food* event, infants should attend longer to the *Anger* and *Fear* emotional expressions relative to the *Disgust* expressions.

Results

Preliminary analyses suggested that the looking-time data were significantly and positively skewed (ps $< .005$). Based on recommendations in the literature (Csibra, Hernik, Mascaro, Tatone, & Lengyel, 2016), the data were log-transformed. For ease of interpretation, reported means and standard deviations are the untransformed looking times (in seconds). All infants (i.e., across age and emotion conditions) attended to the entirety of the familiarization trials. A 3 (Emotion: anger/fear/disgust) × 2 (Age: 14 months/18 months) × 2 (Event Order: new food first/unmet goal first) analysis of variance (ANOVA) was conducted separately for each event (see Table 2 for looking time means and standard deviations). The reported results were unchanged when Total Emotion Vocabulary (i.e., whether infants understood the words "anger," "fear," or "disgust;" scored from 0 to 3) was entered as a covariate.

Unmet goal event. A significant main effect of Age, $F(1, 132) = 4.51$ $p = .035$, $\eta_p^2 = .03$, revealed that the 18-month-olds attended significantly longer to the emotional expressions ($M = 31.85$ s, $SD = 13.34$) compared with the 14-month-olds ($M = 25.66$ s, $SD = 11.41$). As expected, a significant main effect of Emotion also emerged, $F(2, 132) = 4.43$ $p = .014$, $\eta_p^2 = .06$. Follow-up comparisons revealed that infants attended significantly less to the *Anger* expression compared with the *Disgust* expression, $t(84.95) = 2.40$, $p = .019$, $d = .40$. Infants also attended significantly less to the *Anger* expression compared with the *Fear* expression, $t(87.62) = 2.38$, $p = .019$, $d = .43$. Looking time to the *Disgust* expression and the *Fear* expression did not differ, $t(94) = .05$, $p > .25$, $d = .03$.

This main effect was qualified by a significant Emotion × Order interaction, $F(2, 132) = 5.30$, $p = .006$, $\eta_p^2 = .07$ (see online supplemental materials for additional analysis of this order effect). There were no other significant main effects or interactions: Order, $F(1, 132) = .01$, $p > .25$, $\eta_p^2 < .01$; Age × Order, $F(1, 132) = .21$, $p > .25$, $\eta_p^2 < .01$; Age × Emotion, $F(2, 132) = .08$, $p > .25$, $\eta_p^2 < .01$; Age × Order × Emotion, $F(2, 132) = .10$, $p > .25$, $\eta_p^2 < .01$.

New food event. A significant main effect of Order, $F(1, 132) = 8.00$, $p = .005$, $\eta_p^2 = .06$, revealed that infants attended significantly longer to the emotional expressions when the *New Food* event was presented first ($M = 32.94$ s, $SD = 14.23$) compared with when it was presented after the *Unmet Goal* event ($M = 26.25$ s, $SD = 13.23$). A significant Order × Emotion, $F(2, 132) = 4.58$, $p = .011$, $\eta_p^2 = .07$, and Age × Order × Emotion interaction also emerged, $F(2, 132) = 5.73$, $p = .005$, $\eta_p^2 = .08$ (see online supplemental materials for additional analysis). There were no other significant main effects or interactions: Age, $F(1, 132) = 3.42$, $p = .07$, $\eta_p^2 = .03$; Emotion, $F(2, 132) = .85$, $p > .25$, $\eta_p^2 < .01$; Age × Order, $F(1, 132) = 1.20$, $p > .25$, $\eta_p^2 = .01$; Age × Emotion, $F(2, 132) = .88$, $p > .25$, $\eta_p^2 = .01$.

Discussion

After the *Unmet Goal* event, infants attended significantly longer to the incongruent *Disgust* and *Fear* expressions than to the congruent *Anger* expression. This is in line with our hypothesis that infants would expect the Emoter to express anger, rather than disgust or fear, after failing to complete a goal. These results suggest that by 14 months of age, infants match events involving unmet goals to anger expressions. After the *New Food* event, neither 14- nor 18-month-old infants showed differences in their looking time to the three expressions. Thus, infants at this age did not match a food related event to a disgust expression.

One explanation for the lack of predicted findings in the *New Food* event is that infants did not understand that the Emoter was trying a *new* food. Because she willingly served herself the food, infants may have assumed that this was a familiar food that the Emoter liked or desired. As a consequence, infants may have viewed the Emoter's subsequent disgust expression as incongruent or unexpected. To explore this possibility, we created a different *New Food* event for Experiment 2. This event included a second female adult (hereafter, the "Actor"), who fed the Emoter the food. In this second experiment, we also created a fear-congruent event (*Strange Toy*) to examine whether infants are able to match events to fearful expressions.

