Research Article

Holistic Processing Is Finely Tuned for Faces of One's Own Race

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ABSTRACT—***Recognizing individual faces outside one's race poses difficulty, a phenomenon known as the*** **other-race effect.** ***Most researchers agree that this effect results from differential experience with same-race (SR) and other-race (OR) faces. However, the specific processes that develop with visual experience and underlie the other-race effect remain to be clarified. We tested whether the integration of facial features into a whole representation—holistic processing—was larger for SR than OR faces in Caucasians and Asians without life experience with OR faces. For both classes of participants, recognition of the upper half of a composite-face stimulus was more disrupted by the bottom half (the*** **composite-face effect*****) for SR than OR faces, demonstrating that SR faces are processed more holistically than OR faces. This differential holistic processing for faces of different races, probably a by-product of visual experience, may be a critical factor in the other-race effect.***

People are better at discriminating and recognizing faces of their own race than faces of a different race, a phenomenon confirmed experimentally and termed the *other-race effect* (ORE) for face perception (for a meta-analysis, see Meissner & Brigham, 2001). Most researchers agree that the ORE results from the differential experience people have with same-race (SR) and other-race (OR) faces (e.g., Rhodes, Tan, Brake, & Taylor, 1989; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005), but the specific processes that develop with visual experience and lead to the differential ability to recognize SR and OR faces remain to be clarified.

An important question related to this issue is whether different visual cues are extracted from SR and OR faces. Researchers have proposed that the face-processing system is less sensitive to the spatial relations between features in OR faces than in SR faces (Rhodes et al., 1989). In previous studies, this hypothesis was tested only indirectly—by comparing recognition of upright and upside-down faces, because the decrease in performance for upside-down faces (the *face-inversion effect*; Yin, 1969) appears to be due mainly to a loss of the ability to extract such spatial, or configural, relationships (e.g., Freire, Lee, & Symons, 2000; Rhodes, Brake, & Atkinson, 1993). Moreover, the prediction of a larger face-inversion effect for SR faces relative to OR faces has not been clearly supported: Whereas Rhodes et al. (1989; see also Sangrigoli & de Schonen, 2004) found a larger effect for SR than for OR faces, other researchers have observed a larger effect for OR than SR faces (Valentine & Bruce, 1986) or an equally large effect for the two categories of faces (Buckhout & Regan, 1988). Fallshore and Schooler (1995) also provided some indirect support for the configural hypothesis, by showing that SR face recognition was more impaired by verbal description of the faces (an effect called *verbal overshadowing*) than was OR face recognition. Starting from the premise that verbalization disrupts essentially the nonreportable configural processing of faces, the authors interpreted this differential verbal overshadowing as evidence of better configural processing for SR than OR faces.

More recently, Tanaka, Kiefer, and Bukach (2004) showed a greater *whole-part advantage* (i.e., a benefit from the whole face context when processing facial parts; Tanaka & Farah, 1993) for SR than OR faces among Caucasian subjects, a result suggesting that SR faces are perceived more holistically (as a whole or a

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template) than OR faces. However, in contrast to the Caucasian subjects, who had no experience with Asian faces, the Asian subjects in this study had been living in North America for their entire lives and reported having more experience with Caucasian than with Asian faces. Thus, unsurprisingly, the Asian participants showed equally large holistic processing for SR and OR (Caucasian) faces, so the authors could not conclude unequivocally that their results showed differential holistic processing for SR and OR faces. Moreover, no independent measure of the ORE was reported in this study. Another limitation of this work (see also Michel, Caldara, & Rossion, 2004) is related to the ambiguity of the locus of the whole-to-part interference during this task. The whole-part advantage may be due to criterion shifts rather than to improvement in sensitivity when a feature is presented in its context. This would suggest that subjects are not processing faces at a holistic level perceptually, but instead are using information from other features to alter their decision (Wenger & Ingvalson, 2002). Given that in the whole-part paradigm, subjects receive no specific instructions about which part or parts of the stimulus to attend, Caucasian participants may show less contextual effect when presented with Asian faces than when presented with Caucasian faces because they choose to base their decisions for Asian faces on a single feature, whereas they take into account several features for faces of their own race.

