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The Development of Emotion Reasoning in Infancy and Early Childhood

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Abstract

Historically, research characterizing the development of emotion recognition has focused on identifying specific skills and the age periods, or milestones, at which these abilities emerge. However, advances in emotion research raise questions about whether this conceptualization accurately reflects how children learn about, understand, and respond to others' emotions in everyday life. In this review, we propose a developmental framework for the emergence of emotion reasoning—that is, how children develop the ability to make reasonably accurate inferences and predictions about the emotion states of other people. We describe how this framework holds promise for building upon extant research. Our review suggests that use of the term emotion recognition can be misleading and imprecise, with the developmental processes of interest better characterized by the term emotion reasoning. We also highlight how the age at which children succeed on many tasks reflects myriad developmental processes. This new framing of emotional development can open new lines of inquiry about how humans learn to navigate their social worlds.

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INTRODUCTION

For decades, researchers have documented how children first recognize emotions in others. Review papers and introductory textbooks (Berk 2013, LoBue et al. 2019, Ruba & Repacholi 2019, Siegler et al. 2017, Walker-Andrews 1997, Walle & Campos 2012) broadly characterize the emergence of emotion recognition as follows. Between 3 and 7 months of age, infants can discriminate between and categorize different facial configurations (commonly believed to represent discrete emotions such as happy or fear). By 5 to 12 months of age, infants can match facial configurations to corresponding vocalizations (e.g., a smiling face and the sound of laughter). At approximately 1 year, infants engage in social referencing, using adults' emotion reactions to guide their own behavior. Around this time, infants also develop expectations about the types of emotions that will be elicited in certain situations (e.g., failing to complete a goal and anger). From approximately 2 to 3 years of age, children begin to apply verbal labels to emotion stereotypes—mastering vocabulary (in English) such as happy and sad first, and other categories such as disgust several years later (Ridgeway et al. 1985, Widen 2013). Children's understanding of expressive behaviors, emotional causes, appropriate responses, social rules for when and how to display emotions, and the complexities of emotion signaling, such as the ability to intentionally mask emotions (Cole 1986), continues to grow across later childhood and into adulthood. However, advances in emotion research raise questions about whether common conceptualizations, operationalizations, and measurement of these abilities as emotion recognition accurately reflect the developmental processes through which children learn about others' emotions in everyday life (Barrett et al. 2019, Pollak et al. 2019, Ruba & Repacholi 2019).

In this review, we propose a developmental framework for emotion reasoning: the ability to make reasonably accurate inferences and predictions about others' emotions and to organize

appropriate behavioral responses in accordance with those inferences. To highlight how this perspective builds upon and extends extant research, we review the literature, emphasizing how definitions of what is commonly referred to as emotion recognition vary across studies and are dependent upon the approach used to measure children's behavior. Next, we explain how interpretations of data elicited from these methods reflect the guiding theories about the nature of emotion explicitly or implicitly used by researchers, the stimuli selected for a given study, and the type of procedure. We conclude by illustrating how emotion reasoning is an emergent property that results from the integration of numerous developmental processes, each of which matures on a separate, cascading developmental timetable. This perspective represents a shift in focus from establishing when infants and children achieve emotion milestones to determining how they learn and reason about emotion cues.

DEFINING EMOTION REASONING

The literature is replete with a variety of descriptions of children's ability (or lack thereof) to recognize, understand, interpret, identify, perceive, process, discriminate, distinguish, and/or categorize emotions. However, operational definitions of these terms are rare, and when these definitions do exist, they are not applied consistently across studies. For example, many researchers use the term emotion recognition to describe the ability to understand, interpret, infer, read, or perceive another person's feelings. But this term is imprecise. As shown in **Table 1**, emotion recognition has been used to refer to many other related processes as well. These include a child's ability to: (*a*) discriminate, distinguish, or process facial configurations, body postures, or vocalizations as morphologically distinct from one another (e.g., Barrera & Maurer 1981); (*b*) categorize facial configurations as perceptually distinct or as representing distinct internal states in other people (e.g., Bornstein & Arterberry 2003); (*c*) match or associate expressive behaviors across different

Table 1 Example uses of the term emotion recognition in the literature from 1980 to 2020

Reference	Usage
Nelson 1987, p. 897	"Although looking behavior is useful in telling us about discrimination and recognition, it cannot tell us whether infants can derive meaning from facial expression."
Walker-Andrews 1997, p. 437	"Recognition of an emotional expression implies more than detection and discrimination; it involves the person interpreting how someone else will act based on the 'expression' in one's face, voice, and gestures."
Bornstein & Arterberry 2003, pp. 585–86	"Questions pertaining to recognition address whether babies identify a single type of expression, such as a smile, as the same expression despite it being modeled by different people and whether babies identify a person as the same person despite changes in posed facial expression."
Pons et al. 2004, p. 128	"Component I (Recognition). By approximately 3–4 years of age, children start to be able to recognize and name emotions on the basis of expressive cues. For example, most children of this age can recognize and name facial expressions of the basic emotions (happiness, sadness, fear, and anger) when presented as pictures."
Grossmann 2010, p. 219	"At least by the age of 7 months, infants reliably match and recognize emotional information across face and voice."
Barrett et al. 2019, p. 29	"Most of these studies are interpreted as evidence for people's ability to *recognize* or *decode* emotion in facial configurations, on the assumption that the configurations *broadcast* or *signal* emotional information to be recognized or detected. . .A more correct interpretation is that these studies evaluate whether or not people reliably and specifically *infer*, *attribute*, or *judge* emotion in those facial configurations."

THEORETICAL ORIGINS OF EMOTION RECOGNITION

Nearly all developmental studies implicitly endorse classical emotion theories when using the term emotion recognition. Classical emotion theories hold that basic emotions—happiness, sadness, anger, fear, surprise, and disgust—have corresponding universal facial expressions that are easily recognized (Ekman 1994, 2017). Facial displays are thought to be consistent and specific direct readouts of internal emotion states—a scowling person is likely angry, whereas a smiling person is happy. When researchers label stimulus items as representing a specific emotion (i.e., the correct label for a smiling face is happy), this implicitly assumes a one-to-one mapping between expressive behaviors and internal states. Other emotion theories allow for considerable variation in expressions of emotion (Adolphs 2017, Campos et al. 1994) or predict little direct correspondence between outward behaviors and internal emotion states (Barrett 2017, Clore & Ortony 2013, Lutz 1988, Russell 2003). A recent comprehensive review demonstrated that facial expressions lack both consistency (i.e., there is not a single facial configuration for any emotion state) and specificity (i.e., people do not always smile when they are happy) (Barrett et al. 2019). Thus, in reality, there is considerably more variability in how emotions are expressed and interpreted (e.g., a scrunched nose is an expression of disgust, though it is not the only expression of disgust), but this variability is rarely incorporated into research designs in studies of children's development.

modalities (e.g., face, voice, and body) (e.g., Zieber et al. 2014); and (*d*) label or identify facial configurations or other aspects of emotion using common categories in the child's primary language (e.g., Gagnon et al. 2010). All of these disparate processes are assessed similarly—by measuring whether a child responds to a stimulus (e.g., a facial configuration, tone of voice, pictorial scene, or vignette) in a way that is consistent with the researchers' predetermined emotional valuation of the stimulus (e.g., happy is the correct label for a smiling face; a face conveying a smile should be categorized differently from a face with a furrowed brow). In this way, recognition is about responding to the signals conveyed by others and differs from emotion expression or regulation, which typically refers to an individual's own felt or experienced emotion (Hess 2017, Hoehl & Striano 2010a). Of course, part of emotional development also involves reasoning about one's own internal subjective states, but most developmental literature focuses on when children accurately read the cues displayed by others.

