Differences in eye movements between same and other race face recognition.

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Abstract

Eye movements of twelve Caucasian participants were measured whilst they performed a recognition test of same (Caucasian) and other race (Indian) faces. We observed a standard other-race effect, with more items recognised correctly, fewer false alarms, and reduced reaction time to same-race than other-race faces. Additionally, a differential pattern of eye movements between races emerged. During the study phase, same-race faces were fixated more than other-race faces, whilst other-race faces resulted in a greater proportion of fixations to internal face features than same-race faces. At test, whilst no differences between races emerged in the number of fixations or in the proportion of fixations made to internal features, a significantly greater level of fixations were made to the left hemispace for other-race faces for both previously studied and lure faces. These differences in the pattern of fixation plausibly reflect the greater effort in the processing of other-race than same-race faces.

Keywords: other-race effect, eye-tracking, face recognition, same-race faces.

Introduction

The other-race effect refers to the phenomenon that individuals are less proficient at recognising faces from a different race to their own. This is typically characterised by a 'mirror effect', whereby same-race faces attract a higher proportion of hits and a lower proportion of false alarms compared with other-race faces (Meissner & Brigham, 2001). As well as its theoretical importance, the other-race effect has considerable practical significance. In particular, it is well established that minority races in a community are more likely to be wrongfully convicted of a crime on the basis of erroneous eyewitness testimony (Meissner & Brigham, 2001). For instance, Scheck, Neufeld, & Dwyer (2000) found that most cases of mistaken eyewitness identification in the United States were of Caucasian victims misidentifying non-Caucasian suspects.

One explanation for the other-race effect is that individuals process other-race faces in a qualitatively different way to same-race faces. In particular, same-race faces are believed to rely on configural processes to a greater extent than other-race faces. Support for this comes from the composite face effect (e.g., Michel, Rossion, Han, Chung, & Caldara, 2006) in which recognition of the upper half of a face was more disrupted by the bottom half of a different face for same-race than other-race faces. Furthermore, there is greater benefit for same-race than other-race faces from the whole face context when processing individual facial features (the whole/part effect, e.g., Tanaka, Kiefer, & Bukarch, 2004). Additionally, there is evidence that the face inversion effect is more pronounced for same-race than other-race faces (Rhodes et al., 1989; but see Valentine & Bruce, 1986). The greater exposure that people typically have to same-race faces (e.g., Chiroro & Valentine, 1995) may be one reason for the increased use of configural processes (Gauthier & Tarr, 2002). Similarly, perceptual learning (e.g., Gibson & Walk, 1956; McLaren & Mackintosh, 2000) may lead to same-race faces being less tightly clustered in multidimensional space than other-race faces, resulting in easier discrimination of same-race faces (as in "face-space" models, e.g., Byatt & Rhodes, 2004).

Eye movements provide an index to the allocation of visual attention towards facial features (Findlay & Gilchrist, 2003). As such, the pattern of eye movements can provide direct insight into cross-race processing differences. To date, however, eye tracking has seldom been used to explore the other-race effect. One exception is a study by Goldinger, He, & Papesh (2009) which examined eye movements to various features together with pupil dilation (an index of mental processing load in visual attention) for Caucasian and Asian faces, recruiting participants from both these races. Both Caucasian and Asian participants fixated more to same-race than other-race faces, and more to the eyes and hair for same-race faces and more to the nose and mouth for other-race faces. Pupil dilation was greatest for other-race faces, indicating the recruitment of greater resources. A separate study conducted by Blais, Jack, Scheepers, Fiset, & Caldara (2008) found a slightly different pattern of results, with Caucasians focussing on the eyes and East Asians focusing on the nose and mouth, regardless of the race of the faces viewed. As Goldinger et al. (2009) note, this discrepancy may be partially due to the fact that in their study they used faces with neutral emotions, whilst the faces presented in Blais et al. (2008) varied in expression.

