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Contact and other-race effects in configural and component processing of faces

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Other-race faces are generally recognized more poorly than own-race faces. There has been a long-standing interest in the extent to which differences in contact contribute to this other-race effect (ORE). Here, we examined the effect of contact on two distinct aspects of face memory, memory for configuration and for components, both of which are better for own-race than other-race faces. Configural and component memory were measured using recognition memory tests with intact study faces and blurred (isolates memory for configuration) and scrambled (isolates memory for components) test faces, respectively. Our participants were a large group of ethnically Chinese individuals who had resided in Australia for varying lengths of time, from a few weeks to 26 years. We found that time in a Western country significantly (negatively) predicted the size of the ORE for configural, but not component, memory. There was also a trend for earlier age of arrival to predict smaller OREs in configural, but not component, memory. These results suggest that memory for configural information in other-race faces improves with experience with such faces. However, as found for recognition memory generally, the contact effects were small, indicating that other factors must play a substantial role in cross-race differences in face memory.

Our ability to discriminate and recognize thousands of faces is remarkable given their similarity as visual patterns. However, this expertise does not extend equally to all faces, with discrimination and memory generally poorer for other-race than own-race faces (for reviews, see Hancock & Rhodes, 2008; Meissner & Brigham, 2001; Sporer, 2001).[1] These other-race effects (OREs) are not due to intrinsic differences in the discriminability of different populations of faces, because full cross-over interactions

[1] *We use the term 'race' to refer to a visually distinct social group with a common ethnicity.*

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between participant and face race can be observed, but rather reflect differences in the way observers process own- and other-race faces.

These processing differences include poorer configural coding[2] of other-race faces (Hayward, Rhodes, & Schwaninger, 2008; Michel, Caldara, & Rossion, 2006; Michel, Rossion, Han, Chung, & Caldara, 2006b; Rhodes, Hayward, & Winkler, 2006; Rhodes, Tan, Brake, & Taylor, 1989; Tanaka, Kiefer, & Bukach, 2004) and poorer coding of component features in other-race faces (Hayward *et al.*, 2008; Rhodes *et al.*, 2006). These processing differences likely stem from reduced experience or contact with other-race faces (Brigham, Maass, Snyder, & Spaulding, 1982; Chiroro & Valentine, 1995; Furl, Phillips, & O'Toole, 2002; Goldstone, 2003; Malpass & Kravitz, 1969; Meissner & Brigham, 2001; Shepherd, Deregowski, & Ellis, 1974; Slone, Brigham, & Meissner, 2000; Valentine, 1991; Valentine & Endo, 1992; Wright, Boyd, & Tredoux, 2001).

Support for the contact hypothesis comes from several lines of research. OREs tend to be reduced in multiracial populations, where other-race faces are frequently seen and individuated (e.g. Bar-Heim, Ziv, Lamy, & Hodes, 2006; Chiroro & Valentine, 1995; Cross, Cross, & Daly, 1971; Feinman & Entwistle, 1976; Wright *et al.*, 2001). The ORE in recognition memory can be reversed following reversal of contact levels during childhood: Korean adults adopted into Caucasian families as children perform like Caucasians on cross-race recognition tests (Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). In adults, training can reduce the ORE (for a review, see McKone, Brewer, MacPherson, Rhodes, & Hayward, 2007). A large meta-analysis of 29 studies reported a small ($z_r = .13$), but significant, effect of self-reported contact on the ORE (Meissner & Brigham, 2001). Self-reported experience individuating other-race individuals is also associated with reduced OREs in perceptual discrimination (Walker & Hewstone, 2006). Therefore, although contact effects are certainly not always found (for a review, see Meissner & Brigham, 2001), there is substantial evidence that differential experience with own- and other-race faces contributes to OREs in face processing.

Experience with faces from another race could reduce OREs in several ways. It could improve attitudes towards members of the other race, thus increasing motivation to individuate them. Support for this possibility is weak, however, with no evidence that racial attitudes or prejudice affect OREs (for reviews see Ferguson, Rhodes, Lee, & Sriram, 2001; Meissner & Brigham, 2001). Another possibility is that experience enables perceptual learning mechanisms to 'tune' the dimensions on which faces are coded so that they efficiently represent variations within a familiar population (Furl *et al.*, 2002; Goldstone, 2003; Meissner & Brigham, 2001; O'Toole, Deffenbacher, Abdi, & Bartlett, 1991). The utility of these dimensions, which include both features and their spatial relations (Rhodes, 1988), is likely to vary between races. For example, eye color will be less useful for Asian than Caucasian faces. Consistent with a role for perceptual learning, neural networks trained to recognize 'majority' (cf. own-race) and 'minority' (cf. other-race) faces exhibit OREs and poorer differentiation in their representations of other-race faces (Caldara & Abdi, 2006; O'Toole *et al.*, 1991). Other-race faces are also more clustered in human face-space, consistent with poorer differentiation

