



Infant preference for female faces occurs for same- but not other-race faces

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There has been a recent surge of interest in the question of how infants respond to the social attributes of race and gender information in faces. This work has demonstrated that by 3 months of age, infants will respond preferentially to same-race faces and faces depicting the gender of the primary caregiver. In the current study, we investigated emergence of the female face preference for same- versus other-race faces to examine whether the determinants of preference for face gender and race are independent or interactive in young infants. In Expt 1, 3-month-old Caucasian infants displayed a preference for female over male faces when the faces were Caucasian, but not when the faces were Asian. In Expt 2, new-born Caucasian infants did not demonstrate a preference for female over male faces for Caucasian faces. The results are discussed in terms of a face prototype that becomes progressively tuned as it is structured by the interaction of the gender and race of faces that are experienced during early development.

There is a reasonably sized literature on how infants perceive attributes of faces that are not present in non-face objects (e.g. emotion, gender, race). Until recently, much of this literature has focused on the question of mother-stranger differentiation with its implications for the development of attachment (Bowlby, 1969). For example, past studies have examined how soon after birth infants display a preference for mother over stranger (Field, Cohen, Garcia, & Greenberg, 1984), how much exposure to the mother's face is needed to elicit a preference (Bushnell, 2001), what perceptual cues mediate the preference (Bartrip, Morton, & de Schonen, 2001; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995), what brain correlates occur with mother-stranger differentiation (de Haan & Nelson, 1997), and whether the preference can be manifest in other modalities besides vision (Cernock & Porter, 1985; DeCasper & Fifer, 1980). This

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research collectively suggests that the preference for mother over stranger is manifest shortly after birth, and is present in the visual, olfactory, and auditory domains, with the visual preference becoming increasingly reliant on internal features of the face during the first few months of life.

A related line of inquiry has investigated issues regarding how infants perceive emotion information in faces (Nelson, 1987). Studies have examined the roles of static versus dynamic cues in the extraction of emotion information from faces (Caron, Caron, & MacLean, 1988; Caron, Caron, & Myers, 1985) and how multimodal information from face and voice may contribute to infants' developing understanding of emotion (Walker-Andrews, 1997). Other research has considered whether infants (1) extract emotion information more robustly when that information is presented by familiar individuals (Kahana-Kalman & Walker-Andrews, 2001); (2) group gradations of emotional expressions as members of a common category (Bornstein & Arterberry, 2003); and (3) display spontaneous preferences for some facial depictions of emotions over others (Nelson & Dolgin, 1985). Two more recent sets of investigations have continued the focus on how infants respond to the social attributes of faces and have examined, in particular, whether infants respond selectively to gender and race information (Kelly *et al.*, 2005; Kelly *et al.*, 2007a; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002). These studies have produced evidence consistent with the observations of familiarity preference in the face identification literature and spontaneous preference in the face emotion literature.

With regard to the processing of face gender information by infants, Quinn *et al.* (2002) used a categorization task to show that 3- to 4-month-olds familiarized with male faces preferred novel female faces over novel male faces; however, infants familiarized with female faces divided their attention between the novel male and novel female faces, exhibiting a null preference. This asymmetrical pattern of outcomes had previously been observed in a study of 5- to 12-month-olds presented with male versus female faces in a habituation–dishabituation procedure (Leinbach & Fagot, 1993). In an effort to uncover the basis for the asymmetry, Quinn *et al.* (2002) investigated the possibility that infants might have a spontaneous preference for female faces. A female face preference would facilitate a novel category preference for female faces after familiarization with male faces (thereby producing a robust preference) and it would interfere with a novel category preference for male faces after familiarization with female faces (thus producing a null preference). To test the female face preference hypothesis, 3-month-olds were administered a series of paired preference trials with male versus female faces without a prior familiarization period. The infants preferred the female faces.

Subsequent experiments by Quinn *et al.* (2002) showed that the female face preference could not be attributed to longer length hair (i.e. infants still displayed a spontaneous preference for female faces when the male and female faces were presented without hair) or to higher contrast internal features possibly related to greater cosmetic usage (i.e. the preference fell to chance when *inverted* male and female faces without hair cues were presented). The rationale of the latter manipulation was that if infants prefer female faces because they are marked by greater sensory power, then the preference should not be affected by inversion. The null result indicates that the female face preference is dependent on the perception of the internal features in their upright orientation, suggesting that it is indeed a face perception phenomenon.

