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Race-Based Perceptual Asymmetry in Face Processing Is Evident Early in Life

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Abstract

Adults' processing of own-race faces differs from that of other-race faces. The presence of an "other-race" feature (ORF) has been proposed as a mechanism underlying this specialization. We examined whether this mechanism, which was previously identified in adults and in 9-month-olds, is evident at 3.5 months. Caucasian 3.5-month-olds looked longer at a pattern containing a single Asian face among seven Caucasian faces than at a pattern containing a single Caucasian face among seven Asian faces. Homogenous and inverted face control conditions indicated that infants' preference was not driven by the majority of faces in arrays or by low-level features. Thus, 3.5-month-olds found the presence of an other-race face among own-race faces to be more salient than the reverse configuration. This asymmetry suggests sensitivity to an ORF at 3.5 months. Thus, a key mechanism of race-based processing in adults has an early onset, indicating rapid development of specialization early in life.

Adults treat own-race faces differently than other-race faces (e.g., Meissner & Brigham, 2001; Walker & Tanaka, 2003). Such specialization is seen even during the first year of life. For instance, infants as young as 3 months of age prefer own-race to other-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005, 2007a). Also, some studies have documented superior recognition of own-race compared with other-race faces at 3 to 3.5 months (Hayden, Bhatt, Joseph, & Tanaka, 2007; Sangrigoli & de Schonen, 2004). However, Kelly et al. (2007b, 2009) concluded that superior recognition of own-race faces is not seen at 3 months, is only partly evident at 6 months, and is robust by 9 months. Moreover, categorization of own-versus other-race faces is not clearly seen at 6 months but is evident at 9 months (Anzures, Quinn, Pascalis, Slater, & Lee, 2010). In totality, the set of studies to date suggest a gradual development of race-based specialization during the first year of life (also see Balas, Westerlund, Hung, & Nelson, 2011; Ferguson, Kulkosky, Cashon, & Casasola, 2009; Liu et al., 2011; Wheeler et al., 2011).

The current study examined the development of a mechanism proposed by Levin (1996, 2000) that is thought to underlie adults' race-based specialization. Levin hypothesized that adults view other-race faces as containing an "other-race" feature (ORF) that own-race faces

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lack. He found support for this hypothesis by adopting Treisman and Gormican's (1988) notion that fundamental features result in an asymmetry: a feature's presence is more noticeable than its absence. For instance, a Q among Os is more rapidly detected than an O among Qs because of the presence of the line-crossing feature in Qs and its absence in Os. Levin found that Caucasian adults more readily detected an other-race face among own-race faces than an own-race face among other-race faces and concluded that this asymmetry indicates that an other-race face has the readily detectable ORF, whereas its absence in own-race faces is not as noticeable. He also suggested that the presence of an ORF affects the subsequent processing of other-race faces, thus leading to a variety of race-based phenomena, such as superior recognition of own-race faces.

Hayden, Bhatt, Zieber, and Kangas (2009) found that 9-month-olds exhibit a preference that is analogous to the asymmetry exhibited by adults: Caucasian infants looked longer at a pattern containing a single Asian face among seven Caucasian faces than at a pattern containing a single Caucasian face among seven Asian faces. Thus, 9-month-olds exhibited an asymmetry suggesting that the ORF is detected at this age.

The current study examined whether the ORF is detected early in life by testing whether 3.5-month-olds also exhibit a perceptual asymmetry. As described earlier, some aspects of race-based specialization are not evident until after 6 months of age, so it is possible that, unlike 9-month-olds in Hayden et al. (2009), 3.5-month-olds will fail to exhibit evidence of sensitivity to the ORF. On the other hand, sensitivity to this feature at 3.5 months would indicate that a mechanism underlying race-based processing in adulthood is functional early in life. Also, we utilized an inverted face control condition to test the possibility that some low-level feature correlated with but not germane to race leads infants to exhibit a perceptual asymmetry. This control was not utilized in Hayden et al., so there is some uncertainty as to whether infants' performance in that study was driven by race or by low-level features.

