

# Two faces of the other-race effect: Recognition and categorisation of Caucasian and Chinese faces

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**Abstract.** The other-race effect is a collection of phenomena whereby faces of one's own race are processed differently from those of other races. Previous studies have revealed a paradoxical mirror pattern of an own-race advantage in face recognition and an other-race advantage in race-based categorisation. With a well-controlled design, we compared recognition and categorisation of own-race and other-race faces in both Caucasian and Chinese participants. Compared with own-race faces, other-race faces were less accurately and more slowly recognised, whereas they were more rapidly categorised by race. The mirror pattern was confirmed by a unique negative correlation between the two effects in terms of reaction time with a hierarchical regression analysis. This finding suggests an antagonistic interaction between the processing of face identity and that of face category, and a common underlying processing mechanism.

## 1 Introduction

The other-race effect is a collection of phenomena whereby faces of one's own race are processed differently from those of other races. One such occurrence is the own-race recognition advantage whereby own-race faces are recognised *more accurately and faster* than other-race faces (Bothwell et al 1989; Brigham and Malpass 1985; Chiroro and Valentine 1995; Valentine 1991). The effect of race on face recognition is robust in that it occurs across different racial groups (Bothwell et al 1989; Rhodes et al 1989; Shepherd and Derogowski 1981), age groups (Chance et al 1982; Pezdek et al 2003; Sangrigoli and de Schonen 2004a, 2004b), and in both laboratory and field settings (Brigham et al 1982; Cross et al 1971). It has also been confirmed by several meta-analytic studies (Bothwell et al 1989; Meissner and Brigham 2001).

Overshadowed by the vast literature on the own-race recognition advantage is a paradoxical other-race categorisation advantage. When participants are asked to categorise faces by their race, they respond *faster* to other-race faces than to own-race faces (Caldara et al 2004; Levin 1996, 2000; Valentine and Endo 1992). This other-race categorisation advantage has also been demonstrated to be robust with various face stimuli across different racial groups, by using either a race-based categorisation task or just a simple visual-search task. It should be noted, however, that this effect can be modulated by task, stimulus, and participant characteristics, such as simultaneous race–sex categorisation (eg Stroessner 1996), face distinctiveness (eg Valentine and Endo 1992), and participant racial stereotype tendencies (eg Zarate and Smith 1990).

Despite this apparent mirror pattern in response latency for own-race and other-race face processing in different tasks, in most studies the two effects have been investigated separately, with little concurrent examination of the paradoxical phenomena. To recognise a face among others, one must rely on identity-specific facial information; whereas to tell whether a face is Caucasian or Chinese, one must rely on

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information specific to race. According to the classic face-recognition model (Bruce and Young 1986; Burton et al 1990), race-specific information, as well as other face attributes, like gender, age, or facial expression and gaze direction, are visually derived semantic codes. These codes are believed to operate independently of the identity-specific information. Earlier behavioural, neuroimaging, and neuropsychology studies seem to support this hypothesis (Bruce 1986; Etcoff 1984; Haxby et al 2000; Humphreys et al 1993; Young et al 1985, 1993).

In contrast, recent evidence has come to suggest that identity-specific and category-specific codes may interact with each other and be processed with the same cognitive mechanisms (Bruyer et al 2004; Ganel and Goshen-Gottstein 2002; Le Gal and Bruce 2002). Following this point of view, the mirror pattern of the two face-race effects (recognition and categorisation) reflects the trade-off and competition between processing individual identity and categorical facial information of faces from own and other races. It is crucial to note that neuroimaging studies have found a significant difference between own-race and other-race faces in activation in the FFA (fusiform face area)—an area sensitive to processing of facial identity (Golby et al 2001). However, the results were only evident in a recognition task that relied heavily on identity-specific codes. Thus, it is currently unknown whether similar results would be found with a categorisation task that requires the processing of race-specific codes.

