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Toddlers Connect Emotional Responses to Epistemic States

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Abstract

Emotional expressions are typically transient; while we may react emotionally to a new event, we are unlikely to respond with the same emotion once the event becomes familiar. Here we look at whether toddlers understand the relationship between people's epistemic states and their emotional responses. Younger (12-17-month) and older (18-24-month) toddlers were familiarized with a movie in which an observer was knowledgeable or ignorant about a recurring event. On the test trial, the observer saw the event and either remained neutral or changed to a valenced emotional reaction (positive or negative). We predicted that the change from a neutral to a valenced expression would be more surprising if the event was familiar to the observer than if the event was novel. We found an interaction between epistemic state and emotion for older but not younger toddlers. These results suggest that before age two, children begin to understand the transient nature of emotional reactions and their dependence on people's epistemic states.

Keywords: emotion understanding; epistemic state; ignorance; causal reasoning; toddlers

Introduction

The ability to understand others' emotions is a critical component of theory of mind. Although considerable research has looked at how we might recognize others' emotions from overt emotional displays (including facial expressions, vocalizations, body posture, and gait; e.g., Ekman & Friesen, 1971; Bachorowski & Owren, 2003; Meeren, van Heijnsbergen, & de Gelder, 2005; Dael, Mortillaro & Scherer, 2012), an increasing body of work suggests that adults have a rich, abstract intuitive understanding of the conditions that tend to elicit different emotions (Skerry & Saxe, 2015; Ong, Zaki & Goodman, 2015; Wu, Baker, Tenenbaum & Schulz, 2018; Fontaine, Scherer, Roesch, & Ellsworth, 2007; Houlihan & Saxe 2017). This intuitive theory allows us to connect others' probable emotional response to an event to their appraisal that the event was goal congruent, expected, familiar, fair, controllable, etc. (e.g., Fontaine, Scherer, Roesch, & Ellsworth, 2007; Scherer & Meuleman, 2013; Ortony, Clore, & Collins, 1990).

How do children learn this rich intuitive theory of others' emotions? Prior research suggests that even toddlers recognize the importance of goal congruence for predicting others' emotions in response to events. It is less clear whether toddlers can incorporate inferences about others' appraisals of event expectedness, fairness, or controllability into emotion predictions. As a first step, here we ask whether and when toddlers incorporate inferences about the subjective novelty or expectedness of an event into their expectations of others' emotional reactions.

Developmental research suggests that infants and toddlers understand the relationship between the goal congruence[1] of an event and the valence of someone's emotional responses (Chiarella & Poulin-Dubois, 2013, 2018; DeLoache & LoBue, 2009; Repacholi & Gopnik, 1997; Reschke, Walle, Flom, & Guenther, 2017; Skerry & Spelke, 2014; Wu, Muentener, & Schulz, 2017). For example, ten-month-olds look longer if an agent expresses a negative (versus positive) reaction to achieving her objective (Skerry & Spelke, 2014), and 18-month-olds can use an agent's positive and negative emotional responses to identify which of two foods she wants (Repacholi & Gopnik, 1997). A recent study (Wu, Muentener, & Schulz, 2017) suggests a more fine-grained understanding of this relationship: twelve to seventeen-month-olds can differentiate not only cross-valence, but also within-valence emotional expressions, connecting diverse positive emotional vocalizations to their probable external events (e.g., linking funny events to a laughing response, light-up toys to excitement, adorable babies to "Aww…", etc.).

For adult perceivers however, goal congruence is only one feature of events that is used when predicting others' emotional reactions. A second key dimension is whether the event is subjectively familiar and/or expected, versus novel and/or unexpected. Toddlers are certainly able to track which events are subjectively novel to other people (even if the event is not novel for the toddler herself). For instance, in one classic paradigm, a child plays with two objects and an agent, then the agent leaves the room and a third object is introduced. If the agent returns, looks at the three objects and says either "A modi!" or "Wow! Cool!" followed by "Can you give it to me?" 18- and even 12-month-olds selectively assign the object label or hand off the object new to the observer (Tomasello & Haberl, 2003; Tomasello & Akhtar, 1995; see also, O'Neill, 1996; Akhtar, Carpenter, & Tomasello, 1996;

[1] We use the term "goal congruence" in a broad sense here. "Goal" can refer to not only individuals' goals or desires such as losing weight, but also more abstract goals such as being alive, healthy and happy. Thus, although some events investigated in the literature (e.g., seeing something funny or scary) were not explicitly framed as goal congruent or incongruent, the valence of such events was defined implicitly by their congruence with some conventional goals.

