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PAPER

Categorization, categorical perception, and asymmetry in infants' representation of face race

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Abstract

The present study examined whether 6- and 9-month-old Caucasian infants could categorize faces according to race. In Experiment 1, infants were familiarized with different female faces from a common ethnic background (i.e. either Caucasian or Asian) and then tested with female faces from a novel race category. Nine-month-olds were able to form discrete categories of Caucasian and Asian faces. However, 6-month-olds did not form discrete categories of faces based on race. In Experiment 2, a second group of 6- and 9-month-olds was tested to determine whether they could discriminate between different faces from the same race category. Results showed that both age groups could only discriminate between different faces from the own-race category of Caucasian faces. The findings of the two experiments taken together suggest that 9-month-olds formed a category of Caucasian faces that are further differentiated at the individual level. In contrast, although they could form a category of Asian faces, they could not discriminate between such other-race faces. This asymmetry in category formation at 9 months (i.e. categorization of own-race faces vs. categorical perception of other-race faces) suggests that differential experience with own- and other-race faces plays an important role in infants' acquisition of face processing abilities.

Introduction

The main function underlying the ability to form categories is that of cognitive economy. By grouping stimuli into the same category, one reduces the cognitive demands required to differentiate among highly similar, yet slightly different exemplars (Murphy, 2002). Thus, items parsed together in the same category are considered to be equivalent to one another, and at the same time, considered different from stimuli belonging to other categories (Rosch, 1978). There are, however, different levels of exclusivity ranging from broad levels of categorization to fine discriminations between similar exemplars. A global or superordinate level of categorization, for example, is characterized by a high level of inclusiveness, and thus subsumes a number of relatively more defined categories. Basic-level categories, on the other hand, are more exclusive than superordinate-level categories, but can still be further parsed into even more exclusive categories with finer discriminations – so-called subordinate-level categories. Thus, the superordinate category of faces (inclusive of human, dog, and monkey faces, etc.) includes the basic category of human faces, which in turn includes the subordinate categories of Caucasian and Asian faces.

A review of the literature on infants' categorization abilities shows that previous studies have focused mainly on infants' categorization of non-face stimuli. Even newborns demonstrate some degree of categorization with global representations of closed versus open geometric forms (Quinn, Slater, Brown & Hayes, 2001; Turati, Simion & Zanon, 2003). Evidence of superordinate and basic-level categorization of more complex forms (e.g. animals, geometric shapes) has been found among infants as young as 2 to 4 months of age (Behl-Chadha, 1996; Bomba & Siqueland, 1983; Eimas & Quinn, 1994; Quinn, 1987; Quinn & Eimas, 1998; Quinn, Eimas & Rosenkrantz, 1993; Quinn & Johnson, 2000; Quinn, Eimas & Tarr, 2001; Younger & Fearing, 1999). However, despite the early emergence of superordinate and basic-level categorization, subordinate-level categorization emerges at a relatively later age. Quinn (2004) found that although 3- and 4-month-olds were unable to form subordinate categories of different breeds of cats and dogs, 6- and 7-month-olds showed an emerging ability to do so.

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In contrast to the studies that have examined infants' categorization of objects and animals, relatively few studies have examined infants' categorization of faces. The few studies that have examined infants' categorization of human faces have focused on facial attractiveness, expression, and gender. These studies show that 6-month-olds can form exclusive categories of attractive and unattractive faces (Ramsey, Langlois, Hoss, Rubenstein & Griffin, 2004), and infants as young as 4 to 7 months are able to form categories for a variety of expressions such as 'fearful', 'surprised', 'angry', 'happy', and neutral (Bornstein & Arterberry, 2003; Caron, Caron & Myers, 1982; Ludemann & Nelson, 1988; Nelson & Dolgin, 1985; Nelson, Morse & Leavitt, 1979; Serrano, Iglesias & Loeches, 1992, 1995).

With regard to the gender of faces, previous studies have shown that infants as young as 7 to 9 months can form categories of male and female faces (Cohen & Strauss, 1979; Leinbach & Fagot, 1993). Younger and Fearing (1999), on the other hand, found a developmental change in infants' categorization of gender so that 10-month-olds, but not 7-month-olds, showed categorization of male and female faces. A more recent study by Quinn, Yahr, Kuhn, Slater and Pascalis (2002) also found evidence of gender categorization in 3- to 4-month-olds. However, 3- to 4-month-olds showed an asymmetry in their categorization so that they looked longer at a novel female over a novel male after habituation to a number of different male faces, but showed no preference for either the novel female nor the novel male at test after habituation to a number of different female faces. This asymmetry in 3- to 4-month-olds' categorization of male and female faces appears to be driven by their spontaneous preference for female faces. This spontaneous preference for females is, in turn, thought to derive from infants' greater experience with females (e.g. the primary caregiver) – a speculation supported by infants' preference for male faces when their primary caregiver is male (Quinn *et al.*, 2002). A recent study by Rennels and Davis (2008) supports this speculation by showing that mothers' diary entries regarding their infants' daily interactions reflected a greater frequency of interaction with female individuals relative to males. Thus, the asymmetry in infants' categorization of gender might be due to their differential experience between male and female faces, which results in a spontaneous preference for the more familiar face type.

Although findings by Rennels and Davis (2008) in conjunction with results by Quinn *et al.* (2002) provide the best evidence to date to explain the potential role of experience in infants' categorization of faces, the link between differential experience and infants' categorization abilities remains tenuous. A more direct approach to examining how differential experience affects infants' categorization would be to recruit infants with nearly exclusive contact with one category of faces (e.g. male) and little to no contact with a contrasting category of faces (e.g. female). However, such exclusivity is difficult to obtain for gender categorization because infants still typically encounter a mixture of male and female faces despite the fact that their primary caregiver may be male or female.