Our study directly examined differences in the processing of internal features, relative to external features, for same-race compared to other-race faces. We also asked whether there would be cross-race differences in fixation

lateralization. These questions were not directly assessed by Goldinger et al. (2009) but have been investigated in studies tracking eye movements to famous/nonfamous faces (a familiarity benefit similar to the same-race advantage has been robustly established; see Johnston & Edmonds, 2009). For instance, Althoff and Cohen (1999) found that a greater proportion of fixations were delivered to nonfamous than famous faces in fame and emotion judgment tasks. Additionally, they showed that nonfamous faces evoked a greater proportion of fixations to the left hemispace than famous faces. Stacey, Walker, and Underwood (2005) showed that famous faces resulted in greater internal processing than nonfamous faces only under relatively restricted conditions (a matching-faces task). These findings are surprising given that behavioural work suggests that internal features are more important for familiar than unfamiliar face recognition (e.g., Ellis et al., 1979). Althoff and Cohen (1999) suggested that the greater processing of internal features for unfamiliar than familiar faces may reflect the necessity for more efficient sampling of information when viewing unfamiliar faces given that internal features are particularly useful for identifying people. They proposed a similar explanation for the greater left hemispace bias for nonfamous than famous faces - asymmetric viewing is more efficient due to the general symmetry of faces.

Our predictions were somewhat open-ended due to the lack of direct empirical investigation of these issues in the context of the other-race effect. However, given that internal features are regarded as more diagnostic and have greater involvement in configural processing than external features, more fixations to same-race than other-race faces would provide an explanation for the same-race recognition advantage. Nevertheless, this reasoning also applies to the face familiarity effect, yet Althoff and Cohen (1999) observed greater internal feature processing for nonfamous than famous faces. On these grounds, if one assumes that other-race faces can, on the whole, be regarded as less familiar than same-race faces, a greater reliance on internal features for other-race than same-race faces might be anticipated. For similar reasons, the results of Althoff and Cohen would suggest a greater reliance on left hemispace processing for other-race than same-race faces.

Method
Participants
Twelve Caucasian students (3 males, 9 females) from the University of Exeter, ranging in age from 18-39 (M = 22.92, SD = 4.91) participated. No participants had visited Asia for an extended period of time (i.e., over one month). Participants were tested individually in a testing cubicle.

Apparatus
The experiment was run using E-Prime (Psychological Software Tools, 2002) on a Dell PC with a 22-inch color monitor and a standard computer keyboard. Participants sat 0.5 metres away from the screen.

The Eye link II system recorded movements in the right eye using a video-based eye tracker with a head movement compensation system connected to a Dell PC with a 17-inch TFT monitor. Eye movements were sampled on the recording computer at 500Hz. Pupil position was monitored via a miniature infrared CCD video camera mounted on an adjustable headband. The display computer initiated and terminated eye tracking recording on each trial.

Stimuli
Stimuli consisted of forty colour photographs of male faces. Twenty Caucasian (taken from O'Toole et al., 2005) and twenty Indian faces (taken from Jain & Mukherjee, 2002) were used. All faces were full-face view, had neutral expressions, and no distinctive features (e.g., glasses, facial hair). Images were of comparable quality. Pictures were edited using Adobe Photoshop to achieve a resolution of 300-pixels wide; the height was constrained by the natural proportions of the face (average: 370.3-pixels). Faces were cropped, to remove the background of the image. The resulting images were presented centrally on a white background on a screen with a resolution of 800x600 pixels.

Procedure
Our basic procedure was modeled on Experiment 2 of Stacey et al. (2005) with the difference that we manipulated the race of the faces rather than their familiarity. In the study phase, twenty faces were presented. Ten of these faces were Caucasian and ten Indian. Trials began with a black fixation cross for 500ms, followed by a blank screen for 500ms. A face was then presented for 5 seconds. No response was required but participants were instructed to remember the faces.

After a break of around 2 minutes, the test phase began. Here, forty faces were presented: the twenty studied faces (ten Caucasian, ten Indian) and twenty "lure" faces (ten Caucasian, ten Indian) which had not previously been seen. Faces were presented in a random order. Trials began with a black fixation cross lasting 500ms, followed by a blank screen for 500ms. A face was then displayed for 5 seconds. During this time, participants indicated whether they had seen the face previously (by pressing z on the keyboard) or if the face was new (by pressing m). If participants did not answer in time, no response was recorded and participants were encouraged to respond quicker.