Liszkowski, Carpenter, Tomasello, 2008; Luo & Baillargeon, 2007).

Thus, toddlers can tell which objects or events are subjectively novel or unexpected to other people. But do toddlers incorporate this epistemic state into their predictions of other's emotional reactions to events? Evidence to date is unclear. On one hand, a recent study found that by twenty months, toddlers expect that someone with a false belief will express surprise (rather than satisfaction) on observing an unexpected outcome (Scott, 2017). On the other hand, like many claims about early false belief understanding, this result is in tension with earlier studies finding that children fail to predict that someone will be surprised by the unexpected contents of a container until they are five or six *years* old (MacLaren & Olson, 1993; see also Hadwin & Perner, 1991; Ruffman & Keenan, 1996; Wellman & Banerjee, 1991; Wellman & Bartsch, 1988).

In the current study, we test directly whether toddlers can incorporate another person's *Knowledge* or *Ignorance* of an event to predict her emotional reaction. Specifically, adults expect that both *Positive* and *Negative* emotional reactions are likely to be more intense to novel or unexpected events, whereas familiar or expected events are more likely to evoke muted or even *Neutral* reactions (e.g., Fontaine, Scherer, Roesch, & Ellsworth, 2007; Scherer & Meuleman, 2013; Ortony, Clore, & Collins, 1990). Thus, we test toddlers' ability to predict emotional reactions based on a person's epistemic state, independent of any prior information about the goal congruence of the event, or the valence of the emotional reaction. Do toddlers expect that any vigorous emotional reaction to an event is more likely if the person was previously ignorant than if the agent was previously knowledgeable, regardless of whether the emotional reaction is positive or negative?

To measure these expectations, we use a looking time task. Within participants, all toddlers see one sequence in which an agent remains *Ignorant* about an event over four familiarization trials and another sequence in which an agent is *Knowledgeable* about the event (order counterbalanced, with different agents and events between conditions). Between participants, we manipulate whether the agent's final emotional expression to the event is *Positive*, *Negative*, or remains *Neutral*.

We predict that both *Positive* and *Negative* emotional reactions will be more surprising given an agent who already knows about the events than given an agent seeing them for the first time. Thus the primary prediction is that given a valenced reaction (either Positive or Negative) toddlers will look longer in the Knowledgeable condition (where the agent has seen the events and responded neutrally four times before) than in the Ignorant condition (where the agent first notices the event on the test trial). Conversely, the Neutral reaction should be more surprising given an agent first seeing the events than an agent who has seen the events all along. Thus the pattern should reverse: given a Neutral reaction, toddlers should look longer in the Ignorant condition than the Knowledgeable condition. However, since the events themselves are not especially emotive, a neutral reaction may be relatively unsurprising even as a first response, and the effect in the Neutral condition may well be attenuated. The Neutral condition serves primarily as a control to ensure that any change in the predicted direction in infants' looking is driven by the valenced emotional reaction, not merely the shift from ignorance to knowledge. Consistent with previous work suggesting young toddlers' ability to distinguish ignorant and knowledgeable agents (Tomasello & Haberl, 2003; Tomasello & Akhtar, 1995; O'Neill, 1996), we start by testing these predictions with 12-17-month-olds (Experiment 1; pre-registered on the Open Science Framework: https://osf.io/xae5f/?view_only=7b655cac3f744bd3a299591a856301f6). We then run an exploratory experiment (Experiment 2) testing older toddlers: 18-23-month-olds.

Experiment 1

Method

Participants

A pre-registered sample of $N = 48$ 12-17-month-olds (mean: 15.2 months, range: 12.0-17.7 months; 48% girls) were recruited from an urban children's museum. Toddlers were assigned to three emotion conditions (order counterbalanced): positive ($n = 16$, mean: 15.5 months, range: 12.0-17.7 months), negative ($n = 16$, mean: 15.2 months, range: 13.1-17.5 months), and neutral ($n = 16$, mean: 14.9 months, range: 12.1-17.4 months). Twenty-two infants were replaced due to: fussiness ($n = 18$), family interference ($n = 1$), and eyes not visible from videotapes ($n = 3$). While most of the children were white and middle class, a range of ethnicities and socioeconomic backgrounds reflecting the diversity of the local population (47% European American, 24% African American, 9% Asian, 17% Latino, 4% two or more races) and the museum population (29% of museum attendees receive free or discounted admission) were represented throughout.

