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Looking Across Domains to Understand Infant Representation of Emotion

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Abstract

A comparison of the literatures on how infants represent generic object classes, gender and race information in faces, and emotional expressions reveals both common and distinctive developments in the three domains. In addition, the review indicates that some very basic questions remain to be answered regarding how infants represent facial displays of emotion, including (a) whether infants form category representations for discrete classes of emotion, when and how such representations come (b) to incorporate affective meaning, (c) the developmental trajectory for representation of emotional expression at different levels of inclusiveness (i.e., from broad to narrow or narrow to broad?), and (d) whether there is superior discrimination ability operating within more frequently experienced emotion categories.

Keywords

categorization; emotional expressions; faces; objects

Much contemporary research in cognitive development has been directed at understanding the nature and content of the mental structures of infants (e.g., Carey, 2000; Mandler, 2004; Spelke, 2000), with an importance placed on explicating the category knowledge that infants have for objects (Quinn, 2008). In addition, a recent line of work has been specifically investigating how infants extract bio-social category information from faces, such as gender and race (e.g., Lee, Anzures, Quinn, Pascalis, & Slater, in press). This special section on

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infant emotion with a particular emphasis on “think pieces” thus provides an opportunity to examine whether there may be links between the bodies of work on the learning of object concepts, the formation of gender/race categories, and the representation of emotion. That is, one can assess whether the ideas that run through research on category development for generic objects and gender/race information also play out in scholarship on how infants organize classes of facial expression. The comparison of themes among these different literatures is both facilitated and inspired by the writings of Darwin (1872), Ekman (1992), Izard (2009), and Tomkins (1962), who have all argued that emotions can be thought of as qualitatively distinct, natural kinds (but see Barrett, 2006; Panksepp, 2007). In addition, examining how infants represent categories across broad domains encompassing generic objects, bio-social categories such as gender and race, and psychologically based emotion categories such as happiness and sadness, is relevant to the debate concerning global versus domain-specific processing accounts of development (Kail, 2004).

Infants Group Objects into Category Representations

Rosch (1978) argued that the world is structured into categories marked by bundles of correlated attributes. For example, objects like birds have feathers, beaks, two legs, and make chirping sounds, whereas objects like dogs have fur, snouts, four legs, and make barking sounds. Importantly, by the Rosch framework, an organism that can detect such regularities, and compile them into separate representations, is capable of categorization. From this perspective, it becomes important to understand the abilities that infants might have to categorize their environment, as it will be from these abilities that the complex categories of the adult will develop.

Infant categorization has been assessed in procedures that rely on novelty preference (Fantz, 1964), and that involve familiarizing infants with one category of objects (i.e., photographic images or small 3-D toy models) and a test to determine whether infants generalize responsiveness (e.g., looking time) to novel objects of the familiarized category and respond differentially (e.g., with increased looking time or visual preference) to novel objects of the novel category. Moreover, control experiments are needed to determine that the differential responsiveness to the novel category exemplars did not occur because of a spontaneous (i.e., a priori) preference or because of failure to discriminate among the exemplars of the familiarized category. Using these procedures, infants have been shown to form category representations for a variety of object categories (Quinn, 2011).

The most extensively studied domain is that of animals, where the evidence is that infants during the first six to seven months of life can form category representations for (a) mammals that excludes furniture, (b) cats that excludes dogs, and (c) tabby cats that excludes Siamese cats (Oakes & Ribar, 2005; Quinn, 2004; Quinn, Eimas, & Rosenkrantz, 1993; Quinn & Johnson, 2000; Younger & Fearing, 1999). Infants in the same age range have also been shown to form category representations for artifact categories, including a representation for furniture that excludes mammals and a representation for chairs that excludes tables (Behl-Chadha, 1996).

Broad to Narrow Development

There seems to be an ordering to the formation of the category representations, where the broader representations are formed earlier and more readily than the more specific ones (Mandler & McDonough, 1993; Quinn, 2002b). For instance, a global representation for mammals is represented earlier than a basic-level representation for cats (Quinn & Johnson, 2000), and representations for open (i.e., crosses) versus closed (i.e., circles + squares + triangles) classes of geometric forms are represented before individuated representations for circles, crosses, squares, and triangles (Quinn, Slater, Brown, & Hayes, 2001; Turati,

Simion, & Zanon, 2003). These results suggest that the developmental course of early categorization is characterized by increasing differentiation.

