

Brief Report

Fabrice Damon¹

Laurie Bayet¹

Paul C. Quinn²

Anne Hillairet de Boisferon¹

David Méary¹

Eve Dupierrix¹

Kang Lee³

Olivier Pascalis¹

¹Univ. Grenoble Alpes
LPNC

Grenoble, F-38000, France

²Department of Psychological and Brain
Sciences
University of Delaware
USA

³Institute of Child Study
University of Toronto
Toronto, Canada

Can Human Eyes Prevent Perceptual Narrowing for Monkey Faces in Human Infants?

ABSTRACT: Perceptual narrowing has been observed in human infants for monkey faces: 6-month-olds can discriminate between them, whereas older infants from 9 months of age display difficulty discriminating between them. The difficulty infants from 9 months have processing monkey faces has not been clearly identified. It could be due to the structural characteristics of monkey faces, particularly the key facial features that differ from human faces. The current study aimed to investigate whether the information conveyed by the eyes is of importance. We examined whether the presence of Caucasian human eyes in monkey faces allows recognition to be maintained in 6-month-olds and facilitates recognition in 9- and 12-month-olds. Our results revealed that the presence of human eyes in monkey faces maintains recognition for those faces at 6 months of age and partially facilitates recognition of those faces at 9 months of age, but not at 12 months of age. The findings are interpreted in the context of perceptual narrowing and suggest that the attenuation of processing of other-species faces is not reversed by the presence of human eyes. © 2015 Wiley Periodicals, Inc. *Dev Psychobiol* 57:637–642, 2015.

Keywords: infant; perceptual narrowing; monkey faces; human eyes

INTRODUCTION

Perceptual narrowing can be defined as a progression whereby infants maintain the ability to discriminate stimuli to which they are exposed, but lose the ability to discriminate stimuli to which they are not exposed (Scott, Pascalis, & Nelson, 2007). It was first observed for language development (Werker & Tees, 1999). Nelson (2001) drew a parallel with the development of face recognition, proposing that face processing devel-

ops during the first year of life from a broad non-specific system to a human-tuned face processor. By this view, faces present within the visual environment of infants should maintain initial sensitivities; however, those sensitivities should be lost for faces not present within the infant's visual environment. It has since been found that 6-month-olds can recognize different human faces as well as different monkey faces. Such recognition of individual monkey faces disappears by 9 months unless experience with such faces is provided (Pascalis et al., 2005; Pascalis, de Haan, & Nelson, 2002; Scott & Monesson, 2009). Additional studies have reported perceptual narrowing during the first year of life with Barbary macaques (Fair, Flom, Jones, & Martin, 2012; Pascalis et al., 2005) and sheep (Simpson, Varga, Frick, & Frigaszy, 2011). The effect is nevertheless flexible and does not represent the complete loss of an ability, given findings that doubling the familiarization time for 12-month-olds (i.e., 40 s in Fair et al., 2012 vs. 20 s in Pascalis et al., 2002)

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Correspondence to: Fabrice Damon, Laboratoire de Psychologie et NeuroCognition, Université Grenoble Alpes, BP 47 38040, Grenoble Cedex 9, France.

E-mail: fabrice.damon@upmf-grenoble.fr

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allowed them to recognize monkey faces (Fair et al., 2012).

In the domain of face perception, perceptual narrowing can be understood as a phenomenon in which, between 3- to 12-months of age, the face processing system develops in a way that makes processing and recognizing infrequently seen faces (e.g., animal faces) more difficult. It is unclear whether the drop in recognition observed following perceptual narrowing is due to general changes in face processing strategies or to increased focus on salient attributes of frequently seen faces. The developmental changes underlying perceptual narrowing are still actively debated (Flom, 2014; Maurer & Werker, 2014), and several face processing mechanisms have been investigated. Face recognition can be achieved using three types of facial information: featural information (i.e., individual features such as the eyes, nose, and mouth), configural information (i.e., the relations among individual features), and holistic information (i.e., the facial gestalt which fuses featural and configural information into an unbroken whole) (Maurer, Le Grand, & Mondloch, 2002). Ferguson, Kulkofsky, Cashion, and Casasola (2009) compared holistic versus featural processing of own- and other-race faces in 4- and 8-month-old Caucasian infants. While 4-month-olds demonstrated holistic processing for both own- and other-race faces, 8-month-olds showed holistic processing for own-race faces, but other-race faces were processed featurally. However, Zieber et al. (2013) have argued that the drop in recognition associated with perceptual narrowing is not due to a difference in configural processing for human and monkey faces. They reported that 9-month-olds could discriminate rhesus monkey faces that differed only by changes in spacing between the eyes or between the nose and mouth. The Zieber et al. results imply that prior reports of infant inability to recognize monkey faces (Pascalis et al., 2002, 2005; Scott & Monesson, 2009) were not due to a change in the processing of relative distances between features. However, it is important to note that Zieber et al. (2013) used a longer familiarization period than Pascalis et al. (2002, 2005) and only one recognition trial of 8 s instead of two 5 s trials, which may explain the behavioral differences as noted by Fair et al. (2012).