Stimuli & Procedures

We created two comparable sets of movie stimuli. A female actor and a pink box with a monkey puppet were in one set, and another female actor and a blue box with a tiger puppet were in the other (see Figure 1). All movie stimuli can be downloaded here: https://osf.io/va8xg/?view_only=b36670f1ace54908affecee5b1d11f90.

Toddlers were tested in a dimly-lit room at a children's museum. The child's parent sat in a chair, approximately 63 cm in front of the screen (93 cm wide, 56 cm high), holding the child. A laptop was used to execute the stimulus presentation and was concealed behind the screen. After the parent and child were seated, the experimenter went behind the screen and started the presentation. The experimenter was blind to the epistemic state condition (i.e., Knowledgeable or Ignorant) throughout but could see the child and code her looking time via a webcam mounted on the screen. A multi-colored pinwheel was used as an attention getter and was presented first. Once the child looked at it, the experimenter pressed a button to initiate a trial.

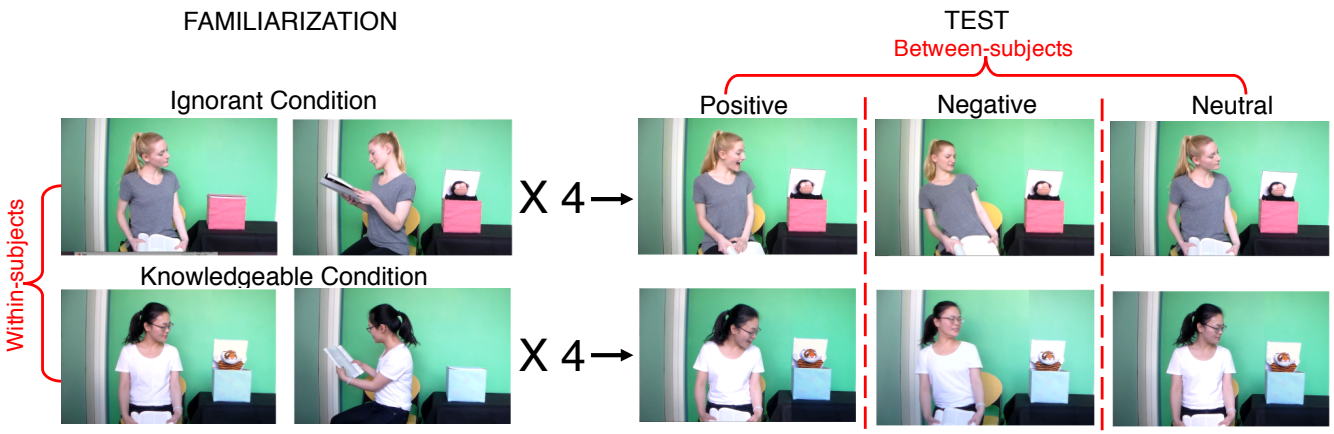

Figure 1 Experimental design

Familiarization Phase An actor appeared on the screen and said: "Hi, baby!" Then the screen turned black and a chime sound was played to get the child's attention. Then the actor reappeared. She sat on a chair holding a book. On her left, there was a box with a lid closed. The actor looked at the child for 2 seconds. Then she turned left, looking at the box for 5 seconds. Then the actor looked back at the child for 2 seconds. Then she turned right, reading the book for 5 seconds. Her expression remained neutral throughout. She repeated this procedure four times. In the meantime, a puppet popped up from inside the box but the timing differed by condition. In the Ignorant condition, the puppet always popped up when the actor was reading the book. Thus, the actor never saw the puppet. In the Knowledgeable condition, the puppet always popped up when the actor was looking at the box. Thus, the actor was familiar with the puppet. See Figure 1. The familiarization phase takes about 70 seconds in total.

Test Phase After familiarization, the screen turned black and a chime sound was played again to get the child's attention. Then the actor reappeared. She looked at the child for 2 seconds. She then turned left, looking at the box. The puppet popped up from inside the box in both the Ignorant and Knowledgeable conditions. In the positive condition, the actor expressed a happy facial expression accompanied by a positive vocalization. In the negative condition, the actor leaned backward and showed a negative face accompanied by a negative vocalization. In the Neutral condition, the actor showed a neutral response, maintaining the same she had during the familiarization phase. See Figure 1. Then the screen froze and the experimenter started to code the child's looking. Once the child looked away for two consecutive seconds, the program automatically moved on to the next trial. Each child participated in an Ignorant condition using one set of stimuli (randomly selected) and a Knowledgeable condition using the other set of stimuli. The order of the conditions was randomized within participants, and the order of the agent's responses (Positive, Negative or Neutral) was counterbalanced across participants.