To date, this possibility has been examined by only two behavioural studies with mixed results. In one study, Levin (1996) divided Caucasian participants into two groups: a deficit group showing the own-race recognition advantage in accuracy and a non-deficit group not showing the effect. Both groups categorised computer-distorted faces as Caucasian or Black. They showed no difference in the other-race categorisation advantage in terms of reaction time, although there was a general other-race categorisation advantage in reaction time when the data for the two groups were combined. This finding suggested that whether or not individuals had an own-race recognition advantage did not predict whether they also had an other-race categorisation advantage. In contrast, Levin (2000) again divided participants into two groups and asked them to search for a Caucasian or Black face among other-race face distractors. This time, the deficit group showed a greater other-race categorisation advantage relative to the non-deficit group as measured by search time. Nevertheless, no significant differences were found in the same study between the two groups in terms of the other-race categorisation advantage when a go/no-go task was used (participants were asked to respond to a target face category but not to a non-target face category).

However, these equivocal outcomes might be due to the different methodologies used in Levin's studies. For example, the stimuli used for testing the own-race recognition advantage were individual faces, but those used to assess the other-race categorisation advantage were morphed or average faces. Also, whereas the recognition paradigm remained identical for various experiments, the method for testing categorisation varied. In one case, a race-based categorisation task was used (Levin 1996), and in another instance, a go/no-go or visual search paradigm was employed (Levin 2000). Furthermore, accuracy was used to measure the own-race recognition advantage and reaction time was used to measure the other-race categorisation advantage. This mismatch in dependent measures might have also contributed, to a certain extent, to the inconsistent findings. Perhaps, more importantly, participants were students from a major US university that is ethnically diverse, and these participants might have had extensive exposure to various other-race faces (indeed, although the other-race recognition advantage is highly robust, a significant proportion of participants in both studies did not show it at all). Thus, any close relationships between the own-race recognition advantage and the other-race categorisation advantage might have been obscured by these factors.

In the present study, to directly examine the interrelation between the paradoxical own-race and other-race face effects, we recruited participants who had near-zero *direct* contact with other-race individuals in the UK and China where over 91% and 99% of the population are either Caucasian or Chinese, respectively. The participants completed a recognition task in which they were required to recognise previously seen Chinese and Caucasian faces and a race-based categorisation task in which they were asked to judge the race of Chinese and Caucasian faces. The two tasks were structured such that the face stimuli were randomly assigned to each task, with the same number of stimuli, the same timing parameters, and the same manual response. It should be noted that the other-race categorisation advantage has been found only with the latency measures and categorisation accuracy has been typically near ceiling. In contrast, the own-race recognition advantage has been obtained in terms of both latency and accuracy. To further ensure comparability between the two tasks, we specifically focused on participants' reaction times when recognising and categorising own-race and other-race faces. To ascertain whether dependent measure mismatches contributed to the inconsistent findings in the previous studies, we also examined the relationship between participants' recognition accuracy and their categorisation reaction times.

On the basis of the existing evidence, we expected to observe both the own-race recognition advantage and the other-race categorisation advantage among Chinese and Caucasian participants, with the former in terms of both accuracy and response latency, and the latter in terms of response latency. More importantly, if the face-identity and race-information processing is carried out independently (Bruce and Young 1986), the two effects should not correlate with each other for both Chinese and Caucasian participants. Alternatively, if a common underlying mechanism is at work, a significant negative correlation should be observed between the two effects. By a common-mechanism account, identifying own-race faces would compete with categorising them; when processing capacity remains constant, increased proficiency at recognising own-race faces must be compensated with a decrease in categorising the same faces.

## 2 Method

### 2.1 Participants

Thirty-two Han Chinese students (sixteen females) from Zhejiang Sci-Tech University, and thirty-five Caucasian students (twenty females) from Sheffield University, participated in the present study. Participants reported no direct contact with other-race individuals. In Sheffield, the population consisted of 91.2% Caucasians and 1% Chinese. In Hangzhou, 99.9% of the population is Han Chinese.

### 2.2 Stimuli

64 Caucasian and 64 Chinese young-adult upright faces with neutral expression (half male and half female) were used. All faces were full-colour, high-quality photographic images taken frontally at a fixed position, digitised in 24-bit colours with a resolution of  $640 \times 480$  pixels.

### 2.3 Design and procedure

The experiment was a  $2 \times 2$  factorial design, with face race (Caucasian versus Chinese) and task type (recognition by identity—hereafter the recognition task—versus categorisation by race—hereafter the categorisation task) as within-subjects factors. The 64 faces from either race were divided into two lists with the same number of female and male faces. For each participant, the faces from one of the two lists were used for the recognition task and those from the other list were used for the categorisation task. In other words, the same participant did not see the same faces in the recognition and categorisation tasks. The assignment of the two lists to the two tasks and the task order was counterbalanced between participants.