Table 2
Experiment 1 Relevant Cell Means (and SD) of Total Looking Time (in Seconds) to the Test Events

Event	Age	Cell *n*	Anger	Disgust	Fear
Unmet goal	All	48	23.72 (14.77)	29.70 (14.75)	30.18 (15.52)
	14 only	24	19.32 (10.81)	27.13 (14.39)	27.66 (14.57)
	18 only	24	28.11 (16.98)	32.27 (14.96)	32.70 (16.34)
New food (1)	All	48	28.08 (13.90)	30.30 (15.06)	30.54 (13.46)
	14 only	24	23.07 (10.45)	27.07 (11.33)	29.68 (13.12)
	18 only	24	33.09 (15.28)	33.53 (17.71)	31.40 (14.03)

Experiment 2

Method

Participants. The sample consisted of 72 (36 girls) 14-month-old (m = 14.10 months, SD = .17, range = 13.74–14.47) and 72 (36 girls) 18-month-old infants (M = 18.09 months, SD = .21, range = 17.62–18.48). Participants were recruited in the same manner as Experiment 1. Parents primarily identified their infants as Caucasian (77%) or multiracial (19%). Approximately 6% of infants were identified as Hispanic or Latino. One additional 14-month-old was tested but excluded from final analyses for fussiness that led to difficulties with accurate coding.

Design. The basic design was the same as Experiment 1. Equal numbers of male and female infants were randomly assigned to one of three emotion conditions (between-subjects): *Anger*, *Fear*, or *Disgust* (n = 48 per condition, 24 per age).

Stimuli.

Familiarization trials. The familiarization trials involved two videotaped events of two adult females, an "Actor" and an "Emoter," interacting with objects. Both events began with the Actor and Emoter sitting at a table, facing each other. The Emoter introduced herself to the infant by looking at the camera and saying "Hi baby" in a pleasant tone of voice. Then, the Emoter and Actor introduced themselves to each other and interacted with different objects in one of two events (described below). Each event was approximately 15 s in length (Figure 2).

In the *New Food* event, the Actor placed a spoon and bowl on the table and said to the Emoter, "I have some food, would you like a bite?" The Emoter responded, "I would." Then, the Actor dipped

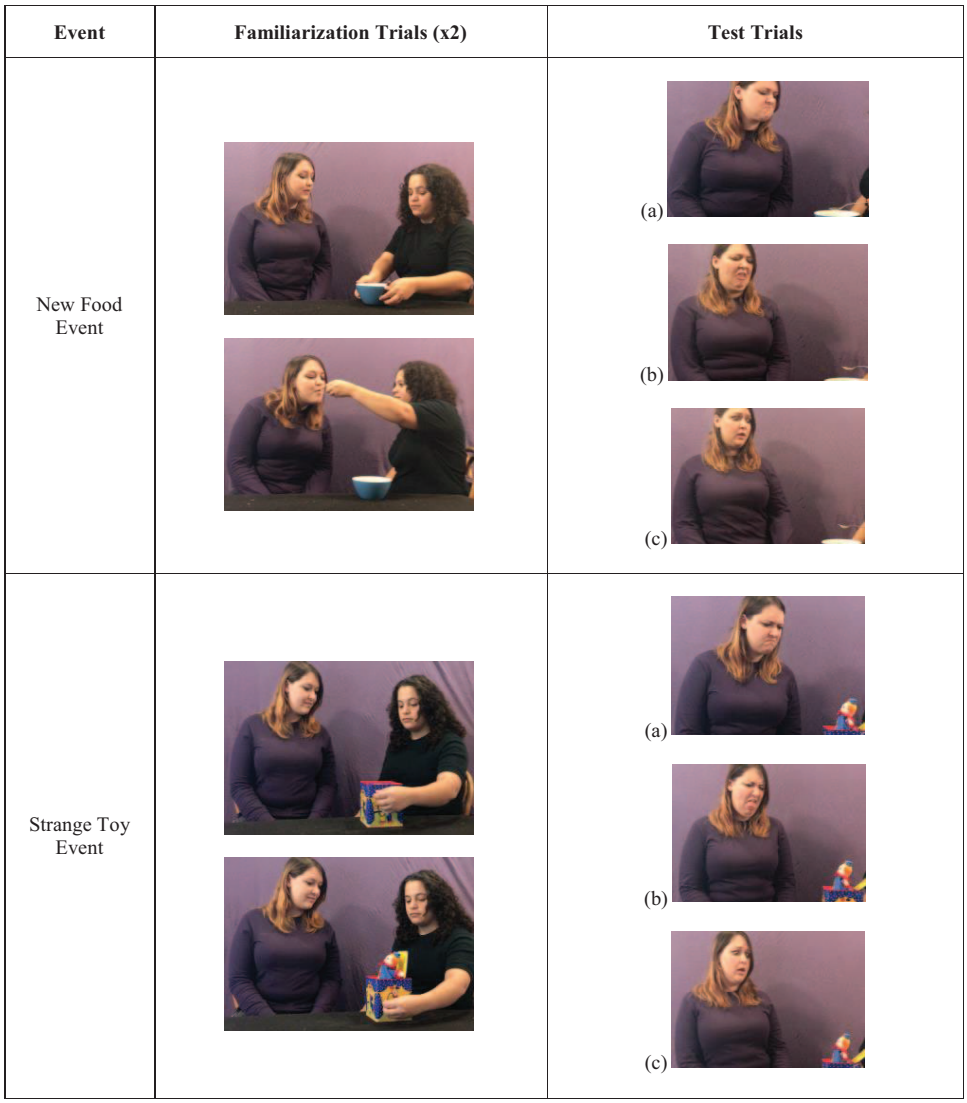

Figure 2. Experiment 2 design. Test trials are depicted for each condition: (a) anger, (b) disgust, and (c) fear. The individuals whose faces appear here gave signed consent for their likeness to be published in this article. See the online article for the color version of this figure.

the spoon into the bowl and brought the food to the Emoter's mouth. The event ended when the spoon was in the Emoter's mouth. In the *Strange Toy* event, the Actor placed a Jack-in-the-box toy on the table, and said to the Emoter, "I have a toy, do you want to see?" The Emoter responded, "I would like to see." Then, the Actor cranked the handle on the toy, producing music, as the Emoter watched. The event ended when the toy jumped out of the box.