Coding

A coder, blind to the epistemic state condition (i.e., Ignorant or Knowledgeable), coded infants' looking offline from videotapes. This coding corroborated the experimenter's decision to end a trial in all but three cases; these three children were dropped and replaced due to premature termination of a trial. Only offline coding was used for further analyses. Another coder coded whether each child looked at the agent and the puppet at least once during the Familiarization phase of each trial. All infants passed this criterion. A different coder, blind to the epistemic state condition, coded how attentive children were during the familiarization phase; children were equally attentive to the ignorant (looking time: M = 42.89s, SD = 11.50) and knowledgeable (looking time: M = 43.52s, SD = 10.91; $t(46)$ = -.30, p = .769) familiarization events.

Results and discussion

We pre-registered a mixed-effects model to look at the effects of Epistemic State (Ignorant or Knowledgeable) and Emotion (Positive, Negative or Neutral). The fixed factors were Epistemic State, Emotion and their interaction, and the random factor was Subject. No slope was defined. We used the *lme* function in the R package *nlme*, version 3.1-131. For brevity, throughout the paper we only report the main effects of the fixed factors; detailed summary (e.g., estimated effects, standard errors, *t*s, and *p*s) of our models can be found here: https://osf.io/s2kzx/?view_only=0db2376533974c28b5d48c1886e1d47f. Our mixed-effects model suggests that the main effect of Epistemic State was significant ($F(1, 45) = 9.71$, p = .003). There was a non-significant trend towards a main effect of Emotion ($F(2, 45) = 2.90$, p = .065). Contrary to our predictions however, the interaction between Epistemic State and Emotion was not significant ($F(2, 45) = 1.27$, p = .289).

As pre-registered, we looked at the effect of Epistemic State for each emotion separately. However, there was no significant difference between the Ignorant and Knowledgeable conditions for either the Negative ($t(15)$ = .96, p = 1.000, 95% CI [-2.50, 6.57]; paired-sample t test; p values were corrected with the Bonferroni method throughout) or Neutral test condition ($t(15) = 1.35$, p = .587, 95% CI [-1.97, 8.84]). Also contrary to our predictions, in the Positive condition, infants looked longer in the Ignorant than the Knowledgeable condition ($t(15) = 3.06$, p = .024, 95% CI [2.17, 12.12]).

We then ran an exploratory analysis, using the same mixed-effects model but collapsing across the two valenced conditions (since we predicted no difference between the Positive and Negative conditions). Additionally, because each child participated in both the Ignorant and Knowledge conditions, and some children looked longer overall than others, we analyzed both children's raw looking time and their proportional looking time in each of the two conditions (calculated by dividing their looking time in each condition by their total looking time in both conditions). Again however, for both the raw looking time and the proportional looking time, only the main effect of Epistemic State was significant (raw: $F(1, 46) = 9.42$, $p = .004$; proportional: $F(1, 46) = 7.47$, $p = .009$). The interaction between Epistemic State and Emotion was not significant (raw: $F(1, 46) = .16$, $p = .693$; proportional: $F(1, 46) = .00$, $p = .982$). Nor was the main effect of Emotion (raw: $F(1, 46) = 2.26$, $p = .140$; proportional: $F(1, 46) = .00$, $p = 1.000$). See Figure 2 a.

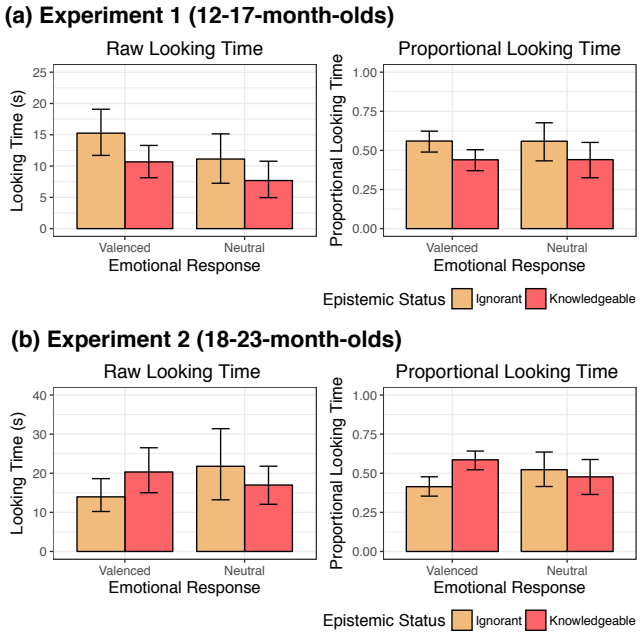

Figure 2. Toddlers' looking time in Experiments 1 and 2. Error bars indicate bootstrapped 95% confidence intervals.