In both the study and test phases, stimuli were presented in a random order. Eye movements were recorded in both phases, with corrections for drift conducted every 5 trials.

Analysis
Eye Movements
Eye movements were analysed using EyeLink Data Viewer Software, which automatically detects saccadic eye movements and analyses these movements into individual fixations using a combined position/velocity/acceleration criterion (a saccade was defined as a period where eye velocity was greater than 30º/sec, eye acceleration was

greater than 8000º/sec² and the eye had deviated at least 0.1° from its starting position). Fixations were defined as periods between saccades. Blink artefacts were automatically removed from the data.

Eye movements were analysed for the entire stimulus presentation period in the study phase. In the test phase, eye movements were analysed up until participants made their response. Using the EyeLink Data Viewer Software, Region of Interests (ROI) were created for internal (i.e., eyes, nose and mouth) and external (e.g., hair, ears) features. Furthermore, ROIs were created for the left and right hemispaces (including both internal and external features). ROIs were drawn separately for each face (c.f., Figure 1). The size of the ROI's between races was closely comparable. Fixations falling outside of the ROIs were excluded from subsequent analyses. In the analyses reported, for ease of exposition, we focus on the pattern of fixations; dwell measures showed a similar pattern.
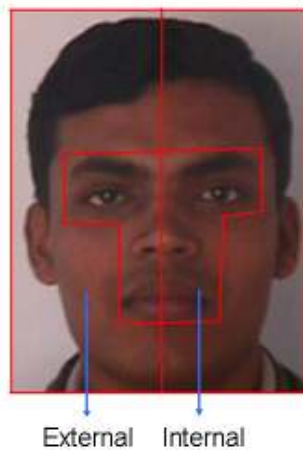

Figure 1. An illustration of how face regions were defined in terms of internal/external and right/left ROI for each face independently.

Results
Behavioural Results
Test Phase
   A paired-samples t-test revealed that the hit rate for studied faces was significantly higher for same-race (Caucasian; M = .85, SD = .14) than other-race (Indian; M = .70, SD = .18) faces, t(11) = 2.51, p = .029. Furthermore, the false alarm rate was higher for other-race (M = .35, SD = .18) than same-race (M = .08, SD = .08) faces, t(11) = 5.75, p <.001. Response time was significantly higher for other-race (M = 1697.22, SD = 478.65) than same-race (M = 1407.15; SD = 376.43) faces, t(11) = 3.08, p = .011. Time outs were minimal (on .004 of trials).

Eye movement data
Study Phase
   Descriptive data of the pattern of eye-movement across the entire 5000ms study period is displayed in Table 1.

Paired-samples t-tests revealed that more fixations were made to internal than external features for both same-race, t(11) = 7.83, p < .001, and other-race, t(11) = 9.51, p < .001, faces. An additional paired-samples t-test, combining both internal and external features, showed that participants made significantly more fixations to same-race (M = 15.13; SD = 3.71) than other-race (M = 14.33; SD = 3.68) faces, t(11) = 2.78, p = .018.

Table 1

The Pattern of Eye Movements in the Study Phase Across the entire Study Period.

	Same-race		Other-race	
	M	SD	M	SD
Number of fixations	15.13	3.71	14.33	3.68
Internal fixations	12.24	3.70	12.37	3.52
External fixations	2.88	1.31	1.97	1.25
Proportion of internal fixations	0.80	0.08	0.86	0.09
Right hemispace fixations	7.25	3.45	6.52	3.46
Left hemispace fixations	7.85	2.37	7.82	2.38
Proportion of left hemispace fixations	0.53	0.16	0.56	0.16