[2] *We use the term 'configural coding' to refer broadly to coding of second-order relations between component features (i.e. variations within the first order configuration of eyes above nose above mouth) and to holistic coding of information about the face as a whole (as in Hayward* et al.*, 2008; Maurer* et al.*, 2002).*

(Byatt & Rhodes, 2004), and elicit weaker face-selective neural responses than own-race faces (Golby, Gabrieli, Chiao, & Eberhardt, 2001).

These studies illustrate the potential of perceptual learning mechanisms to generate OREs. However, little is known about how other-race experience affects face processing mechanisms. Coding of configural information is of particular interest because it is a hallmark of face processing expertise (Diamond & Carey, 1986; for reviews see Maurer, Le Grand, & Mondloch, 2002; Schwaninger, Carbon, & Leder, 2003). The coding of component features has not traditionally been considered important in face expertise, but there is increasing evidence that it too contributes to face expertise (Bartlett, Searcy, & Abdi, 2003; Bruyer & Coget, 1987; Collishaw & Hole, 2000; Hayward *et al.*, 2008; Rhodes *et al.*, 2006). Little is known about the role of other-race contact on either form of coding.

We know of only two studies on how contact affects configural coding, and none on how it affects component coding, of other-race faces. Michel *et al.* (2006) found that other-race experience was associated with more holistic coding of other-race faces (measured using the parts/wholes task, Tanaka & Farah, 1993), but only for Caucasian, and not Asian, participants. Hancock and Rhodes (2008) found that other-race experience (negatively) predicted the configural ORE for both Chinese and Caucasian participants. However, they used inversion decrements as an indirect measure of configural coding and inversion decrements can be substantial for feature coding (e.g. Rhodes *et al.*, 2006) highlighting the need for replication with direct measures.

Our goal was to examine whether other-race contact reduces cross-race differences in memory for configuration and components, using a scrambled/blurred paradigm that directly assesses each type of memory (Hayward *et al.*, 2008; Schwaninger, Lobmaier, & Collishaw, 2002). In this paradigm, the study faces are intact, but the test faces (target and distracters) are all either blurred or scrambled, tapping memory for configural and component information, respectively. The level of blur was chosen so that performance was at chance when it was applied to scrambled faces (for details see Schwaninger *et al.*, 2002). The logic is that in the scrambled condition, all configural information, including holistic information, is disrupted so that faces can only be recognized using individual components. When these rearranged components are sufficiently blurred, participants are simply guessing, meaning that all discriminative information from the components has been removed. When applied to the intact faces, this level of blur therefore removes information about fine detail required for component processing but not first- and, especially, second-order relational information (Diamond & Carey, 1986) thought to be the basis for configural face processing (Collishaw & Hole, 2000; Sergent, 1984).

We tested a large group ($N = 108$) of ethnically Chinese adults, who had resided in Australia for varying lengths of time, on the scrambled/blurred tests. A smaller group ($N = 36$) of ethnically Caucasian adults, living in Australia, was also tested on the scrambled/blurred tests, to confirm that these tests yielded the expected OREs in configural and component processing. We obtained two measures of other-race contact for the Chinese participants: time (months) in Australia and a self-report index, derived from a questionnaire that assesses quantity and quality of contact with Caucasian and Chinese individuals (for details see Hancock & Rhodes, 2008). Other-race contact was not assessed for the Caucasian participants.

Based on previous findings using an indirect measure of configural coding (Hancock & Rhodes, 2008), we hypothesized that contact would (negatively) predict the size of the ORE in our direct measure of configural coding (blur performance). It is an open question whether contact will similarly predict the ORE in component coding (scrambled performance), although the mounting evidence that component coding is better for own-race than other-race faces suggests that it might. We also examined the related question of whether age of arrival (positively) predicts OREs in configural and component processing. Developmental evidence that early visual experience is more crucial for configural than component processing of faces (Le Grand, Mondloch, Maurer, & Brent, 2001, 2004) suggests that age of arrival might be more important in configural than component OREs. Alternatively, early visual experience with *any* faces may be sufficient for good configural coding, in which case age of arrival would not affect the configural ORE.