Thus, 12-17-month-olds showed no evidence of understanding that a suddenly expressed emotional expression would be more likely given a previously ignorant agent than a knowledgeable one. Instead, regardless of the agent's emotional response, these toddlers looked longer when a previously ignorant agent noticed something new than when a knowledgeable agent saw something familiar.

These results are consistent with previous work (Vaish & Woodward, 2010) showing that 14-month-olds can use attention but not emotional cues to predict others' actions: they looked longer when an agent reached for an unattended object than an attended one, regardless of whether she previously expressed a positive or negative response to the attended object. As noted however, Scott (2017) suggests that by 20 months, toddlers are sensitive to the relationship between surprise and false belief; so in Experiment 2, we test 18-23-month-olds, to see whether older toddlers connect others' epistemic states to their emotional reactions.

Additionally, we made a minor change on our stimuli. In our original stimuli, the screen turned black after the Familiarization phase (accompanied by a chime sound) and then the agent reappeared for the Test phase. The short black screen may have made it more difficult to construe the events as a continuous sequence and may also have increased the memory demands of our task. To react to the Test phase as predicted, children would have to hold their representations of the familiarization events in mind during this interval. In our new stimuli, we removed the black screen to reduce some task demands. We retained the chime sound to ensure we had children's attention at the beginning of the Test phase.

Experiment 2

Method

Participants

Forty-eight 18-23-month-olds (mean: 20.7 months, range: 18.2-23.8 months; 46% girls) were recruited from the same children's museum. As Experiment 1, they were assigned to three emotion conditions (order counterbalanced): positive ($n = 16$, mean: 20.5 months, range: 18.2-23.7 months), negative ($n = 16$, mean: 20.6 months, range: 18.2-23.8 months) and neutral ($n = 16$, mean: 21.1 months, range: 18.6-23.1 months). Sixteen children were replaced due to: fussiness ($n = 11$), family interference ($n = 3$), distraction ($n = 1$) and not looking at the test events ($n = 1$).

Stimuli & Procedures

The stimuli and procedures were the same as Experiment 1 except for one minor change. We removed the black screen at the beginning of the Test phase to increase continuity between the Familiarization and Test phases. The modified stimuli can be downloaded here: https://osf.io/va8xg/?view_only=b36670f1ace54908affecee5b1d11f90.

Coding

As Experiment 1, a coder, blind to the epistemic state condition, coded infants' looking offline from videotapes. This coding corroborated the experimenter's decision to end a trial in all cases. Only offline coding was used for further analyses. Another coder coded whether each child looked at the agent and the puppet at least once during the familiarization phase of each trial. All infants passed this criterion. A different coder, blind to the epistemic state condition, coded how attentive children were during the familiarization phase; children were equally attentive to the ignorant (looking time: $M = 52.89$s, $SD = 12.49$) and knowledgeable (looking time: $M = 56.46$s, $SD = 13.32$; $t(46) = -1.47$, $p = .149$) familiarization events.

Results and discussion

We used the same mixed-effects model as Experiment 1 to look at the effects of Epistemic State (Ignorant or Knowledgeable) and Emotion (Positive, Negative, and

Neutral). There was no main effect of Epistemic State ($F(1, 45) = 1.01$, $p = .320$) or Emotion ($F(2, 45) = .21$, $p = .812$); nor was there an interaction ($F(2, 45) = 2.33$, $p = .109$).

However, because we did not have different predictions for the positive and negative conditions, we collapsed data across these two valenced conditions. Specifically, we looked at whether there was a significant interaction between Epistemic State (ignorant or knowledge) and Emotion (*valenced* or neutral). For the Valenced conditions, we predicted that children would look longer in the Knowledgeable than the Ignorant condition but for the Neutral condition, we predicted that the effect would be, if anything, reversed. As in Experiment 1, we analyzed both children's raw looking time and their proportional looking time in each of the two conditions.