Spontaneous Category Preferences

Spontaneous or a priori category preferences are observed when infants prefer exemplars of category A over those of category B without prior familiarization with category B. For example, infants have been shown to prefer cats over horses, tigers over cats, mammals over birds, and vehicles over furniture (Behl-Chadha, 1996; Eimas & Quinn, 1994). It may be that perceptible properties, for example, the salience of the tiger stripes or the shine of the vehicles, can produce preferences that are sufficient to differentiate them from contrast categories. However, in some cases, it can be difficult to specify those properties. For instance, there is no obvious feature that would explain why cats are preferred to horses or mammals are preferred to birds.

The existence of spontaneous category preferences can produce asymmetrical patterns of responding that complicate interpretation over whether infants are forming category representations (Quinn, 2002a). For example, when infants spontaneously prefer category A (e.g., cats) over category B (e.g., horses), then when familiarized with category B, infants will be likely to generalize to novel category B exemplars, and prefer category A exemplars; however, when familiarized with category A, infants will be likely to generalize both to novel category A and category B exemplars. In the former case, a spontaneous preference and a novel category preference work in a common direction, whereas in the latter case, they interfere with each other. Importantly, in the category B familiarization condition, it may be problematic to conclude that infants formed a representation for category B that includes novel instances of category B, but excludes instances of category A. This is because the advantage in looking time to novel exemplars of category A over novel exemplars of category B would have been obtained even without familiarization with category B (because of the spontaneous preference for category A). What does seem reasonable to infer from the spontaneous-preference evidence, however, is that infants are capable of discriminating or differentiating between the exemplars from the contrasting categories. Thus, in instances such as these, it may be safer to conclude that infants are capable of category differentiation, but not category representation, where the latter implies the formation of a representation which incorporates novel instances of the familiarized category and which rejects novel instances from the contrasting category.

A Perceptual to Conceptual Transition

As was implied in the discussion of spontaneous category preferences, infants are likely forming their category representations based on the surface information presented in the stimuli (Mareschal, French, & Quinn, 2000). The representations formed by infants are thus perceptual in nature, and stand in contrast to the knowledge-rich concepts possessed by adults and even young children (Gelman, 2003). For example, infants in the first half-year of life do not know about the genetic and reproductive properties (i.e., cats are labeled as “cat”, have cat DNA, and give birth to kittens) that distinguish cats from dogs. However, the representations formed by infants may be thought of as perceptual placeholders for the acquisition of the more abstract information that is obtained by means of language, and informal and formal tuition. In this respect, category development can be characterized as a process of “enrichment” of representations initially formed through perceptual experience (Madole & Oakes, 1999; Quinn, 2008; Quinn & Eimas, 1997; Rakison & Poulin-Dubois, 2001).

Tuning into People and Faces: Gender and Race

Evidence that infants categorize animals led to research that revealed that infants categorize people, and also use their representation for people as an organizing structure for information acquired about animals (Quinn & Eimas, 1998). This in turn led to studies investigating how infants categorize attributes of people, such as the gender and race of human faces (Anzures, Quinn, Pascalis, Slater, & Lee, 2010; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002).

Gender

Three- to four-month-olds familiarized with male faces prefer novel female faces over novel male faces; however, infants familiarized with female faces do not exhibit a differential preference between male and female faces (Quinn et al., 2002). This asymmetrical pattern of outcomes, previously observed in older infants by Leinbach and Fagot (1993), was found to be due to a spontaneous preference for female over male faces, which in turn was argued to be attributable to the greater familiarity that infants have with female faces because of their greater experience with a female caregiver as well as noncaregiver female faces (Rennels & Davis, 2008). This suggestion was confirmed via investigation of a sample of infants reared with male caregivers. Although the base rate of such a caregiver population is small, Quinn et al. (2002; see also Quinn, 2003) tested eight such infants and found that seven of the eight displayed a preference for the male faces. The overall pattern of findings indicates that infant visual attention to the gender of human faces is strongly influenced by the gender of the primary caregiver's face—the face that infants are likely to have the most contact with on a day-to-day experiential basis.

In addition, 3-month-olds reared by a female caregiver and shown a set of female faces will subsequently prefer a novel female face when paired with one of those shown previously; however, when shown a set of male faces they will not show a novelty preference for a new male face over a familiarized one, even though they are able to discriminate among the male faces when just a single male face is presented and contrasted against another (Quinn et al., 2002). This pattern of results indicates that the infants represent a category of female faces as individual exemplars, whereas the male faces are represented at the summary, category level (i.e., male).