EXPERIMENT 1

In this experiment, we used the stimuli and procedure utilized by Hayden et al. (2009) to test 3.5-month-olds. Infants in the *discrepant* condition were exposed to two patterns, one containing an other-race face among seven copies of an own-race face and the other containing an own-race face among seven copies of an other-race face (see Figure 1). If, like 9-month-olds, 3.5-month-olds exhibit a preference for the former over the latter pattern, then it would indicate that an other-race among own-race contrast is more salient than the reverse. Such an asymmetry would suggest sensitivity to the ORF by 3.5 months of age.

However, it is possible that infants' preferences in the *discrepant* condition would be driven by the majority of faces in the arrays rather than by the racial discrepancies. That is, infants may prefer the pattern with the other-race among own-race faces not because of the race discrepancy, but because the majority of the faces in the array are own-race faces and infants prefer to look at own-race faces (e.g., Bar-Haim et al., 2006; Kelly et al., 2005, 2007a). To examine this issue, we contrasted infants' performance in the *discrepant* condition with the performance of a separate group of infants in the *homogenous* control condition, who were tested for their preference between homogenous patterns of eight own-race and eight other-race faces (Figure 1). If infants' preference for the other-race among own-race pattern in the *discrepant* condition is greater than their preference for the own-race face pattern in the *homogenous* condition, then it would indicate that preference in the former condition was driven by the race discrepancy rather than by the majority of elements in the arrays.

Method

Participants—The participants were forty 3.5-month-olds (*M* age = 112.20 days, *SD* = 4.47, 20 females). The infants in this and the following experiment were Caucasians from middle-class families. Data from nine additional infants were not included because of failure to sample both stimuli ($n = 8$) or fussiness ($n = 1$).

Stimuli—The stimuli were the same as those used in the study by Hayden et al. (2009). They were color photographs of faces of four Asian and four Caucasian females. Two faces of each kind were from the JACNeuf set (Matsumoto & Ekman, 1988; faces N16, N25, N43, N48), while the others were from the MacBrain set (Tottenham et al., 2009; Asian #16 and #19; Caucasian #2 and #8). Four Asian/Caucasian face pairs were constructed from these images. Each infant was tested on one of these pairs. The same contrasts were used with the different groups of infants in the *discrepant* and *homogenous* conditions. As described in Hayden et al. (2009), the hair was removed from the images and the skin tone was matched within pairs of faces. The skin tones were matched in order to avoid discrimination and preference based on skin color contrasts. Two of the face pairs had Caucasian skin tones (i.e., the skin tones of the Asian faces in these sets were changed to match the corresponding Caucasian faces), while the other two pairs had Asian skin tones (i.e., the skin tones of the Caucasian faces in these sets were changed to match the corresponding Asian faces). Thus, equal numbers of Asian and Caucasian faces had natural and artificial skin tones, while within each Asian/Caucasian pair, the skin tones matched.

Eight faces were arranged on a black background in a diamond formation [as in Levin's (1996, 2000) studies; see Figure 1]. Individual faces subtended approximately 3.69° × 5.60° and were located 0.76° apart. Each diamond-shaped pattern subtended approximately 22° × 17.25°. The edge-to-edge distance between the two patterns was 2.93°. In the *discrepant* experimental condition, the Caucasian among Asian displays consisted of a single Caucasian face among seven identical Asian faces, while the Asian among Caucasian displays consisted of a single Asian face among seven identical Caucasian faces (Figure 1). The singleton Caucasian and Asian faces in these patterns were in the same location within face pairings but varied across face pairings. In the *homogeneous* control condition, the displays contained eight identical Asian or Caucasian faces in order to assess overall preference for groups of Caucasian over Asian faces (Figure 1).

Apparatus and procedure—The apparatus and procedure were identical to those used in Hayden et al. (2009). Infants were seated approximately 45 cm in front of a 50-cm monitor in a darkened chamber. Two 8-sec spontaneous preference trials were used to test infants' preference between two patterns. Each trial started with the presentation of an attention-getter (rapidly alternating colored shapes) in the middle of the screen. Once the infant oriented to the middle of the monitor, the attention-getter disappeared and a pair of face patterns appeared on the screen. The left/right locations of the Caucasian/Asian patterns in the *homogenous* condition and the Caucasian among Asian/Asian among Caucasian patterns in the *discrepant* condition were randomly determined and counterbalanced across the set of infants in each condition; this location was changed from one trial to the next to avoid side bias. Each infant was tested on the same patterns across the two trials.