Method

Participants

A sample of 108 ethnically Chinese adults was recruited from the University of Western Australia (35 males, 73 females; mean age = 21.4 years, $SD = 4.0$, range = 17–40). These participants had been in Australia for varying lengths of time, and included a group of 19 students from Zhejiang University in China, who had been in Australia for less than 1 month. Table 1 shows descriptive statistics for the two contact measures for the Chinese students: time (months) in a Western country and self-reported other-race contact. A sample of 36 Caucasian participants (16 males, 20 females) was also recruited from the University of Western Australia.

Table 1. Descriptive statistics for contact and outcome variables for Chinese participants

Variable	*N*	Mean	*SD*	Range
Time in Western country (months)	108	52.9	75.6	1[a], 312
Self-reported other-race contact	108	3.5	1.2	1.0, 6.0
Configural-ORE	108	0.20	0.81	− 1.55, 2.66
Log configural-ORE	108	0.42	0.13	0.0, 0.72
Component-ORE	108	0.14	0.83	− 1.92, 1.85

[a] Individuals who had been in Australia for less than 1 month were assigned a value of 1.

Stimuli and materials

Study and test faces

The stimuli consisted of intact, scrambled and blurred versions of 20 Caucasian and 20 Chinese, male, grey-scale faces (Figure 1), taken from Hayward *et al.* (2008). The faces measured 11.4 cm in width and 14.8 cm in height (6.4° × 8.3° from the viewing distance of 100 cm) and were standardized to an inter-pupil distance of 80 pixels on a canvas of 320 × 420 pixels. When these faces are both scrambled and blurred participants perform at chance levels, verifying that feature cues are unavailable in the blurred versions (Hayward *et al.*, 2008). All faces were displayed within a black frame to eliminate hair cues.

Race contact questionnaire

Hancock and Rhodes's (2008) race contact questionnaire was used to assess contact with Caucasian and Chinese faces. In it, participants indicate their level of agreement (1 = very strongly disagree, 6 = very strongly agree) with statements describing

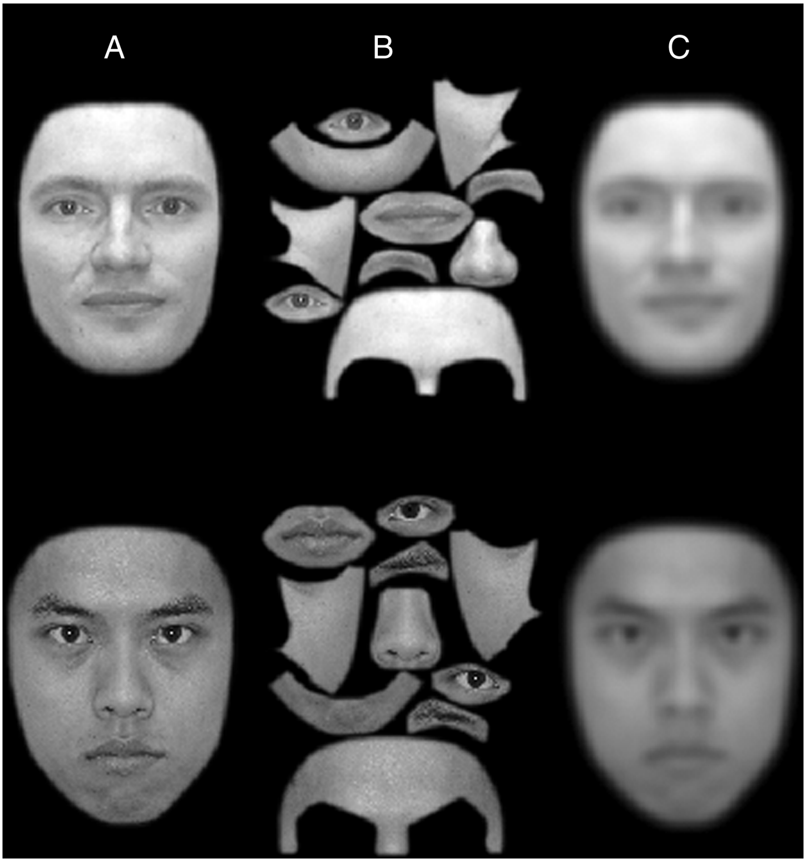

Figure 1. Caucasian and Chinese faces shown in three conditions: (A) original face, (B) scrambled condition, and (C) blurred condition. In the scrambled condition, configural information is removed so participants have to rely on featural information. In the blurred condition, featural information is removed so that participants have to rely on configural information.

contact, primarily social interactions, with Caucasian individuals and with Chinese individuals. The questionnaire has good internal consistency and yields two factors, one for Caucasian contact and one for Chinese contact, in a factor analysis (see Hancock & Rhodes, 2008).

