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Same-race faces are perceived more holistically than other-race faces

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People are better at recognizing same- than other-race faces but the theoretical explanation of this phenomenon is still controversial. Here we tested the hypothesis that the "other-race effect" is related to a reduced ability to encode configural information on other-race faces. Caucasian and Asian participants had to match whole faces to isolated facial features, or onto whole faces differing by a single feature, on both Caucasian and Asian faces. Participants performed better with whole faces as compared to isolated features, demonstrating a "holistic processing" of faces (Tanaka & Farah, 1993). For Caucasian participants, this "whole/ part advantage" was observed only for Caucasian faces. Asian participants who had been living for about a year among Caucasians had a comparable whole/part advantage regardless the race of the faces. These results indicate that same-race faces are processed more holistically than other-race faces, as a result of experience. However, despite processing Caucasian faces as holistically as Asian faces in this paradigm, Asian subjects still presented a large other-race effect. This observation suggests that holistic encoding may be a necessary step in order to be able to recognize other-race faces efficiently, but that it is by no means sufficient to overcome the other-race face effect.

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It is well known that same-race (SR) faces are better remembered than other-race (OR) faces, a phenomenon often reported in the literature as the"other-race effect" (for a recent review see Meissner & Brigham, 2001). The other-race effect is a robust phenomenon that has been empirically demonstrated within different racial groups (Shepherd, 1981) using a wide range of paradigms (e.g., Brigham, Maas, Snyder, & Spaudling, 1982; Cross, Cross, & Daly, 1971; Lindsay, Jack, & Christian, 1991; Malpass, Erksine, & Vaughn, 1988; Walker & Tanaka, 2003). However, its theoretical explanation is still debated (Meissner & Brigham, 2001). It is generally acknowledged that the difference in amount of visual experience people have with same- and other-race faces may account for the OR effect (Chance, Turner, & Goldstein, 1982; Dehon & Brédart, 2001; Elliott, Wills, & Goldstein, 1973; Goldstein & Chance, 1985; Levin, 2000; Meissner & Brigham, 2001; Sangrigoli & de Schonen, 2004; Walker & Tanaka, 2003). However, how visual experience affects the processing of same-race and other-race faces has yet to be determined.

An influential hypothesis about the other-race effect states that it would result from a reduced ability to extract configural information from faces with which we have less experience (Fallshore & Schooler, 1995; Rhodes, Tan, Brake, & Taylor, 1989). Faces constitute a highly homogeneous class of visual stimuli (Damasio, Damasio, & van Hoesen, 1982; Diamond & Carey, 1986), sharing the same features—eyes, nose, mouth, . . .—in the same basic configuration, but differing according to the shape and surface cues of these features, as well as to the relations between them (the second-order configuration; Diamond & Carey, 1986). Since the initial suggestion by Yin (1969), a large number of studies have shown that the coding of these relationships between features is important to process faces adequately, and may subtend a number of well-known empirical phenomena observed on face stimuli. For instance, the notorious face inversion effect (FIE), namely the fact that turning faces upside-down impairs their encoding disproportionately relative to the inversion of other objects (Valentine, 1988; Yin, 1969; for a review see Rossion & Gauthier, 2002) is due to a loss of the ability to encode configural information (e.g., Freire, Lee, & Symons, 2000; Leder & Bruce, 2000; Rhodes, Brake, & Atkinson, 1993; Searcy & Bartlett, 1996). Other empirical observations such as the "face composite effect" (Young, Hellawell, & Hay, 1987), the whole/part advantage (Tanaka & Farah, 1993), the "caricature effect" (Rhodes, Brennan, & Carey, 1987), and the "Thatcher illusion" (Thompson, 1980) have also been related to the processing of configural information (for a recent review on face configuration see Maurer, Le Grand, & Mondloch, 2002). There is evidence that this configural processing of faces—and possibly other object categories (Diamond & Carey, 1986; Gauthier & Tarr, 1997)—is related to our visual experience (Carey, 1992; Le Grand, Mondloch, Maurer, & Brent, 2001).

The hypothesis of a differential configural coding between same-race and other-race faces has been tested previously using the FIE (Rhodes et al., 1989;

Sangrigoli & de Schonen, 2004; Valentine, 1991; Valentine & Bruce, 1986). Rhodes and colleagues (1989) hypothesized that if SR faces are processed more configurally than OR faces, a larger FIE should be observed for SR faces. While these authors confirmed their hypothesis (see also Sangrigoli & de Schonen, 2004) other studies have yielded conflicting results: A larger FIE for OR faces than for SR faces (Valentine, 1991; Valentine & Bruce, 1986), or no difference at all (Buckout & Regan, 1988). Thus, the hypothesis of a differential configural coding between SR and OR faces is not fully supported by empirical data and needs further investigation. Moreover, testing the hypothesis of a better configural processing in SR faces through the FIE has proved difficult because upside-down inversion is thought to disrupt all types of configural information, including first- and second-order configuration, as well as holistic processing (Maurer et al., 2002; Purcell & Stewart, 1988)[1]. Inverting faces also disrupts the processing of local cues defined by shape (e.g., Rhodes et al., 1993), even though local cues defined by surface properties (texture, colour) seem unaffected (Leder & Bruce, 2000). In addition, the FIE represents only an indirect way to test the configural hypothesis since the configuration of the face stimulus is not explicitly manipulated.