Test trials. The test trials were videotapes of the Emoter's emotional expression after each event. The onset of the Emoter's emotional expression occurred after she was fed the food (*New Food*) or after the object popped out of the box (*Strange Toy*). Facial and vocal expressions were displayed in the same manner described in Experiment 1. During the emotional expression, the Emoter maintained her gaze on the spoon and bowl (which was pulled away from her mouth) or the toy (which was on the table). These test videos were cropped so that only the Emoter and the object (i.e., spoon/bowl, toy) were present in the frame. Thus, the Actor was not present in the test trial video. Full videos can be accessed here: https://osf.io/eyujq/?view_only=90be6da30b2842a4b02824bfe47d6cfc. See the online supplemental materials for validation information.

Apparatus, procedure, and scoring. The apparatus, procedure, and scoring were identical to Experiment 1. A second trained research assistant recoded 100% of the tapes offline, without sound. Reliability was excellent, $r = .99$, $p < .001$. Identical results are obtained using the online and offline coding (analyses with the offline reliability coding are reported below).

Similar to Experiment 1, virtually all infants in the sample did not verbally produce the emotion labels "anger/mad," "scared/afraid," or "disgusted" (Table 1). A minority of infants were reported to understand the words "anger/mad" ($n = 38$; 26%), "scared/afraid" ($n = 18$; 13%), and "disgusted" ($n = 5$; 3%).

Hypotheses and analysis plan. Between-subjects analyses were planned separately for each event. Similar to Experiment 1, if infants are able to match different negative emotions to specific events, they should look longer at the expression when it is incongruent with each event, compared with when it is congruent. Thus, after viewing the *New Food* event, infants should attend longer to the *Anger* and *Fear* emotional expressions relative to the *Disgust* expressions. On the other hand, after viewing the *Strange Toy* event, infants should attend longer to the *Anger* and *Disgust* expressions relative to the *Fear* expression.

Results

As with Experiment 1, the data were log-transformed, but reported means and standard deviations are the untransformed looking times (in seconds). All infants (100%), across ages and conditions, attended to the entirety of the familiarization events. A 3 (Emotion: anger/fear/disgust) × 2 (Age: 14 months/18 months) × 2 (Order: new food first/unmet goal first) ANOVA was conducted separately for each event (see Table 3 for looking time means and *SD*s). The reported results were unchanged when Total Emotion Vocabulary was entered as a covariate.

New food event. A significant main effect of Emotion emerged, $F(2, 132) = 3.54$, $p = .032$, $\eta_p^2 = .05$. As predicted, infants attended significantly less to the congruent *Disgust* expression compared with the *Anger* expression, $t(94) = 2.51$, $p = .014$, $d = .60$, and the *Fear* expression, $t(94) = 2.15$, $p = .034$, $d = .57$. Infants did not differ in their looking times to the *Anger* and *Fear* expressions, $t(94) = .24$, $p > .25$, $d = .02$.

There were no other significant main effects or interactions: Age, $F(1, 132) = 1.73$, $p = .19$, $\eta_p^2 = .01$; Order, $F(1, 132) = .08$, $p > .25$, $\eta_p^2 < .01$; Age × Order, $F(1, 132) = .01$, $p > .25$, $\eta_p^2 < .01$; Age × Emotion, $F(2, 132) = 2.34$, $p = .10$, $\eta_p^2 = .03$; Order × Emotion, $F(2, 132) = .82$, $p > .25$, $\eta_p^2 = .01$; Age × Order × Emotion, $F(2, 132) = 1.00$, $p > .25$, $\eta_p^2 = .02$.

Strange toy event. A significant main effect of Age, $F(1, 132) = 6.87$, $p = .010$, $\eta_p^2 = .05$, revealed that the 18-month-olds attended significantly longer to the emotional expressions ($M = 33.15$ s, $SD = 12.88$) compared with the 14-month-olds ($M = 28.32$ s, $SD = 14.18$). There were no other significant main effects or interactions: Order, $F(1, 132) = .58$, $p > .25$, $\eta_p^2 < .01$; Emotion, $F(2, 132) = .18$, $p > .25$, $\eta_p^2 < .01$; Age × Order, $F(1, 132) = .09$, $p > .25$, $\eta_p^2 < .01$; Age × Emotion, $F(2, 132) = 1.40$, $p = .25$, $\eta_p^2 = .02$; Order × Emotion, $F(2, 132) = .62$, $p > .25$, $\eta_p^2 = .01$; Age × Order × Emotion, $F(2, 132) = .42$, $p > .25$, $\eta_p^2 < .01$.

Discussion

Unlike Experiment 1, infants in Experiment 2 matched disgust expressions to an event in which an adult was exposed to a novel food. Using the revised *New Food* event, we found that infants attended longer to the incongruent emotions of *Anger* and *Fear*, compared with the congruent emotion of *Disgust*. Thus, infants matched the tasting of new food with disgust, specifically, rather than other negative, high arousal emotions. However, the results suggest that infants did not match fearful expressions to an event in which an adult was exposed to an unfamiliar object.