The term recognition has been used and applied inconsistently due in part to the overarching theory that has dominated the study of emotion for decades. While many developmental researchers have not explicitly embraced a particular emotion theory and rarely explicitly define what constitutes an emotion within a given study (D'Arms & Samuels 2019, Ruba & Repacholi 2019, Walle & Dahl 2020), nearly all developmental studies implicitly endorse classical emotion theories and use of the term emotion recognition in some way (see the sidebar titled Theoretical Origins of Emotion Recognition).

For this reason, we favor replacing the term emotion recognition with the term emotion reasoning. We define emotion reasoning as the ability to use expressive behaviors and contextual information to make reasonable inferences and predictions about the emotion states and actions of other people and to organize appropriate behavioral responses in light of those inferences.

HOW DO WE MEASURE CHILDREN'S ABILITY TO REASON ABOUT OTHERS' EMOTIONS?

It is difficult to reach firm conclusions about children's emotion reasoning since so many different kinds of approaches have been used by scientists to assess these abilities. Children's emotion

reasoning abilities have been assessed through looking times, event-related potentials (ERPs), behavioral responses, and verbal responses. Here, we briefly describe how each approach measures children's emotion reasoning. In these descriptions, we focus on how each paradigm assesses specific milestone abilities (i.e., purported age at which children reliably succeed at a given task). We also discuss several considerations related to stimuli selection and interpretation of findings. Each of these methods has provided useful information about emotional development, and we suggest new avenues for research to build off of these findings.

Looking-Time Paradigms

Much of the literature on emotion reasoning from birth to approximately 18 months of age uses four variants of looking-time paradigms (Oakes 2010): paired preference, familiarization and habituation, intermodal matching, and violation of expectations (VOE). These methods assess infants' ability to (*a*) discriminate one emotion cue from another, (*b*) categorize cues as perceptually or conceptually distinct, (*c*) match emotion information across expressive modalities (intermodal matching), or (*d*) predict emotion responses to events (event–emotion matching). Common to these approaches is the principle that increases or decreases in infants' visual attention can be used to infer infants' emotion abilities and knowledge.

In paired-preference paradigms, infants are shown two static facial configurations side by side to determine if they can discriminate the stimuli based on perceptual features (e.g., a face with a smile versus a face with a scowl). Results have been interpreted two ways: as a familiarity preference (that infants are more familiar with happy or smiling faces as compared to other facial configurations; see Farroni et al. 2007) or as a novelty preference (that infants are less familiar with facial configurations commonly associated with fear; see Nelson & Dolgin 1985). Little is actually known about the frequency with which specific facial configurations occur in individual infants' environments. Therefore, it is an untested assumption that infant preferential looking is an estimate of the distribution of emotion information in the environment. Furthermore, there are myriad factors that influence preferential looking (see Hunter & Ames 1988, Oakes & Rakison 2019).

Familiarization and habituation paradigms provide more conclusive tests of discrimination, the ability to detect perceptual differences between emotions. In these tasks, infants are presented with a series of facial configurations associated with one emotion (e.g., four different people smiling) (Bornstein & Arterberry 2003, Kotsoni et al. 2001). If infants perceive each stimulus as belonging to the same category (e.g., happiness), their looking times should decrease over the course of habituation, reflecting that they became bored attending to the same category of stimuli. Once infants' looking times drop below a certain threshold (or, in familiarization paradigms, after a fixed number of trials), a new test stimulus is presented. If infants reengage their attention to the test stimulus, researchers infer that infants perceived this new stimulus as categorically different from the one seen during habituation. This interpretation is based upon the principle that infants look longer at items that they find novel (Aslin 2007, Oakes 2010). In paradigms that test discrimination, infants are repeatedly shown facial configurations posed by a single person during habituation and test. In some paradigms that test categorization, the ability to group emotions together as members of the same category, infants are shown either a single person posing different intensities of a facial configuration (e.g., different degrees of smiling) (Bornstein & Arterberry 2003) or the same type of facial configuration (e.g., scowling) posed by multiple people (Ruba et al. 2017). Infants are thought to have formed an emotion category if they treat a novel instance of the category as familiar (e.g., if habituated to four people scowling, infants do not dishabituate to a novel person scowling at test) (Quinn et al. 2011). Based on these methods, discrimination emerges by 5 months

of age (Bornstein & Arterberry 2003; Grossmann 2010; Nelson et al. 1979, 2006), and categorization emerges at approximately 7 months of age (Kestenbaum & Nelson 1990, Ludemann 1991, Safar & Moulson 2017).

Looking-time paradigms also assess emotion reasoning by measuring infants' ability to match emotion information across modalities. In intermodal matching studies, infants are presented with two facial configurations (associated with two different emotions) side by side while a vocalization that matches one of the facial configurations is played. If infants look longer at the facial configuration that is congruent with the vocalization (e.g., a smiling face and a positive tone of voice) as compared to the nonmatching configuration (e.g., a frowning face and a positive tone of voice), this is taken as evidence that the infant matches the similar emotion conveyed across the modalities. Based on these methods, intermodal matching emerges at approximately 5 months of age (Vaillant-Molina et al. 2013, Walker 1982, Walker-Andrews 1986).

Event–emotion matching uses variations of a VOE paradigm (Baillargeon et al. 1985) to test whether infants expect that certain events are associated with particular emotions. Infants are shown a video of an event (e.g., receiving a gift) followed by a person displaying two facial configurations (either unimodally or with a vocalization) (Chiarella & Poulin-Dubois 2013, Hepach & Westermann 2013, Skerry & Spelke 2014). One facial configuration is thought to be congruent (e.g., happiness) and the other incongruent (e.g., anger). If infants have formed expectations between facial configurations and eliciting events, they are expected to look longer at facial configurations that are incongruent or violate infants' expectations (Reschke et al. 2017b, Ruba et al. 2020a). Based on these methods, the ability to match emotions to events develops between 10 and 18 months of age (Ruba et al. 2019, 2020a).