For the recognition task, participants first passively viewed and were asked to remember 16 Caucasian and 16 Chinese faces presented in random order, repeated for three times to enhance memorisation (a centrally located fixation cross-hair was presented for 500 ms between the same stimuli). After this phase, those learned faces were randomly mixed with another 32 unlearned faces (16 from each of the two race categories) for recognition. Participants were asked to press either '1' or '2' on the number pad to indicate whether the face had been previously seen or not.

For the categorisation task, participants were asked to press the same keys as in the recognition task to indicate whether the face was a Caucasian or Chinese face, which was shown only once. The key assignment was counterbalanced between participants in both tasks.

Participants sat in a dimly lit quiet room and saw the faces from a visual angle of 12.4 deg in height and 16.4 deg in width. Faces were presented with E-Prime (Psychology Software Testing, Pittsburgh, PA) via a PC computer. In the recognition task, the faces were presented for 2 s per face in the learning phase. In the recognition phase and the categorisation task, the faces were presented for up to 5 s depending on the key press. Participants were asked to respond as fast and as accurately as possible. Before each study or test face was presented, participants were asked to look at a centrally located fixation cross-hair with a random variable interstimulus interval between 500 and 1000 ms.

### 3 Results

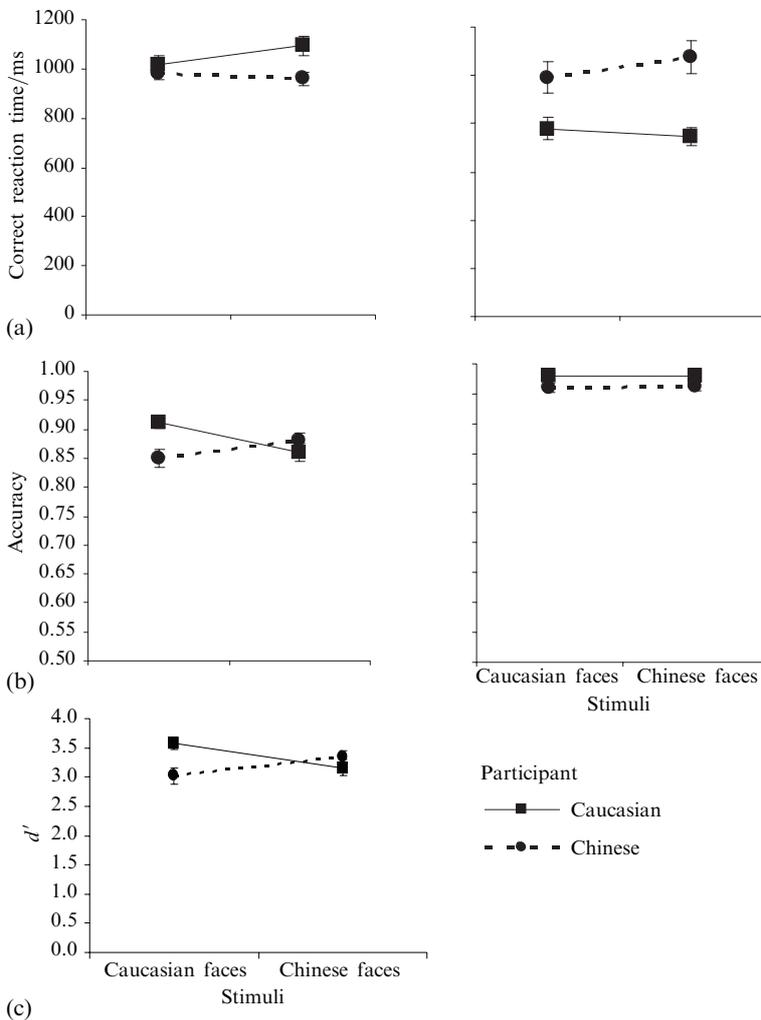
Preliminary analyses showed that the effects of participant gender and face gender were not significant. Thus, the two factors were excluded from further analyses. We first performed an omnibus ANOVA to examine the two face-race effects (for recognition and categorisation) in the two participant groups (Caucasian and Chinese), on both the reaction time and accuracy. Then a hierarchical regression analysis was conducted to evaluate the relationship between the two face-race effects.