Procedure

Participants initially viewed 10 (five Caucasian, five Chinese) intact study faces. Each face was shown twice, for 10 s each time, with a 1 s inter-stimulus interval. These 20 study trials were shown in random order, and participants were instructed to remember the faces for a later memory test. Immediately following this study phase, participants were shown 20 test stimuli (10 old, 10 new), all of which were either scrambled (testing recognition based on features) or blurred (testing recognition based on configuration), and asked to indicate whether each stimulus was old or new, using labelled keyboard keys. Each test face remained visible until the participant responded. Participants were informed that accuracy was more important than speed. Participants then repeated this study-test sequence, with 10 different (five Caucasian, five Chinese) study faces. They then completed two additional study-test sequences for the other test type. Half the participants were tested on scrambled faces first, and half on blurred faces first. Order of test type was counterbalanced with assignment of faces to study and test blocks. Finally, Chinese participants completed the race contact questionnaire.

Results

Cross-race effects

We used the signal detection measure, d', to measure recognition performance independent of response bias (Green & Swets, 1966). Separate d' values were calculated from hit and false-alarm rates for each race of face (own and other) and test type (blurred and scrambled). Hit and false-alarm rates of 1 and 0 were converted to .95 and .05 (MacMillan & Creelman, 2005). A three-way ANOVA was conducted on the d' scores (Table 2), with participant race (Chinese and Caucasian) as a between-participants factor and race of face (own-race and other-race) and test type (scrambled and blurred) as repeated measures factors. The results replicated previous findings with this task (Hayward *et al.*, 2008; Schwaninger *et al.*, 2002). There was a significant own-race advantage, with better performance for own-race ($M = 0.96$, $SE = 0.06$) than other-race faces ($M = 0.75$, $SE = 0.06$), $F(1, 142) = 14.65$, $p < .0001$, and performance was significantly better for blurred ($M = 1.20$, $SE = 0.07$) than scrambled faces ($M = 0.51$, $SE = 0.06$), $F(1, 142) = 77.77$, $p < .0001$. There were no other significant effects. Notably, we found no interaction between race of face and test type, $F < 1$, and so no evidence that the own-race advantage was greater for configural than component recognition. Finally, planned t tests confirmed that the own-race advantage was significant for both blurred, $t(142) = 2.45$, $p < .02$, and scrambled test faces, $t(142) = 3.82$, $p < .0002$ (collapsing across participant race). These results confirm that memory is better for own-race than other-race faces, whether it is based on configural or feature information. Performance was significantly above chance in all conditions, ts > 2.58, ps $< .01$.

Table 2. Mean (*SE*) sensitivity (d') scores as a function of participant race, test type, and face race

Test type	Blurred		Scrambled	
Face race	Own-race	Other-race	Own-race	Other-race
Chinese participants	1.41 (0.08)	1.21 (0.08)	0.59 (0.07)	0.45 (0.07)
Caucasian participants	1.16 (0.14)	1.02 (0.13)	0.70 (0.12)	0.31 (0.12)

Contact analyses

Multiple regression was used to test the contact hypothesis. We assessed the effects of contact separately for OREs in configuration memory and component memory for the Chinese participants. These OREs were measured as the cross-race difference (Chinese minus Caucasian, i.e. own-race minus other-race) in d' for blurred and scrambled test faces, respectively (see Table 1 for descriptive statistics). Component-ORE scores were normally distributed and configural-ORE scores were log transformed to achieve normality. Two measures of contact were examined: time in a Western country (months, log transformed) and self-reported contact (mean response to other-race items in contact questionnaire). Pearson product–moment correlations between all variables are shown in Table 3. Not surprisingly, the two contact measures were highly correlated. Interestingly, OREs in configural and feature processing were uncorrelated, suggesting that these are distinct aspects of face expertise.