Event-Related-Potential Paradigms

Researchers have examined when infants reason about others' emotion through psychophysiological recordings of brain electrical activity. Most of this research has examined ERPs, although a few recent studies have used functional near-infrared spectroscopy (Grossmann 2015, Krol et al. 2019, Porto et al. 2020, Ravicz et al. 2015). ERPs are averaged recordings of electrical signals from the scalp, which represent the synchronous firing of neurons in response to a stimulus. This method is typically used with infants at or around 7 months of age (for a summary table, see van den Boomen et al. 2019) because ERPs are sensitive to head and eye movement, and infants at this age are less mobile than older infants. In these paradigms, infants observe multiple brief (less than 1,000 ms) presentations of static facial configurations associated with different emotions while neural activity is recorded. If infants show a different pattern of neural activity when viewing one type of facial configuration (e.g., a happy smiling face) compared to another facial configuration (e.g., a fearful face with wide eyes), it is assumed that infants discriminate between the emotions on a neural level (Kobiella et al. 2008).

Infant ERP studies have primarily focused on three patterns of neural activity. The N290 and P400 are thought to be related to the processing of faces (i.e., as precursors to the adult N170) (Rigato et al. 2010), and the Nc is thought to relate to increased allocation of attention (de Haan et al. 2003). Researchers have used these patterns to make inferences about cognitive processes underlying infants' discrimination. For example, infants show a greater Nc response to pictures of facial configurations with wide eyes compared to pictures of smiling faces (Peltola et al. 2008, 2009), which researchers have suggested reflects greater allocation of attention to facial configurations associated with fear or threat signaling (Leppänen & Nelson 2012). Based on these methods, the ability to discriminate facial configurations emerges by 5 months of age (Jessen & Grossmann 2015, Taylor-Colls & Pasco Fearon 2015, van den Boomen et al. 2019), and a fear bias emerges at approximately 7 months of age (Leppänen & Nelson 2012, Peltola et al. 2013, Xie et al. 2019).

Behavioral-Response Paradigms

Paradigms that require infants to manipulate objects, select objects, or provide similar motoric responses have been used to measure emotion reasoning with infants 10 months of age and older. Many of these paradigms test social referencing, which is the ability to use another person's emotion to guide the child's own behavior (Campos & Stenberg 1981). In these paradigms, an experimenter or caregiver displays an emotion (typically via the face and voice) in response to a novel object (e.g., a moving, noise-making toy robot). Other novel stimuli have included live animals (Hornik & Gunnar 1988), human strangers (Feinman & Lewis 1983), and the visual cliff apparatus (Sorce et al. 1985). Several infant responses have been measured, including approach (e.g., latency to touch the object), contact (e.g., duration of touch), and affect (e.g., facial or vocal expressions in the presence of the object). Researchers reason that if infants approach the novel object linked to a positive emotion while avoiding the object linked to a negative emotion, then infants appreciate something about the communicative value of those emotions (e.g., happiness indicates lack of threat, disgust indicates that an object should be avoided). Based on these methods, social referencing emerges at approximately 12 months of age (Carver & Vaccaro 2007, Slaughter & McConnell 2003, Vaish et al. 2008).

Verbal-Response Paradigms

Most studies that assess emotion reasoning with children 2 to 3 years and older use paradigms that require children to provide some type of verbal response (Dashiell 1927). Variations of verbal-response paradigms measure two different classes of abilities. The first are paradigms that assess children's understanding of emotional causes or consequences. Here, children are provided with an emotion label (e.g., happy), a description of an emotional behavior (e.g., "Danny jumped up and down and clapped his hands"), or a picture of a facial configuration (e.g., a smiling face). The child is then asked to verbally describe the emotional cause or consequence of the stimulus (Russell & Widen 2002b; Widen & Russell 2004, 2010b). Note that with this method, the researcher has predetermined the correct responses that are probabilistically frequent but not always true (e.g., people are happy when they receive gifts; when people are happy, they smile; when people are smiling, they are happy). If children provide responses that align with the emotion stereotypes of the researcher, then it is concluded that children understand the causes or consequences of the tested emotion.

In a second variant of this paradigm, researchers present children with pictures of facial configurations and ask them to (*a*) provide a verbal label for each configuration (free label) or (*b*) select a label from a list to describe each configuration (forced choice) (Widen & Russell 2003, 2010b). Children may also be asked to label a description of an emotional cause (e.g., "Danny's friends came to his party and gave him some nice presents") or a behavioral consequence (e.g., "Something made Danny jump up and down and clap his hands") (Widen & Russell 2004, 2011). In variations that reduce some of these verbal demands, children either (*a*) select a target facial configuration from an array when given a label (e.g., "Which one is happy?"), (*b*) respond yes or no to whether a facial configuration displays a target emotion (e.g., "Does this person feel angry?") (Widen & Russell 2008), or (*c*) sort pictures of facial configurations into boxes marked by an emotion label (e.g., "Only happy people go in this box") or a target facial configuration (e.g., a smiling face) (Russell & Widen 2002a, Widen & Russell 2008). Children's responses are marked as correct or incorrect depending on whether their interpretations align with the researcher's stereotype of how emotions ought to be labeled. Based on these methods, the ability to describe emotional causes or consequences and label pictures of facial configurations develops gradually starting at approximately 2 to 3 years of age (Widen 2013).

Emotion-Reasoning Paradigms: Past and Future

The methods described above have generated the research base for the field and created a rough developmental timetable for when children discriminate, categorize, respond to, and label different emotions. Yet to advance knowledge of emotional development, several issues need to be addressed regarding the stimuli and procedures commonly used to measure emotion reasoning. Below, we address these issues and offer suggestions for future research.

Stimuli selection and the ontological status of emotions. Ultimately, measuring children's abilities to discriminate, categorize, respond to, and label stimuli is a valid index of emotion reasoning only if those stimuli truly signal discrete internal emotion states. Since facial configurations do not always communicate distinct emotion episodes (Barrett et al. 2019), measuring a child's ability to discriminate, categorize, respond to, and label these stimuli may not be indicative of their emotion reasoning in everyday life. This is not to say that facial configurations are meaningless or random; they are simply more dependent on context, less consistent, and less specific than researchers have previously believed. Classic methods of measuring emotions have four limitations that can be addressed to move the field forward.

First, most sets of emotion stimuli represent only a small and stereotyped sampling of the emotion information that children encounter in the world. Developmental researchers have long acknowledged the limited ecological validity of two-dimensional, posed, static faces presented without background context. These stimuli are exaggerated caricatures of emotions that are comparatively easier to label and categorize (Goldstone et al. 2003) and do not capture the extremely wide variation in how humans actually express emotions (Barrett et al. 2019). Stimuli also reflect peak, full-intensity emotion displays that are infrequent in human interactions (Leitzke et al. 2020, Pollak et al. 2009). In addition, most emotion reasoning studies rely on only a single channel of information: the face. However, the psychological meaning of facial configurations depends on a multisensory context. Additional critical information comes from body posture, tone of voice, and the situation or context in which the emotion communication occurs (Aviezer et al. 2008, De Gelder et al. 2004, Meeren et al. 2005). Indeed, compared to adults, children devote even greater attention to contextual information in making emotion judgments, actively cross-referencing facial and contextual cues (Leitzke & Pollak 2016). Thus, researchers must examine emotions that are expressed multimodally and in context to fully determine how children come to reason about emotions in others.