With the low-level perceptual accounts failing to provide an explanation for the female face preference, Quinn *et al.* (2002) next considered a more cognitive hypothesis. Specifically, because all of the participants in their experiments had been reared by

female primary caregivers, they hypothesized that infants might respond preferentially to female faces because they are more similar to the caregiver face than male faces. This reasoning is also consistent with the familiarity principle that infants follow in showing greater responsiveness to mother than stranger. If infants are responding preferentially to faces that are more similar to their caregiver, then infants reared with male caregivers should prefer male faces. In fact, although the base-rate of such a caregiver population is small, Quinn and colleagues (see also Quinn, 2003) have tested eight such infants on a spontaneous preference test with upright male and female faces without hair, and seven of the eight infants displayed preferences 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.

Kelly *et al.* (2005) sought to determine whether the familiarity-based account that explains how infants respond to gender information in faces might be applicable to the question of how infants respond to race/ethnicity information from faces. Caucasian new-born and 3-month-old infants born to Caucasian caregivers and exposed to predominantly Caucasian faces were presented with Caucasian–African, Caucasian–Asian, and Caucasian–Middle Eastern face pairings. Although the new-borns did not display differential preferences for any of the face comparisons, the 3-month-olds preferred the same-race faces in each of the pairings. Although one might interpret the null performance of the new-borns by arguing for a biological limitation imposed by poor vision (e.g. Banks & Salapatek, 1981), this account is weakened by the finding that new-borns can discriminate between faces from within their own ethnic group (Pascalis & de Schonen, 1994; Turati, Cassia, Simion, & Leo, 2006). It follows that if infants can discriminate between faces from within their own ethnic category, then they should be able to discriminate between faces from different ethnic categories. These observations indicate that although there was sufficient sensory sensitivity available to the new-borns to discriminate between faces from the different ethnic groups, the preference for the faces from the same ethnic group was not present.

If sensory maturation is not responsible for the developmental difference between the new-borns and the 3-month-olds in Kelly *et al.* (2005), the implication is that the predominant exposure which most infants have to same-race faces is driving the spontaneous preference for them. This experientially based interpretation has been bolstered by the follow-up studies of Bar-Haim, Ziv, Lamy, and Hodes (2006) and Kelly *et al.* (2007a). Bar-Haim *et al.* reported that 3-month-old Israeli infants exposed mostly to Caucasian faces preferred Caucasian to African faces, whereas Ethiopian infants exposed mainly to African faces preferred African to Caucasian faces. Moreover, a group of Ethiopian infants born in Israel and exposed to both African and Caucasian faces did not display a differential preference between Caucasian and African faces. Kelly *et al.* (2007a) provided evidence that cross-race preferences in 3-month-olds extend beyond the perceptually robust contrast between Caucasian and African faces by demonstrating that Chinese infants preferred Asian faces over African, Caucasian, and Middle Eastern faces. The combined pattern of results indicates that differential exposure during the first 3 months of life to same- and other-race faces results in a consistent preference for same-race faces.

Given the experientially driven preferences that 3-month-old infants display for same-race faces and faces depicting the gender of the primary caregiver, the question arises as to how infants will respond to gender information from same- and other-race faces. Specifically, will infants reared by a female primary caregiver display a preference for female faces irrespective of whether those faces are from the same or another race? This question

has been left open because in the Quinn *et al.* (2002) study, the infant participants were predominantly Caucasian and the faces presented were mostly Caucasian.

Although the question at hand has been motivated by past developmental research and has focused specifically on differential *preferences* in infants, it is also relevant to models of face *processing* that have been proposed in the adult literature. For example, Bruce and Young (1986) described a model of adult face processing in which different attributes of faces (i.e. gender, race) were computed independently of one another and independent of the mechanisms associated with face recognition. Empirical work has however shown that the speed of gender categorization is affected by face familiarity with the gender of familiar faces more rapidly extracted than the gender of unfamiliar faces (Rossion, 2002). In addition, gender information has been shown to be more accurately and efficiently processed from same-race faces than from other-race faces (O'Toole, Peterson, & Deffenbacher, 1996). This latter set of results thus suggests that gender and race information are not processed independently of one another in adults. In fact, the O'Toole *et al.* findings are actually consistent with a hierarchical processing model in which race information is superordinate to and processed before gender information. If such a model of adult face processing can be applied to infant face preferences, then the implication is that the preference for female faces observed for same-race faces might be interfered with by a switch to other-race faces.