It also has been suggested recently that perceptual narrowing could reflect a refinement of the processing of familiar faces (Maurer & Werker, 2014). Such refinement might imply an enhancement of the diagnosticity of certain features or a decrement of others or both with age. The human eye, because of its salience, is a candidate for enhancement. It is unique in the animal kingdom in having a widely exposed white sclera which is paler than the facial skin or iris of

the eye (Kobayashi & Koshima, 1997). In adults, information from the eye area is critical for a stimulus to be processed as a face (Bentin, Golland, Flevaris, Robertson, & Moscovitch, 2006). Evidence of attraction to human eyes can be found early in development, as newborns prefer to look at a female adult face with open eyes when paired with the same face with closed eyes (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000). Moreover, Di Giorgio, Méary, Pascalis, and Simion (2012) reported that 3-month-olds prefer to orient toward human faces more than monkey faces, with greater scanning on human than monkey eyes. Typically, by 3 months of age, infants begin to scan faces extensively with increasing interest toward the eyes (Hainline, 1978; Haith, Bergman, & Moore, 1977; Maurer & Salapatek, 1976). In addition, Dupierix et al. (2014) reported that monkey faces with human eyes (from Caucasian individuals) elicited longer looking time in 3- to 12-month-olds than monkey faces with their original eyes.

Human eyes also seem to play an important role in face recognition. It has been shown that experimental manipulation of the contrast polarity relationship between the white sclera versus darker iris and pupil disrupts newborn preference for facelike patterns (Farroni et al., 2005), and affects face discrimination by 7- to 8-month-olds (Otsuka et al., 2013). In addition, contrast-reversed eyes diminish the hemodynamic response of brain areas involved in face processing in 6-month-olds (Ichikawa, Otsuka, Kanazawa, Yamaguchi, & Kakigi, 2013), suggesting that the typical contrast relationship of human eyes might be an important cue for a stimulus to be processed as a face. Furthermore Key, Stone, and Williams (2009) reported that eye changes compared to mouth changes had a greater impact on face perception mechanisms in 9-month-olds. Caucasian eyes seem to be of particular importance at least for Caucasian infants, since the advanced recognition ability for own-race faces in these infants occurs at the same time as increased fixation on the eyes of such faces (Wheeler et al., 2011; Xiao, Quinn, Pascalis, & Lee, 2014). Interestingly, despite a diminution in recognition for other-race faces, the scanning paths of Caucasian infants were similar for own- and other-race faces (Xiao et al., 2014), as if Caucasian eyes provided more useful information than other-race eyes to achieve face recognition.

The current study aimed to determine if the presence of human Caucasian eyes in monkey faces facilitated the ability of Caucasian 9- to 12-month-olds to process and recognize them. If human Caucasian eyes are a diagnostic cue for face recognition by Caucasian infants, their presence embedded in monkey faces

might help both age groups to present a significant novelty preference. Also, Caucasian 6-month-olds were tested as a control group to confirm that their ability to discriminate monkey faces found in previous reports (Pascalis et al., 2002, 2005; Scott & Monesson, 2009) is being maintained with the addition of human eyes. We used the same stimuli as Pascalis et al. (2002, 2005) and Scott and Monesson (2009) to ensure valid comparison. We also used the short familiarization time and test trial time from Pascalis et al. (2002, 2005) which make the task more demanding, and as such, are candidate conditions to observe a facilitation of processing due to human Caucasian eyes (if any is to observed).