Table 3. Pearson product–moment correlations between variables ($N = 108$)

	Component-ORE	Time in West	Self-reported other-race contact	Arrival age
log configural-ORE	0.020	− 0.225*	− 0.120	0.168†
Component-ORE		0.046	− 0.051	− 0.155
Time in West			0.573**	− 0.607**
Self-reported other-race contact				− 0.507**

*$p < .05$; **$p < .0001$; †$p < .10$.

Contact and the configural ORE

We assessed the effects of each contact measure on the configural ORE in separate regressions. All residuals were normally distributed. Time in a Western country negatively predicted the configural ORE, indicating that Chinese individuals who had spent longer in Australia had smaller configural OREs. The unstandardized regression coefficient was negative and the confidence interval (CI) excluded zero (Table 4).[3] The model was significant, $F(1,106) = 5.64$, $p < .02$, although it explained a very modest amount of variance (adjusted $R^2 = 4.3\%$). Self-reported contact also negatively predicted the configural ORE (Table 4), but the model was not significant, $F(1,106) = 1.54$, $p = .22$. Taken together, these results indicate a small improvement in configuration memory for other-race faces, as experience with such faces increases.

Contact and the component ORE

Time in a Western country did not significantly predict the component ORE (Table 4). The unstandardized regression coefficient was close to zero, the CI included zero and the model was not significant, $F(1,106) = 0.22$, $p = .64$. Nor did self-reported contact predict the component ORE (Table 4). The unstandardized regression coefficient was close to zero, the CI included zero and the model was not significant, $F(1,106) = 0.28$, $p = .60$. These results provide no evidence that poorer memory for component features in other-race faces is experience-dependent.

Comparing contact effects for configural and feature OREs

A z test (Steiger, 1980) showed that the correlations of experience (time in a Western country) with the configural ORE and with the component ORE differed significantly,

[3] *We specifically recruited recently arrived Chinese students, as well as those who had spend many years in a Western country, to ensure a wide range of contact levels. Because an extreme groups approach can inflate standardized measures of effect size, we focus on unstandardized regression coefficients (Preacher, Rucker, MacCallum, & Nicewander, 2005). Re-analysis excluding this recently arrived group did not change the results.*

Table 4. Summary of multiple regression results for contact variables predicting OREs in configuration and feature memory ($N = 108$)

Predictor variable	*B*	*SE of B*	CI	β
log configural-ORE				
Time in West	−0.035	0.015	−0.064, −0.006	−0.225*
Self-reported other-race contact	−0.013	0.010	−0.034, 0.008	−0.120
Component-ORE				
Time in West	0.045	0.097	−0.146, 0.237	0.045
Self-reported other-race contact	−0.036	0.068	−0.170, 0.098	−0.051

Note. 95% confidence intervals are shown. *$p < .05$.

$z = 1.99$, $p < .03$. Therefore, the ORE in configuration memory may be more experience-dependent than the ORE in component memory.

Age of arrival in a Western country

Age of arrival varied from 0 (arrived in first year of life) to 36 years, with a mean of 17.4 ($SD = 7.5$) years (median = 19.5, interquartile range = 16.0, 21.0). There was a trend for earlier arrival to predict smaller configural OREs, $F(1,106) = 3.09$, $p < .09$ ($B = 0.003$, $\beta = 0.17$, CI = 0.000, 0.006), although this could reflect the very high correlation between arrival age and time in a Western country in this sample, $r = -.61$, $N = 108$, $p < .0001$. Arrival age did not predict the component ORE, $F(1,106) = 2.61$, $p < .11$ ($B = -0.017$, $\beta = -0.155$; CI $= -0.038$, 0.004) and the effect was in the wrong direction.

Discussion

Using regression, we have shown that greater contact with other-race faces predicts smaller configural OREs. This is the first direct demonstration that links other-race contact with memory for configural information in other-race faces. Previously, Hancock and Rhodes (2008) found that increased contact was associated with larger inversion effects on recognition of other-race faces. They interpreted this finding as evidence that contact increases configural coding of other-race faces. Our results provide direct support for that interpretation.

In contrast, memory for component information in other-race faces did not appear to be affected by contact. This null finding cannot be attributed to a weaker ORE for component memory (Table 2) or to smaller variance in the component than configural ORE (Table 1). It may, however, reflect the considerable difficulty of the component task used here. Performance was above chance, but well below that on the configural task, and it is possible that contact effects would be seen with an easier component task. Alternatively, component coding may be genuinely less dependent on experience than configural coding, as suggested by developmental studies (Le Grand *et al.*, 2001, 2004; Mondloch, Le Grand, & Maurer, 2002).