Second, children are often asked to judge emotion in facial configurations that are posed by actors who are not authentically expressing the targeted emotion. Instead, actors are directed to move their faces in certain ways or to create stereotypes of common emotion ideas (e.g., "Make yourself look sad"). These actors are likely not in the targeted emotion state (e.g., sadness) when the photo was taken and, thus, do not show the range of signals accompanied by that emotion state. In other words, the actor might not look as they really would if something truly sad had happened. If such an event did occur, it is unlikely that the actor would feel only a single emotion or express that single emotion in an intense, exaggerated fashion. As a consequence, studies that use posed expressions may not generalize to how children infer emotion from facial movements in everyday life. Further, if there is no underlying emotion in these posed expressions, it may not be possible to determine whether participants are providing accurate responses. Studies cannot be improved simply by using photographs of spontaneous emotions. In fact, when participants are asked to judge spontaneous faces in the absence of any context, agreement scores plummet, as compared to those seen for posed expressions (Kayyal & Russell 2013, Naab & Russell 2007). In real life, children are engaging in something more than reasoning about emotion information

displayed on a face alone; they are incorporating context to make meaning of emotion cues. A fruitful next step is to measure aspects of children's emotion reasoning above and beyond their ability to accurately infer emotion from stereotyped facial configurations.

Third, nearly all studies of children's emotion reasoning have tested a limited range of possible human emotions—typically happiness, sadness, anger, surprise, fear, and disgust. These are stereotypes that fail to capture the range of how people spontaneously move their faces, gesture, and vocalize to express emotion. Although there has been considerable debate about how many emotions exist and what the criteria are for deciding what is and is not an emotion (Ortony & Turner 1990), recent research suggests that there are many more emotions that are experienced and perceived than have been studied in the laboratory (Cordaro et al. 2018, 2020; Cowen & Keltner 2017; Srinivasan & Martinez 2018). Researchers who study emotion often hold a broader view of emotion categories, but in practice, most studies fall back on a simplified, classical view by using stimuli that represent only six or so basic categories. These studies also conceptualize emotions as easily differentiable categories, although most human events elicit a range of fluctuating feeling states. Nearly all cross-cultural studies of children's emotion reasoning have focused on this small set of emotions. Future research should examine a wider range of emotions, including emotions that do not correspond to stereotyped facial configurations (e.g., amusement or sympathy; see Wu et al. 2017), as well as how children perceive more realistic, spontaneous emotions.

Fourth, most studies with infants (i.e., age 2 years and younger) compare a facial configuration from a positive emotion category (e.g., happiness) to a facial configuration from a negative emotion category (e.g., sad). This creates a confound in that the stimuli not only reflect different emotion categories, but also differ in other properties, such as valence and arousal. For this reason, most studies cannot distinguish whether differences that emerge between stimuli reflect infants' reasoning about specific emotion categories (e.g., happy versus sad), reasoning about valence (e.g., positive versus negative or approach versus withdrawal), or reasoning about arousal (e.g., high versus low intensity) (Ruba et al. 2017, 2019). This has led to interpretive disagreements regarding the basis of infants' developing emotion understanding (Ruba & Repacholi 2019). Depending on the research question of interest, future studies might consider whether matching emotion stimuli based on affective dimensions (i.e., valence and arousal) is necessary to reveal the processes by which infants reason about emotions in others.

Alternative interpretations of extant paradigms. The creative paradigms designed to measure emotion reasoning have created a deep knowledge base about component skills involved in the emergence of human emotion capacities. This leaves the field poised to begin posing a next generation of questions. We are now confronted with the challenge that children need not engage in emotion reasoning per se to successfully discriminate or categorize facial or vocal stimuli. Below, we review what we have learned from the paradigms commonly used in the field and propose ways in which alternative interpretations of existing data can stimulate future research about the ontogenesis of emotion (for similar arguments about theory of mind tasks, see Quesque & Rossetti 2020).

Looking-time and event-related-potential paradigms. Researchers have long debated whether measures of infant visual attention can be interpreted as reflecting complex cognitive processes beyond simple perceptual discrimination (Aslin 2007, Madole & Oakes 1999). This range of rich versus lean interpretations is well represented in the literature on emotion reasoning. Researchers have concluded that shifts in infants' visual attention either (*a*) reflect deep knowledge about infants' ability to infer emotional meaning in stimuli or (*b*) indicate awareness that perceptual properties of a stimulus have changed (Quinn et al. 2011). We agree with the latter interpretation

and argue that infants need not appreciate the conceptual meaning of emotions to discriminate or categorize facial configurations. Discrimination and categorization studies likely measure basic perceptual and cognitive processes rather than an infant's reasoning about others' emotions (Ruba et al. 2017, Ruba & Repacholi 2019). For example, stereotypical facial configurations associated with happiness have upturned smiles, whereas stereotypical facial configurations associated with fear have wide eyes (Ekman & Friesen 1975). In some studies, infants could be discriminating between stimuli on the basis of salient perceptual features (e.g., eyes or teeth), rather than of affective meaning (Caron et al. 1985, Ruba et al. 2020b).

Data from intermodal-matching paradigms are less likely to be accounted for by simple perceptual discrimination (Walker-Andrews 1997). Many researchers have concluded that infants look significantly longer at matching videos (i.e., a happy body when a happy voice is playing) compared to nonmatching videos (i.e., an angry body when a happy voice is playing), because they recognize emotions across these modalities (Heck et al. 2018, Walker-Andrews 1997). However, it is also possible that infants' looking times reflect memory for learned associations between these expressive cues rather than an appreciation of emotional meaning (Grossmann et al. 2006). Infants could succeed in these tasks by learning that certain facial configurations (e.g., a smile) and certain vocalizations (e.g., laughter) tend to co-occur in the environment.

Similarly, infants' neural responses to different facial configurations in ERP paradigms are sometimes interpreted as an appreciation of an emotion's signal value. Several researchers have concluded that infants show increased Nc activity in response to scowls and faces with wide eyes because infants understand the threat-related signaling of anger and fear (Hoehl & Striano 2008, Leppänen 2011, Peltola et al. 2008). These interpretations may well be correct. However, it is also plausible that these facial configurations are relatively novel for infants. Typically developing children are unlikely to encounter and be familiar with faces that have scowls or wide eyes (Camras & Sachs 1991, Malatesta & Haviland 1982, Rosen et al. 1992). Given that infants may seldom see many negative facial configurations in their environment, increased allocation of attention to these stimuli may reflect a novelty bias. In this case, differences in neural activity may reflect lower-level attentional biases rather than any conceptual understanding of or reaction to threat.

Verbal-response paradigms. In contrast to looking-time and ERP data, verbal responses appear to be a more straightforward way to assess children's emotion reasoning. However, a child generating an emotion label (e.g., happy) for a posed image of a smiling face is consistent with numerous other interpretations. Specifically, these tasks might actually reflect a child's awareness of emotion stereotypes—that is, culturally scripted correlates or caricatures of emotions. This knowledge is informative and predicts children's social and academic competencies (Izard et al. 2001), but it does not necessarily indicate that a child can make an accurate assessment about what another person is feeling.