The influence of differential experience on infants' categorization might be better examined via infants' experience with own- and other-race faces. Infants' experience with other-race faces is naturally limited because they are typically born into single-race families. Thus, infants' racial categorization of faces provides the ideal opportunity to determine how differential experience with different types of faces affects category formation. It is possible that differential experience with own-race and other-race faces can lead to the formation of different types of categories.

Previous studies that have examined the ability to process own- and other-race faces have found that although adults are generally highly accurate in discriminating between own-race faces, they show a relatively diminished ability to discriminate between other-race faces (reviewed in Meissner & Brigham, 2001). This so-called other-race effect in recognition has been attributed to our differential experience with different categories of faces, so that we are experts at discriminating between different faces from a category with which we have a high level of experience, but we are relatively poor at discriminating between different faces from a category with which we have a low level of experience (Furl, Phillips & O'Toole, 2002; Hancock & Rhodes, 2008). Such differential experience may cultivate different mental representations of own- and other-race faces which influence subsequent processing of different facial categories. For example, representations of other-race faces may be more densely clustered together relative to representations of own-race faces (Valentine, 1991). Consequently, other-race faces are more difficult to discriminate and recognize than own-race faces.

Developmental studies have shown that the foundations for the adult other-race effect are already present in early infancy. Even newborns demonstrate recognition memory for faces (Pascalis & de Schonen, 1994), and by 3 months of age, infants are able to differentiate between different female faces (Quinn *et al.*, 2002) and different own-race faces (Hayden, Bhatt, Joseph & Tanaka, 2007; Pascalis, de Haan, Nelson & de Schonen, 1998; Sangrigoli & de Schonen, 2004). Three-month-olds' spontaneous preference for faces with which they have more experience (i.e. typically own-race faces) also shows that young infants can differentiate between own-race and other-race faces (Bar-Haim, Ziv, Lamy & Hodes, 2006; Kelly, Quinn, Slater, Lee, Gibson, Smith, Ge & Pascalis, 2005; Kelly, Liu, Ge, Quinn Slater, Lee, Liu & Pascalis, 2007a). Similar to findings in adult participants, infants' ability to discriminate between different faces has been found to be dependent on their experience with the category to which the faces belong.

They can differentiate between own-race faces but eventually lose the ability to differentiate between other-race faces (Kelly, Quinn, Slater, Lee, Ge & Pascalis, 2007b; Kelly, Liu, Lee, Quinn, Pascalis, Slater & Ge, 2009) unless experience with such other-race faces is introduced (Sangrigoli & de Schonen, 2004) and maintained (Sangrigoli, Pallier, Argenti, Ventureyra & de Schonen, 2005).

In contrast to the extensive research on infants' discrimination between different faces, infants' ability to *group* faces into discrete categories has yet to be fully investigated. Infants' categorization of human faces has been restricted to attractiveness, expression, and gender. More importantly, few studies have examined how infants' differential experience with faces might influence their categorization of faces (e.g. gender, race, age, etc.). Thus, considering the sparse literature examining infants' facial categorization, combined with the lack of research regarding infants' abilities to categorize faces based on race in particular, the present paper will investigate how differential experience with own-race and other-race faces influences facial categorization during infancy.

The present study examined Caucasian 6- and 9-month-olds' ability to categorize Caucasian and Asian female faces. Six-month-olds were specifically chosen because existing evidence suggests that an emerging ability to form subordinate-level categories is present at this age (Quinn, 2004). Nine-month-olds were also tested based on previous studies showing more refined categorization skills in older infants (Caron *et al*., 1982; Ludemann, 1991). The present study expressly sought the answer to three questions: (i) Can infants categorize faces by race? (ii) Are there differences in infants' categories of own-race and other-race faces? (iii) Are there developmental differences in infants' racial categorization?

Experiment 1

To investigate infants' categorization of own-race and other-race faces, participants were familiarized with either Caucasian female faces or Asian female faces. Familiarization was then followed by novel female faces from the familiar race category, as well as by novel female faces from the novel race category. If 6- and 9-month-olds are able to categorize human faces according to race, then they should show the following: (i) a decrease in looking across the familiarization trials (i.e. habituation), (ii) similar looking at the two novel exemplars from the familiarized race category relative to looking at the last two familiarization trials (i.e. generalization of responsiveness to novel exemplars from the familiarized category), and (iii) increased looking towards the novel faces from the novel race category relative to their looking at the novel faces from the familiarized race category (i.e. differential responsiveness to novel exemplars from a novel category). If, however, 6- and 9-month-olds are unable to categorize faces according to race, then they should not display differential responsiveness to the novel faces from the novel race category.

Method

Participants

Forty-two full-term Caucasian 6-month-olds (M = 196.17 days, SD = 8.82 days, 23 males) and 37 Caucasian 9-month-olds (M = 290 days, SD = 9.80 days, 19 males) participated in the study. All infants were reported to have had no experience or very little experience with Asian faces (i.e. interacting with an Asian individual no more than once per month). An additional eight 6-month-olds and 13 9-month-olds were excluded due to fussiness and crying.

Stimuli

Colour photographs of eight young adult Caucasian females and eight young adult Asian females were used. Female faces were used because infants typically have more experience with female faces, and thus demonstrate more refined face processing (e.g. recognition) of female relative to male faces (see Ramsey-Rennels & Langlois, 2006; Quinn *et al*., 2002). All faces showed a frontal pose and neutral expression, and were also free from any cropping (e.g. with hair and facial contour) to ensure that infant participants would see the stimuli in their natural form. Sixteen colour photographs of various objects were also used (e.g. a red pepper, a multi-coloured plate, a white pot with pink flowers and green leaves, a box of markers, a toy turtle on wheels, etc.). Photographs of the faces and objects were cropped in Adobe Photoshop and placed on a black background.