Due to the significant difference between groups in terms of the mean number of fixations, we calculated the mean proportion of fixations to internal features (internal features/ [internal features + external features]). Next, we divided the study interval into five separate 1000ms time bins to better characterise differences in the processing of other-race and same-race faces over time. This information is displayed in Figure 2. We then conducted a within-subject ANOVA with two factors, race (same-race and other-race) and time interval (0-1000ms, 1001-2000ms, 2001-3000ms, 3001-4000ms, and 4001-5000ms) to investigate this data. This yielded a significant effect of race, $F(1,11) = 14.994$, $p = .003$, $\eta^2_p = .577$, with the proportion of fixations to internal features significantly greater for other-race than same-race faces. There was, however, no significant effect of time interval, $F(4,44) = .723$, $p = .581$, $\eta^2_p = .062$, and no significant interaction between time period and race, $F(4,44), = .070$, $p = .991$, $\eta^2_p = .006$, indicating that the main effect of race remained consistent across time.
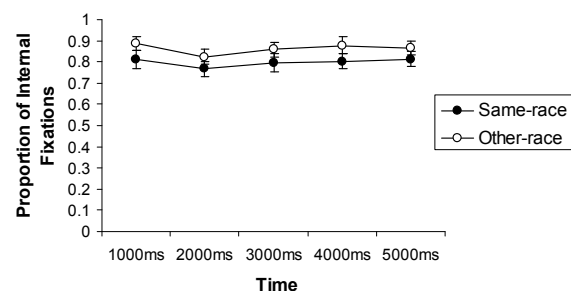

Figure 2. The mean proportion of fixations to internal face features across time intervals for same-race and other-race faces.

We calculated the mean proportion of fixations to the left hemispace (left hemispace/[left hemispace + right hemispace]) and conducted one-sample t-tests which

showed that fixations to the left hemispace did not differ from 0.5 (chance) for either same-race (M = .53; SD = .16), t(11) = .67, p = .52, or other-race (M = .56; SD = .16), t(11) = 1.25, p = .24, faces. Figure 3 displays the mean proportion of fixations to the left hemispace across the study interval for both same-race and other-race faces. A within-subject ANOVA with two factors, race (other-race, same race) and time interval (0-1000ms, 1001-2000ms, 2001-3000ms, 3001-4000ms, and 4001-5000ms) revealed that there was no significant effect of race, $F(1,11) = 2.171$, p = .169, $\eta^2_p = .165$. There was, however, a significant effect of time interval, $F(1,11) = 5.783$, p = .001, $\eta^2_p = .345$, with the proportion of fixations to the left hemispace decreasing across the study period. Furthermore, there was also a significant interaction between race and time interval, $F(4,44) = 3.321$, p = .018, $\eta^2_p = .232$. T-tests, assessing the nature of this interaction, indicated that other-race faces had a significantly greater proportion of fixations to the left hemispace than same-race faces for the first 1000ms time bin, t(11) = 2.702, p = .021, but that there were no differences between face type for the other time periods (all Ps > .05).
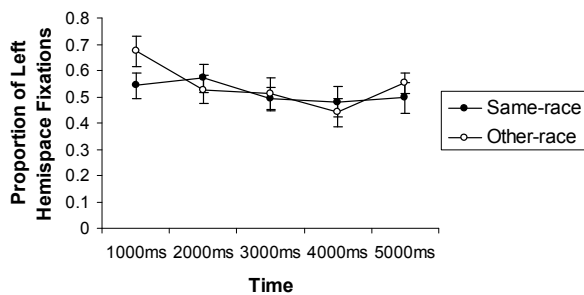

Figure 3. The mean proportion of fixations to the left hemispace across time intervals for same-race and other-race faces.

Test Phase

Descriptive data for the test phase are shown in Table 2. As in the study phase, paired-samples t-tests revealed that there were no differences between same-race and other race faces for either studied, t = 1.399, p = .189, or lure faces, t(11) = .466, p = .651. There were more internal than external fixations for both "seen", t(11) = 10.46, p < .001, and "new", t(11) = 8.16, p < .001, same-race faces; similarly, there were more internal than external fixations for "seen", t(11) = 8.37, p < .001, and "new", t(11) = 9.63, p < .001, other-race faces.

As for the study phase, we calculated the mean proportion of fixations to the internal features. Unlike in the study phase, however, we did not partition the fixations into time intervals due to differences both within and between participants in the time spent viewing the faces. Table 2 shows the mean proportion of fixations to internal features for both other-race and same-race faces for both studied and lure faces. A 2x2 within subject ANOVA, with the factors

being race (other-race, same-race) and presentation type (studied faces, lure faces) found no significant effect of race, $F(1,11) = .369$, p = .556, $\eta^2_p = .032$, and no significant effect of presentation type, $F(1,11) = .072$, p = .793, $\eta^2_p = .007$. There was a marginal interaction, $F(1,11) = 4.469$, p = .058, $\eta^2_p = .289$, which did not reach significance.