#### 3.1 Reaction time

Figure 1 shows the accuracy and reaction time results for Chinese and Caucasian faces from both the recognition and categorisation tasks. The reaction time for each participant for each face type in each condition was obtained by averaging the latencies of the trials in which the participant gave correct responses. Trials with reaction times above two standard deviations were excluded. The ANOVA was performed with task type (categorisation versus recognition) and face race (Caucasian versus Chinese) as within-subjects factors, and participant race as between-subjects factor on the reaction time data.

A significant main effect of task type was found ( $F_{1,65} = 14.86$ ,  $p < 0.001$ ,  $\eta^2 = 0.19$ ). Participants were faster in the categorisation task (mean,  $M = 906.85$ , standard deviation,  $SD = 205.69$ ) than in the recognition task ( $M = 1028.71$ ,  $SD = 284.44$ ). There was also a significant effect of face race ( $F_{1,65} = 8.41$ ,  $p < 0.01$ ,  $\eta^2 = 0.11$ ), and of participant race ( $F_{1,65} = 4.97$ ,  $p < 0.05$ ,  $\eta^2 = 0.07$ ). The Caucasian faces were responded to faster ( $M = 952.43$ ,  $SD = 217.73$ ) than were the Chinese faces ( $M = 983.13$ ,  $SD = 214.67$ ); and Caucasian participants were faster ( $M = 910.07$ ;  $SD = 211.61$ ) than Chinese participants ( $M = 1025.49$ ,  $SD = 211.61$ ).

There was a significant interaction between task type and participant race ( $F_{1,65} = 29.61$ ,  $p < 0.001$ ,  $\eta^2 = 0.31$ ). Caucasian participants were faster in the categorisation task ( $M = 763.14$ ,  $SD = 284.15$ ) than in the recognition task ( $M = 1057.00$ ,  $SD = 205.49$ ), whereas Chinese participants performed similarly fast in both tasks (categorisation:  $M = 1050.56$ ,  $SD = 284.15$ ; recognition:  $M = 1000.42$ ,  $SD = 205.49$ ). The interaction between face race and participant race was not significant.



**Figure 1.** (a) Reaction time, (b) accuracy, and (c)  $d'$  for Caucasian and Chinese faces in Caucasian (solid line) and Chinese (dotted line) participants in the recognition (left panels) and categorisation (right panels) tasks. Standard error bars are shown.

The crucial three-way interaction between task type, face race, and participant race was significant (see figure 1a for means and standard errors) ( $F_{1,65} = 28.59$ ,  $p < 0.001$ ,  $\eta^2 = 0.31$ ). Paired  $t$ -tests showed that Caucasian participants recognised Caucasian faces faster than Chinese faces ( $t_{34} = -4.99$ ,  $p < 0.001$ ), and categorised Chinese faces faster than Caucasian faces ( $t_{34} = 2.68$ ,  $p < 0.05$ ), whereas Chinese participants recognised Chinese faces faster than Caucasian faces ( $t_{31} = 2.25$ ,  $p < 0.05$ ), and categorised Caucasian faces faster than Chinese faces ( $t_{31} = 3.32$ ,  $p < 0.01$ ). This mirror pattern between the own-race recognition advantage and the other-race categorisation advantage (figure 1a) indicates that, as expected, own-race faces and other-race faces were processed differently in the two tasks, for both Caucasian and Chinese participants.

### 3.2 Accuracy

An ANOVA with task type (categorisation versus recognition) and face race (Caucasian versus Chinese) as within-subjects factors, and participant race as a between-subjects factor, was performed on the accuracy data as measured by percentage of correct responses (figure 1b). The main effect of task type was significant ( $F_{1,65} = 122.58$ ,

$p < 0.001$ ,  $\eta^2 = 0.65$ ). Participants were more accurate in the categorisation task ( $M = 0.97$ ,  $SD = 0.07$ ) than in the recognition task ( $M = 0.88$ ,  $SD = 0.03$ ). The main effect of the participant race was also significant ( $F_{1,65} = 7.00$ ,  $p < 0.05$ ,  $\eta^2 = 0.10$ ). Caucasian participants ( $M = 0.93$ ,  $SD = 0.04$ ) were more accurate than Chinese participants ( $M = 0.91$ ,  $SD = 0.03$ ). The main effect of the face race, however, was not significant (Caucasian faces:  $M = 0.92$ ,  $SD = 0.04$ ; Chinese faces:  $M = 0.92$ ,  $SD = 0.05$ ). There was a significant interaction between face race and participant race ( $F_{1,65} = 9.60$ ,  $p < 0.01$ ,  $\eta^2 = 0.13$ ).