In the present study, we aimed to clarify directly and unambiguously whether SR faces are perceived more holistically than OR faces. To do this, we used the face-composite paradigm (Young, Hellawell, & Hay, 1987), probably the most compelling demonstration of holistic face processing (Le Grand, Mondloch, Maurer, & Brent, 2004; Maurer, Le Grand, & Mondloch, 2002), to test subjects of different races who had no experience with OR faces.

We tested Caucasian and Asian participants who had been born in and were living in Western Europe and Korea, respectively. After ensuring that the two populations exhibited a clear advantage in recognizing SR faces, we sought to determine the extent to which they perceived SR and OR faces holistically. In the face-composite paradigm (Young et al., 1987), the top half of a face is joined to the bottom half of another face. Observers are slower to name the identity of the top part of the face when the bottom part (to be ignored) is aligned with the top part, creating a *composite face*, than when the top and bottom parts are misaligned (i.e., offset laterally). Since its first demonstration, this *composite-face effect* has been replicated and extended to unfamiliar faces in experiments using matching tasks (e.g., Le Grand et al., 2004), providing compelling evidence that the perception of a novel face configuration—understood here in the sense of a gestalt—in a facial composite interferes with the recognition of its constituent parts. We predicted that the composite-face effect in a delayed matching task with unfamiliar faces would be larger for SR than OR faces in the two groups of participants. Such a result would support the hypothesis that SR faces are perceived more holistically than OR faces.

METHOD

Participants

Thirty Caucasian (Belgian; 21 females; mean age = 22.9 years, range: 19–29 years) and 30 Asian (Korean; 15 females; mean age = 20.09 years, range: 18–25 years) students took part in the experiment. None of the participants had significant experience with OR faces (as assessed by a questionnaire), and all had normal or corrected-to-normal vision.

Stimuli

All the facial stimuli were full-front views of Belgian or Chinese (from Beijing) students (between 18 and 25 years old) who were unfamiliar to the participants. The students posed with neutral expressions, and external features were removed. The photographs subtended a visual angle of approximately 4.58° by 3.44° and were displayed on a computer screen using E-Prime 1.1.

Old/New Face Recognition Task

For the old/new face recognition task, we used 40 faces of each race (half males). All photographs were shown in color on a white background.

Composite Task

For the composite task, 40 new faces of each race (half males) were used as stimuli. All photographs were shown in gray scale. The composites were created by first dividing the faces into top and bottom segments by slicing them in the middle of the nose (Figs. 1a and 1b). For each original face, we constructed four composite face stimuli, two for *same* trials and two for *different* trials (see Procedure). For the *same* trials, we joined the top segment of the original face to the bottom segment of another face of the same gender: In one of these composites, the two halves were aligned, and in the other, they were misaligned (by positioning the middle of the bottom segment next to the extreme left side of the top segment; see Figs. 1a and 1b). For the *different* trials, we joined the same bottom segment used in the *same* trials to the top segment from an entirely different face. Again, one of these stimuli was aligned, and the other was misaligned (see Figs. 1a and 1b). Thus, the bottom part of the four composite faces associated with each original face was always the same, and the top part was either the top segment of the original face (*same* trials: only the bottom part differed from the bottom part of the original face) or the top segment of a different face (*different* trials: both top and bottom parts differed from the original face). Stimuli were presented on a gray rectangle (6.7° by 5.16°) against a white background.

Procedure

Participants were tested individually, at a distance of 100 cm from the computer screen.