Race

A similar finding, of attunement to the category of faces that is most often encountered, is seen in the comparison of how infants attend to same- versus other-race faces. When shown own-race faces paired with other-race faces, newborn infants demonstrate no spontaneous preference for faces from their own ethnic group (Kelly et al., 2005). However, at three months, infants show a significant looking preference for own-race faces, a finding that applies to Caucasian, African, and Chinese infants (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly, Liu, et al., 2007; Kelly et al., 2005).

Further evidence for selective tuning to same- over other-race faces becomes evident in within-category discrimination ability as infancy progresses. Despite showing a preference for looking at own-race faces, 3-month-old Caucasian and Chinese infants are able to discriminate between individual faces within their own-race group and from within other-race groups (Kelly et al., 2009; Kelly, Quinn, et al., 2007). However, after extensive continued experience with own-race faces and limited experience with other-race faces, by nine months their discrimination was restricted to own-race faces.

With regard to categorization of race, the one relevant study conducted to date has reported that the ability to respond to categories based on the race of faces develops sometime

between six and nine months of age (Anzures et al., 2010). In particular, 9-month-old Caucasians separated categories of female Caucasian and Asian faces (i.e., they generalized to novel instances of the familiarized race category and responded differentially to novel instances of the novel race category), whereas 6-month-old Caucasians did not. The 6-month-olds showed differential responsiveness (i.e., a significant increase in looking) to Caucasian faces after familiarization with Asian faces, but showed no such increase in looking at Asian faces after familiarization with Caucasian faces. The 6-month-old data are characterized by the same pattern of responsiveness that was exhibited by 3- to 4-month-olds responding to male and female faces.

It is likely that 6-month-olds' performance in the racial-categorization task was influenced by the spontaneous preference for own-race faces. Infants' spontaneous preference for own-race faces could have driven the observed increase in looking at own-race faces after familiarization with other-race faces, and would have hindered increased looking at the less preferred other-race faces after familiarization with own-race faces. Thus, it appears that younger infants' racial categorization may be influenced by a spontaneous preference for the category of faces with which they have the most experience, whereas older infants are able to parse categories of own-race and other-race faces. However, there was additionally an important sense in which even the older infants' representations for same and other races were not symmetrical. Specifically, at nine months of age, same-race faces were discriminated, suggesting that they were *categorized* (where a category refers to a grouping together of discriminably different entities that are responded to equivalently). By contrast, at the same age, other-race faces were not discriminated, suggesting that they were represented through *categorical perception* (where the perception is of similar exemplars that are difficult to discriminate). This pattern of results in turn implies that same and other races are, by nine months, represented by different mental structures.

Infants as Experts?

The contrasts between how infants respond to male versus female faces and same- versus other-race faces may represent an expert–novice difference in early perceptual-cognitive development. Over the last 15 years, a literature has arisen on how perceptual expertise can emerge in adults (Bukach, Gauthier, & Tarr, 2006; Tanaka & Gauthier, 1997). One of the hallmark characteristics of perceptual expertise is that objects within an expert domain tend to be recognized at a specific subordinate level, rather than at a generic category level. For example, a bird expert is likely to identify a sparrow as a “sparrow” rather than as a “bird.” This marker of expertise has been referred to as the “downward shift in recognition” (Tanaka, 2001). The downward shift in recognition observed for female and same-race faces suggests that gender and race are stimulus domains where expertise-like effects have already become evident in infants.

Object versus Person Perception

The finding that infants direct attention to the more *familiar* gender and race fits well with data showing that infants prefer mother over stranger in studies assessing responsiveness to face identity (e.g., Bushnell, 2001). The familiarity rule that holds for face attributes contrasts with the *novelty* rule that infants seem to follow when processing information about generic non-face objects (Fantz, 1964). This comparison raises the interesting possibility that infant looking is directed by two different systems of motivation: a social system that directs infants to form attachment relationships with familiar objects and a non-social system that directs infants to explore the properties of novel objects in their environment. It also harkens back to the idea that infant behavior is organized by complementary systems for attachment security and exploration-based mastery of the

environment (Bowlby, 1988), and is consistent with the notion that different mechanisms underlie processing of objects versus people (e.g., Neisser, 1994).