Experiment 3 aimed to replicate the significant Emotion effects obtained in Experiments 1 and 2. Thus, infants were shown the *Unmet Goal* event (from Experiment 1) and the revised *New Food* event (from Experiment 2) followed by either *Anger* or *Disgust* expressions. Given that there were no significant Age × Emotion

Table 3
Experiment 2 Relevant Cell Means (and SD) of Total Looking Time (in Seconds) to the Test Events

Event	Age	Cell *n*	Anger	Disgust	Fear
New food (2)	All	48	35.31 (16.83)	26.19 (13.23)	34.92 (17.18)
	14 only	24	36.54 (18.18)	25.90 (12.72)	28.98 (17.13)
	18 only	24	34.07 (15.66)	26.48 (13.99)	40.85 (15.36)
Strange toy	All	48	30.75 (16.56)	28.92 (14.33)	28.33 (15.69)
	14 only	24	30.64 (17.77)	25.44 (14.22)	22.42 (12.96)
	18 only	24	30.86 (15.65)	32.41 (13.87)	34.24 (16.19)

interactions in the first two experiments, only 14-month-olds were tested in this final experiment.

Experiment 3

Method

Participants. The sample consisted of 48 (24 girls) 14-month-old (M = 14.06 months, SD = .21 months, range = 13.45–14.47). Participants were recruited in the same manner as Experiment 1. Parents primarily identified their infants as Caucasian (85%) or multiracial (13%). Approximately 4% of infants were identified as Hispanic or Latino. Two additional infants were tested but excluded from final analyses for fussiness that led to difficulties with accurate coding.

Design. The basic design was the same as Experiment 1. Equal numbers of male and female infants were randomly assigned to one of two emotion conditions (between-subjects): *Anger* or *Disgust* (n = 24 per condition).

Stimuli. The familiarization trials consisted of the *Unmet Goal* event from Experiment 1 and the revised *New Food* event from Experiment 2. Infants saw either *Anger* or *Disgust* expressions during the test trials.

Apparatus, procedure, and scoring. The apparatus, procedure, and scoring were identical to Experiment 1. A second trained research assistant recoded 100% of the tapes offline, without sound. Reliability was excellent, r = .99, p < .001. Identical results are obtained using the online and offline coding (analyses with the offline reliability coding are reported below).

Similar to Experiment 1 and 2, virtually all infants in the sample did not verbally produce labels for the emotions of anger and disgust (Table 1). A minority of infants were reported to understand the words "anger/mad" (n = 9; 19%) and "disgusted" (n = 4; 8%).

Hypotheses and analysis plan. We hypothesized that the significant main effects of Emotion obtained in Experiments 1 and 2 would be replicated in a new sample of 14-month-old infants. Between-subjects analyses were planned separately for each event. Thus, after viewing the revised *New Food* event, we expected infants to attend longer to the *Anger* expression relative to the *Disgust* expression. On the other hand, after viewing the *Unmet Goal* event, we expected infants to attend longer to the *Disgust* expression relative to the *Anger* expression.

Results

As with Experiment 1 and 2, the data were log-transformed, but reported means and standard deviations are the untransformed looking times (in seconds). All infants (100%), across conditions, attended to the entirety of the familiarization events. A 2 (Emotion: anger/disgust) × 2 (Order: new food first/unmet goal first) ANOVA was conducted separately for each event. The reported results were unchanged when Total Emotion Vocabulary was entered as a covariate.

New food event. A significant main effect of Emotion, $F(1, 44) = 4.13$, p = .048, η_p^2 = .09, revealed that infants attended significantly less to the *Disgust* expression (M = 28.64s, SD = 15.50) compared with the *Anger* expression (M = 34.93s, SD = 12.38). This main effect was qualified by a significant Order × Emotion interaction, $F(1, 44) = 4.36$, p = .043, η_p^2 = .09 (see online supplemental materials for additional analysis). There was no significant main effect of Order, $F(1, 44) = .65$, $p > .25$, η_p^2 = .02.

Unmet goal event. Counter to our hypothesis, infants did not attend significantly less to the *Anger* expression (M = 28.17s, SD = 11.60) compared with the *Disgust* expression (M = 30.06s, SD = 17.93), $F(1, 44) = .19$, $p > .25$, $\eta_p^2 < .01$. There were no significant effects related to the order in which the event was presented: Order, $F(1, 44) = 2.39$, p = .13, η_p^2 = .05; Order × Emotion, $F(1, 44) = .03$, $p > .25$, $\eta_p^2 < .01$.

Discussion

Experiment 3 partially replicated the results of the prior two experiments. Similar to Experiment 2, we found that 14-month-old infants matched a disgust expression to an event in which an adult was exposed to a novel food. However, Experiment 3 did not replicate the effects from the *Unmet Goal* event in Experiment 1. Unlike Experiment 1, infants did not match an anger expression to an event where an adult failed to meet a goal.

General Discussion

The current studies are the first to directly address the question of whether infants are able to form event-emotion matches for different high arousal, negative emotions (e.g., anger vs. disgust). Moreover, virtually all of the previous studies examining infants' conceptual emotion categories have tested emotional expressions *across the dimensions of valence and/or arousal*. The current experiments begin to fill this theoretically important gap in the literature by comparing three emotions from the *same dimensions of valence and arousal*: anger, disgust, and fear. Taken together, the results indicate that by 14 months of age, infants are able to match *some* of these negative, high arousal emotions to specific eliciting events. However, the findings also suggest that there might be different developmental trajectories for different negative emotions.