Table 2

The Pattern of Eye Movements in the Test Phase.

	Same-race				Other-race			
	Lure		Studied		Lure		Studied	
	M	SD	M	SD	M	SD	M	SD
Internal fixations	4.86	1.58	4.45	1.53	5.43	1.80	5.01	2.10
External fixations	0.66	0.78	0.66	0.49	0.77	0.68	0.55	0.64
Proportion of internal fixations	0.89	0.09	0.87	0.08	0.88	0.10	0.91	0.10
Right hemispace fixations	2.59	1.97	2.31	1.57	2.32	1.42	2.11	1.66
Left hemispace fixations	2.92	1.38	2.80	1.05	3.88	1.51	3.45	1.47
Proportion of left hemispace fixations	0.55	0.21	0.57	0.20	0.64	0.16	0.64	0.20

The mean proportion of fixations to the left hemispace for both studied and lure same-race and other-race faces are shown in Table 2. One sample t-tests showed that fixations to the left hemispace were reliably greater than chance (0.5) for both studied, t(11) = 2.551, p = .027, and lure, t(11) = 2.960, p = .013, other-race faces. There was no significant asymmetry, however, for either studied, t(11) = 1.200, p = .256, or lure, t(11) = .768, p = .459 same-race faces. In terms of the proportion of fixations made to the left hemispace, a 2x2 within-subject ANOVA, yielded no significant main effect of presentation type (studied, lure), $F(1,11) = .980$, p = .344, $\eta^2_p = .082$, and no significant interaction between face type and race, $F(1,11) = .148$, p = .708, $\eta^2_p = .013$, but there was a significant main effect of race, $F(1,11) = 8.619$, p = .014, $\eta^2_p = .439$. Paired-samples t-tests revealed that the effect of race was significant for both studied, t (11) = 2.404, p = .035 and lure, t(11) = 2.274, p = .044, faces with a greater proportion of fixations to the left hemispace for other-race than same-race faces.

Discussion

We investigated the pattern of fixations of Caucasian participants while they performed a recognition task on a group of Caucasian (same-race) and Indian (other-race) faces. Consistent with previous studies, we found evidence for a "mirror-effect" (Meissner & Brigham, 2001); participants had fewer hits (recognising "seen" faces), more false alarms (incorrectly recognising "new" faces), and a longer response time for other-race than same-race faces.

In the study phase, we found, consistent with Goldinger et al. (2009), that participants made more fixations to same-race than other-race faces. Additionally, participants made a greater proportion of fixations to internal features for other-race than same-race faces. We divided the study period into five time periods to examine whether the nature of this effect changed over time. However, there was no indication of a time x face type interaction, which indicates that this

effect remained consistent throughout the study period. We also directly examined the lateralization of the fixations that participants made to same-race and other-race faces. Whilst there was no overall effect of race type, there was a significant effect of time with fixations becoming more equally divided between the left and right hemispace over time. Furthermore, we also found that there was a significant interaction between race and time, with a greater proportion of fixations made to the left hemispace for other-race than same-race faces for the first 1000ms time interval but not for the remaining four time intervals.

At test, stimuli were divided into those seen in the study phase, and "lure" stimuli which were only presented at test. For both types of faces there was no difference in the proportion of internal fixations to same-race or other-race faces. However, there was a significant effect of race for both studied and lure faces in terms of the proportion of fixations made to the left hemispace. Specifically, we observed a greater left hemispace bias for other-race than same-race faces.

The demonstration in the study phase that a greater proportion of fixations were made to internal features for other-race faces than same-race faces is consistent with previous work (e.g., Goldinger et al., 2009). In this regard, an explanation similar to that proposed by Althoff and Cohen (1999) to account for the greater proportion of internal fixations to nonfamous than famous faces seems applicable to our results. Specifically, Althoff and Cohen (1999) argued that there was greater need to effectively process the internal features, which are critical to face recognition, for nonfamous than famous faces. Our finding may, therefore, be due to the less efficient extraction of the internal features for other-race than same-race faces. The fact that participants made fewer fixations to other-race than same-race faces whilst trying to remember them supports the assumption that other-race face information is processed less easily (see also Goldinger et al., 2009). The more efficient processing of internal feature information for same-race faces would, consequently, provide greater opportunity to focus on external feature information, which still has informational value for recognition. This explanation is also consistent with Goldinger et al. (2009) who found greater pupil dilation for other-race than same-race faces, indicating greater processing effort for other-race faces.