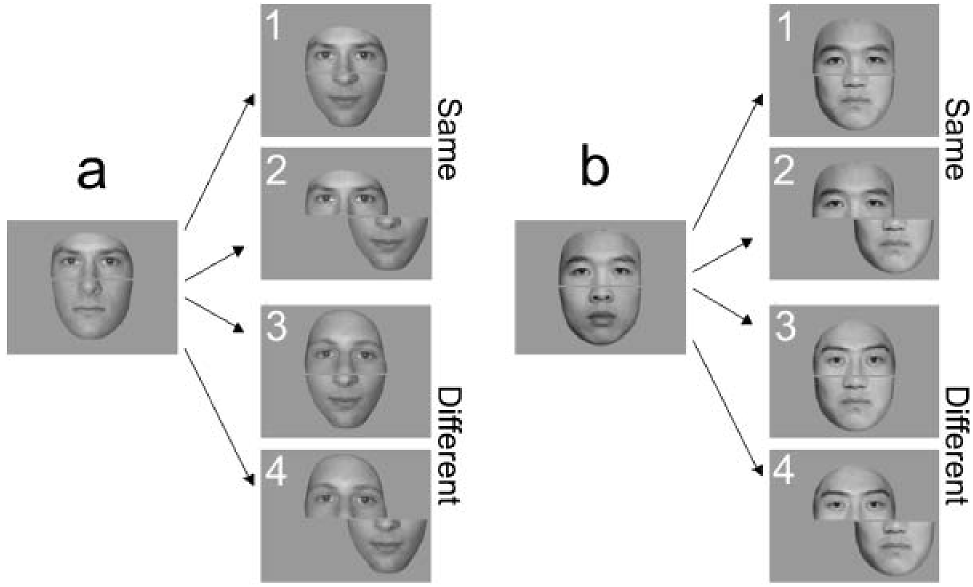

Fig. 1. Examples of experimental stimuli from the composite task. The composite stimuli were created by slicing original Caucasian (a) and Asian (b) faces in the middle of the nose and then joining different top and bottom parts. For each original (target) face, four composites, all using the same bottom part from another face, were constructed: (1) the target's upper part aligned with that bottom part, (2) the target's upper part misaligned with that bottom part, (3) a different upper part aligned with that bottom part, and (4) a different upper part misaligned with that bottom part. The first two kinds of composites, which required a ''same'' response, were critical for the experiment.

Old/New Face Recognition Task

The ORE was measured first. Participants were presented with 20 faces of each race, one by one (3 s each, interstimulus interval = 1 s), and were told explicitly to encode the faces in memory. This encoding phase was followed by a forced-choice recognition task in which 40 faces (20 old and 20 new) were presented individually. Participants had to indicate whether each face was an old or a new one by pressing one of two keys on the computer keyboard. Each face remained on the computer screen until the participant's response, or for a maximum of 2 s. Participants did not know the ratio of old to new faces and did not receive any feedback on their responses. Faces of the two races were presented in separate blocks, with the order of presentation for SR and OR blocks and the response keys being counterbalanced across participants. As in previous studies (e.g., Carroo, 1986), d' indices (Swets, Tanner, & Birdsall, 1961) for Caucasian and Asian faces were calculated for each participant.

Composite Task

Each trial began with the presentation of a 300-ms fixation cross at the center of the computer screen. The fixation cross was followed by a blank screen for 200 ms and then a target face for 600 ms. After a 300-ms blank screen, a second stimulus was presented until response, or for a maximum of 1 s. In each trial, the target was an original face, and the second stimulus was one of the four corresponding composite faces (Figs. 1a and 1b). Participants were instructed to ignore the lower parts and to decide as accurately and as quickly as possible whether the upper part of the second stimulus was the same as or different from the upper part of the target. (Responses were made using two keys, with mapping of key to response counterbalanced across participants.) After 8 practice trials, four blocks of 70 trials were presented. Each block contained 35 trials with Asian faces and 35 trials with Caucasian faces, presented randomly, with an interstimulus interval of 1 s. For each race, 20 trials required a "same" decision, and the remaining 15 required a "different" decision. As a result, a total of 160 *same* trials and 120 *different* trials were presented. This bias, equal for the aligned and misaligned conditions and for the two races of faces, was introduced because only *same* trials were of interest for the purposes of our study, the composite effect being assessed by the difference in performance between the misaligned and the aligned conditions for *same* trials (Le Grand et al., 2004).

RESULTS

The ORE: Old/New Face Recognition Task

Both Caucasian and Asian participants were much better at recognizing SR than OR faces (Fig. 2a), as shown by the significant interaction between race of participant and race of face, $F(1, 58) = 24.03$, $p_{rep} = .99$, $\eta^2 = .29$. Mean d' values for Caucasian participants were 2.2 and 1.34 for Caucasian and Asian faces, respectively, post hoc $t(29) = 4.42$, $p_{rep} = .99$. For