Procedure

Infants were seated in a high-chair positioned 60 cm from a 42-inch television screen on which the stimuli (27.50 × 27.50 cm; 25.81° visual angle) were presented. Parents sat at the back of the room and out of the infants' field of vision during testing. All infants were videotaped during testing so that the direction and duration of their looking times could be coded.

Infants were assigned to one of two conditions. Each condition comprised three phases: (i) familiarization trials, (ii) generalization trials, and (iii) test trials. In Condition A (Caucasian to Asian), 21 6-month-olds (12 males) and 19 9-month-olds (11 males) were familiarized with six different Caucasian female faces presented in successive order. Each Caucasian face was paired with a different object. While the faces belonged to the same racial category, the objects belonged to different basic-level categories (see Figure 1).

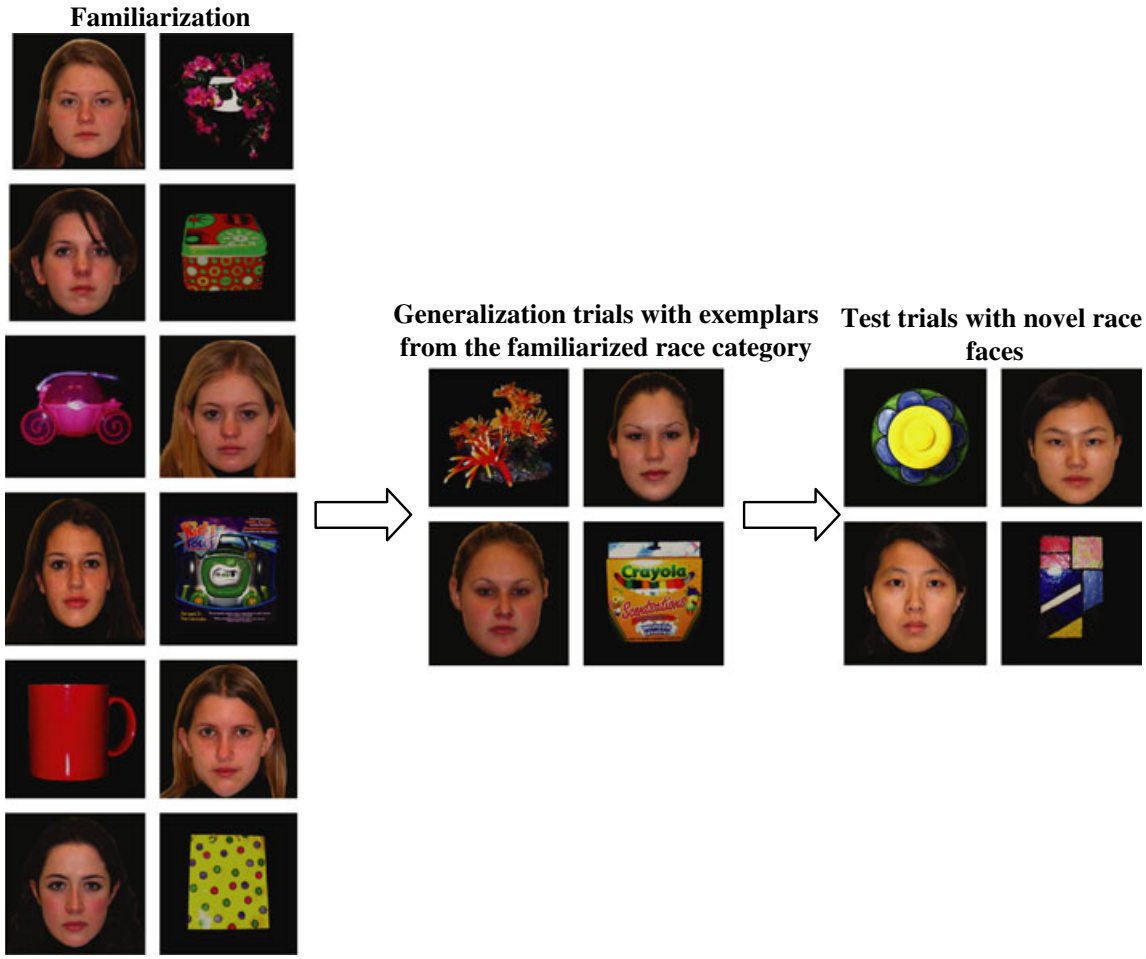

Figure 1 *Example of Condition A (Caucasian to Asian) stimuli (left: habituation trials; right: generalization and test trials).*

The familiarization phase in Condition A was immediately followed by two generalization trials each showing a novel exemplar from the *familiarized* race category (i.e. Caucasian) paired with different objects. These two generalization trials with the novel exemplars from the familiarized race category were included to ensure that infants were able to generalize habituation to novel instances from the same category. This was then immediately followed by two test trials each showing a novel exemplar from a *novel* race category (i.e. Asian) paired with different objects.

In Condition B (Asian to Caucasian), 21 6-month-olds (11 males) and 18 9-month-olds (eight males) were familiarized with six different Asian female faces presented in successive order. Each Asian face was paired with a different object. Familiarization with Asian faces was then immediately followed by two generalization trials each showing a novel exemplar from the *familiarized* race category (i.e. Asian) paired with different objects. This was immediately followed by two test trials each showing a novel exemplar from the *novel* race category (i.e. Caucasian) paired with different objects.

Within each condition (i.e. A or B), infants were also randomly assigned to one of four different versions comprising a different random order of different face–object pairings. The left/right presentation of faces and objects also alternated randomly across trials. For all infants, each trial remained on the screen until 6 seconds of looking at the stimuli had been accumulated.