A video camera, located on the top of the computer monitor, was used to record infants' behavior onto a DVD. Coding of infants' performance was conducted off-line, with the coder unaware of the left/right location of the stimulus patterns. The DVD player was slowed to 20% of the normal speed during coding. A separate coder recoded data from eight infants in order to obtain a reliability measure. The Pearson's correlation between the two observers' scores was .97.

Results and discussion

The dependent measure was the percentage preference for the majority Caucasian pattern (i.e., preference for the Asian among Caucasian pattern in the *discrepant* condition and for the homogenous Caucasian pattern in the *homogenous* condition). It was computed by dividing the look duration to the majority Caucasian pattern by the total look duration to both patterns during the two trials and multiplying this ratio by 100.

An analysis of outlier status (Tukey, 1977; using SPSS version 17.0; IBM, Armonk, NY) revealed that the scores of two infants in the *discrepant* condition were outliers. The final analyses were conducted without these scores. Scores were higher in the *discrepant* than in the *homogenous* condition (Table 1). A *t* test revealed that infants in the *discrepant* condition exhibited a preference score that was significantly greater than the chance level of 50%, $t(17) = 2.62$, $p < .02$. That is, infants in this condition exhibited a significant preference for the Asian among Caucasian pattern over the Caucasian among Asian pattern. In contrast, infants in the *homogenous* condition did not exhibit a preference, $t(19) = -.70$, $p > .10$ (Table 1). Moreover, a group (*discrepant*, *homogenous*) × face pair (*1, 2, 3, 4*) analysis of variance revealed only a significant group main effect, $F(1,30) = 5.68$, $p < .03$, $\eta_p^2 = .16$. This indicates that performance did not differ across the four face pairs, and infants' scores were significantly higher in the *discrepant* than in the *homogenous* condition. Thus, for 3.5-month-old Caucasian infants, an array containing an Asian face among seven Caucasian faces is more salient than an oppositely configured array. This result indicates that the ORF is a characteristic of other-race faces that captures 3.5-month-olds' attention.

Also, the fact that performance did not differ across the four face pairs indicates that race-based processing is evident even when the skin tone is matched. This finding is consistent with several prior studies that have found race-based processing differences when gray scale images are used (Anzures, Pascalis, Quinn, Slater, & Lee, in press; Hayden et al., 2007) or when skin tone is explicitly matched (Hayden et al., 2009; also see Balas & Nelson, 2010; Balas et al., 2011; Bar-Haim, Saidel, & Yovel, 2009). Thus, race-based processing in infancy appears to be primarily driven by morphological features.

EXPERIMENT 2

A potential alternative to the conclusion that 3.5-month-olds in Experiment 1 exhibited a race-based perceptual asymmetry is that some unknown feature correlated with but not pertinent to race drove infants' performance. For instance, it is possible that the pigmentation of the eyes was different in one race than the other, and this led infants to exhibit an asymmetry akin to Levin's (1996, 2000) findings with adults. Experiment 2 addressed this issue by testing infants with inverted faces (Figure 2). If some low-level feature like pigmentation led infants to exhibit a perceptual asymmetry, then the same feature would be available in inverted faces and infants should exhibit the same preference as in Experiment 1. If, however, infants' preference is affected by inversion, then it would suggest that performance in Experiment 1 was not because of irrelevant low-level features.

Method

Participants—Twenty 3.5-month-olds (*M* age = 113.20 days, *SD* = 5.49, eight females) participated. Data from an additional two infants were not included because of failure to sample both stimuli (*n* = 1) or looking for <1 sec during the trials (*n* = 1).

Stimuli—The stimuli were the ones used in the *discrepant* condition of Experiment 1, except that each individual face in the patterns was inverted (Figure 2).

Apparatus and procedure—The apparatus and procedure were the same as those used in Experiment 1.