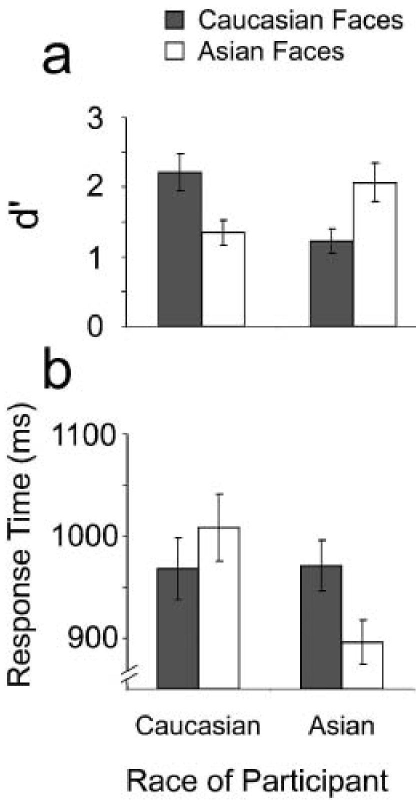

Fig. 2. Results from the old/new face recognition test: d' scores (a) and response times for correct trials (b) as a function of race of face and race of participant. Error bars indicate standard errors of the mean.

Asian participants, mean d' values were 1.22 and 2.06 for Caucasian and Asian faces, respectively, post hoc $t(29) = 2.93$, $p_{rep} = .96$. Neither the main effect of race of participant nor the main effect of race of face was significant, $F(1, 58) = 0.24$ and 0.002, respectively.

A similar pattern was found for correct response times (RTs): Both Asian and Caucasian participants were faster at recognizing SR than OR faces (Fig. 2b), as revealed by the highly significant crossover interaction between race of participant and race of face, $F(1, 58) = 18.20$, $p_{rep} = .99$, $\eta^2 = .24$. Main effects were not significant, $F(1, 58) = 1.67$ and 2.18 for race of participant and race of face, respectively ($p > .1$). Mean RTs of Caucasian participants were 968 ms and 1,008 ms for Caucasian and Asian faces, respectively, post hoc $t(29) = 2.03$, $p_{rep} = .87$. Among Asian participants, mean RTs were 971 ms and 896 ms for Caucasian and Asian faces, respectively, post hoc $t(29) = 4.08$, $p_{rep} = .99$.

Holistic Processing of SR and OR Faces

Accuracy

Subjects were more accurate on misaligned than aligned *same* trials, showing a composite-face effect, $F(1, 58) = 44.88$, $p_{rep} = .99$, $\eta^2 = .44$.[1] Critically, the three-way interaction among race of participant, race of face, and alignment of the parts was highly significant, $F(1, 58) = 12.47$, $p_{rep} = .98$, $\eta^2 = .18$. As expected, Caucasian participants exhibited a larger composite effect (i.e., a larger difference between the misaligned and aligned conditions) for Caucasian as compared with Asian faces (Fig. 3a), $t(29) = 3.30$, $p_{rep} = .97$. Subsequent t tests revealed that they exhibited a significant composite effect for Caucasian faces, $t(29) = 5.75$, $p_{rep} = .99$, but not for Asian faces, $t(29) = 1.46$, n.s. Among Asian participants, the composite-face effect was significant for both Caucasian faces, $t(29) = 4.04$, $p_{rep} = .99$, and Asian faces, $t(29) = 5.71$, $p_{rep} = .99$, but it was marginally larger for Asian faces, $t(29) = -1.61$, $p_{rep} = .86$ (Fig. 3b).

Although simple effects should be interpreted with caution in the presence of a significant interaction, direct comparisons between Caucasian and Asian faces revealed that Caucasian participants were better at matching the top parts of misaligned Caucasian faces than at matching the top parts of misaligned Asian faces, $t(29) = 6.30$, $p_{rep} = .99$ (Fig. 3a). However, in the aligned condition, Caucasian participants' accuracy did not differ between Caucasian and Asian faces, $t(29) = 0.07$, n.s. (Fig. 3a), because of the larger interference caused by the alignment of the two parts in Caucasian faces. For Asian participants, there was no difference between Asian and Caucasian faces in the misaligned condition to start with, $t(29) = 1.09$, n.s. (Fig. 3b). Consequently, there was a significant difference in favor of Caucasian faces in the aligned condition, $t(29) = 2.87$, $p_{rep} = .95$, because of the larger interference for Asian faces.