METHOD

Participants

Participants were 20 full-term Caucasian 6-month-olds (six females; mean age = 194.3 days; range = 186–199 days), 20 Caucasian 9-month-olds (nine females; mean age = 283 days; range = 275–293), and 20 Caucasian 12-month-olds (six females; mean age = 375.3 days; range = 365–388). A further 23 infants were excluded due to side bias on at least one test trial (looking at one side of the display for 95% or more of the total looking time i.e., 4.75 s, $n = 6$), insufficient looking time on at least one test trial (less than 50% of the total looking time, i.e., 2.5 s, $n = 2$), fussiness ($n = 1$) or procedural errors (i.e., familiarization time different from 20 s, $n = 14$). This definition of side bias (i.e., 95% of looking time on one side) is widely used in infancy research (Dupierrix et al., 2014; Hayden, Bhatt, Zieber, & Kangas, 2009; Kelly et al., 2007; Kovack-Lesh, Horst, & Oakes, 2008; Mareschal, French, & Quinn, 2000).

Stimuli

The stimuli were colored full-frontal faces of six Barbary macaques and six rhesus macaques. Faces were cropped, put into an oval shape, and presented

against a grey background. When projected onto the screen, each picture was 26.5 cm high and 21.5 cm wide. When viewed at a distance of 60 cm, the stimuli subtended $44^\circ \times 34^\circ$ degrees of visual angle. Stimulus size and brightness were kept uniform by using Adobe Photoshop. Monkey faces were modified by replacing the original eyes with human Caucasian eyes. Replacement was done by weighting pixel values in the original and replacement eyes according to a bi-dimensional Gaussian. Each face contained eyes from a different individual (see Fig. 1). Eyes differed by color, size, and shape, but they all came from Caucasian individuals. The inter-eye distance was normalized for all stimuli. In addition to the individual faces used in the familiarization phase, three test pairs were created (representing the familiarized and novel face) per monkey species (i.e., six pairs)

Procedure

Infants were tested in a quiet room and seated on a parent's lap approximately 60 cm away from a 52×32.5 cm monitor onto which the images were projected. Parents were instructed to fixate centrally above the screen and remain quiet during testing.

Familiarization. During familiarization, infants were presented with a single stimulus in the center of the screen until they had accumulated 20 s of looking time to the stimulus, as monitored by the experimenter. This timing was chosen to be identical to the procedure used in our previous studies with this category of stimuli (Pascalis et al., 2002, 2005). The particular monkey faces (Barbary or rhesus macaques) were counterbalanced across infants.

Test phase. The test phase consisted of two 5-s trials, to be consistent with Pascalis et al. (2002, 2005). On each trial, two faces (novel and familiar) were presented side-by-side on the screen. The images were separated by a 9 cm gap. On the first test trial, when

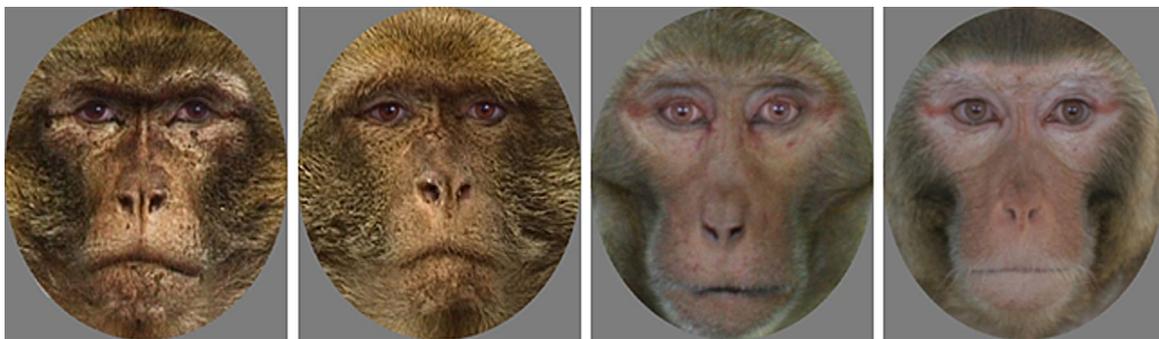


FIGURE 1 Examples of the Barbary and rhesus macaque faces used as stimuli.