The effect of contact on the configural ORE was observed with both an objective contact measure (time in Western country) and a subjective self-report measure. However, only the former effect was significant. Self-report measures are intrinsically vulnerable to forgetting and memory biases (e.g. over-reliance on recent events), and this may explain the weaker effects for that measure. Limited variability in the self-report scores could also have reduced the effect, although the variability was similar to that obtained by Hancock and Rhodes (2008), where self-reported contact did (negatively) predict OREs.

Age of arrival in Australia did not significantly predict either the configural or the component ORE. Our data, therefore, provide no clear evidence that early arrival is necessary for, or facilitates, successful other-race face processing. Adult training studies point to a similar conclusion (e.g. Hills & Lewis, 2006). Nevertheless, further investigation of arrival-age effects is warranted for several reasons. First, few of our participants arrived during infancy or childhood (only 25% arrived before age 16), when age effects seem most likely. Second, even with this limitation, we found a trend for earlier arrival to predict smaller configural OREs (although this could reflect the high association between arrival age and amount of contact). Finally, there are strong hints of arrival-age effects in other studies. For example, although Korean adults who had been adopted into US families as children showed reversed OREs in recognition memory, Korean participants who had arrived as adults did not (Sangrigoli *et al.*, 2005).

Many factors covary with amount of cross-race experience and the mechanisms underlying their effects on face recognition remain subject to debate. The present results identify better memory for configural information in faces as one such mechanism. This may reflect enhanced perceptual sensitivity to variations in configural information resulting from perceptual learning mechanisms.

The small size of the contact effects observed here, as well as those for face recognition memory generally (Meissner & Brigham, 2001) suggests that factors independent of experience are also important. One may be poor motivation to individuate other-race faces, perhaps because they are perceived as out-group members (Rodin, 1987). Several lines of evidence support a motivational effect. Recognition of other-race faces improves with increased motivation to individuate them (Ackerman *et al.*, 2006; Hugenberg, Miller, & Claypool, 2007) and memory for own-race faces declines when they are classified as out-group members (reducing motivation to individuate them; Bernstein, Young, & Hugenberg, 2007). Ambiguous-race faces are remembered more poorly (MacLin & Malpass, 2001) and processed less holistically when classified as other-race than own-race faces (Michel, Corneille, & Rossion, 2007). Race-specifying information may also be coded at the expense of individuating information in other-race faces (Levin, 1996, 2000; Levin & Angelone, 2001), although this is not always found (Rhodes, Locke, Ewing, & Evangelista, 2009; Stoessner, 1996; Valentine & Endo, 1992; Zarate & Smith, 1990). Poor motivation to individuate other-race faces in everyday life may also limit improvements in perceptual sensitivity to configural and other information associated with increased experience with other-race faces.

There has been a long-standing controversy over the role of contact in OREs in face recognition. Our results clearly support a role of contact. Increased contact predicted smaller OREs in memory for face configurations. The contact effect was small, but similar in size to that observed in face recognition generally, suggesting that experience-related differences in memory for face configurations may explain the experience-related component of OREs in face recognition (see Hancock & Rhodes, 2008). Our findings also add to the increasing evidence that sensitivity to component, as well as configural, information contributes to face expertise, with a clear own-race advantage observed for both types of memory. However, unlike memory for configurations, memory for components was not related to contact.

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References

Ackerman, J. A., Shapiro, J. R., Neuberg, S. L., Kenrick, D. T., Becker, D. V., Giskevicius, V., *et al.* (2006). They all look the same to me (unless they're angry). *Psychological Science*, *17*, 836–840.

Bar-Heim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science*, *17*, 159–163.

Bartlett, J., Searcy, J., & Abdi, H. (2003). What are the routes to face recognition? In M. Peterson & G. Rhodes (Eds.), *Perception of faces, objects and scenes: Analytic and holistic processes* (pp. 21–52). New York: Oxford University Press.

Bernstein, M. J., Young, S. G., & Hugenberg, K. (2007). The cross-category effect: Mere social categorization is sufficient to elicit an own-group bias in face recognition. *Psychological Science*, *18*, 706–712.

Brigham, J. C., Maass, A., Snyder, L. D., & Spaulding, K. (1982). Accuracy of eyewitness identifications in a field setting. *Journal of Personality and Social Psychology*, *42*, 673–681.