EXPERIMENT I

In Expt 1, 3- to 4-month-old Caucasian infants were presented with a standard visual preference test with adult male and female Asian and Caucasian faces. The task consisted of four 10-s trials in which infants were presented with male Asian (or Caucasian) faces paired with female Asian (or Caucasian) faces. If information for face race and gender are independent determinants of infant face preferences, then one would expect infants to show a preference for female over male faces regardless of their familiarity with the race of the faces. Alternatively, if face race and gender information interact to determine the face preferences of young infants, and the nature of interaction is such that race is superordinate to gender, then one would expect infants to show a preference for female faces only for the races of faces with which they are familiar, whereas they should show no differential preferences for male and female faces of an unfamiliar race.

Method

Participants

The participants were 20 full-term 3-month-old infants (11 females) with a mean age of 113.85 days ($SD = 10.03$). Two additional infants were excluded from the final sample due to side bias ($N = 1$) or fussiness ($N = 1$). All of the infants had been reared since birth by a female primary caregiver and mothers reported that their baby had received little or no contact with people from non-Caucasian ethnic groups.

Stimuli

The stimuli were morph pictures. Each face represented an average made of six faces using 73 points from each face as processed by the software developed by Steve Maddock from The University of Sheffield. Three faces from each category (female

Asian, female Caucasian, male Asian, and male Caucasian) were created for a total of 12 faces in the stimulus set. The images were carefully cropped so that only the face, including ears and hair, was visible on the slides. Examples of one male–female face pairing for each race are presented in Figure 1.

Procedure

Three-month-old infants were tested in a quiet room where they were seated on their mother's lap approximately 60 cm away from a screen on to which the images were projected. All mothers were instructed to fixate centrally above the screen and to remain quiet during testing. Eye-movements were recorded and the film was then digitized to be analyzed frame by frame by two independent observers on a computer using specialized software. The average level of inter-observer agreement was high (Pearson $r = .90$).

When projected on to the screen all images measured 10 cm wide × 15 cm high and were positioned side by side separated with a 12-cm gap. Each pair of images was displayed until 10 seconds of fixation time had elapsed. Between each image pairing, a blank screen was presented for 5 seconds or until the infant moved their eyes from the final point of fixation from the previous trial. A black and white CCD camera (specialized for low light conditions) was used to film the infant's eye-movements. This was displayed to the experimenters, during recording, on an ITC control monitor. Time



Figure 1. Examples of the male (left panel) and female (right panel) face stimuli from the Asian (top panel) and Caucasian (bottom panel) races presented to the infants.

was recorded and displayed on the control monitor using a Horita II (TG-50) at 25 frames per second.

Each infant was presented with two female-male face pairings from each race for a total of four 10-s trials. The particular male and female faces for each pairing were randomly selected for each infant. Order of presentation of the races was counterbalanced across infants. Left-right positioning of gender was also counterbalanced across infants on the first trial and reversed on each successive trial.

Results and discussion

Summed looking time to the female faces was divided by summed looking time to the female and male faces for each race and converted to a percentage score by multiplying by 100. The mean preference for female over male Caucasian faces was reliably different from chance, $M = 57.69\%$, $SD = 12.00$, $t(19) = 2.87$, $p < .01$, and 16 of 20 infants had preferences above 50%, binomial probability, $p = .01$. By contrast, the preference for female over male Asian faces was not significantly different from chance, $M = 47.96$, $SD = 11.64$, $t(19) = -0.78$, $p > .20$, and only 8 of 20 infants had above-50% preferences (binomial probability, $p = .50$). Moreover, the two means were reliably different from each other, $t(19) = 2.35$, $p < .05$.