Moreover, this interaction was further modulated by the task type, inducing a significant three-way interaction (see figure 1b for means and standard errors) ( $F_{1,65} = 13.15$ ,  $p < 0.01$ ,  $\eta^2 = 0.17$ ). Paired  $t$ -tests showed that Caucasian participants were more accurate with the Caucasian faces than the Chinese faces ( $t_{34} = 3.69$ ,  $p < 0.01$ ), and Chinese participants were more accurate with the Chinese faces than the Caucasian faces ( $t_{31} = -2.31$ ,  $p < 0.05$ ) in the recognition task. This result indicates an own-race recognition advantage in accuracy for both Caucasian and Chinese participants (figure 1b). However, both groups of participants failed to show a significant other-race categorisation advantage in accuracy in the categorisation task. This is consistent with previous reports that also failed to show the other-race categorisation advantage in terms of accuracy, likely as a result of the ease of the categorisation task.

To rule out the possibility that response bias might have unduly affected response accuracy, we performed a signal detection analysis based on the data from the recognition task. For the three occasions when false alarm (FA) rates were 0, we followed the conventional correction formulae whereby  $FA = 1/(2N)$  when the observed  $FA = 0$  and  $N =$  maximum number of false alarms.

An ANOVA with face race (Caucasian versus Chinese) as a within-subjects factor and participant race as a between-subjects factor was performed on the discriminability measure ( $d'$ ) for the recognition task. A significant interaction was found for  $d'$  in the recognition task (figure 1c) ( $F_{1,65} = 18.657$ ,  $p < 0.001$ ,  $\eta^2 = 0.23$ ; Caucasian participants on Caucasian faces: mean  $d' = 3.58$ ,  $SD = 0.62$ ; Caucasian participants on Chinese faces: mean  $d' = 2.97$ ,  $SD = 0.74$ ; Chinese participants on Caucasian faces: mean  $d' = 3.17$ ,  $SD = 0.79$ ; Chinese participants on Chinese faces: mean  $d' = 3.33$ ,  $SD = 0.62$ ). Paired  $t$ -tests showed a significant advantage for own-race faces for both groups ( $t_{34} = 3.33$ ,  $p < 0.01$  for Caucasian participants;  $t_{31} = -2.80$ ,  $p < 0.01$  for Chinese participants).

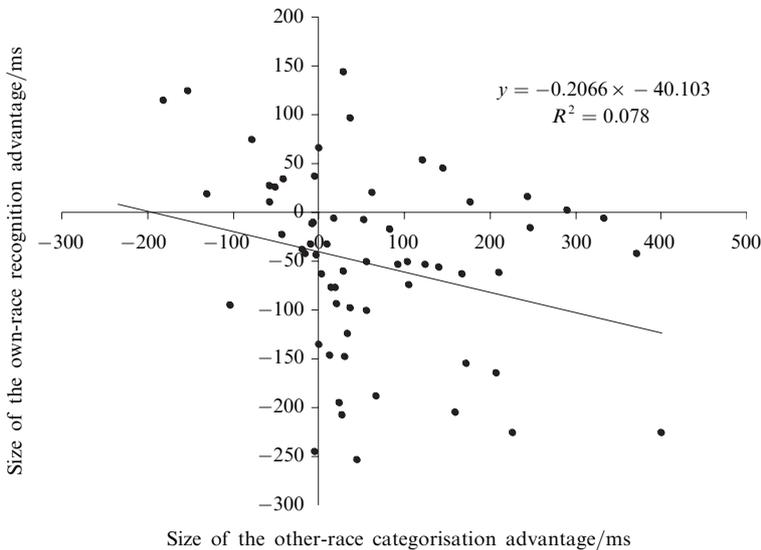
However, another ANOVA with face race (Caucasian versus Chinese) as a within-subjects factor and participant race as a between-subjects factor was performed on the response bias measure (criterion  $c$ ) for the recognition task showed neither a significant main effect nor a significant interaction of face race and participant race (face race:  $F_{1,64} = 1.87$ , ns; participant race:  $F_{1,64} = 0.28$ , ns; interaction:  $F_{1,64} = 0.69$ , ns). The means and standard deviations of criterion  $c$  for each condition and group are as follows: Caucasian participants on Caucasian faces—mean criterion  $c = 0.12$ ,  $SD = 0.29$ ; Caucasian participants on Chinese faces—mean criterion  $c = 0.15$ ,  $SD = 0.37$ ; Chinese participants on Caucasian faces—mean criterion  $c = 0.05$ ;  $SD = 0.37$ ; Chinese participants on Chinese faces—mean criterion  $c = 0.14$ ,  $SD = 0.37$ ). Thus, the own-race recognition advantage findings based on the accuracy data were not due to response biases.