This novel face–object paradigm is based on a modified version of a procedure used by Cohen and Brunt (2009), and was used to avoid potential problems inherent in the traditional method – the visual familiarization and novelty preference technique – typically used to study infants' categorization abilities. In this traditional method, infants are first familiarized with images of different exemplars belonging to the same category, followed by test trials showing a novel exemplar from the familiarized category paired with a novel exemplar from a novel category. If infants have formed an exclusive category of the familiarized stimuli, then they should look less at novel exemplars from the familiarized category and instead look more at novel exemplars from a novel category. However, this novelty preference paradigm is disadvantaged if there exists a spontaneous preference for one of the two categories under comparison. If a spontaneous preference exceeds infants' typical preference for novelty, then the traditional novelty preference paradigm would fail to

produce a novelty preference at test when a novel exemplar from the familiarized but preferred category is paired with an exemplar from a novel category. Thus, our sequential presentation of the faces avoids the pairing of the preferred own-race faces with the less preferred other-race faces. The second reason for using this novel face–object paradigm in examining infants' categorization abilities is that research has shown that paired presentation of different stimuli aids infants' encoding of such stimuli (Fagan, 1978). A third advantage in using this novel face–object paradigm is that the objects served to maintain infants' interest and attention on the screen (i.e. after infants' spontaneous preference for each face has dissipated, they can transfer their attention to the object). The inclusion of such objects was deemed helpful considering the lengthy nature of the task (i.e. 10 trials).

Coding

Videos of the infants during testing were subjected to a frame-by-frame analysis. Infants' duration and direction of looking were coded by two research assistants using the Queen's University Observational Videocoding System (Baron, Wheatley, Symons, Hains, Lee & Muir, 2001). Inter-rater reliability was assessed by comparing the coding on a randomly selected set of videos. The computed Cohen's Kappa for 10% of the total number of participants (i.e. eight videos) showed that the agreement between the two coders in terms of duration and direction of looking was .85.

Results

Familiarization trials

An examination of infants' looking patterns during habituation showed that on average, infants looked away from the stimuli approximately 34.71% (SD = 26.60) of the time. Thus, infants generally attended to the stimuli presented during habituation. To determine whether infants had sufficiently habituated to the familiarized race of faces, an ANOVA was conducted on the percentage of time spent looking at the faces relative to the objects during the familiarization phase. A preliminary analysis showed that the main effect of participant gender and the interactions with participant gender were not significant (p values > .05), and thus the follow-up analysis was collapsed across male and female participants.

The 6 (familiarization trials) × 2 (face ethnicity: Caucasian or Asian) × 2 (participant age: 6- or 9-month-old) ANOVA revealed a main effect of familiarization trials with the Greenhouse-Geisser correction, $F(4.07, 305.34) = 3.86$, $p < .05$, $\eta^2 = .05$, suggesting that 6- and 9-month-olds showed a significant decrease in looking at the faces (i.e. first familiarization trial: M = 61.52%, SD = 19.92%; last familiarization trial: M = 53.09%, SD = 23.79%) as the trials progressed. That is, despite the changing identity of the faces, infants from both age groups showed a decrease in looking at such faces, presumably because they habituated to female faces from a single race. The remaining main effects of face type and participant age were not significant (p values > .05).

There was also a significant interaction between the familiarization trials and face ethnicity, $F(4.07, 305.34) = 3.09$, $p < .05$, $\eta^2 = .04$, reflecting the differential rates of habituation towards Caucasian and Asian faces. More specifically, participants showed a quicker decline in their looking at Asian faces (i.e. first familiarization trial: M = 65.08%, SD = 19.50%; last familiarization trial: M = 51.77%, SD = 19.54%) relative to their looking at Caucasian faces (i.e. first familiarization trial: M =58.05%, SD = 19.92%; last familiarization trial: M = 54.38%, SD = 27.51%). This differential rate of habituation is most likely due to the Caucasian infants' preference for own-race faces (Bar-Haim *et al.*, 2006; Kelly *et al.*, 2005). The remaining two-way and three-way interactions were not significant (p values > .05).

Familiarization vs. generalization and test trials

An examination of infants' looking patterns during test showed that on average, infants looked away from the stimuli approximately 35.35% (SD = 29.30) of the time. Thus, infants were in general attentive towards the stimuli during test. An ANOVA was conducted on the percentage of time spent looking at the faces relative to the objects to determine whether infants were doing the following: (i) generalizing their decreased looking behaviour towards two additional novel exemplars from the familiarized race category, and (ii) displaying differential responsiveness (i.e. increasing looking) to two novel exemplars from the novel race category relative to the two novel exemplars from the familiarized race category. A preliminary analysis showed that the main effect of participant gender and the interactions involving participant gender were not significant, and thus follow-up analyses were collapsed across male and female participants.

The average percentage of time spent looking at faces relative to objects during the last two familiarization trials, the average percentage of time spent looking at the two novel faces from the familiar race category, and the average percentage of time spent looking at the two novel faces from the novel race category were computed as the three levels of the within-subjects factor for the ANOVA. To determine whether infants generalized habituation to novel familiar race faces and dishabituation to novel race faces, a 3 (type of trial: habituation trials, familiar race exemplar trials, or novel race exemplar trials) × 2 (Condition A or Condition B) × 2 (participant age: 6- or 9-month-old) ANOVA was conducted to specifically test the quadratic relationship between the three types of trials (i.e. familiarization faces, novel

familiar race faces, novel race faces). The ANOVA revealed a significant quadratic function for type of trial, $F(1, 75) = 8.95$, $p < .05$, $\eta^2 = .11$, suggesting that the infants may be generalizing responsiveness to the novel familiar race faces and displaying differential responsiveness to the novel race faces. However, the interaction between type of trial, condition, and participant age was also significant, $F(1, 75) = 5.38$, $p < .05$, $\eta^2 = .07$, suggesting that the quadratic nature of the three types of trials differed across the two conditions and/or the two age groups. Thus, separate analyses were conducted for 6- and 9-month-olds. The remaining interactions were not significant (p values > .05).