The present results replicate those reported by Quinn *et al.* (2002) in which 3-month-old infants reared by female caregivers preferred female over male faces when the infant participants and face stimuli were mostly Caucasian. The current outcomes also extend the earlier findings by demonstrating that the preference for female faces by infants reared by female caregivers does not extend across races at 3 months of age. Because the gender preference of the infants in Quinn *et al.* was reversed for a sample of infants reared with male primary caregivers, an experiential account of the preference seems to be in order. To establish convergent evidence for this account, in Expt 2, we examined the responsivity of Caucasian new-born infants to the Caucasian male and female face pairings from Expt 1. While new-born infants in the first couple of days of life will have been exposed mainly to their mother's face, it is unclear whether such experience would be sufficient to induce the infants to prefer female faces over male faces.

EXPERIMENT 2

Expt 2 was a replication of Expt 1, except that it was conducted with Caucasian new-born infants and only the Caucasian male and female face pairings were presented.

Method

Participants

The participants were 16 full-term healthy new-borns (6 females) with a mean age of 2.64 days, $SD = 1.30$. A further 13 new-borns were excluded from the final sample due to side bias or not looking ($N = 7$), fussiness ($N = 1$), or falling asleep ($N = 5$). All of the participants were Caucasian infants born to Caucasian mothers.

Stimuli

The stimuli were the Caucasian face pairings from Expt 1.

Procedure

New-borns were tested in a quiet room, seated in a semi-upright position in a padded infant car chair which was secured to a table, limiting movement and ensuring safety, approximately 30 cm (due to lesser visual acuity compared with 3-month-olds, a shorter viewing distance is appropriate for new-borns) from a screen measuring (45 cm × 30 cm) on to which the paired images were projected. Eye-movements were recorded and the film was digitized to be analyzed frame by frame by two independent observers on a computer using specialized software. The average level of inter-observer agreement was high (Pearson $r = .87$).

When projected on to the screen all images measured 18 cm × 18 cm (14° visual angle) and were positioned side by side separated with a 9-cm gap. Each pair of images was displayed until 10 seconds of fixation time had elapsed. If the new-born spent 10 seconds looking away from the projected images, the trial was terminated. Between each image pairing, a blank screen was presented for 5 seconds or until the new-born moved their eyes from the final point of fixation from the previous trial.

Each new-born was presented with a different male and female face pairing on each of two 10-s trials. The particular male and female faces for each pairing were randomly selected for each infant. Left-right positioning of gender was counterbalanced across infants on the first trial and reversed on the second trial.

Results and discussion

The mean preference for the female faces was 48.11 ($SD = 18.12$), a value that was not significantly different from chance, $t(15) = -0.42$, $p > .20$, but was significantly different from the mean preference for the Caucasian female faces observed for the 3-month-olds participating in Expt 1, $t(34) = 1.90$, $p < .05$, one tailed. In addition, just 8 of the 16 new-borns showed preferences for the female faces above 50%, binomial probability, $p = 1.0$. This pattern of outcomes suggests that the preference for Caucasian female faces observed in the Caucasian 3-month-old infants reared by Caucasian female caregivers in Expt 1 is an experientially based effect.

GENERAL DISCUSSION

Prior research had established that by 3 months of age, infants show a preference for (1) the gender of faces that matches with the gender of their primary caregiver (Quinn *et al.*, 2002) and (2) same-race faces (Bar-Haim *et al.*, 2006; Kelly *et al.*, 2005, 2007a). Because the participants tested in Quinn *et al.* were mostly Caucasian infants and the images presented in the laboratory were mostly Caucasian faces, it was not clear whether the preference that female-caregiver-reared infants displayed for female faces at 3 months of age would extend to other-race faces. The present study was undertaken to resolve this ambiguity in the literature.

Two major findings emerged from our investigation. First, the preference for female faces by 3-month-old infants reared by female caregivers appears to be specific to same-race faces. In particular, in Expt 1, 3-month-old Caucasian infants reared by Caucasian

caregivers and exposed predominantly to Caucasian faces since birth showed a preference for female over male Caucasian faces, but not to female over male Asian faces. Second, the preference for female over male faces that is specific to the race of the primary caregiver and the race of faces experienced predominantly since birth does in fact appear to be driven by differential experience. This conclusion is supported by the finding from Expt 2 that Caucasian new-born infants born to Caucasian mothers did not prefer Caucasian female over male faces. It should be noted that the null preference of the new-born infants cannot be attributed to immature visual resolution ability because neonates have been shown to be able to discriminate between faces from within the female face gender category, i.e. mother versus stranger (e.g. Field *et al.*, 1984), thereby indicating that visual acuity should also be sufficient to discriminate between two individual faces chosen from different gender categories, i.e. male versus female.