Future research can build upon these emotion labeling procedures by increasing the specificity of these methods. First, forced-choice response tasks may inadvertently influence children's performance (Russell 1994, Widen 2013). For example, a child might hear a vignette such as "One day, Danny built a block tower. But then another kid came and knocked Danny's tower down on purpose. How does Danny feel?" (Widen & Russell 2011). Children are asked to select a response from a list containing labels or from images of stereotypical facial configurations. These designs place artificial constraints on how children can interpret emotions; they must select a response that the researcher has provided and determined is correct (in this case, anger). Children are unable to judge a face as expressing a nonlisted emotion category (e.g., frustrated or hopeless), nonemotional mental state (e.g., rejection, avoidance, or fatigue), or physical experience (e.g., pain). It also

prevents a combined response, such as if the child believes Danny simultaneously feels angry, sad, frustrated, and tired.

Another issue is that the listed words in verbal response tasks may also teach children the researchers' expected answers. This might occur through a process of elimination, whereby children more frequently select words that are not chosen on prior trials (Nelson et al. 2018; Nelson & Russell 2016a,b). This might also occur during practice trials. Although intended to ensure that children understand a task, practice trials may also train children to adopt the emotion stereotypes or assumptions held by the researchers and what types of emotion answers are expected in the task. Further, the simple presence of language in these tasks also influences children's responses. Children more easily match a facial configuration (e.g., a scowling face) to an emotion word (e.g., angry) than to another facial configuration (e.g., another scowling face) (Russell & Widen 2002a,b; Widen & Russell 2004, 2010a). Thus, labeling tasks may implicitly teach children how the researchers themselves interpret the stimuli rather than measure the child's own interpretations of these facial configurations.

Reorienting from age-based milestones to mechanisms of developmental change. While much research has documented when various emotion reasoning–related abilities emerge, there has been little progress in understanding how emotion reasoning develops. Historically, studies have used a specific methodology (e.g., looking time) during a narrow age period (e.g., 5 months) to examine the existence of an ability related to emotion reasoning (e.g., discrimination). However, no single ability is itself sufficient to claim a child can adaptively reason about emotion. Ultimately, a conceptualization of emotion reasoning as comprising specific milestone abilities that emerge at certain ages is limited in its capacity to describe developmental change (Woodard & Pollak 2020). In the next section, we discuss how examining other developmental processes can provide a new framework for studying the development of emotion reasoning.

DEVELOPMENTAL PROCESSES INVOLVED IN EMOTION REASONING

According to a developmental cascades perspective (Oakes & Rakison 2019), every aspect of development, such as language learning or category formation, is the result of interrelated cascading processes. This is likely also true for emotion (Hoemann et al. 2020b). For example, the ability to detect and attend to a person's facial, vocal, or bodily gestures requires sensory maturity and developed attentional processes. To consider causes or explanations for a person's emotion requires working memory for the current emotion context, long-term memory of past experience with emotions and eliciting events, and an ability to make predictions and inferences about the future. Generating a response to another person's emotion requires various motoric abilities and, potentially, inhibitory control to halt a prepotent response. The ability to verbally label expressive behaviors and talk about emotional situations requires the ability to speak and knowledge of emotion labels. Further, earlier-developing processes, such as visual attention, build the foundation for later-emerging processes like emotion labeling. Integrating these developmental processes is essential to determining how emotion reasoning develops in infancy and early childhood. In this section, we examine how these processes develop and are recruited by emotion reasoning tasks.

Sensory Maturity

Early in development, infants' visual systems are immature. Newborns have poor contrast sensitivity and thus can detect only patterns of high-contrast elements (Atkinson et al. 1977, Banks & Salapatek 1978). In addition, newborns have poor visual acuity, measured by the ability to see fine

details (Atkinson & Braddick 1983), and poor smooth-pursuit tracking, measured by the ability to track visual stimuli with smooth eye movements (Von Hofsten & Rosander 1997). Contrast sensitivity, visual acuity, and smooth-pursuit tracking all develop rapidly in the first 3 to 4 months (Atkinson & Braddick 1983, Leat et al. 2009, Richards & Holley 1999). Further, infants do not have the same level of color vision as adults before 3 months of age (Adams & Courage 1995). Yet, facial coloration is a cue that disambiguates facial configurations associated with different emotions (Thorstenson et al. 2018). Thus, in the first few months of life, infants may not have access to the necessary visual information that conveys emotion (Nelson 1987). Compared to the visual system, infants' auditory systems are more mature at birth, as much development occurs prenatally (DeCasper & Fifer 1980, Graven & Browne 2008, Werner 2002). For this reason, young infants may have less access to visual emotion information compared to other types of emotion information (Vaish & Striano 2004; Waters et al. 2014, 2017). These developing sensory capacities influence whether infants in the first few months of life perceive sufficient information to reason about others' emotions, particularly from facial cues.

Attention

Attention has many components, each with its own maturational timetable. Here, we describe some of the (nonexhaustive) ways in which attentional development influences emotion reasoning. From birth, infants have a bias to attend to faces and face-like stimuli (Johnson et al. 1991, Morton & Johnson 1991). This face preference is unstable over the first months of life before it increases over the next 2 years (Di Giorgio et al. 2012; Frank et al. 2009, 2012, 2014; Johnson et al. 1991; Libertus & Needham 2011) and into adulthood (Amso et al. 2014, Leitzke & Pollak 2016). With increasing age, children also show greater looking to hands (Aslin 2009, Fausey et al. 2016, Frank et al. 2012, Yoshida & Smith 2008), which may be related to changing motor skills and/or a growing appreciation of actions.

With respect to faces specifically, there are developmental differences in how children attend to different facial features. While newborn infants rarely scan faces (Haith et al. 1977), 4-month-olds scan internal and external facial features (Caron et al. 1973), which are typically involved in conveying emotion. By 7 months of age, infants show holistic processing of faces (Cohen & Cashon 2001, Oakes & Ellis 2013). In addition, infants show attentional biases to certain facial features. As infants develop, they shift from focusing on the eyes of faces to the mouths, particularly when people are talking and smiling (Frank et al. 2012, Oakes & Ellis 2013). Children also demonstrate attentional preferences for some facial configurations over others (Quinn et al. 2011), particularly for those associated with fear. This "fear bias" is absent at 3 months of age, emerges at approximately 7 months, and decreases thereafter (Grossmann & Jessen 2017, Leppänen & Nelson 2012, Leppänen et al. 2018, Peltola et al. 2013, Xie et al. 2019). The fear bias intersects with a general negativity bias, which appears during the middle of the first year of life (Vaish et al. 2008). Taken together, the ability to orient and attend to different aspects of expressive behaviors, particularly the face, influences whether a child has perceived sufficient information to reason about others' emotions.