Results and discussion

An outlier analysis did not reveal any outliers. Infants failed to exhibit a preference with inverted faces (Table 1). The mean preference score of 48.24% was not significantly different from 50%, $t(19) = -.61$, $p > .10$. Moreover, infants' score in the upright *discrepant* condition of Experiment 1 was significantly greater than the score in the inverted *discrepant* condition of Experiment 2, $t(36) = 2.26$, $p < .05$, $d = .73$. Thus, inversion disrupted infants' performance, indicating that it is unlikely that infants' asymmetrical preference in Experiment 1 was due to some low-level feature that is unrelated to race.

GENERAL DISCUSSION

An array containing an other-race face among own-race faces is more salient to 3.5-month-olds than an array containing an own-race face among other-race faces. This perceptual asymmetry suggests sensitivity to an ORF in other-race faces at this age. Thus, a key mechanism underlying race-based processing in adulthood (Levin, 1996, 2000; Sporer, 2001) is functional early in life.

Levin (1996, 2000) suggested that adults' sensitivity to the ORF causes several race-based phenomena. For instance, he argued that the inferior recognition of other-race faces (the other-race effect, ORE) is caused by the ORF leading adults to emphasize the category of other-race faces at the expense of the presumably less relevant individuating information. The sensitivity to ORF at 3.5 months might promote such cognitive economy early in life by channeling infants' attention toward appropriate information from different people with whom they have different levels of social interaction.

It is therefore possible that sensitivity to the ORF at 3.5 months of age also causes the ORE in infancy. That is, infants might detect the ORF in an other-race face and become less likely to process individuating information that they normally process in own-race faces. Such a possibility is supported by findings by Hayden et al. (2007) and Sangrigoli and de Schonen (2004) that infants exhibit the ORE around 3 to 3.5 months of age, the age at which they exhibited evidence of an ORF in the current study.

As noted earlier, however, other studies claim that the ORE is not evident at 3 months and becomes robust only between 6 and 9 months (Kelly et al., 2007b, 2009). It is not clear why there are discrepancies in the onset of the ORE in different studies. It is likely due to stimulus and procedural differences. For instance, studies that have failed to find the ORE in younger infants have typically tended to use images containing external features (e.g., Kelly et al., 2007b, 2009), whereas those that have found the ORE have used stimuli without external features (Hayden et al., 2007) or with concealed external features (Sangrigoli & de Schonen, 2004). Because younger infants typically rely on external features more than older infants (e.g., Rose, Jankowski, & Feldman, 2008), when these features are available, younger infants may be able to use them to discriminate between faces of all races, whereas older infants may rely on internal features and be affected by the race-specific information. In contrast, when external features are not present, younger and older infants have only internal features to rely upon and consequently may be affected by the ORF.

Besides the ORE, studies suggest that other kinds of race-based phenomena have different developmental onsets. For instance, preference for own-race faces has been shown at 3 months (Bar-Haim et al., 2006; Kelly et al., 2005, 2007a), whereas differential categorization of own-versus other-race faces is thought to become robust only sometime after 6 months (Anzures et al., 2010). Given that Levin (1996, 2000) tied the presence of the ORF to a variety of race-based phenomena, future studies need to examine how its presence at 3.5 months of age is related to differential onset and developmental trajectories of various race-based functions.

A limitation of the current study is that only Caucasian infants were used. There would be more certainty about the presence of the ORF if Asian infants had participated and had exhibited the opposite preference. Such a finding would rule out the possibility that a nonrace feature in the faces used in the current study led to the asymmetrical attention. Note, however, that the inversion condition in Experiment 2 suggested that infants' performance was not based on low-level nonrace features. Moreover, two of the four pairs of faces used in the current study (from the JACNeuf set) were part of a set of stimuli that led to clear cross-cultural performance in adults in a previous study (Beihl et al., 1997). It is thus unlikely that the evidence of ORF obtained in the current study was a result of stimulus artifacts. Nevertheless, in the absence of a cross-race asymmetrical preference, one cannot rule out the possibility that some nonrace-related aspects of the stimuli used in the current study contributed to the infants' asymmetrical preference.