Six-month-olds. A 3 (type of trial: habituation trials, familiar race exemplar trials, or novel race exemplar trials) × 2 (Condition A or Condition B) ANOVA showed that the type of trial did not reflect a quadratic function ($p > .05$). However, the interaction between the type of trial and condition was significant, $F(1, 40) = 5.31$, $p < .05$, $\eta^2 = .12$, suggesting that the quadratic nature of the trials differed across the two conditions (see Figure 2).

Follow-up paired-samples t-tests with sequential Bonferroni adjustment showed a different pattern of results across the two conditions. In Condition A (Caucasian to Asian), 6-month-olds showed no difference in looking at the last two Caucasian faces from the familiarization trials and the novel Caucasian faces ($p > .05$). Six-month-olds, thus, showed generalized habituation to novel exemplars of the familiar race. However, there was no significant difference between infants' looking at the novel Caucasian exemplars and the Asian test faces ($p > .05$). This lack of differential responsiveness to the novel Asian test exemplars relative to the novel Caucasian exemplars suggests that 6-month-olds did not form a category of Caucasian faces that excluded Asian faces. Only seven of the 21 6-month-olds in Condition A showed an increase in looking from the novel Caucasian exemplars to the Asian test faces. The remaining 14 infants showed either no difference in looking or a decrease in looking from the novel Caucasian exemplars to the Asian test faces.

In Condition B (Asian to Caucasian), 6-month-olds showed no difference in looking at the last two Asian familiarization faces and the novel Asian faces ($p > .05$). Thus, similar to infants in Condition A, infants in Condition B also generalized responsiveness to novel exemplars of the familiar race. Moreover, they did show a significant difference in their looking at the two novel Asian exemplars relative to the two novel Caucasian test faces, $t(20) = 2.36$, $p < .05$. Sixteen of the 21 6-month-olds in Condition B showed an increase in looking from the novel Asian exemplars to the Caucasian test faces.

Nine-month-olds. The 3 (type of trial: habituation trials, familiar race exemplar trials, or novel race exemplar trials) × 2 (Condition A or Condition B) ANOVA showed a significant quadratic function for type of trial, $F(1, 35) = 13.45$, $p < .05$, $\eta^2 = .28$. The interaction between the type of trial and condition was not significant ($p > .05$), suggesting that the trials showed a quadratic function in both conditions (see Figure 3). Follow-up paired-samples t-tests with sequential Bonferroni correction showed a significant decrease in looking from the familiarization faces to the novel exemplars from the familiar race category, $t(36) = 3.11$,

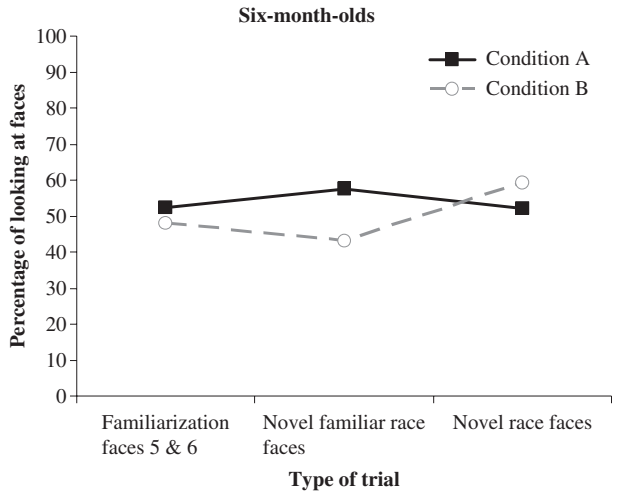

Figure 2 *Six-month-olds' percentage of looking at the familiarization faces, the novel exemplars from the familiar race category, and the novel race faces in Condition A (Caucasian to Asian) and Condition B (Asian to Caucasian) of the categorization task.*

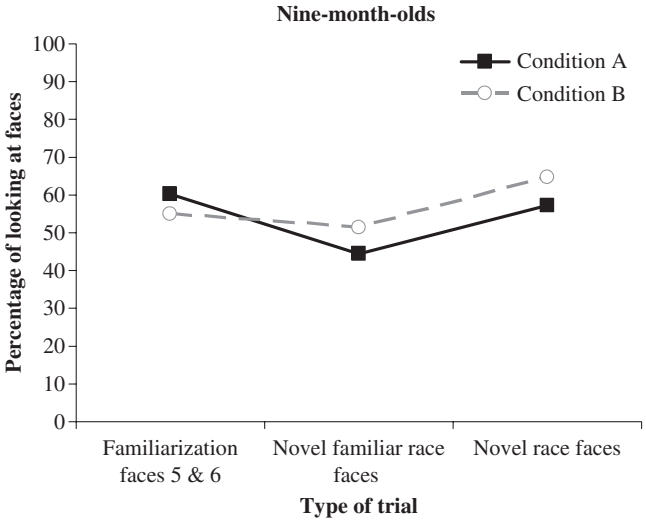

Figure 3 *Nine-month-olds' percentage of looking at the familiarization faces, the novel exemplars from the familiar race category, and the novel race faces in Condition A (Caucasian to Asian) and Condition B (Asian to Caucasian) of the categorization task.*

$p < .05$, suggesting that 9-month-olds showed further habituation to the familiar race faces. In addition, looking at the novel test exemplars from the novel race category was significantly greater than looking at the novel faces from the familiarized race category, $t(36) = 3.28$, $p < .05$. Twenty-eight of the 36 9-month-olds showed an increase in looking from the familiarized race exemplars to the novel race exemplars. Thus, in contrast to the asymmetrical pattern of performance on the test trials for the own- and other-race familiarization conditions for the 6-month-olds, the 9-month-olds showed differential responsiveness to novel race faces in both conditions.