The goal of the present study was to test directly the hypothesis of a differential configural processing of SR and OR faces and to investigate the relationship between this configural processing and the other-race effect. To this aim, we tested one type of configural processing, clearly defined in the literature, namely the concept of "holistic processing", according to which faces are processed as a whole (or a template) in which individual features are unparsed and interdependent (Davidoff & Donnelly, 1990; Homa, Haver, & Schwartz, 1976; Sergent, 1984). In a classical paradigm, Tanaka and Farah (1993) used an old/new recognition task in which participants first learned a set of faces with associated names, and then had to recognize the features of the faces that they had seen before. These features were presented either in the context of the whole face, or in isolation. In these conditions, participants were better at recognizing a feature presented in the facial setting relative to its presentation in isolation. This effect is referred to the "whole/part advantage" and is taken as evidence that faces are processed as a whole. The whole/part advantage has been reported in several studies using long-term memory tasks (Donnelly & Davidoff, 1999; Tanaka & Sengco, 1997) or perceptual matching

[1] Several terms are used in the literature to point to configural processing of faces (see Maurer et al., 2002; Rossion & Gauthier, 2002). Besides the general first order configuration (i.e., the basic configuration of the features—the two symmetrical eyes above the central nose and the mouth, etc. ; Diamond & Carey, 1986) shared by all faces there are at least two conceptual definitions of configuration in the literature: Holistic processing (i.e., processing of a face as a whole/gestalt; Davidoff & Donnelly, 1990; Tanaka & Farah, 1993) and second-order configuration (i.e., the distances among features; e.g., Rhodes et al., 1993)

tasks (Davidoff & Donnelly, 1990; Farah, Wilson, Drain, & Tanaka, 1998; Palermo & Rhodes, 2002; Tanaka, Kiefer, & Bukach, 2004).

Here, we investigated the configural/holistic processing of SR and OR faces by using the whole/part advantage paradigm in a two-alternative forced-choice (2AFC) delayed matching task. The task required Asian and Caucasian participants to discriminate the features of SR and OR faces, presented either in the context of the whole face or in isolation. We expected that the whole/part advantage would be larger for SR faces as compared to OR faces, in agreement with the proposal that experience with SR faces lead to an advantage in processing configural information. In addition, all participants performed an old/new recognition task with whole faces, designed to measure the other-race effect.

METHOD

Participants

Twenty-two Caucasian and twenty-four Asian participants took part in the study. However, the data of four participants were dropped from the analysis because their overall accuracy was below 60%. As a result, 21 participants for each race formed our group of subjects. Caucasian participants (16 females/5 males; mean age = 21.67 years) were undergraduate students in Psychology who participated for class credits and research assistants of the department. Most of Asian participants (18 females/3 males; mean age = 23.76 years) were from China (18; plus 3 from Taiwan) and had been living in Europe for 12 months and 2 days on average. Most of them were recruited in a Chinese Student Association in Belgium and they were paid for their participation. All participants had a normal or corrected-to-normal vision.

Stimuli

Seventy-four Caucasian and seventy-four Chinese faces were used as stimuli in total (half males, half females). All faces were young students (between 18 and 25 years old) unfamiliar to the participants, either from Belgium, or from China (Beijing) and all photographs were coloured full-front face views with external features removed (Figure 1), posing with a neutral expression. Two sets of 40 faces of each race were used to measure the other-race effect in all participants. The remaining faces (34 of each race) were used to test the holistic processing of faces ("holistic processing test").

For the "whole" condition of the "holistic processing test", a distractor face was created for each 34 faces (by race), using Adobe Photoshop 7.0, by replacing the eyes, or the mouth, or the nose from the target with the respective feature of another face. The individual features were then

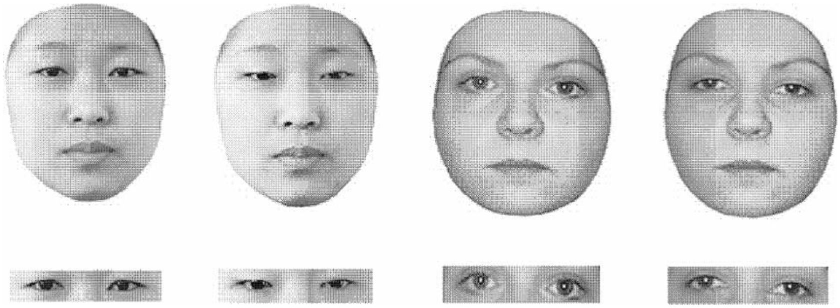

Figure 1. Examples of pairs of whole faces and isolated features (Asian and Caucasian) used in the holistic processing test.

extracted from each of the target faces and the distractors (or altered faces) to be used in the "part" condition (Figure 1). Thus, the physical difference between a target and its distractor was identical for the two conditions, "whole" and "part". Each target subtended a visual angle of $4.25^\circ \times 5.42^\circ$. The two test faces subtended approximately $4^\circ \times 5.8^\circ$ and isolated features were all of $3.26^\circ \times 0.41^\circ$. Stimuli were displayed on a computer screen using the presentation software E-Prime 1.1, on a white background.