In two experiments, we found that infants as young as 14 months of age expected an Emoter to express disgust, rather than anger or fear, after being exposed to a new food. This effect only appeared with an event in which an Emoter was fed a bite of food by another person (Experiments 2 and 3). The effect was not evident when the event involved an Emoter eating a bite of food that she served herself (Experiment 1). As discussed previously, one explanation for these different findings is that the original *New Food* event in Experiment 1 was ambiguous. Another explanation is that infants are better able to understand emotions when they are expressed in interpersonal contexts (Reschke et al., 2017; Walle & Campos, 2012).

In Experiment 1, we also found that 14- and 18-month-old infants expected an Emoter to express anger, rather than disgust or fear, after failing to complete a goal. However, in Experiment 3, 14-month-olds did not form this match. One interpretation of these inconsistent findings is that Experiment 3 (n = 24 infants per emotion condition) was underpowered. In Experiment 1, there were twice as many infants (n = 48 14- and 18-month-olds in each emotion condition). However, the Emotion effect was significant (p < .05) in Experiment 1 when only the 14-month-old data (n =

24) were analyzed. An alternative explanation is that, at 14 months of age, infants are only beginning to link anger with unmet goals. As a consequence, the effects may be weak and somewhat unreliable at this early point in development. However, given the findings from Experiment 1, this linkage may be more firmly in place by 18 months of age.

Neither the 14- nor the 18-month-olds expected an Emoter to express fear, rather than disgust or anger, after encountering an unfamiliar toy. One possible explanation is that the *Strange Toy* event was ambiguous, leading infants to view anger, disgust, and fear as equally plausible responses to the Jack-in-the-box. Anger could be a congruent emotion if the Emoter did not like or was annoyed by the noise of the toy. Likewise, disgust could also be congruent if infants conflated that emotion with "dislike." Future research should examine infants' understanding of fear using other types of events that infants may view as prototypical elicitors (e.g., snakes, a person encountering a steep cliff; DeLoache & Lobue, 2009; Sorce et al., 1985). Another possibility is that fear is a later emerging emotion category than disgust and anger. It is noteworthy that in previous habituation/familiarization looking-time studies, infants typically show sustained attention to facial displays of fear, even after habituation to these expressions (e.g., Kotsoni et al., 2001; Nelson et al., 1979). This suggests that fearful expressions may be particularly novel or attention-getting for infants. In line with this, caregivers have described fearful expressions as "unnatural" and "uncharacteristic of their normal behavior" (Camras & Sachs, 1991; Rosen, Adamson, & Bakeman, 1992). In addition, it has been theorized that infants do not experience fear themselves until sometime in the second half of the first year of life, while expressions of anger and disgust are thought to emerge earlier in development (Lewis, 2000).

The fact that infants matched disgust to a novel food event is also consistent with what is known about infants' everyday experience with this emotion. For instance, as infants engage in more independent exploration in the second year of life, parents commonly express disgust in response to the child touching and mouthing certain objects and substances (Stevenson, Oaten, Case, Repacholi, & Wagland, 2010). Moreover, infants frequently display disgust expressions themselves when they are introduced to new foods (Rozin & Fallon, 1987). Thus, by 14 to 18 months of age, infants have had multiple opportunities to learn the associations between expressions of disgust and novel foods.

On the other hand, if these types of experiences are important, then it seems surprising that 14-month-olds did not reliably match anger to unmet goals. Anger expressions are thought to be especially salient for infants during the second year of life (e.g., Grossmann, Striano, & Friederici, 2007; Ruba et al., 2017). With the onset of crawling and walking, infants are increasingly exposed to other people's expressions of anger (e.g., Campos et al., 2000), and, as parents exert more control over their child's behavior, infants increasingly express anger/frustration themselves (Saarni, Campos, Camras, & Witherington, 2007). These experiences should be sufficient to provide the basis for infants to learn the association between unmet goals and anger. Ultimately, more work on event-emotion matching is needed to determine if disgust has developmental precedence over fear and anger and, if so, whether this is based on differential personal experience with these emotions and events.

There has been much debate over the nature of infants' conceptual emotion categories. In particular, some researchers have argued that infants form narrow conceptual categories for different emotions, like happiness, anger, and disgust, in the first year of life (e.g., Nelson, 1987; Walker-Andrews, 1997). Others have argued that preverbal infants only have broad, valence- and arousal-based conceptual categories (Barrett, 2017; Barrett et al., 2007). In particular, these researchers have argued that conceptual categories for different negative emotions (e.g., anger vs. disgust vs. fear) cannot be acquired before children have learned emotion labels (Barrett, 2017)—a case of language sculpting thought (or in this case emotions). Emotion labels (e.g., "anger") are thought to bind these variable instances of an emotion together into our "commonsense" adult emotion category. Without emotion verbal labels to do this work of binding, it is argued that emotional expressions are too perceptually variable for children to identify them as belonging to an emotion category. For this reason, it is thought that preverbal infants, who do not have emotion labels, do not interpret emotional expressions in terms of narrow categories (Barrett, 2017; Lindquist & Gendron, 2013; Widen, 2013). Given that the majority of infants in our sample did not have the labels "anger," "fear," or "disgust" in their vocabularies (Table 1), one might predict that they would be unable to match different negative, high arousal emotions to specific eliciting events. Therefore, it is noteworthy that preverbal infants as young as 14 months of age expected an Emoter to express disgust, rather than anger or fear, after being exposed to a new food. This finding suggests that it may indeed be possible for infants to begin forming narrow conceptual categories for some emotions (i.e., disgust) before learning emotion labels.