the infant first looked at the images, the experimenter started a 5 s countdown. At the end of the 5 s, the images disappeared from the screen. The same faces were presented on the second test trial with their left/right position on the screen reversed. On the second test trial, another 5 s countdown was initiated when the infant looked at the images. Left-right positioning of the novel/familiar faces on the first test trial was counterbalanced across infants. Eye movements were recorded throughout, and the film was digitized for frame-by-frame analysis by two independent observers who used specialized computer software to code looking time to each of the two faces. The observers were blind to the screen positions of the faces being viewed by the infants. The average level of inter-observer agreement was high (Pearson $r = .95$).

RESULTS

A preliminary ANOVA including participant sex and monkey species as between-subjects factors and the percentage of fixation to the novel stimulus as the dependent variable revealed no significant effects involving sex differences ($F[1,56] = 1.8, p = .179$) or monkey species ($F < 1$), so these variables were not included in the analyses.

We conducted an ANOVA with age group (6-, 9-, and 12-month-olds) as a between-subjects factor and the percentage of fixation to the novel stimulus as the dependent variable. The ANOVA yielded a main effect of age, $F(2,57) = 3.26, p = .046, \eta^2 = .10$. To explore the effect of age on infant response to the novel stimulus, we conducted two-tailed t -tests on each age group. The mean novelty preference score of the 6-month-olds was significantly higher than that of the 12-month-olds ($t[38] = 2.61, p = .013$), but not reliably greater than that of the 9-month-olds ($t[38] = .47, p = .67$). In addition, the mean novelty preference of the 9-month-olds was marginally different from that of the 12-month-olds ($t[38] = 1.84, p = .073$) (see Table 1 for the mean novelty preference scores).

To further investigate novelty preferences within each age group, we conducted a series of two-tailed t -tests to

determine whether the time spent looking at the novel stimulus combined from both trials of the test phase differed from the chance level of 50%. Six-month-old infants demonstrated a significant novelty preference, $t(19) = 3.61, p = .002$, Cohen's $d = .81$, and 18 out of 20 infants had preferences above 50%, binomial probability, $p < .001$. Nine-month-olds also showed evidence of discrimination, $t(19) = 2.16, p = .043$, Cohen's $d = .48$, although not at an individual level: 14 out of 20 infants had preferences above 50%, binomial probability, $p = .11$. Twelve-month-olds, however, did not show reliable evidence of discrimination, $t(19) = -.30, p = .764$, Cohen's $d = .07$, and just 9 out of 20 infants had preferences above 50%, binomial probability, $p = .82$.

DISCUSSION

The aim of the current study was to investigate the influence of human Caucasian eyes on the recognition of monkey faces by Caucasian infants at a time when perceptual narrowing is normally observed. Six- and nine-month-olds showed evidence of recognition of monkey faces with human Caucasian eyes, whereas 12-month-olds failed to do so. The failure of 12-month-olds to benefit from the human Caucasian eyes for individual monkey face recognition suggests an effect of context set by other external cues of the monkey faces (e.g., fur, nose shape), implying that the role of human eyes embedded in human faces is different than when embedded in monkey faces. Furthermore, similar scan paths associated with increased looking time for the eyes in own- and other-race faces (Xiao et al., 2014) do not prevent decline in discriminating other-race faces (Kelly et al., 2007, 2009). The extraction of facial information, such as the eyes, might be more efficient in own- than other-race faces as infants grow older. In the current study, 12-month-old infants might have failed to extract eye information from monkey faces. However, because of the null result and without the use of an eye tracking device, we cannot be confident that the 12-month-old participants actually noticed the substitution of the eyes.