Another point to note is the fact that 3-month-olds in some prior studies have exhibited a preference for own-race faces over other-race faces (Bar-Haim et al., 2006; Kelly et al., 2005, 2007a). In contrast, in the *homogenous* condition of Experiment 1 (and in Hayden et al., 2009), infants failed to exhibit a preference between Caucasian versus Asian faces. Many stimulus and procedural factors might account for this difference. For example, eight copies of a Caucasian face were paired with eight copies of an Asian face in the *homogenous* condition, whereas only one face from each race was used in the studies by Bar-Haim et al. (2006) and Kelly et al. (2005, 2007a). The larger number of faces in the current study may have led infants to divide their attention in the time available and may have prevented the exhibition of own-race preference. Moreover, unlike in prior studies, external features were absent from the current stimuli and the skin tone was matched between the faces from the two races, and these factors could have caused the discrepant outcomes. Procedural differences (e.g., 8-sec trials in the current study versus trials that lasted until infants accumulated 10 sec of look duration in Kelly et al., 2005) may have also contributed to the different results.

While the current results support Levin's (1996, 2000) findings of the presence of an other-race fundamental feature, not all studies of adults' race-based processing support Levin's model. For instance, there are questions about the conditions under which an other-race face among own-race faces is detected more rapidly than the opposite arrangement (Lipp et al., 2009). There is also support for some alternative explanations for race-based specialization in adulthood (Rhodes, Locke, Ewing, & Evangelista, 2009). However, the consistency of the current findings and those of Hayden et al. (2009) with Levin's model and empirical findings suggests that Levin's mechanism of race-based processing has validity in infancy.

Another point worth noting is that, in prior research, the use of arrays of objects with embedded discrepancies of the sort used in the current study ("pop-out" arrays) has resulted in findings of superior sensitivity in infants than the use of individual stimuli. For instance, contrary to prior conclusions (Kellman & Arterberry, 1998; Yonas, Arterberry, & Granrud, 1987), studies in which "pop-out" arrays were used (Bertin & Bhatt, 2006; Bhatt & Bertin, 2001; Bhatt & Waters, 1998) indicated that even infants as young as 3 months of age are sensitive to three-dimensional information in static images. Arrays provide a high level of contrast to infants and highlight differences, thereby enabling attention to relevant information and superior discrimination. Such arrays are also more realistic in capturing processing demands in some circumstances, such as those involving visual search (Wolfe, Alvarez, Rosenholtz, Kuzmova, & Sherman, 2011). Thus, stimulus arrays of the sort used in the current research have the potential to reveal greater sensitivity in infants and better capture the functioning of the face processing system in some kinds of natural scenes (e.g., detecting a person in a crowd) than individual stimuli of the sort used in typical face processing studies.

In summary, the current study extends the findings of Hayden et al. (2009) by indicating the presence of the ORF at 3.5 months and provides evidence against the possibility that the perceptual asymmetry exhibited by infants in the current study and in Hayden et al. was driven by low-level, nonracial features. The results indicate that the mechanism of race-based specialization exhibited by adults and older infants has its origin quite early in life.

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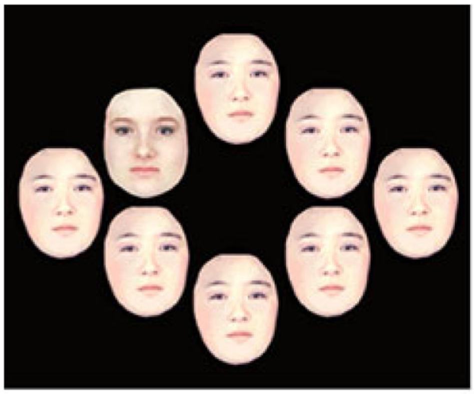
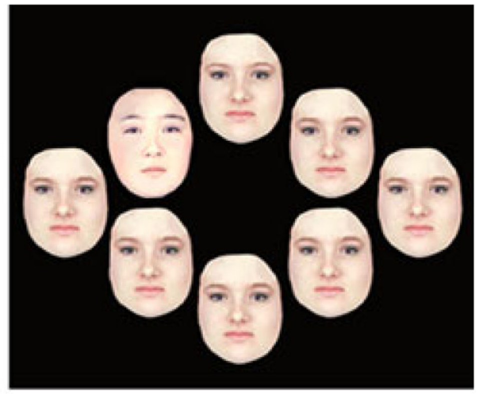
Discrepant Condition