Bruyer, R., & Coget, M. C. (1987). Features of laterally displayed faces: Saliency or top-down processing? *Acta Psychologica*, *66*, 103–114.

Byatt, G., & Rhodes, G. (2004). Identification of own-race and other-race faces: Implications for the representation of race in face-space. *Psychonomic Bulletin and Review*, *11*, 735–741.

Caldara, R., & Abdi, H. (2006). Simulating the "other-race" effect with autoassociative neural networks: Further evidence in favor of the face–space model. *Perception*, *35*, 659–670.

Chiroro, P., & Valentine, T. (1995). An investigation of the contact hypothesis of the own-race bias in face recognition. *Quarterly Journal of Experimental Psychology*, *48A*, 879–894.

Collishaw, S. M., & Hole, G. J. (2000). Featural and configurational processes in the recognition of faces of different familiarity. *Perception*, *29*, 893–909.

Cross, J. F., Cross, J., & Daly, J. (1971). Sex, race, age and beauty as factors in recognition of faces. *Perception and Psychophysics*, *10*, 393–396.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, *115*, 107–117.

Feinman, S., & Entwisle, D. R. (1976). Children's ability to recognise other children's faces. *Child Development*, *47*, 506–510.

Ferguson, D. P., Rhodes, G., Lee, K., & Sriram, N. (2001). "They all look alike to me": Prejudice and cross-race face recognition. *British Journal of Psychology*, *92*, 567–577.

Furl, N., Phillips, P. J., & O'Toole, A. J. (2002). Face recognition algorithms and the other-race effect: Computational mechanisms for a developmental contact hypothesis. *Cognitive Science*, *26*, 797–815.

Golby, A. J., Gabrieli, J. D. E., Chiao, J. Y., & Eberhardt, J. L. (2001). Differential responses in the fusiform region to same-race and other-race faces. *Nature Neuroscience*, *4*, 845–850.

Goldstone, R. L. (2003). Do we all look alike to computers? *Trends in Cognitive Sciences*, *7*(2), 55–57.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics*. New York: Wiley.

Hancock, K., & Rhodes, G. (2008). Contact, inversion and the other-race effect in face recognition. *British Journal of Psychology*, *99*, 45–56.

Hayward, W. G., Rhodes, G., & Schwaninger, A. (2008). An own-race advantage for components as well as configurations in face recognition. *Cognition*, *106*, 1017–1027.

Hills, P. J., & Lewis, M. B. (2006). Reducing the own-race bias in face recognition by shifting attention. *The Quarterly Journal of Experimental Psychology*, *59*, 996–1002.

Hugenberg, K., Miller, J., & Claypool, H. M. (2007). Categorization and individuation in the cross-race recognition deficit: Toward a solution to an insidious problem. *Journal of Experimental Social Psychology*, *43*, 334–340.

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2001). Early visual experience and face processing. *Nature*, *410*, 890.

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2004). Impairment in holistic face processing following early visual deprivation. *Psychological Science*, *15*, 762–768.

Levin, D. T. (1996). Classifying faces by race: The structure of face categories. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *22*, 1364–1382.

Levin, D. T. (2000). Race as a visual feature: Using visual search and perceptual discrimination tasks to understand face categories and the cross-race recognition deficit. *Journal of Experimental Psychology: General*, *129*, 559–574.

Levin, D. T., & Angelone, B. L. (2001). Visual search for a socially defined feature: What causes the search asymmetry favoring cross-race faces? *Perception and Psychophysics*, *63*, 423–435.

MacLin, O. H., & Malpass, R. S. (2001). Race categorization of faces: The ambiguous race face effect. *Psychology, Public Policy and Law*, 7(1), 98–118.

MacMillan, N. A., & Creelman, C. D. (2005). *Detection theory* (2nd ed.). Mahwah, NJ: Erlbaum.

Malpass, R. S., & Kravitz, J. (1969). Recognition for faces of own and other race. *Journal of Personality and Social Psychology*, *13*, 330–334.

Maurer, D., Le Grand, R., & Mondloch, C. J. (2002). The many faces of configural processing. *Trends in Cognitive Sciences*, *6*, 255–260.

McKone, E., Brewer, J. L., MacPherson, S., Rhodes, G., & Hayward, W. G. (2007). Familiar other-race faces show normal holistic processing and are robust to perceptual stress. *Perception*, *36*, 224–248.

Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy and Law*, *7*, 3–35.