Infant Processing of Emotion Information

Having briefly reviewed the literatures on how infants represent generic object categories and how they represent gender and race as bio-social attributes of faces, we are now in a position to examine whether some of the major trends described in these literatures might also be observed in the literature on how infants represent emotion information (i.e., for objects: category organization based on environmental structure, spontaneous preference, development from broad to narrow, a transition from perceptual to conceptual; for bio-social attributes of faces: spontaneous preference, superior discrimination ability, and categorization versus categorical perception for faces from the more frequently versus less frequently experienced classes). Alternatively, it may be the case that when examining the literature on how infants represent emotion information, distinct developments not shared with the literatures on how infants represent generic object or gender/race categories may be observed. The latter would not be altogether unexpected given evidence in adults that recognition of face identity and emotion may be accomplished by at least some distinct mechanisms (Sergent, Ohta, Macdonald, & Zuck, 1994).

Do Infants Form Category Representations for Discrete Classes of Emotion?

Given the evidence that generic object categorization by infants may capitalize on environmental structure that takes the form of categories marked by bundles of correlated attributes, and the fact that facial expressions are also marked by such structures (e.g., smiling expressions are signaled by toothiness, crinkly eyes, raised cheeks, and upturned lips; whereas fearful expressions are displayed by eyes wide open, furrowed and raised eyebrows, and a stretched mouth), one may ask the basic question of whether infants can categorize distinct facial expressions. The answer is possibly “yes,” but the evidence is surprisingly fragile. In one early study (Caron, Caron, & Myers, 1982), 7-month-olds habituated to female faces depicting happiness or surprise generalized habituation to novel female faces depicting the familiarized expression and dishabituated to novel female faces depicting the novel expression. This pattern of responding would be consistent with infants categorizing happiness and surprise as distinct expressions; however, it would also be consistent with the possibility that infants were responding to a “toothiness” feature present in the happy faces and absent in the surprised faces. On the one hand, “toothiness” may be a natural feature that helps to separate happiness from an emotion such as surprise; on the other hand, it falls short of being a defining feature of happiness because one can pose more moderate, less prototypic smiles without showing teeth. Moreover, if the infants were relying on this feature alone and not processing the affective meaning of the expression more generally, then it might lead to confusing two categories of expression where “toothiness” is present in both. In fact, such was the finding in a follow-up study where the infants were presented with contrasting categories in which the models depicted toothy smiling versus toothy anger (Caron, Caron, & Myers, 1985).

Subsequent studies have attempted to avoid the likelihood that infants may focus on individual nondefining features by varying the information presented to infants during familiarization. By changing intensities of an expression, a common emotion can be portrayed with differences among the exemplars (e.g., toothy and nontoothy mouths). In one such investigation (Ludemann & Nelson, 1988), 7-month-olds familiarized with toothy and nontoothy faces depicting happiness generalized looking-time responsiveness to novel toothy and nontoothy faces depicting happiness, and responded differentially (i.e., with increased visual attention) to toothy and nontoothy faces depicting fear. This evidence is in accord with the idea that infants formed a category representation for facial expressions

depicting happiness that included novel faces depicting happiness, but excluded novel faces depicting fear. However, the results were asymmetrical in that when the infants were familiarized with faces depicting fear and subsequently tested on novel faces depicting fear and novel faces depicting happiness, the infants generalized responsiveness to both sets of novel faces. Moreover, the infants were shown to display spontaneous heightened visual responsiveness to the faces depicting fear over the faces depicting happiness (see also Nelson & Dolgin, 1985). The longer looking to the fear expressions after familiarization with the happy expressions was thus arguably an outcome of a spontaneous preference rather than a true novel-category preference that occurred as a consequence of familiarization with a contrasting expression. As noted earlier, this pattern of findings would be consistent with the idea that infants are differentiating between the categories of faces depicting happiness versus fear, although it is more difficult to make the case that the infants formed distinct category representations for the two emotional expressions. That is, the infants may be shown capable of discriminating between models depicting happiness on the one hand and fear on the other based on spontaneous preference for fear over happiness, but that does not necessarily equate with grouping together the various examples depicting happiness into a common representation that excludes examples depicting fear.