### 3.3 Relationship between the two face-race effects

The above results revealed the anticipated mirror pattern between the two face-race effects in terms of group mean response latency. To examine whether this mirror pattern also existed at the individual participant level, we computed the size of the own-race recognition advantage in reaction time. This measure was obtained by subtracting each participant's reaction time for the own-race faces from that for the other-race faces in

the recognition task. The difference scores greater than 2 standard deviations were excluded from the subsequent analysis (four scores in total). Similarly, we computed the size of the own-race recognition advantage in discriminability by subtracting each participant's  $d'$  for recognising the other-race faces from that for recognising the own-race faces. Further, the size of the other-race categorisation advantage in reaction time was obtained by subtracting the reaction time of the own-race faces from that of the other-race faces in the categorisation task to generate a different score for each participant.

A correlation analysis collapsed across the participant race revealed a significant negative correlation between the size of the own-race recognition advantage in reaction time and the size of the other-race categorisation advantage in reaction time (see figure 2;  $r_{63} = -0.50$ ,  $p < 0.0001$ ), consistent with the mirror pattern found in the ANOVA analysis. However, the size of the own-race recognition advantage in discriminability and the size of the other-race categorisation effect in reaction time was not significantly correlated ( $r_{63} = 0.15$ , ns).



**Figure 2.** The correlation between the sizes of the own-race recognition advantage in reaction time (x axis) and the other-race categorisation advantage in reaction time (y axis).

However, the significant relationship found between the size of the own-race recognition advantage in reaction time and the size of the other-race categorisation effect in reaction time could originate from general factors such as processing speed and participant race. To rule out these possibilities, two hierarchical regression analyses were performed so as to examine the unique relationship between the two face-race effects after these extraneous factors were controlled.

For the first regression analysis, we used the size of the own-race recognition advantage in reaction time as the dependent measure. At the first step, the participant race factor was entered into this model to account for any difference between Chinese and Caucasian participants because a significant effect of race was found in terms of participant race (see the ANOVA results above). Also, the participant's recognition reaction time was entered into the model because it was found to be significantly related to the size of the own-race recognition advantage in reaction time ( $r_{63} = -0.36$ ,  $p < 0.001$ ). This variable was thus entered into the regression analysis first to partial out any possible contribution of the overall processing speed in face recognition.

**Table 1.** Summary of the hierarchical regression analysis of the relation between the own-race recognition advantage and the other-race categorisation advantage.

Step	Measures	<i>B</i>	Confidence interval (upper/lower bound)	<i>t</i>	$R^2_{\text{change}}$
<i>With own-race recognition advantage in reaction time as dependent variable</i>					
1					0.30***
	Participant race	86.02	41.29/130.75	3.85***	
	Correct recognition reaction time	-0.14	-0.26/-0.02	-2.37*	
2	Other-race categorisation advantage	-0.25	-0.42/-0.08	-2.96**	0.09*
3	Other-race categorisation advantage × participant race	0.89	-1.50/3.29	0.72	0.02
	Other-race categorisation advantage × correct recognition reaction time	0.001	-0.001/0.002	0.94	
	Overall $R^2$				0.41***
<i>With own-race recognition advantage in discriminability as dependent variable</i>					
1					0.22**
	Participant race	0.71	0.34/1.09	3.81***	
	Correct recognition reaction time	0.00	-0.001/0.001	-0.62	
2	Other-race categorisation advantage	0.00	-0.001/0.002	-0.63	0.01
3	Other-race categorisation advantage × participant race	0.002	-0.02/0.02	0.72	0.01
	Other-race categorisation advantage × correct recognition reaction time	0.00	0.00/0.00	0.24	
	Overall $R^2$				0.23***

Note: \*\*\*  $p < 0.001$ ; \*\*  $p < 0.01$ ; \*  $p < 0.05$ .