On the other hand, it is likely that, at this point in development, infants do not have fully formed emotion concepts. Although infants seem to be incorporating information about "emotion events/causes" into their early category of disgust by 14 months of age, other components may not emerge until after the acquisition of emotion language (Widen, 2013). For instance, the work of Walle and colleagues (2017) suggests that it is not until about 19 to 24 months of age that infants begin to incorporate information about functional affective responding into their category of disgust. It is noteworthy that emotion labels are emerging in infants' productive vocabularies at this age (Ridgeway, Waters, & Kuczaj, 1985), and future work should explore the links between language and emotion categories in these older infants. Although the current studies did not find that infants' looking time varied with their emotion vocabulary, future research could explicitly analyze these questions with larger sample sizes.

It is important to note that the effects in these three experiments were small. This is perhaps not surprising given that looking time studies more generally, as well as those that test event-emotion matching specifically (e.g., Wu et al., 2017), also report small effects (for a discussion, see Oakes, 2017). Furthermore, in our studies, infants had to make distinctions between negative emotional expressions that had a high degree of perceptual similarity (e.g., the emotions activate similar facial features) and conceptual similarity (e.g., all were threat-relevant emotions). Even older children and adults struggle to distinguish these particular emotions (e.g., Ruba, Wilbourn, Ulrich, & Harris, 2018; Widen, 2013). In addition, matching negative emotions to specific events may be an emerging ability at 14 months of age. Thus, the relative immaturity of this ability combined with the inherently difficult nature

of the task may explain why (a) the *Unmet Goal* event failed to replicate in Experiment 3 among the 14-month-olds, and (b) neither 14- nor 18-month-olds matched fearful expressions to the *Strange Toy* event in Experiment 2.

In summary, this research adds to the small body of literature exploring preverbal infants' ability to match emotions to events. By testing three emotions within the same dimension of valence and arousal, the current studies were able to explore whether infants' event-emotion matches reflect relatively narrow conceptual categories for different emotions (i.e., anger vs. fear vs. disgust). To determine whether infants' conceptual emotion categories are broad versus narrow, it is *necessary* to use emotional expressions within the same dimension of valence and arousal. However, this test alone is not *sufficient* to determine the boundaries of infants' emotion categories. For instance, an infant may show a different response to anger expressed in a social context (toward another person) compared with anger expressed in a nonsocial context (toward an object), yet infants may not view these instances of "anger" as belonging to separate categories. It is important to replicate the current findings with a wider array of events to more precisely determine the nature of infants' conceptual emotion categories.

The findings presented here represent an important step toward understanding the nature of infants' conceptual emotion categories, but much is still unknown. For instance, it is unclear whether infants' responses reflect (a) learned associations between different emotional displays (e.g., happiness) and specific events (e.g., receiving a desired object), or (b) an understanding of the causal link between emotions and events. Future research will also need to determine whether infants more readily form event-emotion matches when they have personally experienced these pairings in their daily lives (e.g., eating novel foods and disgust expressions) compared with pairings that are relatively unfamiliar (e.g., jumping over a barrier and sad expressions; Skerry & Spelke, 2014). In addition, further research is needed to determine *how* emotion concepts are acquired during infancy and the extent to which these might be impacted by parental socialization (within and across cultures). Future research should also continue to explore the nature of infants' emotion categories by examining different components, such as behavioral consequences and functional affective responding. Nonetheless, the current research illustrates the importance of testing a variety of emotional expressions in order to more fully understand the nature of infants' conceptual emotion categories.

References

Baillargeon, R., Spelke, E. S., & Wasserman, S. (1985). Object permanence in five-month-old infants. *Cognition, 20,* 191–208. http://dx.doi.org/10.1016/0010-0277(85)90008-3

Barrett, L. (2017). *How emotions are made: The secret life of the brain*. New York, NY: Houghton Mifflin Harcourt.

Barrett, L. F., Lindquist, K. A., & Gendron, M. (2007). Language as context for the perception of emotion. *Trends in Cognitive Sciences, 11,* 327–332. http://dx.doi.org/10.1016/j.tics.2007.06.003

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25,* 49–59. http://dx.doi.org/10.1016/0005-7916(94)90063-9

Campos, J., Anderson, D., Barbu-Roth, M., Hubbard, E., Hertenstein, M., & Witherington, D. (2000). Travel broadens the mind. *Infancy, 1,* 149–219. http://dx.doi.org/10.1207/S15327078IN0102_1

Camras, L., & Sachs, V. (1991). Social referencing and caretaker expressive behavior in a day care setting. *Infant Behavior & Development, 14,* 27–36. http://dx.doi.org/10.1016/0163-6383(91)90052-T

Chiarella, S. S., & Poulin-Dubois, D. (2013). Cry babies and pollyannas: Infants can detect unjustified emotional reactions. *Infancy, 18*(Suppl. 1), E81–E96. http://dx.doi.org/10.1111/infa.12028

Csibra, G., Hernik, M., Mascaro, O., Tatone, D., & Lengyel, M. (2016). Statistical treatment of looking-time data. *Developmental Psychology, 52,* 521–536. http://dx.doi.org/10.1037/dev0000083

DeLoache, J. S., & Lobue, V. (2009). The narrow fellow in the grass: Human infants associate snakes and fear. *Developmental Science, 12,* 201–207. http://dx.doi.org/10.1111/j.1467-7687.2008.00753.x

Eimas, P. D. (1994). Categorization in early infancy and the continuity of development. *Cognition, 50,* 83–93. http://dx.doi.org/10.1016/0010-0277(94)90022-1

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska symposium on motivation* (Vol. 19, pp. 207–283). Lincoln, NE: University of Nebraska Press.