In another study where “toothiness” was not an issue because all the female models posing expression had closed mouths, infants as young as four months of age were presented with the category contrasts of happiness versus anger, happiness versus neutral, or anger versus neutral in a habituation–dishabituation procedure (Serrano, Iglesias, & Loeches, 1995). Each infant in the study participated in two of the six possible conditions (i.e., happy → angry, angry → happy, happy → neutral, neutral → happy, angry → neutral, neutral → angry), one on each of two consecutive days of testing. Infants displayed a pattern of responsiveness consistent with having formed a category representation when happy or angry faces were contrasted against neutral faces (i.e., they generalized to novel instances of the familiarized expression and responded differentially to novel instances of the novel expression). However, in the happy versus angry contrast, while infant responsiveness was consistent with category formation when familiarized with angry faces and tested with novel angry and happy faces, infants familiarized with happy faces responded differentially (i.e., with increased looking time) to both novel happy and angry faces. The asymmetrical performance raises the issue of a priori preference that was not assessed in the study (although see discussion below for evidence of an a priori preference for happy over angry faces; e.g., LaBarbera, Izard, Vietze, & Parisi, 1976). In addition, in the two conditions where the evidence was positive, the category contrasts were of faces depicting presence (i.e., happy or angry) versus absence of emotion (i.e., neutral), which would in turn be consistent with an account in which infants can detect whether faces are displaying emotion, but cannot necessarily separate different types of emotions into one or another category. It is also worth noting that although within-category discrimination ability can be inferred for the happy faces, it was not assessed for the various categories and cannot be inferred for the angry and neutral faces, thereby leaving open the question of whether generalization to novel instances from the familiarized expression reflected an active grouping process consistent with having formed a category representation or simply a failure to discriminate.

A more recent study examined infant categorization of expression information among 5-month-olds presented with women’s faces smiling at different intensities and depicting a happy expression, and once again, the contrast expression was fear (Bornstein & Arterberry, 2003). At this age, the infants did not display an a priori preference for fearful over happy expressions (see also Peltola, Leppanen, Silja, & Hietanen, 2009). However, after habituation to the happy faces, the infants dishabituated both to novel faces depicting happiness and to novel faces depicting fear, although the novel faces depicting fear were dishabituated to more than the novel faces depicting happiness. While one may argue that

such differential dishabituation is consistent with categorization, it is also vulnerable to the critique that the infants did not display the hallmark signature of categorization, namely, responding to the novel as if it were familiar (i.e., equivalent responding to the novel and familiarized instances of the familiarized category). The pattern of responsiveness that was observed is actually consistent with infants simply responding to the test stimuli based on their relative similarity to the familiarization stimuli, and without a grouping together of the novel and familiarized instances of the familiarized expression into a common representation.

Overall, then, while the evidence is consistent with infants differentiating between categories of emotion (e.g., Ludemann & Nelson, 1988), it is less clear that infants are forming category representations for discrete classes of emotion. At present, the unresolved issues include whether (a) differential responsiveness to a novel emotion might be attributable to an a priori preference, (b) generalization to novel instances of a familiarized emotion reflects within-category discrimination failure, and (c) infant responding includes the trademark evidence for categorization (i.e., equivalent responding to novel instances of a familiarized emotion).

Spontaneous Category Preferences

Just as we saw that there were spontaneous category preferences for some generic object and race/gender face contrasts, there is also evidence for such preferences with classes of facial expression. As mentioned, fearful expressions are preferred to happy ones (Ludemann & Nelson, 1988; Nelson & Dolgin, 1985). In addition, joyful expressions are preferred to angry ones (Grossmann, Striano, & Friederici, 2007; LaBarbera et al., 1976; Wilcox & Clayton, 1968). As was true for generic objects, category preferences in the domain of emotion can be difficult to interpret. For example, one of the observed preferences is for a negative (fear) over positive (happy) emotion, whereas the other is for a positive (joy) over negative (anger) emotion. In the case of fear being preferred to happiness, it could be that fearful faces are simply more salient to the infants or mediated by different underlying processing mechanisms (Johnson, 2005; Whalen et al., 1998). Alternatively, given that caregivers tend to display faces depicting positive affect (Malatesta & Haviland, 1982), the preference for fear could reflect a novelty response of the sort commonly observed in the generic object domain (but see Peltola, Leppanen, Palokangas, & Hietanen, 2008). Even more speculatively, it might reflect a response to the affective tone of the emotion, that is, as an obligatory defensive response to attend to a face that signals impending danger (Nelson, 1987).

As for the preference for happy over angry faces, the infants may be responding preferentially to the more familiar emotion, a conclusion that would be consistent with the type of preference observed for the gender and race of faces. It is also possible that infants attend less to angry faces because anger expressions induce gaze aversion (Schwartz, Izard, & Ansul, 1985). The differential response to happiness when contrasted with fear versus anger raises the larger issue of whether development of emotion processing is monolithic or whether different emotions have different developmental trajectories and determinants. However the meaning of the spontaneous preferences for different emotion categories comes to be interpreted, the existence of such preferences reinforces our earlier conclusion that infants differentiate among classes of facial expressions.