RTs

There was also a general composite-face effect in correct RTs, $F(1, 58) = 106.9$, $p_{rep} = .99$, $\eta^2 = .65$, participants being faster on misaligned trials than on aligned trials (Fig. 4). The three-way interaction of interest was marginally significant, $F(1, 58) = 3.85$, $p_{rep} = .87$, $\eta^2 = .06$. Caucasian participants were faster for misaligned than aligned faces, whether the faces were Caucasian, $t(29) = 5.17$, $p_{rep} = .99$, or Asian, $t(29) = 3.415$, $p_{rep} = .98$, and there was no statistical difference between the two races of faces, $t(29) = -1.08$. Asian participants were also faster for misaligned than aligned faces, whether the faces were Caucasian, $t(29) = 6.76$, $p_{rep} = .99$, or Asian, $t(29) = 9.89$, $p_{rep} = .99$, but for these participants, the composite-face effect was larger for Asian than Caucasian faces, $t(29) = 1.81$, $p_{rep} = .89$.

[1]Generally bad performance on OR misaligned faces could prevent an unambiguous interpretation of the difference in the composite-face effect found for SR versus OR faces. Note, however, that performance on OR misaligned faces was generally good on both *same* trials (88.2% and 93.7% correct for Caucasian and Asian subjects, respectively) and *different* trials (84.8% and 88.8% correct). Moreover, a two-way analysis of variance conducted on accuracy rates for *different* misaligned trials showed no significant effect for either the within-subjects factor of race of face, $F(1, 58) = 2.78$, n.s., or the between-subjects factor of race of participant, $F(1, 58) = 0.93$, n.s., and no significant interaction, $F(1, 58) = 1.94$, n.s.

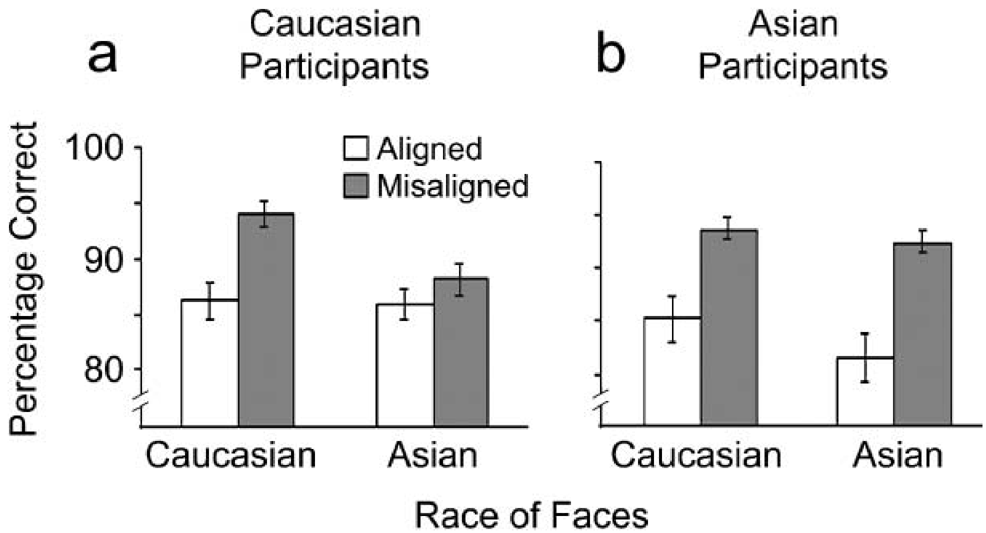

Fig. 3. Results from the composite task. The graphs show accuracy for *same* trials among Caucasian (a) and Asian (b) participants, for both Caucasian and Asian faces. The difference between the aligned and misaligned conditions shows the composite-face effect. Error bars indicate standard errors of the mean.

Correlation Analyses

We used correlation analyses to investigate the relation between the ORE and the difference in the composite-face effect for SR versus OR faces. The ORE was calculated for each participant by subtracting the d' for OR faces from the d' for SR faces. The differential in the composite-face effect was calculated by subtracting the composite-face effect (percentage correct in the misaligned condition − percentage correct in the aligned condition) for OR faces from the composite-face effect for SR faces. The differential composite-face effect was not correlated with the amplitude of the ORE (−.18, n.s., and .15, n.s., for Caucasian and Asian participants, respectively).