Discussion

The results from Experiment 1 show that infants can categorize faces according to race by 9 months of age. More specifically, 9-month-olds habituated to the race of female faces during familiarization, and further habituated to two novel exemplars from the familiarized race category. Nine-month-olds also showed a significant increase in looking at the novel race faces in both conditions, suggesting that they had formed discrete categories of Caucasian and Asian faces.

Experiment 1 also showed that although 6-month-olds habituated to the race of female faces during familiarization, and generalized habituation to two novel exemplars from the familiarized category, they showed an asymmetry in their responsiveness to the novel race faces at test. Six-month-olds showed a significant increase in looking at own-race Caucasian faces relative to novel Asian faces when familiarized with Asian faces. In contrast, they showed no significant increase in looking at the other-race Asian faces relative to novel own-race Caucasian faces when familiarized with Caucasian faces. This asymmetry has two possible explanations that may be related. One explanation is that there exists a developmental change in racial categorization so that the ability to form discrete categories of faces based on race is acquired sometime between 6 to 9 months of age. A second explanation is that 6-month-olds are able to form discrete categories of faces based on race, but their asymmetry in categorization may be driven by their preference for own-race faces (Kelly *et al*., 2005, 2007a). A preference for own-race faces would have facilitated a preference for novel Caucasian faces over novel Asian faces after familiarization with Asian faces, but interfered with a preference for novel Asian faces over novel Caucasian faces after familiarization with Caucasian faces. It is possible that a developmental change in which the categorization response of infants becomes sufficiently powerful to overcome a spontaneous perceptual preference may underlie the performance difference between the 6- and 9-month-olds – a point that we return to in the General Discussion.

It should be noted that the present procedure attempted to reduce the spontaneous preference by pairing the faces with novel objects. However, the spontaneous preference for own-race faces may to be too strong to be overcome by 6-month-olds, leading to their asymmetrical results. In contrast, 9-month-olds appear to be able to overcome the spontaneous preference and consequently demonstrated more refined and separated categories of faces based on race.

However, categories can differ in the extent to which individual exemplars can be differentiated. *Categorization* refers to the formation of discrete groups, each of which comprises similar yet distinguishable exemplars, whereas *categorical perception* refers to the formation of discrete groups comprising similar exemplars that are difficult to discriminate (see Quinn, 1987; Quinn & Eimas, 1998; Repp, 1984). Thus, if infants have separate categories for own-race and other-race faces *and* if they can also discriminate between different own-race faces as well as between different other-race faces, then they can be described as *categorizing* own- and other-race faces. However, if infants show differential responsiveness to novel-race faces at test, but show no evidence of differentiation between individual exemplars from within own- and other-race categories, then they can be described as engaging in *categorical perception* of own- and other-race faces. Thus, Experiment 2 was conducted to further investigate the nature of infants' categorization of faces based on race by determining whether they can discriminate between Caucasian faces as well as between Asian faces.

Experiment 2

Method

Participants

Eighteen full-term 6-month-olds ($M = 200.11$ days, $SD = 21.12$ days, 12 males) and 18 full-term 9-month-olds ($M = 285.61$ days, $SD = 9.01$ days, three males) participated in the study. All infants were Caucasian and were reported to have had little to no experience with Asian faces. One additional 6-month-old and one 9-month-old were excluded from the analyses due to fussiness and crying.

Stimuli

The colour photographs of Caucasian and Asian female faces from Experiment 1 were used.

Procedure

An infant-controlled habituation procedure was used during which infants were familiarized with a single female face and subsequently presented with a novel

female face from the same race category to test their ability to discriminate between such faces. Face pairings from the Caucasian and Asian sets of stimuli were randomly selected for each infant. The familiarization face remained on the screen until 2 seconds of looking away had passed. The familiarization face was then continuously presented until infants' looking in a single trial decreased to 50% or less than 50% of the average of two consecutive trials with the longest looking. The familiarization trials were then followed by two test trials. The first test trial was always a 5-second presentation of the familiar face. The second test trial was a 5-second presentation of a novel female face of the same race as the familiar face. Eighteen infants (nine 6-month-olds and nine 9-month-olds) were tested in the Caucasian condition and 18 infants (nine 6-month-olds and nine 9-month-olds) were tested in the Asian condition. If infants can discriminate between the familiarized and novel faces chosen from within a race category, then they should show a novelty preference (i.e. greater percentage of looking at the novel faces relative to familiarized faces). However, if infants *cannot* discriminate between the familiarized and novel same-race faces, then one would not expect them to show a difference in the percentage of looking at the novel face versus the familiar face.

Coding

Videos of the infants during testing were subjected to a frame by frame analysis. Inter-rater reliability was assessed by comparing the coding on a randomly selected set of videos. The computed Cohen's Kappa for 20% of the total number of participants (i.e. seven videos) showed that the agreement between the two coders in terms of duration and direction of looking was .95.

Results

An ANOVA on the duration of habituation was conducted to ensure that habituation to Caucasian and Asian faces did not differ across participants. Considering that the preliminary analysis showed that neither the main effect of participant gender nor the interactions with gender was significant (p values > .05), the follow-up analysis collapsed across participant gender. A 2 (face ethnicity: Caucasian or Asian) × 2 (participant age) ANOVA showed no significant main effects or interaction (p values > .05), which suggests that both 6- and 9-month-olds showed comparable levels of habituation to both Caucasian and Asian faces. Thus, there appeared to be no difference in infants' attentional allocation towards Caucasian and Asian faces.