Table 1. Mean Novelty Preferences and Looking Times for the Novel and Familiar Test Stimuli for 6-, 9-, and 12-Month-Old Infants

Age Group (months)	Mean Proportion of Looking Time to the Novel Face (%)			Mean Looking Time to the Novel Face (sec)		Mean Looking Time to the Familiar Face (sec)	
	<i>SD</i>	<i>p</i>		<i>SD</i>		<i>SD</i>	
6	56.3	7.8	<.01	5.04	.92	3.92	.83
9	55.0	10.4	<.05	5.11	.92	4.22	1.10
12	49.4	8.9	<i>ns</i>	4.54	1.01	4.60	.77

Table 2. Mean Percentage of Looking Time to the Novel Monkey Faces in Previous Studies Using the Same Stimuli and the Same Procedure as the Current Study

	6 Months	9 Months	12 Months
Current study: Human eyes	56.3	55.0	49.4
Pascalis et al. (2005): Monkey eyes	56.2	49.8	
Scott & Monesson (2009): Monkey eyes, group 1	63.9	Not applicable	
Scott & Monesson (2009): Monkey eyes, group 2	59.4	49.9	
Scott & Monesson (2009): Monkey eyes, group 3	65.6	49.5	

In contrast with the findings from the 12-month-olds, the 9-month-olds were able to discriminate monkey faces when human eyes were introduced. The current results with the 9-month-olds also contrast with previous reports which have shown that infants from this age group have difficulty with recognizing monkey faces when tested with the same stimuli, i.e., the same monkey faces, but with the original monkey eyes with the same procedure (Pascalis et al., 2002, 2005) or with a longer familiarization time (i.e., 30 s instead of 20 s) (Scott & Monesson, 2009). As illustrated by the novelty preference data presented in Table 2, 9-month-olds tested with original monkey faces present a flat preference not different from 50% in three studies. An exception comes from Zieber et al. (2013) who reported that 9-month-olds can discriminate monkey faces. Critically though, Zieber et al. used a different procedure and a different set of monkey faces than Pascalis et al. (2002, 2005) and Scott and Monesson (2009), which may account for the behavioral differences observed. The currently reported data thus present evidence that a significant novelty preference is observed at this age, showing that the presence of human eyes facilitated discrimination for 9-month-olds tested in this demanding situation with short familiarization time (20 s) and test trial time (two 5-s trials).

The present findings provide support for the idea that eyes become increasingly important in face processing during infancy (Key et al., 2009; Wheeler et al., 2011; Xiao et al., 2014). It should be noted, however, that the positive evidence of discrimination observed in the 9-month-olds was somewhat fragile in terms of being present in the analysis of group, but not individual, performance. Nine-month-olds thus seem to present a transitional pattern, as suggested by the increased variability in that age group, and also by the difference between individual and group scores. Although 9-month-olds looked significantly longer at the novel faces at the group level, the proportion of infants with preferences

above 50% was not significant. Moreover, the size of the novelty preference is diminished compared to the 6-month-olds (Cohen's $d = .81$ for the 6-month-olds, Cohen's $d = .48$ for the 9-month-olds), which is consistent with the idea of a gradual attenuation in the processing of faces from other species.

When taking into consideration that older infants present evidence of holistic processing for own- but not other-race faces (Ferguson et al., 2009), we would speculate that they also do not process other-species faces holistically, an idea that has not yet been tested. As suggested by Rossion and Boremanse (2008), a holistic face representation could act as a template to guide not only face recognition, but also the perception of simple features. Unfamiliar categories of faces that do not match this template or match it to a lesser extent (i.e., other-species faces), will not benefit from this representation. Even though human Caucasian eyes are important for face recognition in Caucasian infants, they might still need to be embedded in the correct face template, i.e., Caucasian faces for Caucasian infants, in order to provide useful information. In fact, if human Caucasian eyes are especially crucial, we would predict a decrease in recognition for Caucasian faces in which the original eyes are substituted with other-species eyes (and perhaps other-race eyes) in 9- and 12-month-old Caucasian infants.

To summarize, the present findings contribute to our understanding of perceptual narrowing by demonstrating that the presence of human eyes in monkey faces did not alter 6-month-old ability to discriminate other species faces, but did provide a degree of facilitation of discrimination of other-species faces in 9-month-olds. However, the incorporation of human eyes into monkey faces was not sufficient to facilitate the discrimination of other-species faces in 12-month-olds. It will be interesting to determine in future work if manipulation of other internal features or their configurations could be more or less successful in affecting the course of perceptual narrowing not only for face species, but also for face race and age.

NOTES

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