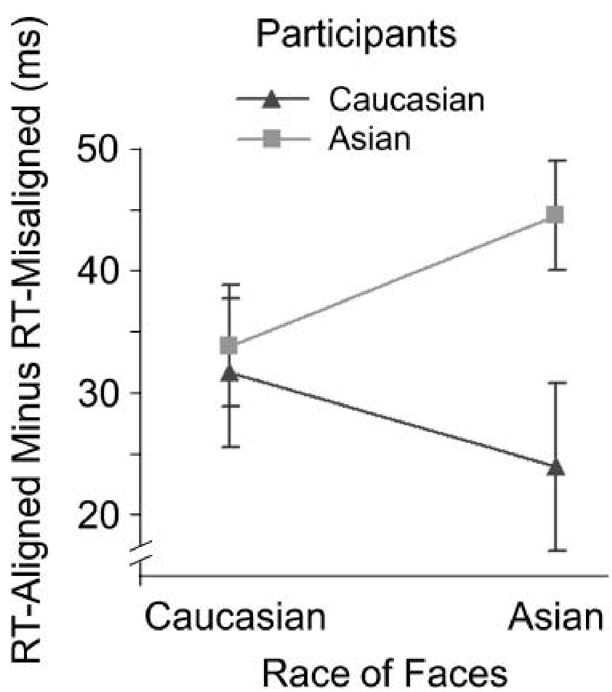

Fig. 4. Response time (RT) difference between the aligned and misaligned conditions as a function of race of face and race of participant. The greater the RT difference, the greater the slowing down on aligned trials (the composite-face effect). Error bars indicate standard errors of the mean.

DISCUSSION

In summary, we found the composite-face effect in both races of participants for both races of faces, but this effect was significantly larger for SR than for OR faces, confirming the hypothesis that SR faces are perceived more holistically than OR faces.

The gist of holistic processing of faces is that spatial relations are quickly and efficiently extracted from the incoming visual stimulus by means of a stored holistic facial representation (Maurer et al., 2002; Tanaka & Farah, 1993; Young et al., 1987). The present findings provide direct evidence that the representations underlying holistic face perception are coarsely defined, being able to accommodate to faces of a different race to a certain extent. However, these representations are specific enough that holistic processing is more important for faces with which one has extensive visual experience, namely, SR faces.

Individuals in many societies report that members of other races all look alike (Feingold, 1914), and a greater ability to discriminate among SR faces than among OR faces has been demonstrated in numerous studies, across different racial groups (e.g., Bothwell, Brigham, & Malpass, 1989; Meissner & Brigham, 2001). More than a century ago, Galton (1883) suggested that a face is processed as a “whole unit” or a Gestalt-like representation, a proposal that has been largely demonstrated empirically over the past two decades (e.g., Davidoff & Donnelly, 1990; Tanaka & Farah, 1993; Young et al., 1987). Integrating these findings, Rhodes et al. (1989) proposed that the

ORE is due to less efficient holistic or configural coding for OR than SR faces, but this hypothesis had not received strong empirical support before the present study. In particular, the present results provide much more compelling evidence that SR faces are processed more holistically than OR faces than did the previous work of Tanaka et al. (2004; see also Michel et al., 2004). This is not only because the present data were obtained in two groups of subjects having no experience with OR faces, but also because the paradigm used is clearer regarding the source of the holistic influence on the processing of face parts. In the whole-part paradigm, subjects are given no specific instruction about which part or parts of the stimulus to attend and encode, and they may choose to base their decisions on a single feature or on several features. In the present study, for both SR and OR faces, participants were explicitly instructed to focus on a part of the face stimulus, and the interference of the other part arose automatically, when the two parts were aligned. By showing that the effect of alignment is larger for SR than OR faces, the present results provide compelling evidence that SR faces are processed more holistically than OR faces, most likely as a by-product of visual experience.