Memory

While there are evolving views about how memory is structured, we describe the following processes based on commonly held views. Working memory, or the ability to maintain and manipulate information over brief periods of time without reliance on external aids or cues (Best & Miller 2010), is also present early in development. Infants' visual short-term memory capacity increases over the first year of life (Rose et al. 2001, Ross-Sheehy et al. 2003) and continues to improve over

the preschool years (Garon et al. 2008). However, the ability to combine working memory and a motoric response (e.g., reaching for hidden objects) may have a more protracted developmental course (Nelson 1995). Similarly, long-term memory also undergoes developmental changes throughout the first few years of life (Bauer et al. 2000), although even infants demonstrate a capacity for long-term memory (Meltzoff 1988, Rovee-Collier 1999). Long-term memory enables children to compare currently observed emotions and situations with previously experienced emotion instances. For example, children from families with a history of physical abuse have a bias to categorize facial configurations as angry, likely due to the recalled prevalence of these faces in their environments (Pollak & Kistler 2002, Pollak & Sinha 2002). Likewise, infants' familiarity preferences for facial configurations associated with happiness and novelty preferences for facial configurations associated with fear are perhaps due to the presence and absence, respectively, of similar facial configurations in their environments (Malatesta et al. 1989, Malatesta & Haviland 1982). This type of contextual comparison is thought to be fundamental to how emotions are perceived (Barrett 2017). In all, both working and long-term memory influence whether and how children reason about others' emotions in their present environments.

Predictions and Inferences

In our view, the crux of emotion reasoning is the ability to make an inference about how another person is feeling (i.e., the cause of another person's internal state) and/or make a prediction about how that person is likely to act. Engaging in this type of reasoning is a complex process that often requires, in addition to the abilities described above, some understanding of intentions, desires, and/or beliefs (Reschke et al. 2017a). An understanding of each of these mental states emerges at a different developmental period. In the first year of life, infants develop an understanding of others' goal-directed actions (Ruba et al. 2020a, Skerry & Spelke 2014, Woodward 1998), which facilitates an understanding of others' intentions (Meltzoff 1995) and desires (Repacholi & Gopnik 1997) by 18 months of age. In the second year of life, children also engage in perspective taking—appreciating that others' visual and mental perspectives may differ from those of the child (Denham 1986, Moll & Tomasello 2006, Wellman et al. 2000). However, children's ability to understand others' beliefs does not emerge until later in development. At approximately 3 years of age, children begin to appreciate that a person's beliefs impact behavior (Wellman & Woolley 1990, Wellman et al. 2001). It is not until 4 years of age that children start to understand that false beliefs can also guide people's actions, although infants may have some earlier implicit understanding as well (Keen 2003, Onishi & Baillargeon 2005). Thus, in order to infer or predict another person's emotion, a child needs (*a*) some understanding of desires, intentions, and beliefs (which may be acquired through associative learning or via theory of mind) and (*b*) sufficient experience upon which to base their inferences and predictions.

Reaching, Crawling, and Walking

Marked behavioral and social changes occur alongside motor development in the first 2 years of life. For example, reaching (between 3 and 5 months of age) increases infants' preference for faces (Libertus & Needham 2011, 2014). Through reaching experiences, infants may learn to understand themselves and others as agents who act on the world. Crawling (at approximately 6 to 8 months of age) provides infants the opportunity to move toward or away from objects, people, and situations (Adolph et al. 2007), which could further enrich their understanding of emotions (Campos et al. 2000). While infants in the first months of life seldom observe negative emotions (Malatesta & Haviland 1982, Malatesta et al. 1989), parents of locomoting infants increasingly express anger as they attempt to control their infant's behavior (Campos et al. 1992). In return,

infants express negative affect when these goals are blocked. Compared to crawling, walking (at approximately 12 to 19 months of age) further changes the types of social interactions that infants have with other people (Adolph et al. 2012). Walking infants engage in more active bids for social interaction (Clearfield et al. 2008, Karasik et al. 2011). Further, mothers of walkers are more likely to provide action directives (e.g., "Put it there"), are less praising of infant behavior, and engage in more repeated attempts to stop forbidden actions (Biringen et al. 1995, Karasik et al. 2014). Taken together, the behavioral and social changes that occur alongside motor milestones provide children with environmental experiences that may influence emotion reasoning development.

In responding to another person's emotions, children also need to organize and potentially inhibit their own motoric behavior. Inhibitory control, the ability to inhibit responses to irrelevant stimuli while pursuing a goal, develops in the first 6 years of life, with marked improvements between 3 and 6 years alongside maturation of the frontal lobe (Diamond & Taylor 1996). With respect to emotions, infants as young as 15 months display inhibitory control of their motor behavior (e.g., not engaging in actions forbidden by a seemingly angry experimenter), although there is individual variability in this behavior (Repacholi et al. 2016a,b). Thus, children often demonstrate the ability to reason about others' emotions in part by utilizing some degree of inhibitory control.

Word Learning

Children begin producing emotion words in infancy at approximately 18 months of age (Bretherton et al. 1986, Ridgeway et al. 1985), although a small number of children may receptively understand some emotion words before this time (Ruba et al. 2020a). Emotion words enter children's vocabularies in a systematic fashion, with happy and sad as the first emotion words learned and words such as disgust learned much later (Widen 2013). With increasing age, children's ability to learn emotion words improves (Shablack et al. 2019), and children are also provided with more support with emotion word learning. Specifically, parents give more explanations and ask more questions to their children across the second year of life, a process that may facilitate emotion vocabulary development (Brownell et al. 2013, Dunn et al. 1987, Fletcher & Reese 2005, Sénéchal et al. 1995).

Further, emotion words are not psychologically inert—they shape how emotions are inferred (Doyle & Lindquist 2018; Fugate et al. 2010, 2018; Gendron et al. 2012; Ruba et al. 2018). In general, labels shape how categories are learned (Gelman & Waxman 2010, Lupyan et al. 2007). With respect to emotions, it is hypothesized that the process of learning emotion labels restructures emotion from broad concepts based on affect (i.e., positive versus negative) to more narrow concepts based on discrete emotions (e.g., happy versus angry) (Barrett 2017, Lindquist & Gendron 2013, Widen 2013; but see Ruba & Repacholi 2019; Ruba et al. 2019, 2020b). In this way, children's acquisition of emotion labels may be fundamental to their perception and understanding of emotions (Hoemann et al. 2019, 2020a,b; Ruba et al. 2020b).