The results from the 3-month-old infants are consistent with the findings from adults that gender information is more rapidly and efficiently extracted from familiar and same-race faces (O'Toole *et al.*, 1996; Rossion, 2002). They are inconsistent with models of adult face processing in which gender and race are extracted from faces independently of one another (Bruce & Young, 1986). The implication is that the system which directs infant preferences among faces becomes progressively tuned to a face prototype that is structured by the *interaction* of the gender and race of faces that are experienced during early development. This conclusion is in accord with results showing that while both 1- and 3-month-olds can individuate faces, only 3-month-olds show evidence of forming a prototype (de Haan, Johnson, Maurer, & Perrett, 2001). In addition, the O'Toole *et al.* results with adults, alongside the current findings and those of Kelly *et al.* (2005, 2007a) with infants, are actually consistent with a system of preferential looking towards faces in infants in which information about race comes before and is superordinate to information about gender. This is because in Kelly *et al.* (2005, 2007a), the preference for same- over other-race faces occurred for both male and female face pairings, whereas in the current study, the preference for female over male faces occurred for same- but not other-race faces.

Evidence from fMRI neuroimaging studies in adults indicates that differential responsiveness to same- and other-race faces is linked to differential activity in the fusiform region (Golby, Gabrieli, Chiao, & Eberhardt, 2001). In addition, enhanced amygdalar activation has been observed for outgroup categories of faces (Phelps *et al.*, 2000), although such activation can be manipulated by varying the goals of the perceiver (Wheeler & Fiske, 2005). ERP studies of race and gender processing in adults have been linked with early appearing components, indicating that the relevant categories are derived rapidly (120 ms post-stimulus in the case of race and 145–185 ms post-stimulus in the case of gender), although the N170 signal that has been associated with identifying a stimulus as a face was not modulated by either gender or race information (Ito & Urland, 2003; Mouchetant-Rostaing, Giard, Bentin, Aguera, & Pernier, 2000). The connection between the neural correlates of face processing in adults and infants is strengthened by the finding that 2-month-old infants show an activation for faces in the fusiform cortex as adults do (Tzourio-Mazoyer *et al.*, 2002). The neural correlates of the preference for the more familiar gender and race by young infants have not yet been specified, although infant recognition of mother versus stranger has been linked with an enhanced Nc component in ERP studies in 6-month-olds (de Haan & Nelson, 1997). One might therefore look for such enhancement in ERP investigations of the familiar gender and same-race preference in infants. In addition, in accord with the hierarchical processing account from the adult literature and the infant preferences

observed in the current study versus Kelly *et al.* (2005, 2007a), one might examine whether the signals corresponding with gender extraction in infants have longer latencies than those corresponding with race extraction.

The neonate findings are relevant to the question of the nature of the representation that new-born infants have for faces. The results indicating that new-borns do not respond differentially to gender or race information are consistent with the idea that the representation which infants bring to the task of face learning is largely, although not completely, unspecified. The available data suggest that the new-born face representation must be sufficiently general so as not to favour particular categories of gender or race, but adequately structured so as to direct a preference for attractive over unattractive faces (Slater, Quinn, Hayes, & Brown, 2000). Although new-born infants do respond preferentially to mother over stranger, such a preference could be prompted by olfactory (Cernock & Porter, 1985) or auditory (DeCasper & Fifer, 1980) cues. For example, if the maternal voice has been learned prenatally, and new-born infants can rapidly associate specific sounds with particular sights (Slater, Brown, & Badenoch, 1998), then the maternal face could be preferred because it is fast-mapped by association with the mother's voice. This latter point is illustrated in a report by Sai (2005) who showed that new-borns need to have experience of the face-voice matching to be able to present a preference for the mother's face a few hours after birth. While the precise nature of the new-born face representation needs to be resolved by additional research, the results showing that 3-month-olds respond preferentially to the more familiar gender and race suggests that the infant's face representation becomes rapidly configured towards these dimensions of experience during the initial weeks of life.