Ekman, P., & Friesen, W. (1978). *Facial action coding systems*. Palo Alto, CA: Consulting Psychologists Press.

Fehr, B., & Russell, J. (1984). Concept of emotion viewed from a prototype perspective. *Journal of Experimental Psychology: General, 113,* 464–486. http://dx.doi.org/10.1037/0096-3445.113.3.464

Gelman, S. A., & Markman, E. M. (1986). Categories and induction in young children. *Cognition, 23,* 183–209. http://dx.doi.org/10.1016/0010-0277(86)90034-X

Grossmann, T., Striano, T., & Friederici, A. D. (2007). Developmental changes in infants' processing of happy and angry facial expressions: A neurobehavioral study. *Brain and Cognition, 64,* 30–41. http://dx.doi.org/10.1016/j.bandc.2006.10.002

Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature, 450,* 557–559. http://dx.doi.org/10.1038/nature06288

Hepach, R., & Westermann, G. (2013). Infants' sensitivity to the congruence of others' emotions and actions. *Journal of Experimental Child Psychology, 115,* 16–29. http://dx.doi.org/10.1016/j.jecp.2012.12.013

Hertenstein, M. J., & Campos, J. J. (2004). The retention effects of an adult's emotional displays on infant behavior. *Child Development, 75,* 595–613. http://dx.doi.org/10.1111/j.1467-8624.2004.00695.x

Izard, C. E. (1994). Innate and universal facial expressions: Evidence from developmental and cross-cultural research. *Psychological Bulletin, 115,* 288–299. http://dx.doi.org/10.1037/0033-2909.115.2.288

Klinnert, M., Emde, R., Butterfield, P., & Campos, J. (1986). Social referencing: The infant's use of emotional signals from a friendly adult with mother present. *Developmental Psychology, 22,* 427–432. http://dx.doi.org/10.1037/0012-1649.22.4.427

Kotsoni, E., de Haan, M., & Johnson, M. H. (2001). Categorical perception of facial expressions by 7-month-old infants. *Perception, 30,* 1115–1125. http://dx.doi.org/10.1068/p3155

Lewis, M. (2000). The emergence of human emotions. *Handbook of Emotions, 2,* 265–280.

Lindquist, K., & Gendron, M. (2013). What's in a word? Language constructs emotion perception. *Emotion Review, 5,* 66–71. http://dx.doi.org/10.1177/1754073912451351

Mandler, J., & McDonough, L. (1993). Concept formation in infancy. *Cognitive Development, 8,* 291–318. http://dx.doi.org/10.1016/S0885-2014(93)80003-C

Martin, N. G., Maza, L., McGrath, S. J., & Phelps, A. E. (2014). An examination of referential and affect specificity with five emotions in infancy. *Infant Behavior and Development, 37,* 286–297. http://dx.doi.org/10.1016/j.infbeh.2014.04.009

Martin, N., Witherington, D., & Edwards, A. (2008). The development of affect specificity in infants' use of emotion cues. *Infancy, 13,* 456–468. http://dx.doi.org/10.1080/15250000802329370

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology, 31,* 838–850. http://dx.doi.org/10.1037/0012-1649.31.5.838

Moses, L. J., Baldwin, D. A., Rosicky, J. G., & Tidball, G. (2001). Evidence for referential understanding in the emotions domain at twelve and eighteen months. *Child Development, 72,* 718–735. http://dx.doi.org/10.1111/1467-8624.00311

Nelson, C. A. (1987). The recognition of facial expressions in the first two years of life: Mechanisms of development. *Child Development, 58,* 889–909. http://dx.doi.org/10.2307/1130530

Nelson, C. A., Morse, P. A., & Leavitt, L. A. (1979). Recognition of facial expressions by seven-month-old infants. *Child Development, 50,* 1239–1242. http://dx.doi.org/10.2307/1129358

Oakes, L. M. (2017). Sample size, statistical power, and false conclusions in infant looking-time research. *Infancy, 22,* 436–469. http://dx.doi.org/10.1111/infa.12186

Oakes, L., Sperka, D., & Cantrell, L. (2015). *Habit 2*. Unpublished software, Center for Mind and Brain, University of California, Davis, CA.