A second ANOVA was conducted to compare the percentage of time (i.e. from the fixed 5 seconds during which each test face was presented) infants spent looking at the familiarized test face versus the percentage of time infants spent looking at the novel test face. A preliminary analysis showed that neither the main effect of participant gender nor any of the interactions involving gender was significant. Thus, follow-up analyses were collapsed across participant gender. A 2 (face ethnicity: Caucasian or Asian) × 2 (face familiarity: familiar vs. novel) x 2 (participant age) ANOVA was conducted with the percentage of time infants looked at each test face during their sequential 5-second presentation as the dependent variable. The analysis showed a significant main effect of face ethnicity, $F(1, 32) = 6.47$, $p < .05$, partial $\eta^2 = .17$, which reflected greater looking in the Caucasian condition relative to looking in the Asian condition. Neither the main effect of face familiarity nor the main effect of participant age was significant (p values > .05).

There was also a significant interaction between face ethnicity and face familiarity, $F(1, 32) = 4.14$, $p = .05$, partial $\eta^2 = .12$. Follow-up analyses revealed that although infants showed a significant novelty preference in their percentage of looking at Caucasian faces (M = 68.79%/3.44 seconds, SD = 23.16%; novel face: M = 82.15%/4.11 seconds, SD = 17.69%), $t(17) = 3.44$, $p < .05$, they showed no novelty preference for Asian faces (familiar face: M = 64.60%/3.23 seconds, SD = 26.16%; novel face: M = 56.76%/2.84 seconds, SD = 24.99%), $p > .05$ (see Figure 4). The remaining two- and three-way interactions were not significant (p values > .05). Thus, although both 6- and 9-month-olds discriminated between different Caucasian (i.e. own-race) faces, they did not discriminate between different Asian faces.

Discussion

Experiment 2 was conducted to examine whether 6- and 9-month-olds could discriminate between different Caucasian faces and different Asian faces. Results indicated that although both 6- and 9-month-olds showed comparable habituation to both Caucasian and

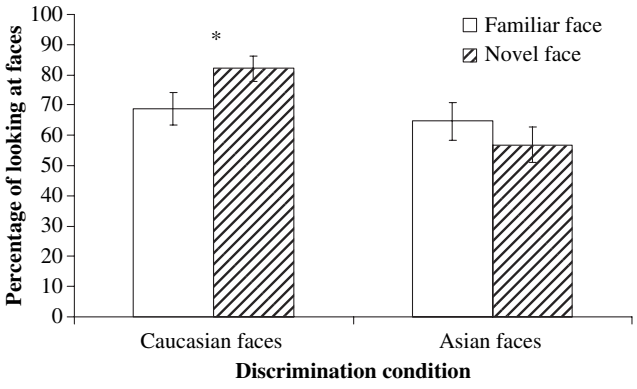

Figure 4 *Six- and 9-month-olds' percentage of looking at the familiar face versus the novel face in the discrimination task. * indicates a significant difference in looking at the familiar vs. novel face.*

Asian faces, they showed a novelty preference in only the Caucasian face condition. That is, both 6- and 9-month-olds were able to discriminate between own-race Caucasian faces, but they were unable to discriminate between different other-race Asian faces. This differential ability in discriminating between own-race Caucasian faces and between other-race Asian faces is likely due to infants' greater experience with own-race faces. These results are consistent with previous findings that an other-race effect in face recognition is evident in adults (reviewed in Meissner & Brigham, 2001) and begins its development during infancy (Hayden *et al*., 2007; Kelly *et al*., 2007b, 2009; Sangrigoli & de Schonen, 2004).

General discussion

The present study examined whether 6- and 9-month-olds can form separate categories of female faces differing in racial background. The results revealed two main findings: (i) 9-month-olds can form face categories according to race, and (ii) 9-month-olds' categories of own-race and other-race faces are qualitatively different from one another. However, the present study is unable to offer conclusive evidence regarding whether 6-month-olds are also able to form face categories according to race.

Experiment 1 showed that 9-month-olds could form categories of faces based on race. They showed differential responsiveness (i.e. increased looking) to the novel race faces at test relative to the novel faces from the familiar race category, regardless of whether they were habituated with Caucasian faces or Asian faces. Thus, 9-month-olds were able to form exclusive racial categories from the more global category of human faces.

However, Experiment 2 showed that 9-month-olds' subordinate categories of own-race Caucasian and other-race Asian faces are qualitatively different from one another in terms of whether or not the individual exemplars can be differentiated. More specifically, 9-month-olds were able to discriminate between different own-race Caucasian faces, presumably because they have greater experience with such faces, but they did not discriminate between different Asian faces. Thus, 9-month-olds' subordinate category of Caucasian female faces can be further parsed into an even more exclusive level – that of identity, whereas their subordinate category of Asian female faces appears to be less differentiated considering the lack of evidence for discrimination between different Asian exemplars.

Overall, results from Experiments 1 and 2 taken together suggest that 9-month-olds engage in *categorization* of own-race Caucasian faces and *categorical perception* of other-race Asians faces. The present results thus imply that the processes leading to category formation and differentiation (i.e. categorization vs. categorical perception) may develop as a function of differential experience with faces. The pre-existing ability to discriminate between own-race faces prior to 9 months of age thus appears to be a precursor that is associated with the subsequent ability to engage in categorization of own-race faces, whereas a lack of experience with other-race faces leads to poor discriminability between individual exemplars and subsequent categorical perception of other-race faces.