A Perceptual to Conceptual Shift?

When infants begin differentiating among facial expressions of emotion, are they doing so on a perceptual basis, that is, via the surface features (and their configural arrangements) of the stimulus displays, without necessarily registering the affective tone of those displays

(Caron, Caron, & Myers, 1985; Nelson, 1987; Oster, 1981)? Evidence relevant to the issue of whether infants are recognizing the affective quality of different facial expressions comes from studies that assess whether infant behavioral responses are judged to be in accord with the meaning of the expressions. For example, Sorce, Emde, Campos, and Klinnert (1985) reported that 12-month-olds' responses to a visual cliff task varied as a function of the emotional expression depicted by the caregiver in a social referencing context, although sizeable proportions of infants in that study did not reference the caregiver, and even among those that did, some behaved contrary to expectation (see discussion in Nelson, 1987). Similarly, the Serrano et al. (1995) study described earlier measured behavioral reactions such as approach and smiling when happy faces were depicted, and avoidance and frowning when angry faces were depicted. Although, overall, positive reactions tended to be more frequent during habituation to happy than to angry expressions, and negative reactions occurred more often to angry than to the other two expressions, the results were inconsistent. That is, infants habituated to happy and neutral expressions did not show behavioral differences, and those habituated to angry and happy expressions did not differ in the frequency of positive and negative responses to angry expressions.

Another approach to the question of whether infants perceive affective tone when discriminating among different classes of facial expression has been to investigate whether infants represent a superordinate grouping of positive emotions (happiness + surprise) as distinct from a superordinate grouping of negative emotions (anger + fear). Ludemann (1991) reported that 10-month-olds (but not 7-month-olds) habituated to female models alternately depicting happy and surprised facial expressions generalized habituation to novel models depicting the familiarized expressions, and dishabituated to novel models depicting anger and fear. This pattern of responsiveness is consistent with infants representing positive emotions as distinct from negative ones, but it is unclear whether it is necessary to invoke categorization of affective tone (as positive or negative) as the underlying explanation. All the infants needed to do to perform successfully was to recognize the equivalence of the novel and familiarized models depicting happiness and the novel and familiarized models depicting surprise, and perceive that the novel expressions of fear and anger did not belong to either of the two familiarized categories. That is, the infants may simply have perceived that the facial expressions of fear and anger were distinct from the facial expressions of happiness and surprise, without having grouped fear and anger or happiness and surprise into negative versus positive superordinate representations. A more convincing way to demonstrate the existence of such superordinate representations would have been to familiarize infants with multiple positive (or negative) expressions, and then test for generalization to novel instances of a novel positive (or negative) expression and differential responsiveness to novel instances of novel negative (or positive) expressions. Thus, for example, examining whether an infant that was familiarized to expressions of fear and anger, generalized to sadness, and responded differentially to expressions of enjoyment and interest, would constitute a more definitive test of whether infants are representing superordinate structures for positive versus negative affective tone.

Yet another approach to investigating whether infants represent the affective meaning of facial expressions has been to inquire whether infants could use a centrally positioned voice that had a particular affective tone (e.g., happy, sad, angry) to guide looking at two simultaneously presented facial expressions positioned to the left and right of the voice (Walker-Andrews, 1997). Only one of the facial expressions matched the voice in affective content. Infants, by seven months of age, preferred the facial expression that matched the sound. This evidence is consistent with the view that infants are sensitive to the affective tone that binds the visual expressions with auditory voices; however, it is also in accord with the view that infants simply know that a particular voice inflection is associated with a

specific facial expression. This latter view based on learned associations need not appeal to affective meaning as the gluing agent for the face and voice.

If the evidence does not compel the conclusion that infants differentiating among categories of facial expression are registering the affective tone of those expressions, does that render such evidence as uninteresting? We think not. Recall that in the domain of generic objects, young infants are believed to initially form category representations based on surface appearance. These perceptual placeholder representations come to be enriched through incorporation of more abstract attributes (Quinn, 2008), so that they develop into the more knowledge-based concepts of children and adults. In the same way, infants categorically differentiating among classes of facial expression, even if based solely on surface cues (e.g., raised vs. lowered lip corners) and devoid of affective tone, could be a starting point for the development of category representations that gradually come to be associated with vocal cues (e.g., rising and falling intonation patterns) and life experiences inclusive of social referencing situations (e.g., where fearful facial expressions are linked with threatening stimuli). Over time, then, the representations come to be enriched to the point where they carry social signal value, thereby allowing infants to recognize the meaning of discrete facial expressions.