Although we have advocated an experientially driven account for the pattern of observed preferences, one may question what particular component of experience is most responsible for directing infant visual responsiveness. That is, one could argue that it is the caregiver's face attributes or the attributes of the non-caregiver faces commonly encountered during the first three months of life. Because most infants are born to a female caregiver of the same race and also exposed predominantly to non-caregiver female faces (Ramsey-Rennels & Langlois, 2006) and non-caregiver same-race faces, the question of whether it is the single caregiver's face or the multiple non-caregiver faces or their combination that is providing the crucial experience is unclear. The findings from Quinn *et al.* (2002), who had reported that the preference for female faces reared by female caregivers was reversed in a small sample of infants reared by male caregivers, suggest that in the case of the gender preference, it is the experience with the caregiver's face that determines the preference. In contrast, in the case of race, the result of Bar-Haim *et al.* (2006) showing that Ethiopian infants born in Israel and exposed to both African and Caucasian non-caregiver faces did not display a differential preference between Caucasian and African faces suggests that the non-caregiver faces experienced most frequently direct infant preference for same- versus other-race faces. This analysis suggests that the different aspects of experience may be contributing to the preference for the gender matching that of the primary caregiver and the preference for same-race faces.

Another conclusion that receives support from the pattern of findings emerging from across the studies of infant responsiveness to gender and race information from faces is that race may be a more potent cue for directing infant visual preference than gender. As noted, while the 3-month-old preference for female over male faces in the present study was limited to same-race faces, the 3-month-old preference for same-race faces observed by Kelly *et al.* (2005, 2007a) was manifest for both female and male faces.

Whether this effect is driven by salience differences in the contrasts between different genders and races or differences in the frequency of contact for the different genders and races or some combination of the two is unclear. However, any of the above would be consistent with a scheme in which race information supersedes gender information in directing infant visual preferences among faces. Moreover, the difference in responsiveness to gender and race in infants does seem consistent with the finding that processing advantages for same-race faces can be observed from infancy through childhood and into adulthood (Kelly *et al.*, 2007b; Meissner & Brigham, 2001; Sangrigoli & de Schonen, 2004a, 2004b), whereas gender processing seems more labile during the developmental course of the life-span (Wild *et al.*, 2000).

A related question of interest is what perceptual cues in the faces play a role in producing the null preference for the male versus female faces within the category of Asian faces for the 3-month-old Caucasian infants. What is different about the Asian faces relative to the Caucasian faces that might be blocking the preference for female faces? It may be that when the faces are Asian, both the male and female faces are perceived as novel in terms of features and skin tone. By this reasoning, it would be interesting to determine how 3-month-old Caucasian infants reared by a Caucasian female caregiver and exposed predominantly to Caucasian faces would respond when presented with a pair of male and female Caucasian faces modified with an Asian skin tone.

One limitation of the current study is that only Caucasian participants born to and reared with Caucasian caregivers were tested. It will therefore be important to extend the results of the study to infants and caregivers from other ethnic groups to assess whether the findings can be generalized across ethnic groups.

The finding that infants direct their attention to the more *familiar* gender and race fits well with the data showing that infants prefer mother over stranger in studies assessing responsiveness to face identity (Bartrip *et al.*, 2001; Bushnell, 2001; Field *et al.*, 1984). It is also consistent with the finding that infants extract emotion information from faces more readily when the faces depicting the emotion are portrayed by familiar individuals (Kahana-Kalman & Walker-Andrews, 2001). In addition, familiarity preferences for gender and race in infants are in accord with the report that physically abused children perceive anger in emotionally ambiguous faces more often than children who have not been abused (Pollak & Kistler, 2002). The familiarity rule that infants seem to follow when processing various social attributes from faces (identity, emotion, race, gender) not present in non-face objects contrasts with the *novelty* rule that infants seem to follow when processing information about generic non-face objects (Fagan, 1970; Fantz, 1964). This analysis is not without difficulties in as much as Pascalis and de Schonen (1994) have shown a novelty preference for an individual face following familiarization with a different face, but it 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.

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