The model was significant (see table 1;  $R^2_{\text{change}} = 0.30$ ,  $F_{2,60,\text{change}} = 12.94$ ,  $p < 0.0001$ ). Consistent with the above ANOVA finding, Caucasian participants had a greater own-race recognition advantage in reaction time than Chinese participants. Also, the faster the correct recognition reaction time, the greater the own-race recognition advantage in reaction time.

Second, the critical factor, the size of the other-race categorisation advantage in reaction time, was entered into the model. This second step was also significant ( $R^2_{\text{change}} = 0.09$ ,  $F_{1,59,\text{change}} = 8.76$ ,  $p < 0.01$ ; table 1). Thus, after partialling out the effect of the participant race and reaction time in face recognition, the size of the own-race recognition advantage was still significantly related to the size of the other-race categorisation advantage in terms of response latency. The faster one recognised own-race faces than other-race faces, the slower one categorised own-race faces relative to other-race faces. At the third step, we further tested the effect of the interaction of the size of the other-race categorisation advantage with the participant race and the reaction time in face recognition on the size of the own-race recognition advantage. The interaction terms were not significant (table 1).

For the second regression analysis, we used the size of the own-race recognition advantage in discriminability as the dependent variable, which was obtained by subtracting the  $d'$  for recognising the other-race faces from that for recognising the own race faces. The same predictors used in the first regression analysis were used in this second regression analysis with the predictors and their interaction terms entered into the analysis in three hierarchical steps. The crucial second and third steps were not significant, suggesting that the own-race recognition advantage in discriminability was not significantly related to the other-race categorisation advantage in reaction time (table 1).

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## 4 Discussion

In the present study, we concurrently examined the mirror pattern of the own-race recognition advantage and the other-race categorisation advantage. As expected, Caucasian participants recognised Caucasian faces more accurately and faster than Chinese faces but categorised Chinese faces faster than Caucasian faces. This mirror pattern was completely replicated with Chinese participants who recognised Chinese faces more accurately and faster than Caucasian faces but categorised Caucasian faces faster than Chinese faces.

This finding is the first in the literature to obtain a clear mirror pattern of the own-race and other-race face recognition and categorisation effects in terms of the reaction time. The fact that Chinese participants' responses were entirely opposite to Caucasian participants' responses when recognising and categorising the same face stimuli rules out the possibility that our findings were due to the specifics of face stimuli used. Further, because our recognition and categorisation tasks had highly similar tasks structure and demand, we can confidently attribute the mirror pattern of the own-race and other-race effects to processing differences involved in recognising and categorising own-race and other-race faces.

More importantly, our correlational analyses revealed that the own-race recognition advantage *in reaction time* was significantly related to the other-race categorisation advantage in reaction time. Further, the hierarchical regression analyses confirmed that this relation was still significant after partialling out the effects of such factors as participants' recognition reaction time and race. In particular, the faster participants recognised their own-race faces relative to other-race faces, the slower they categorised their own-race faces. This result suggests that the own-race recognition advantage is closely related to the other-race categorisation advantage in terms of processing speed. An implication is that expertise at efficiently recognising one's own-race faces is not a cost-free accomplishment. It is achieved at the cost of efficient categorisation of such faces. This finding is in line with the hypothesis that the processes of recognition and categorisation may have a common underlying processing mechanism. Recognising faces with which one has a high level of expertise interferes with categorising them.

However, the exact nature of this interference is unclear. The lack of significant correlation between the own-race recognition advantage in *discriminability* and the other-race categorisation advantage in reaction time suggests that the interference may be rooted in efficiency rather than accuracy. In other words, the increased expertise at recognising own-race faces may negatively affect the speed by which we categorise such faces but not whether we can categorise the faces correctly. This possibility explains in part the inconsistent findings by Levin (1996, 2000) who typically used accuracy or discriminability to measure the own-race recognition advantage but latency to measure the other-race categorisation advantage. However, it is premature to accept this efficiency hypothesis. This is because we, like many other previous researchers, were unable to obtain the other-race categorisation advantage in discriminability owing to participants' near-ceiling performance in the categorisation task. Thus, at this point, the current finding regarding the interaction between the cross-race face categorisation and recognition effects should be interpreted with caution owing to such limitations. Future studies need to increase the difficulty level of the categorisation task (eg reducing the viewing time) to avoid ceiling performance. In this way, one can ascertain whether the mirror pattern of the two cross-race effects exists in terms of not only response latency but also discriminability.