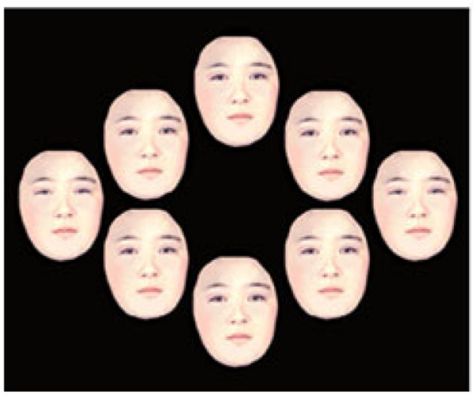


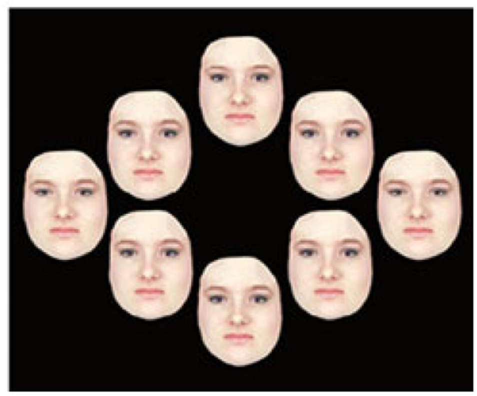


Caucasian among Asian Faces Display

Asian among Caucasian Faces Display

Homogenous Condition





Asian Face Display

Caucasian Face Display

Figure 1.

Examples of the face arrays used in Experiment 1. In the *discrepant* condition, infants saw an Asian face among seven copies of a Caucasian face paired with a Caucasian face among seven copies of an Asian face. In the *homogenous* condition, infants saw a homogeneous display of Asian faces paired with a homogeneous display of Caucasian faces. The dependent measure was the preference for the majority Caucasian image in each condition (i.e., the Asian among Caucasian faces display in the *discrepant* condition, and the homogeneous Caucasian face display in the *homogenous* condition).

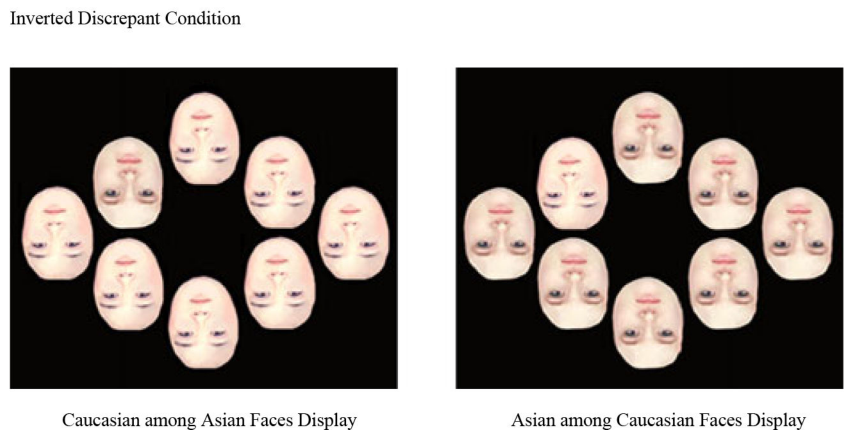


Figure 2.
Examples of the inverted face arrays used in Experiment 2. They were the same as the patterns used in the *discrepant* condition of Experiment 1, except that the faces were inverted.

TABLE 1

Mean Preference Scores (Percentages) for the Majority Caucasian Displays in Experiment 1 and 2

	Preference for majority Caucasian display		
	N	**M (SE)**	**t**
Upright (Experiment 1)			
Discrepant condition	18	57.48 (2.85)	2.62 *
Homogenous condition	20	47.95 (2.93)	−.70
Inverted (Experiment 2)			
Discrepant condition	20	48.24(2.89)	−.61

Note.

* $p < .02$, two-tailed; significantly different from the chance level of 50%.