Given this, it is striking that the internal feature bias for other-race races appears relatively transient – this effect did not come close to reaching significance in the test phase. One might have reasonably expected a greater reliance on the more diagnostic internal features would also have been present in the test phase where the behavioural differences between same-race and other-race faces emerged. Instead, the effect was only detectable when participants were explicitly asked to encode the stimuli rather than when the requirement was to retrieve the stimuli. As such, this pattern of findings is in line with the idea that the greater bias to internal features for other-race than same-race faces reflects an encoding related perceptual process rather than a

retrieval-based process (for related behavioural evidence see Lindsay, Jack, & Christian, 1991; Tanaka et al., 2004; but see also Papesh, & Goldinger, 2009).

One caveat to the idea that the internal feature bias for other-race than same-race faces reflects an encoding rather than a retrieval process is that, as is common in face recognition studies (e.g., Goldinger et al., 2009; Stacey et al., 2005) the same picture of each face was shown at both study and test. This may have increased the reliance on pictorial codes during recognition rather than structural (abstracted memory representations) codes (Longmore, Liu, & Young, 2008), which are assumed to underlie face recognition outside the lab. This may, therefore, account for the difference between phases rather than the differing requirements of the study and test phases. However, as Longmore et al. (2008) note, if recognition was purely picture based, one might have expected equivalent recognition performance on other-race and same-race faces which was not the case in our study. Nevertheless, this potential issue could be addressed in future work by showing different photographs at study and test.

The pattern of fixations across the study and test phases was somewhat different to the internal feature effect. In the study phase, there was evidence of a greater bias to the left hemispace for other-race faces on first viewing the stimuli but this effect was not detectable over the remainder of the study period. In contrast, we found a left hemispace bias for other-race than same-race faces for both studied and lure faces in the test phase. Broadly speaking, therefore, these results indicate a greater lateralization asymmetry for other-race than same-race faces which was most marked in the test phase than the study phase. This may reflect that whilst the internal features effect appears to be due to encoding processes, the lateralization effect may reflect retrieval processes and is present only in the initial stages of encoding the stimuli. The demonstration that a greater proportion of fixations were made to the left hemisphere for other-race than same-race faces during recognition is again similar to Althoff and Cohen's (1999) finding of greater left hemispace viewing for nonfamous than famous faces. This finding can also be explained by postulating greater processing requirements for other-race than same-race faces. Under high processing demands, it appears efficient to focus primarily on the most diagnostic regions. This would mean a greater focus on one side of the face, given that faces are generally symmetrical (Althoff & Cohen proposed a similar explanation). We note that the limitations that Althoff and Cohen identified in their study concerning assessment of laterality effects (e.g., possible differences in texture or luminance between sides) similarly apply to our experiment. Future work could assess the generality of our effect by flipping one half of the face in a counterbalanced design such as in Rhodes (1985).

Previous work indicates that familiarity effects in face processing are influenced by task demands (Stacey et al., 2005). Our findings should, therefore, be generalised to different paradigms as well as to different races. Future

work should also include participants from different races to investigate cross-over interactions between recognition performance and the race of the participants. This would ensure that our findings are due to differences in cross-race face processing rather than factors such as the properties of the stimuli themselves. One issue with this sort of study, however, is that due to the extensive media exposure to Caucasian faces which means such faces are highly familiar to most populations, it might be preferable to carry out follow-up cross-over studies with non-Caucasian races. Nevertheless, our findings provide compelling evidence for processing differences between same-race and other-race faces. They also indicate that there may be overlap in the processes that underlie the same-race benefit and the familiarity advantage. Much remains to be understood, and this study should only be seen as a first step, but we hope that our experiment will help motivate future eye tracking work in this important area.

Acknowledgments

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