Michel, C., Caldara, R., & Rossion, B. (2006). Same-race faces are perceived more holistically than other-race faces. *Visual Cognition*, *14*, 55–73.

Michel, C., Corneille, O., & Rossion, B. (2007). Race-categorization modulates holistic face encoding. *Cognitive Science*, *31*, 911–924.

Michel, C., Rossion, B., Han, J., Chung, C-S., & Caldara, R. (2006b). Holistic processing is finely tuned for faces of our own race. *Psychological Science*, *17*, 608–615.

Mondloch, C. J., Le Grand, R., & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception*, *31*, 553–566.

O'Toole, A. J., Deffenbacher, K. A., Abdi, H., & Bartlett, J. A. (1991). Simulating the "other-race effect" as a problem in perceptual learning. *Connnection Science Journal of Neural Computing, Artificial Intelligence and Cognitive Research*, *3*, 163–178.

Preacher, K. J., Rucker, D. D., MacCallum, R. C., & Nicewander, W. A. (2005). Use of the extreme groups approach: A critical re-examination and new recommendations. *Psychological Methods*, *10*, 178–192.

Rhodes, G. (1988). Looking at faces: First-order and second-order features as determinants of facial appearance. *Perception*, *17*, 48–63.

Rhodes, G., Hayward, W. G., & Winkler, C. (2006). Expert face coding: Configural and component coding of own-race and other-race faces. *Psychonomic Bulletin and Review*, *13*, 499–505.

Rhodes, G., Locke, V., Ewing, L., & Evangelista, E. (2009). Race coding and the other-race effect in face recognition. *Perception*, *38*, 232–241.

Rhodes, G., Tan, S., Brake, S., & Taylor, K. (1989). Expertise and configural coding in face recognition. *British Journal of Psychology*, *80*, 313–331.

Rodin, M. J. (1987). Who is memorable to whom: A study of cognitive disregard. *Social Cognition*, *5*, 144–165.

Sangrigoli, S., Pallier, C., Argenti, A. M., Ventureyra, V. A. G., & de Schonen, S. (2005). Reversibility of the other-race effect in face recognition during childhood. *Psychological Science*, *16*, 440–444.

Schwaninger, A., Carbon, C. C., & Leder, H. (2003). Expert face processing: Specialization and constraints. In G. Schwarzer & H. Leder (Eds.), *Development of face processing* (pp. 81–97). Göttingen: Hogrefe.

Schwaninger, A., Lobmaier, J. S., & Collishaw, S. M. (2002). Role of featural and configural information in familiar and unfamiliar face recognition. *Lecture Notes in Computer Science*, *2525*, 643–650.

Sergent, J. (1984). An investigation into component and configurational processes underlying face recognition. *British Journal of Psychology*, *75*, 221–242.

Shepherd, J. W., Deregowski, J. B., & Ellis, H. D. (1974). A cross-cultural study of recognition memory for faces. *International Journal of Psychology*, *9*, 205–211.

Slone, A. E., Brigham, J. C., & Meissner, C. A. (2000). Social and cognitive factors affecting the own-race bias in Whites. *Basic and Applied Social Psychology*, *22*, 71–84.

Sporer, S. L. (2001). Recognizing faces of other ethnic groups. An integration of theories. *Psychology, Public Policy and Law*, *7*, 36–97.

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin*, *87*, 245–251.

Stroessner, S. J. (1996). Social categorization by race or sex: Effects of perceived non-normalcy on response times. *Social Cognition*, *14*, 247–276.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology*, *46A*, 225–245.

Tanaka, J. W., Kiefer, M., & Bukach, C. (2004). A holistic account of the own-race effect in face recognition: Evidence from a cross-cultural study. *Cognition*, *93*, B1–B9.

Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion, and race in face recognition. *Quarterly Journal of Experimental Psychology*, *43A*, 161–204.

Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: The effects of race and distinctiveness. *Quarterly Journal of Experimental Psychology A*, *44A*(4), 671–703.

Walker, P. M., & Hewstone, M. (2006). A perceptual discrimination investigation of the own-race effect and intergroup experience. *Applied Cognitive Development*, *20*, 461–475.

Wright, D. B., Boyd, C. E., & Tredoux, C. G. (2001). A field study of own-race bias in South Africa and England. *Psychology, Public Policy and Law*, *7*, 119–133.

Zarate, M. A., & Smith, E. R. (1990). Person categorization and stereotyping. *Social Cognition*, *8*, 161–185.

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