RECONSIDERING THE ROLE OF DEVELOPMENT IN EMOTION REASONING

Traditionally, emotional development is described in terms of age-related milestones. If we focus on when certain emotion-related behaviors emerge, then discrimination, categorization, and intermodal matching of emotions emerge in the first year of life; event–emotion matching and social referencing emerge in the second year of life; and the ability to label and talk about emotions emerges by the third year of life. However, it remains unclear whether measurements of a child's ability to discriminate, categorize, and label pictures of stereotyped facial configurations

INFERENCES ABOUT EMOTIONS RELY UPON MANY ABILITIES

When people emote, they engage in biological motion; therefore, a child must discern a perceptual boundary for when an emotion signal begins and ends. The child must also detect and attend to the relevant emotion cues in their environment and then discriminate these cues from other environmental features (e.g., distinguish a scowl from a sneer from a smile). The child must then categorize the cues as an emotionally relevant pattern, distinguishing relevant cues from other bodily movements that are emotionally irrelevant. This requires the child to remember and link percepts, binding together related features—for example, the sound and appearance of a cry, an open mouth, widened eyes, shouting, and awareness that an unexpected event has just occurred—to infer someone else's emotion state. Because no single feature consistently maps onto an emotion construct, the child must also maintain flexibility in how features are categorized; for example, although upset shouting people often have open mouths, sometimes upset people purse their lips together. Once a child has inferred and perhaps labeled the person's emotion state, the child must make a prediction about another person's behavior to determine how to respond. This final step requires the child to reason that a particular emotion state caused, resulted from, or is a correlate of perceived cues or actions. Thus, emotion inferences about another person's emotion state require integration of multiple abilities.

support rich conclusions about children's ability to reason about emotion cues. Further, each of these milestones is necessary, but not sufficient, to claim that a child can reason about others' emotions. Ultimately, a deeper consideration of developmental processes, experimental methodology, and the ontological status of emotions is necessary to determine when and how emotion reasoning develops (see the sidebar titled Inferences About Emotions Rely upon Many Abilities).

Emotional development milestones are contingent upon the maturation of other developmental abilities across the first few years of life (see **Figure 1**). For instance, discrimination abilities are inconsistent prior to 4 months of age (e.g., Farroni et al. 2007, Young-Browne et al. 1977), possibly due to developing visual acuity and contrast sensitivity abilities (Nelson 1987). Similarly, increases in visual short-term-memory capacity (Rose et al. 2001, Ross-Sheehy et al. 2003) may explain why categorization abilities are not reliable prior to 7 months of age (e.g., Caron et al. 1985, Lee et al. 2015). Intermodal matching, which is also inconsistent prior to 5 months of age (Kahana-Kalman & Walker-Andrews 2001), is tied to memory for (and experience with) learned associations between facial configurations and vocalizations (Grossmann et al. 2006). Further, the development of all of these abilities may also be related to increasing attentional preferences for faces across the first year of life (Di Giorgio et al. 2012, Frank et al. 2014). Event–emotion matching develops between 10 and 18 months of age (Ruba et al. 2019, 2020a), possibly because infants are concurrently developing an understanding of others' goals, intentions, and desires (Meltzoff 1995, Repacholi & Gopnik 1997, Woodward 1998). Such knowledge is necessary to form predictions and inferences about another person's emotional response. This may partly explain why, in general, infants younger than 10 months do not engage in social referencing (Slaughter & McConnell 2003, Walden & Baxter 1989, Walden & Ogan 1988; but see Vaillant-Molina & Bahrick 2012). These young infants who are not yet crawling or walking may also lack the ability to organize (and/or inhibit) a motoric response to another person's emotion. In ERP studies that remove these motoric demands, infants as young as 3 months appear to engage in a type of social referencing (Carver & Vaccaro 2007, Hoehl et al. 2008, Hoehl & Striano 2010b). Finally, children's abilities to label emotions are directly related to the presence of these words in their vocabulary. Given that language, and emotion labels specifically, emerges in the second year of life (Ridgeway et al. 1985), it is perhaps unsurprising that performance in verbal response tasks is tenuous prior to 3 years of age (Widen 2013).

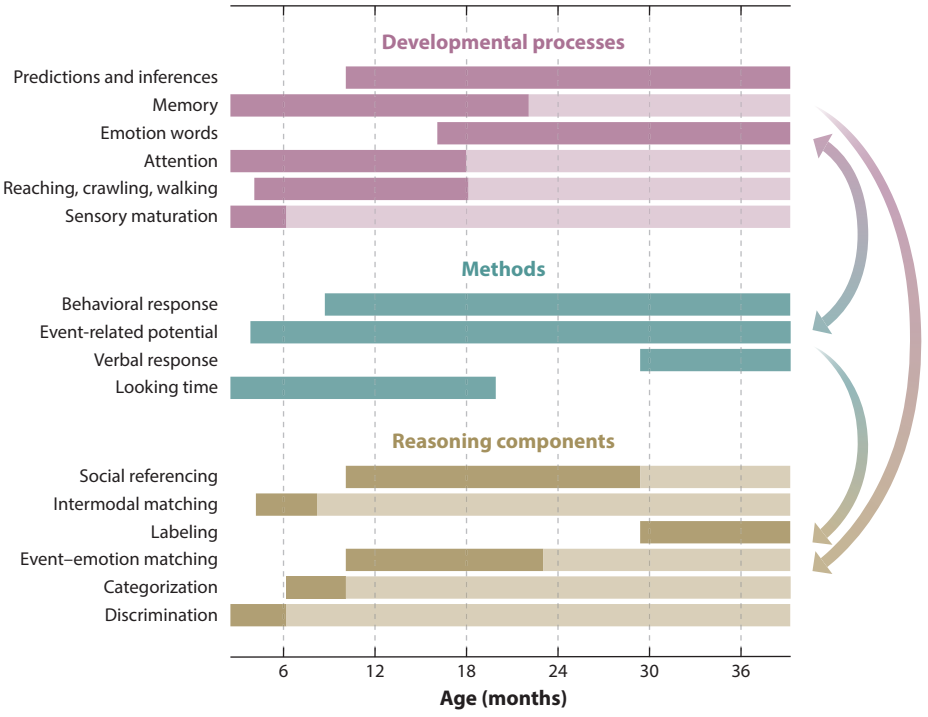

Figure 1

Conceptual framework for designing and interpreting developmental research on emotion reasoning. The emergence of various emotion reasoning components (i.e., milestone abilities) depends upon experimental methodology and the cascading development of other processes, which all vary as a function of child age (in months). For developmental processes (*purple*), darker bars indicate periods of rapid development; lighter bars represent periods in which development may still be occurring. In reasoning components (*brown*), darker bars indicate when the ability is primarily tested; lighter bars indicate that these abilities develop over time as well.

In addition, different kinds of tasks place differing demands on these developmental abilities. Looking-time and ERP paradigms are reliant on infant sensory, attentional, and memory development; maturation of each of these capacities influences whether infants are able to reason about others' emotions. Habituation procedures that test discrimination and categorization require that infants detect, attend to, and remember facial configurations in order to differentiate these from novel facial configurations at test. Studies of intermodal matching further require that infants recall associations between facial configurations and vocalizations in their home environments. As paradigm complexity increases, children need to possess additional abilities in order to succeed. Children must not only detect, attend, and remember emotion information, but also make predictions and inferences, organize a motor response, and/or label stimuli. For example, looking-time paradigms that assess event–emotion matching require infants to predict or infer how a person feels in an emotional situation. In behavioral-response paradigms that assess social referencing, children need not only to make predictions and inferences about another person's emotion, but also to behaviorally respond (perhaps inhibiting a prepotent response). Finally, verbal-response paradigms often require children to label an emotion (e.g., labeling paradigms) in addition to potentially forming predictions and inferences (e.g., story paradigms). In sum, paradigms that assess emotion reasoning differ not only in their outward structure and dependent variables, but also in the developmental abilities needed to succeed at the task.