Narrow to Broad Development?

As described in the earlier section on generic object categorization, there is evidence that development proceeds from broad to narrow, with more inclusive representations such as mammal formed earlier and more readily than more exclusive representations for cats or tabby cats (Mandler & McDonough, 1993; Quinn & Johnson, 2000). Is there corresponding evidence in the domain of emotion representation? We do not know of any systematic efforts to address this question, where, for example, infants are investigated for their ability to categorize positive versus negative emotions before categorizing one positive emotion versus another or one negative emotion versus another. There was the one study mentioned previously (Ludemann, 1991) where facial depictions of happiness + surprise were contrasted with facial depictions of fear + anger. As noted, this study may not be a strong test of superordinate representation of positive versus negative emotion, because there was no evidence for generalization to a novel class of the familiarized emotion. Still, it was the case that 10-month-olds succeeded at the task, whereas 7-month-olds did not. Moreover, by seven months of age, there is the spontaneous-preference data indicating that infants can at least categorically differentiate among expressions such as happiness, anger, and fear (LaBarbera et al., 1976; Ludemann & Nelson, 1988). Such a pattern of evidence hints at the possibility that infants may begin parsing the domain of facial expressions by differentiating among individual classes of emotion before grouping such classes into more inclusive superordinate positive versus negative structures. This accounting would also be consistent with the idea that infants initially register facial expressions as stimulus configurations and only subsequently as signals that carry affective meaning. It would further suggest a possible reconciliation between discrete versus dimensional accounts of emotion (Izard, 2009; Russell & Ridgeway, 1983). Initially, there may be representation of individual emotion categories, and with development, those categories come to be grouped into broader superordinate structures based on a positive versus negative dimensional split (e.g., pleasure versus displeasure).

Individual Differences

As described in the section on how infants respond to gender and race information in faces, there are individual or group differences depending on the gender of the primary caregiver and the race of faces most frequently encountered. One can ask whether such individual differences might also be manifest when it comes to how infants respond to facial displays

of emotion. As noted earlier, the predominant displays that caregivers model for infants are positive (Malatesta & Haviland, 1982), and thus the preference that has been observed for happy over angry facial expressions (LaBarbera et al., 1976) would be consistent with the findings that infants look more to the more familiar gender and race of faces that are encountered. Of interest is that we know of no evidence where during development infants come to individuate exemplars more readily within more frequently experienced emotion categories, that is, positive emotion categories, than within less frequently experienced emotion categories, that is, negative emotion categories (Malatesta & Haviland, 1982), which would be another potential analog to what is observed in the gender and race domains. One study that examined within-category discrimination for a positive expression (i.e., happy) and a negative expression (i.e., fear) actually reported a failure to discriminate within both expressions among 7-month-old infants (Kotsoni, de Haan, & Johnson, 2001; see also Leppanen, Richmond, Vogel-Farley, Moulson, & Nelson, 2009), so it is possible that development of within-category individuation abilities for emotion classes may proceed differently from what has been observed for gender and race classes.

One might also ask about infant responding to emotional displays in caregiving contexts that deviate from the norm. There is evidence that children who have suffered a history of physical abuse (presumably coupled with facial displays of anger) are more likely than children who have not suffered abuse to perceive anger in emotionally ambiguous faces (Pollak & Kistler, 2002). What about infants reared by caregivers with clinical depression? At least one study suggests that infants of caregivers reporting more depressive symptoms tended to visually prefer more intense forms of frowning facial expressions (Striano, Brennan, & Vanman, 2002; but see de Haan, Belsky, Reid, Volein, & Johnson, 2004), and an additional study indicated that infants of depressed mothers may perceive sad expressions as more familiar than happy ones (Hernandez-Reif, Field, Diego, Vera, & Pickens, 2006). These results are in accord with the idea that infants respond to facial displays of emotion in a similar manner to the way they respond to gender and race information in faces, namely, with familiarity. It would be of further interest to know if infants with depressed caregivers come to show lowered discrimination abilities for exemplars of positive expression categories.