In contrast to 9-month-olds' categorization abilities, 6-month-olds' racial categorization of faces remains ambiguous. Six-month-olds demonstrated an asymmetry in their looking behaviour in that they showed a significant increase in looking at own-race Caucasian faces relative to novel other-race Asian faces after familiarization with Asian faces, but they showed no significant increase in looking at other-race Asian faces over novel own-race Caucasian faces after familiarization with Caucasian faces. This apparent asymmetry in differential responsiveness to the novel race faces at test may be indicative of a developmental change in the racial categorization of faces between 6 and 9 months of age. Additionally, this asymmetrical pattern of looking across conditions may have been driven by 6-month-olds' spontaneous preference for own-race Caucasian faces. Despite our efforts to avoid the influence of spontaneous preference by presenting the faces sequentially, the spontaneous preference for own-race faces may be so strong that it was able to bias looking behaviour across trials. A new procedure that is not limited or confounded by infants' spontaneous preferences should, therefore, be developed to adequately study 6-month-olds' racial categorization of faces.

Thus, the present results cannot rule out the possibility that 6-month-olds may also be categorizing own-race Caucasian faces and engaging in categorical perception of other-race Asian faces, but that such processing is masked by a stronger spontaneous preference for own-race faces. If this is the case, then in contrast to the 6-month-olds, infant responding to own- and other-race categories at 9 months is in some sense 'freed' from spontaneous preference so that categorization is symmetrical across conditions. This possible development between 6 and 9 months of age thus suggests a weaning away from categories based on spontaneous perceptual preference to categories that can overcome perceptual preference. Such a trend is in accord with a transition from perceptual-to-conceptual representations that has been proposed for the development of categories in general (Madole & Oakes, 1999; Quinn & Eimas, 1997; Rakison & Poulin-Dubois, 2001). The fact that 9-month-olds, but not 6-month-olds, can become freed from spontaneous perceptual preference to show symmetrical categorization may reflect a developmental change from perceptual to more conceptual categorization between 6 and 9 months of age. Alternatively, the spontaneous preference for own-race faces might diminish with age so that 9-month-olds no longer have to overcome such

perceptual preference in their response to the category distinction.

Six-month-olds' asymmetrical pattern of looking across conditions and 9-month-olds' racial categorization of faces is consistent with previous findings showing an asymmetry in young infants' subordinate categorization of facial expressions (Caron *et al.*, 1982; Ludemann, 1991; Ludemann & Nelson, 1988; Nelson & Dolgin, 1985; Nelson *et al.*, 1979) and a subsequent formation of more refined and exclusive subordinate categories among older infants (Caron *et al.*, 1982; Ludemann, 1991). As might be the case in the present study, previous findings have also alluded to a spontaneous preference for a particular type of face (e.g. faces showing a fearful expression or female faces) in driving the asymmetry in looking behaviour in young infants (Bornstein & Arterberry, 2003; Nelson & Dolgin, 1985; Quinn *et al.*, 2002). In particular, 6-month-olds' asymmetrical pattern of looking across conditions parallels previous findings of 3- and 4-month-olds' asymmetrical categorization abilities for female and male faces (Quinn *et al.*, 2002). Quinn *et al.* speculated that this asymmetry was driven by infants' spontaneous preference for female faces, which in turn may have developed due to their greater experience with female relative to male faces.

Although 6-month-olds' racial categorization remains ambiguous, 9-month-olds in the present study clearly showed evidence of discrete categories for Caucasian and Asian faces. However, future studies should examine *how* 9-month-olds form these separate categories, and how the results may be relevant to the larger debate over whether categories are perceptually or conceptually driven (Mandler, 2000; Quinn & Eimas, 1997). We suspect that there was a perceptual basis for 9-month-olds' categorization. In particular, 9-month-olds in the present study may have been relying on differences in the shape of facial features to form separate categories for Caucasian and Asian faces. However, as noted, there also seems to be a conceptual component to the categorization of the 9-month-olds inasmuch as this age group demonstrated symmetrical categorization performance that was not affected by the spontaneous preference for own-race faces.

To our knowledge, the current study is the first to investigate infant responding to race category information in faces. Additional studies are, therefore, needed to ensure that our novel findings can be replicated. Conducting an identical study with Asian infants would determine whether the same asymmetry would be evident among the 6-month-olds except in the opposite direction (i.e. dishabituation in Condition A only), and whether this asymmetry disappears by 9 months of age as was found in the present study. It would also be informative to examine infants' racial categorization of faces using facial stimuli that differ in race from those used in the present study. For example, are infants' categorization abilities for Caucasian versus Asian faces the same as their categorization abilities for Caucasian versus African faces? Thus, future studies should be conducted to ensure that the novel findings in the present study are replicated with a different sample and with faces from other ethnic backgrounds.

Future studies should further examine how infants' categorization of own-race faces and categorical perception of other-race faces influences even finer-grained subordinate levels of category formation (e.g. categories of gender or age within own-race and other-race faces). It is possible that relative to a categorical perception of Asian faces, categorization of Caucasian faces might subsume a greater number of subordinate-level categories due to the greater discriminability between within-category exemplars. However, with age, discriminatory and recognition abilities for other-race faces improves to above chance levels despite the advantage for own-race faces (MacLin, Van Sickler, MacLin & Li, 2004; Pezdek, Blandon-Gitlin & Moore, 2003). Thus, relative to infants, older age groups' other-race face categories might encompass a greater number of subordinate-level categories. However, as long as experience with other-race faces remains minimal, and there remains an advantage in recognition for own-race faces, own-race face categories would likely consist of an even greater number of subordinate-level categories relative to the number of subordinate-level categories for other-race faces. Findings from the present study thus impel further study of the role of differential experience in infants' responding to, as well as older age groups' perception of, social category information in faces.

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