Quinn, P. C., Anzures, G., Izard, C. E., Lee, K., Pascalis, O., Slater, A. M., & Tanaka, J. W. (2011). Looking across domains to understand infant representation of emotion. *Emotion Review, 3,* 197–206. http://dx.doi.org/10.1177/1754073910387941

Quinn, P., & Eimas, P. (1997). A reexamination of the perceptual-to-conceptual shift in mental representations. *Review of General Psychology, 1,* 271–287. http://dx.doi.org/10.1037/1089-2680.1.3.271

Repacholi, B. M. (1998). Infants' use of attentional cues to identify the referent of another person's emotional expression. *Developmental Psychology, 34,* 1017–1025. http://dx.doi.org/10.1037/0012-1649.34.5.1017

Reschke, P., Walle, E., Flom, R., & Guenther, D. (2017). Twelve-month-old infants' sensitivity to others' emotions following positive and negative events. *Infancy, 22,* 874–881. http://dx.doi.org/10.1111/infa.12193

Ridgeway, D., Waters, E., & Kuczaj, S. (1985). Acquisition of emotion-descriptive language: Receptive and productive vocabulary norms for ages 18 months to 6 years. *Developmental Psychology, 21,* 901–908. http://dx.doi.org/10.1037/0012-1649.21.5.901

Rosen, W., Adamson, L., & Bakeman, R. (1992). An experimental investigation of infant social referencing: Mothers' messages and gender differences. *Developmental Psychology, 28,* 1172–1178. http://dx.doi.org/10.1037/0012-1649.28.6.1172

Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review, 94,* 23–41. http://dx.doi.org/10.1037/0033-295X.94.1.23

Ruba, A. L., Johnson, K. M., Harris, L. T., & Wilbourn, M. P. (2017). Developmental changes in infants' categorization of anger and disgust facial expressions. *Developmental Psychology, 53,* 1826–1832. http://dx.doi.org/10.1037/dev0000381

Ruba, A. L., Wilbourn, M. P., Ulrich, D. M., & Harris, L. T. (2018). Constructing emotion categorization: Insights from developmental psychology applied to a young adult sample. *Emotion, 18,* 1043–1051. http://dx.doi.org/10.1037/emo0000364

Russell, J. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39,* 1161–1178. http://dx.doi.org/10.1037/h0077714

Safar, K., & Moulson, M. C. (2017). Recognizing facial expressions of emotion in infancy: A replication and extension. *Developmental Psychobiology, 59,* 507–514. http://dx.doi.org/10.1002/dev.21515

Saarni, C., Campos, J. J., Camras, L. A., & Witherington, D. (2007). Emotional development: Action, communication, and understanding. *Handbook of child psychology*. http://dx.doi.org/10.1002/9780470147658.chpsy0305

Shariff, A., & Tracy, J. (2011). What are emotion expressions for? *Current Directions in Psychological Science, 20,* 395–399. http://dx.doi.org/10.1177/0963721411424739

Skerry, A. E., & Spelke, E. S. (2014). Preverbal infants identify emotional reactions that are incongruent with goal outcomes. *Cognition, 130,* 204–216. http://dx.doi.org/10.1016/j.cognition.2013.11.002

Sorce, J., Emde, R., Campos, J., & Klinnert, M. (1985). Maternal emotional signaling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology, 21,* 195–200. http://dx.doi.org/10.1037/0012-1649.21.1.195

Stevenson, R. J., Oaten, M. J., Case, T. I., Repacholi, B. M., & Wagland, P. (2010). Children's response to adult disgust elicitors: Development and acquisition. *Developmental Psychology, 46,* 165–177. http://dx.doi.org/10.1037/a0016692

Vaish, A., Grossmann, T., & Woodward, A. (2008). Not all emotions are created equal: The negativity bias in social-emotional development. *Psychological Bulletin, 134,* 383–403. http://dx.doi.org/10.1037/0033-2909.134.3.383

Walden, T. A., & Ogan, T. A. (1988). The development of social referencing. *Child Development, 59,* 1230–1240. http://dx.doi.org/10.2307/1130486

Walker-Andrews, A. S. (1997). Infants' perception of expressive behaviors: Differentiation of multimodal information. *Psychological Bulletin, 121,* 437–456. http://dx.doi.org/10.1037/0033-2909.121.3.437

Walle, E., & Campos, J. (2012). Interpersonal responding to discrete emotions: A functionalist approach to the development of affect specificity. *Emotion Review, 4,* 413–422. http://dx.doi.org/10.1177/1754073912445812

Walle, E. A., Reschke, P. J., Camras, L. A., & Campos, J. J. (2017). Infant differential behavioral responding to discrete emotions. *Emotion, 17,* 1078–1091. http://dx.doi.org/10.1037/emo0000307

Warneken, F., & Tomasello, M. (2007). Helping and cooperation at 14 months of age. *Infancy, 11,* 271–294. http://dx.doi.org/10.1111/j.1532-7078.2007.tb00227.x

Widen, S. (2013). Children's interpretation of facial expressions: The long path from valence-based to specific discrete categories. *Emotion Review, 5,* 72–77. http://dx.doi.org/10.1177/1754073912451492

Widen, S., & Russell, J. (2008). Children acquire emotion categories gradually. *Cognitive Development, 23,* 291–312. http://dx.doi.org/10.1016/j.cogdev.2008.01.002

Widen, S., & Russell, J. (2011). In building a script for an emotion, do preschoolers add its cause before its behavior consequence? *Social Development, 20,* 471–485. http://dx.doi.org/10.1111/j.1467-9507.2010.00594.x

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition, 69,* 1–34. http://dx.doi.org/10.1016/S0010-0277(98)00058-4

Wu, Y., Muentener, P., & Schulz, L. (2017). One-to four-year-olds connect diverse positive emotional vocalizations to their probable causes. *Proceedings of the National Academy of Sciences, 114,* 11896–11901. http://dx.doi.org/10.1073/pnas.1707715114

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