Finally, nearly all evidence for children's abilities to reason about emotions is predicated on the assumption that facial configurations (e.g., smiling) signal a specific emotion to be recognized or detected (e.g., happy). This assumption about the relationship between the stimuli used in a study as a reflection of human emotion confuses what is known with what is being tested. A more accurate interpretation is that these studies indicate whether children reliably and specifically infer or judge a particular emotion in facial configurations (Barrett et al. 2019). This confusion in the scientific literature—and the reification of emotion categories such as happy or angry as invariable structures that exist in the natural world—may explain why very few studies have actually investigated the processes by which children learn to reason about emotion states from cues in their environments. Together, these considerations reframe what emotion reasoning milestones might truly reflect and potential next steps for understanding the ontogenesis of children's ability to reason about emotion.

CONCLUSIONS AND FUTURE DIRECTIONS

The corpus of research on the development of emotion reasoning is sufficiently robust to pose a next generation of research questions and theories. Our review of the literature has led us to favor the term emotion reasoning over emotion recognition. Recognition implies that emotion cues (e.g., facial configurations and voices) signal unambiguous information that maps directly to and can be accurately recognized as another person's emotion state; this is an assumption that may be predicated on unsound premises (Barrett et al. 2019). In contrast, emotion reasoning captures the ability of children to use expressive behaviors, contextual information, and their own learning histories to make reasonable and adaptive inferences and predictions about other people's internal states and future behaviors, allowing children to anticipate and organize appropriate behavioral responses. Moreover, a traditional focus on emotion recognition is oriented around stimuli. In other words, there is a presumed ground truth emotion in a facial image, and the question is whether the child responds to it accurately. In contrast, an emotion-reasoning perspective is perceiver based.[1] Research questions can be oriented around what children are trying to do, what problem children are trying to solve, and how they are using available cues to successfully navigate their social worlds. In this view, emotion reasoning is not a monolithic ability reached at a particular developmental moment but rather is comprised of multiple components that cascade into more and more complex applications. No one component (e.g., discrimination or labeling) is a complete index of emotion reasoning, but each is an important building block of the developmental process.

We see tremendous promise in future research that is designed and guided by this broader developmental framework, which may also reveal new alternate interpretations of extant data and hypotheses for new studies (LoBue & Adolph 2019). For example, social-referencing studies have found that 12- to 24-month-olds do not show differential behavioral responses to an experimenter who displays different high-arousal, negative emotions (e.g., anger, disgust, and fear) (Martin et al. 2014, Sorce et al. 1985, Walle et al. 2017). Instead, infants tend to show similar behavioral avoidance for all of these signals. Similar results emerge using the caregiver's tone of voice (Mumme et al. 1996). By 14 months of age, the positive or negative tone of a caregiver's voice will affect what an infant will touch, even an hour later, but these effects are limited to approach versus avoidance signals rather than specific emotions (Hertenstein & Campos 2004, Vaillant-Molina & Bahrick 2012, Vaish & Striano 2004). One interpretation is that infants at this age do not recognize these high-arousal negative emotions (Barrett 2017, Lindquist & Gendron 2013, Widen

[1]We thank Linda Camras for suggesting this heuristic of stimulus- versus perceiver-based approaches.

2013). But there are many other interpretations that could each provide new directions and insight into emotional development. Such possibilities are that (*a*) infants are motorically limited in their responses and do not yet have a repertoire of distinct behavioral responses for each signal, (*b*) infants have not yet learned emotion labels (e.g., anger or disgust) or had sufficient self-relevant experiences to make these distinctions meaningful and thus have not acquired distinct emotion concepts, and/or (*c*) infants have not adequately encoded representations for these emotions because of developing attention, memory, or inhibitory control systems. In fact, when researchers use looking-time tasks, which reduce some of these motoric and cognitive demands, infants appear to differentiate between high-arousal negative emotions (Ruba et al. 2017, 2019, 2020a).

A challenge for future researchers is loosening their reliance on the most commonly used and easily available sets of stimuli. Since much past research attention has examined the same small set of stereotyped facial configurations (e.g., anger versus sadness), there are few data available about how children learn to understand and use the variable emotion signals they encounter in their everyday environments or how children learn to understand meaningful gradations in the intensity of emotions, such as a difference between someone being annoyed versus enraged (Leitzke et al. 2020). In our view, the key to children's emotion reasoning is their ability to learn about and navigate the tremendous variability inherent in human emotion (Plate et al. 2019). It is important for a next generation of research to embrace this real-world variability in research designs rather than artificially restrict it. As experienced social beings, older children and adults understand that similar actions can have different meanings: Three people can produce similar smiles, with one person feeling joy, another person feeling nervous, and the third feeling condescension. Three people might also feel similar emotions but behave in different ways: One winning athlete might respond with a huge smile, another with tears, and a third with exaggerated facial movements that resemble pain or some other combination of cues. Successful emotion learners appreciate that it is difficult to infer what someone else is feeling without context about what has recently transpired. This is the real-world complexity of emotion that children end up learning: There is little one-to-one mapping between the things people do and the ways they are feeling, and variation is the norm, but human emotions are not random, and the parameters and systematicity of the variation is learnable (Ruba & Repacholi in press).

Much more research is needed to determine how children learn to categorize and use this variable information. This goal can be achieved by employing approaches that will allow developmental scientists to discover, rather than prescribe, how children use emotions in everyday life. Such methods may include using emotions that do not correspond to stereotyped facial configurations or emotions that are expressed multimodally and in context. A broader, perceiver-based framework of children's developing emotion reasoning can generate new ideas about children's social-emotional learning. Since there is no clear moment when a child can first reason about others' emotion, it is more elucidating to ask how components of emotion reasoning develop and change across the life span and how these components combine to help children navigate the complex communicative system of human emotions.

SUMMARY POINTS

1. Prior research has explored children's ability to understand, interpret, infer, read, or perceive another person's emotions, yet there has been no consensus definition for emotion recognition or related milestone abilities.

2. We propose a perceiver-based emotion reasoning perspective, which captures the ability of children to use expressive behaviors and contextual information to make reasonable and adaptive inferences and predictions about other people and to organize appropriate behavioral responses.
3. Children's emotion reasoning has been measured in a variety of ways using paradigms that assess looking times, event-related potentials (ERPs), behavioral responses, and verbal responses; data from these approaches are necessary, but not sufficient, to claim a child can reason about emotions.
4. The development of emotion reasoning is the result of interrelated, cascading processes, including sensory maturity, attention, memory, the ability to make predictions and inferences, motor development, and emotion-label learning.

FUTURE ISSUES

1. How do children reason and learn about the diverse and highly variable cues that humans express to convey their feelings?
2. How do children learn to integrate contextual information when forming inferences about another person's emotions?
3. How do other developmental processes (e.g., cognitive, motor, and language development) influence the development of emotion reasoning?
4. How can scientists capture a greater range of emotion cues in both laboratory-based and naturalistic settings beyond the small set of stereotyped stimuli that comprise most of the extant literature on emotion?
5. What methods can researchers develop in order to discover rather than prescribe how children reason about emotions in everyday life?

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