The older toddlers showed the predicted interaction between Epistemic State and Emotion both considering their raw looking time ($F(1, 46) = 4.05$, $p = .050$) and the proportional looking time ($F(1, 46) = 6.38$, $p = .015$). In the Valenced conditions, there was a marginally significant effect in the predicted direction for the raw looking time ($t(31) = 2.38$, $p = .076$, 95% CI [-12.33, -.39]; paired-sample t tests; p values were corrected with the Bonferroni method throughout), and a significant effect for the proportional looking time ($t(31) = 2.74$, $p = .020$, 95% CI [-.30, -.04]). For the Neutral condition, the Knowledgeable and Ignorant conditions did not differ either by raw ($t(15) = .92$, $p = .748$, 95% CI [-6.37, 15.97]) or proportional looking time ($t(15) = .39$, $p = 1.000$, 95% CI [-.21, .30]).

In sum, collapsing across valence, the results suggest that 18-23-month-old toddlers connect agents' emotions to their epistemic states: toddlers are more likely to expect a new emotional response from a previously ignorant agent than from a knowledgeable one. However, the results are not robust to considering each valenced response separately. Further research must replicate the design and analyses to establish the strength of the effect.

General Discussion

In two experiments, we found that toddlers between 12 and 17 months old were sensitive to an agent's epistemic state: looking longer when an ignorant agent saw something new than when a knowledgeable agent saw something familiar. However, they appeared insensitive to the agent's emotional response to those events (Experiment 1). By contrast, 18-23-month-old toddlers looked longer when a knowledgeable agent had an emotional response to events she had previously viewed neutrally than when a previously ignorant agent changed her expression from neutral to valenced on first observing the event (Experiment 2). Note that this cannot be due to ancillary features of contrast between the Ignorant and Knowledgeable conditions because the pattern did not emerge when the agent's expression remained neutral. These results suggest that at least by the second half of the second year, toddlers have some understanding of the emotional consequences of an agent's epistemic state. They understand that emotional reactions are more likely to novel than familiar events even when they cannot specifically predict anything about the content of the emotion.

This study differs from earlier research showing that infants as young as 12 months expect someone to attend to and be excited by novel rather than familiar objects (Tomasello & Haberl, 2003). In that study, both attentional and emotional cues were available, and infants may have primarily used attentional, not emotional, cues to decide that "Wow! Cool!" referred to the object that was new to the speaker. By contrast, in our study, we separated the effects of attention and emotion by looking at the interaction between the agent's epistemic state and her emotional response. Although the younger toddlers were sensitive only to an agent's epistemic state, there was an interaction between epistemic state and emotion in the older toddlers, suggesting that the emotional cues made a distinct contribution. These results are consistent with other findings suggesting that infants and children have an early understanding of some antecedent causes of others' emotions (e.g., Chiarella & Poulin-Dubois, 2013, 2018; DeLoache & LoBue, 2009; Repacholi & Gopnik, 1997; Reschke et al., 2017; Scott, 2017; Skerry & Spelke, 2014; Wu et al., 2017).

Note that in the positive and negative conditions, the agent expressed both an emotional facial expression and an emotional vocalization to the test event; in the neutral condition however, the agent maintained her neutral face without any vocalization. Thus, the valenced conditions differed from the neutral one both in a change of facial expression and the presence of an emotional vocalization. We are agnostic of whether the facial, vocal or both types of cues drove the effects of our study. However, our data suggest that the older toddlers did not simply responded to the presence or absence of novel emotional cues. That is, they did not look longer overall in the valenced conditions than the neutral condition (see Figure 2 b). Instead, their looking time was influenced jointly by whether the agent expressed novel emotional responses, and whether the agent was ignorant of or knowledgeable about the event, suggesting that the toddlers incorporated the agent's epistemic state in expecting her emotional reactions to events.

Additionally, the interaction between Epistemic State and Emotion became significant in Experiment 2 only when we collapsed across the two valenced conditions (positive and negative conditions). We did not have enough statistical power to analyze the effects in the two valence domains separately. Future work could take a closer look at this as well as replicating our findings. Our current data, however, provides initial evidence that at least by the second half of the second year, toddlers begin to understand that people's emotional reactions depend on what they do or do not know about events. Much work remains to be done to understand how these early abilities develop into the rich, intuitive theory of emotion found in human adults (Skerry & Saxe, 2015; Scherer & Meuleman, 2013; Fontaine et al., 2007; Ortony et al., 1990; Ong et al., 2015; Wu et al., 2018). However, our study begins to shed some light on the early emerging

abilities that may be fundamental to our later-developing sophisticated understanding of emotions.

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