Another point is also worth noting. It is possible that the mirror pattern of the own-race and other-race effects observed here is a manifestation of a broader phenomenon. It has been found that people recognise faces of their own age and gender better than faces of other ages or gender (Anastasi and Rhodes 2005, 2006; Wright and Sladden 2003).

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It has been recently found that when faces were assigned into arbitrary in-group and out-group categories, participants recognised in-group faces better than the out-group faces, similar to the own-race recognition advantage (Bernstein et al 2007). Although concurrent categorisation studies have yet to be conducted with regard to categorising own-age and other-age, gender or arbitrary in-group and out-group faces, it seems reasonable to conjecture that a mirror pattern of the recognition and categorisation effects will be observed beyond cross-race face processing.

There have been some suggestions why increased experience and expertise with processing one category of faces should affect detrimentally the categorisation of faces of this category. One influential theoretical framework (Valentine 1991) suggests that faces are represented in a multidimensional space where each dimension represents a type of perceptually relevant face information. It has been hypothesised that the distances between face representations are tuned by experience. Compared with own-race faces, the distances between other-race faces are shorter and hence form a higher density (Byatt and Rhodes 2004). This higher density interferes with individual identification which is needed in the recognition task because each other-race face can be confused with its neighbours. However, this higher density can benefit categorisation at the group level because of the increased activation of the other-race faces as a group.

Another possibility proposed by Levin (1996, 2000) is that categorisation may not necessarily take place earlier than individuation. The sequence of categorisation and individuation depends on one's processing expertise. Levin (1996, 2000) argued that when individuals process a category of faces with which they have limited experience, categorical information is encoded first, followed by individuating information. In contrast, when individuals process a category of faces for which they have expertise, individuating information is automatically encoded first, followed by categorical information. This hypothesis predicts that the response latency in recognition of own-race faces should be faster than categorisation of the same faces, and recognition of other-race faces should be slower than categorisation of the same faces.

A third alternative hypothesis is that individuals devote differential processing resources (eg attention) to a face's categorical and individuating information depending on whether the face is in-group and familiar versus out-group and unfamiliar (Sporer 2001). When encountering unfamiliar out-group faces, individuals may devote more resources to categorical information than individuating information. In contrast, when encountering familiar in-group faces, individuals may devote more resources to individuating information. Indeed, recent studies showed that the improvement in recognition of other-race faces can be achieved by directing participants to attend to the individuating information of other-race faces (Hills and Lewis 2006; Hugenberg et al 2007).

Specifically designed studies are needed to test these different hypotheses directly. For example, it has been found that own-race faces are represented in a more densely distributed fashion than other-race faces (Byatt and Rhodes 2004). To confirm the multidimensional hypothesis, one needs to assess whether such difference in distribution density indeed has differential consequences for recognition and categorisation of own-race and other-race faces (see Jaquet et al 2008 for possible methods to test such possibilities). To test Levin's hypothesis, one needs to design tasks especially sensitive to the sequences of processing of face race and identity information. Sporer's hypothesis on the other hand requires obtaining information about resource allocation during the processing of own-race and other-race faces. Evidence to support and disconfirm these hypotheses not only will shed light on the exact relation between other-race recognition and categorisation but also on the nature of cognitive mechanisms underlying face identity and category processing.

In summary, the present study used identical face stimuli and task demand and structure and revealed that both Chinese and Caucasian participants showed the same

mirror pattern of the own-race recognition advantage and other-race categorisation advantage in terms of reaction time but not in terms of discriminability. Further, after partialling out the effects of various factors, the speed at which individuals categorised other-race faces as opposed to own-race faces was significantly related to the speed at which they individuated own-race faces as opposed to other-race faces. This significant negative correlation suggests an antagonistic relationship between face individuating and categorisation in reaction time: increased efficiency at individuating faces may come at the cost of efficiency at categorising the same faces. This antagonistic relationship may be a general face processing phenomenon and reflects competition between categorisation and individuation of faces with which individuals have different levels of expertise.

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