The amount of visual experience with OR faces is undoubtedly an important factor in the ability to recognize them (Brigham, 1986; Carroo, 1986), although it appears to be the quality of OR contact, rather than the quantity, that is critical (Brigham, 1986; Chiroro & Valentine, 1995). Recent studies also indicate that the ORE, which is observed as early as age 3 (Sangrigoli & de Schonen, 2004), can be reversed following subsequent experience with another race of faces (Sangrigoli et al., 2005). These findings can be related to the role of visual experience in shaping holistic processing. Over development, holistic processing of faces takes over a more analytic processing, reaching mature levels by 6 years of age (Carey & Diamond, 1994; Tanaka, Kay, Grinnell, Stansfield, & Szechter, 1998), or perhaps earlier (Pellicano & Rhodes, 2003). Moreover, it has been demonstrated that visual experience before the age of 6 months is necessary for holistic processing to develop normally (Le Grand et al., 2004). The role of visual experience in the development of holistic processing is also supported by adults' performance with nonface objects. In adults, faces are processed more holistically than common objects (Tanaka & Farah, 1993). However, visual expertise increases holistic processing abilities with nonface objects (e.g., cars or "Greebles"), as demonstrated by studies using the composite paradigm (Gauthier, Curran, Curby, & Collins, 2003; Gauthier & Tarr, 2002). The hypothesized relations among the ORE, visual expertise, and holistic processing are also reinforced by neuroimaging data showing that an area of the middle fusiform gyrus that responds preferentially to faces (Kanwisher, McDermott, & Chun, 1997) is more activated when observers match whole faces than when they match facial parts (Rossion et al., 2000), and is more activated in response to SR than to OR faces (Golby, Gabrieli, Chiao, & Eberhardt, 2001).

Given that holistic processing is observed to some extent for OR faces, our data suggest that among adults, extensive visual experience with OR faces should lead to an increase in holistic processing for these faces, and perhaps to better recognition of them. However, we did not observe significant correlations between the differential holistic processing for SR and OR faces and the ORE in our two populations of subjects, and thus the relation between this differential holistic processing and the other-race face effect remains unclear. Although the absence of a significant effect must be interpreted with caution, it suggests that the differential holistic processing between SR and OR faces may be only one of several factors accounting for the ORE. For instance, it may be that certain nonconfigural cues are also more efficiently extracted from SR than from OR faces, which could account for the results showing that Caucasian participants are better at matching the top parts of misaligned faces when the faces are Caucasian as compared with Asian. In addition, holistic processing may be necessary but not sufficient for adequate discrimination of individual faces, as shown by developmental studies: Children ages 5 to 6 are relatively poor at recognizing faces (e.g., Bruce et al., 2000; Mondloch, Geldart, Maurer, & Le Grand, 2003), even though they have acquired mature holistic processing (Pellicano & Rhodes, 2003; Tanaka et al., 1998). If holistic processing is necessary but not sufficient to become a face expert, people should require less experience to process OR faces holistically than to recognize them efficiently. Further studies will be needed to clarify the relation between the differential holistic processing of SR and OR faces and the ORE.

A number of researchers have proposed that the ORE is caused by an early categorization of race ("it's an Asian") at the expense of individuality ("it's Jack"; Levin, 2000; MacLin & Malpass, 2001), rather than by an inability to generalize visual expertise from SR faces to OR faces. According to this race-categorization view, once a face is categorized as belonging to an OR population, it is not processed at the individual level, the level that is optimal for face processing and that is used by default with SR faces (Levin, 2000; MacLin & Malpass, 2001). The present results are compatible with both the hypothesis that the ORE is due to a reduced ability to process OR faces and with the hypothesis that the ORE is due to an early categorization of race. However, by clearly identifying one way in which SR and OR faces are processed differently (i.e., they differ in the degree of holistic processing), our observations may provide means to test these different theoretical positions in future work.

Finally, in addition to showing greater holistic processing for SR than OR faces, our results, in line with previous findings (Tanaka et al., 2004), suggest that Asians process faces more holistically than Caucasians. Several factors, such as great exposure to Caucasian faces in the media (e.g., Hollywood movies), may explain why Asians process Caucasian faces, in addition to Asian faces, holistically. An interesting alternative explanation supported by several studies, however, is that by default Asian people process information more holistically (i.e., in relation to the context) than Westerners do. This tendency has been demonstrated both in cognitive tasks (Nisbett, Pen, Choi, & Norenzayan, 2001) and in perception tasks involving nonface stimuli (Ji, Peng, & Nisbett, 2000; Kitayama, Duffy, & Larsen, 2003). In any event, this general processing difference between races cannot fully account for the crossover interaction observed here, which demonstrates that OR faces are processed less holistically than SR faces, most likely as a by-product of visual experience.

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