Dynamic Displays of Facial Expression

One might ask whether infants would process emotion information differently if presented with dynamic as opposed to static emotional expressions. Indeed, much of the current knowledge about infants' face and emotion processing comes from studies using static stimuli. Moreover, experiments that have used dynamic faces have typically consisted of intermodal matching tasks that include presentations of faces with voices (reviewed in Walker-Andrews, 1997). In such studies, it is difficult to parcel out the specific contribution of the visible dynamic motion properties of the facial expression. Researchers have long recognized the importance of motion in perceptual development (Gibson, 1969; Kellman & Arterberry, 1998). For example, dynamic displays of faces drive infants to scan the internal features of the face (Haith, Bergman, & Moore, 1977) earlier than static displays (Maurer & Salapatek, 1976). Infants also show an inversion effect at three months of age with faces presented dynamically (Gusella, Muir, & Tronick, 1988) as opposed to five–six months of age when faces are presented statically (Cohen & Cashon, 2001). In addition, infants show face–voice matching of gender at six to eight months of age when faces are dynamic (Patterson & Werker, 2002; Walker-Andrews, 1997); intermodal matching of gender begins at nine–twelve months of age when faces are static (Poulin-Dubois, Serbin, Kenyon, & Derbyshire, 1994). These findings suggest that dynamic face displays might be used to test infants' ability to process face emotions. However, it should also be noted that the facilitative effect of dynamic displays might be due to the amount of information provided

(e.g., testing methods using dynamic stimuli tend to be longer than those using static stimuli), or due to additional cues that might not be related to facial emotional displays (e.g., body motion). These issues must be empirically addressed by systematically comparing the effects of dynamic displays to nondynamic ones on infants (see Muir & Lee, 2003, for details). Nevertheless, given the fact that the infants encounter mainly dynamic displays of facial emotions, for ecological validity, the use of dynamic displays should be considered in future studies.

Conclusions

This article began with brief reviews of the literatures on how infants represent categories of (a) generic object classes and (b) bio-social attributes of faces such as gender and race. It then proceeded to a discussion of how infants represent facial expression categories. Three major conclusions emerge, although these conclusions largely take the form of identifying unresolved issues.

First, some very basic questions remain to be answered in terms of how infants represent discrete categories of emotion. That is, when contrasting facial expressions are presented to infants in the context of a categorization task, will one be able to find the signature evidence for categorization in which infants generalize responsiveness to novel examples of the familiarized expression, and respond differentially to novel instances of novel expressions? In addition, will the evidence for generalization to novel instances of the familiarized expression be shown not to be attributable to within-category discrimination failure, and will the evidence for differential responsiveness be shown not to be explainable via a priori preference? When and how do such representations come to incorporate information about the social-signal value of the facial classes? What is the developmental trajectory for representation of emotional expression at different levels of inclusiveness (i.e., from broad to narrow or from narrow to broad), and what are the implications for discrete versus dimensional accounts of emotion processing? Finally, will one find evidence for superior discrimination abilities operating within more frequently observed emotion categories?

Second, it does appear that there are some common threads running through the literature on the representation of generic objects, face gender and race, and face expression. One example is the existence of spontaneous preferences for exemplars of one over another category. Moreover, for the face categories, across the literatures on gender, race, and emotion, there is the suggestion that infants are responding preferentially to the more familiar categories. Another possible commonality is a perceptual to conceptual shift in the content of the representations, which was previously proposed in the domain of generic object classes, and which was presently suggested to apply to the domain of facial expression categories.

Third, the representation of facial expression information by infants may also reflect unique developments not observed for the representation of generic objects. For example, whereas the literature on generic object categorization strongly suggests that development proceeds from broad to narrow, the little evidence that exists on representation of facial expression categories hints at the possibility that development may actually proceed from narrow to broad.

The observations that there are both common and distinct features to how infants represent category information for generic objects, face gender and race, and face emotion are consistent with the idea that there may be both domain-independent and domain-specific processes at work in the various domains (Kail, 2004). That is, basic principles of learning and development may operate within each domain, although faces may be unique in the

sense of conveying a wealth of information that is absent in generic objects (e.g., emotion, gender, race, trustworthiness). The latter observation is consistent with the idea that person perception may be mediated by mechanisms that have at least some distinct properties relative to those underlying object perception (Neisser, 1994). Whether such differences reflect core processes or are the result of induction during development remains a matter of debate (Johnson & Vecera, 1996; Spelke, 2000), as does whether the mechanisms governing person perception can be further split along biological and psychological lines (Carey, 1985; Keil, 1989). However such questions come to be answered, the present article suggests that much remains to be learned by examining development across domains and by investigating how infants form category representations for facial expressions of emotion in particular.

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