Procedure

All participants were tested individually, in a quiet dimly lit room. They performed a task designed to measure the other-race effect before completing the "holistic processing test". Both were administered within a single session of about 40 min. At the end of the experiment, all participants filled out a questionnaire about the amount of experience they had with OR faces (e.g., the number of people of the other-race that they know personally, the number of months they have spent in Europe, etc.).

The other-race effect: Old—new recognition task. In the study phase, participants were presented with 20 faces of each race and were instructed to encode them visually because they would be required to recognize them later. Each face remained on the centre of the screen for 3 s, with an interstimulus interval (ISI) of 1 s.

In the test phase, which followed immediately the study phase, participants performed a forced-choice recognition test on 40 faces presented individually. The 20 target faces had to be identified as accurate and as fast as possible among 20 distractor faces. Each face was presented until the subject's response, or for a maximum of 2 s. Participants responded by pressing one of two keys on a keyboard to indicate if they had previously seen the face or not. The experiment began with six practice items (three trials of each race). Participants did not know the ratio of old and new faces, and did not receive any feedback for their responses. Faces were blocked by race. After completing the old/new task for a set of one race of faces, participants learned the other set of faces (other-race). The order of race face presentation was counterbalanced across participants.

Holistic processing test. The task used was a 2AFC matching test, adapted from the whole/part paradigm of Tanaka and Farah (1993). In each trial, participants were first resented with a target face on the centre of the screen during 500 ms. The second stimulus appeared 1050 ms later, following a sequence of two blank screens (300 ms) and a mask inserted in between (450 ms). It was either a pair of faces (whole condition) or a pair of features (part condition), presented side by side (Figure 1). One of them was the target (whole condition) or an isolated feature taken from the target (part condition), and the other was a distractor. Crucially, the distractor differed from the target by only one feature (eyes, nose, or mouth). Participants were required to identify the target face (in the whole condition) or the target's feature (in the part condition) as fast as possible by pressing the left or right of two keys. The faces/features remained on the screen for maximum 3 s. Trials were spaced by 1000 ms. Twelve practice trials (six trials for each race) were presented before the beginning of the experiment. The left and right positions of the target stimuli were counterbalanced across test items and participants received no feedback for their responses. Only "eyes" trials were used in the analyses because of the dramatic increase in error rates observed when faces differ only by mouth or nose (see Joseph & Tanaka, 2002; Pellicano & Rhodes, 2003; Tanaka & Farah, 1993; Wenger & Townsend, 2000). The few "noses" and "mouth" trials were used as catch trials to avoid participants focusing their attention on the eyes only, and were not analysed further.

Participants were presented with two blocks of 68 trials, one Asian and one Caucasian, presented twice each. Among these 68 trials, there were 40 valid trials (20 in each condition) and 28 catch trials (14 in each condition). This results in a total of 160 valid trials.

Half of participants began with a block of Caucasian faces (40 items + 20 catch trials) and the other half with a block of Asian faces, with Asian and Caucasian blocks of stimuli counterbalanced throughout the experiment.

Data analysis

For the measure of the other-race effect for each participant, *d′* was used as a measure of recognition accuracy for Caucasian and Asian faces for each participant. Two *d′* values were computed for each participant, one for Caucasian and one for Asian faces. Derived from the signal detection theory (Swets, Tanner, & Birdsall, 1961), *d′* is generally used to measure the sensitivity of participants to detect the presence of a target during old/new recognition tests. A *d′* near to 0 corresponds to the chance level, and a larger *d′* value indicates a better performance. This statistical measure has been applied in previous studies of the OR effect (e.g., Carroo, 1986; Chance et al., 1982; Goldstein & Chance, 1985; Malpass & Kravitz, 1969; Shepherd, Deregowski, & Ellis, 1974). Two *d′* values were computed for each participant, one for Caucasian and one for Asian faces. Two separate two-way repeated measure analysis of variance (ANOVA) were performed on *d′* scores and on correct response times respectively, with face race (Asian, Caucasian) as within-subjects factor and participant's race (Asian, Caucasian) as between-subjects factor. For the holistic processing task (2AFC), accuracy rates and response times were submitted to separate $2 \times 2 \times 2$ ANOVAs for participants ($F1$) and items ($F2$) with the race (Asian vs. Caucasian) and the type (whole vs. part) of stimuli as within-subjects factors, and the race of participants as between-subjects factor. Correlation analyses were performed to test the relationship between the other-race effect, the whole/part advantage and the interracial experience of participants.

RESULTS

The other-race face effect

Accuracy. Main effects of participant's race and face race were not significant, $F(1, 40) < 1$ for both effects, but the interaction between these two factors was highly significant, $F(1, 40) = 15.42$, $p < .001$. As expected, Caucasian and Asian participants were better at recognizing same- than other-race faces (Figure 2). For Caucasian participants, mean *d′* values

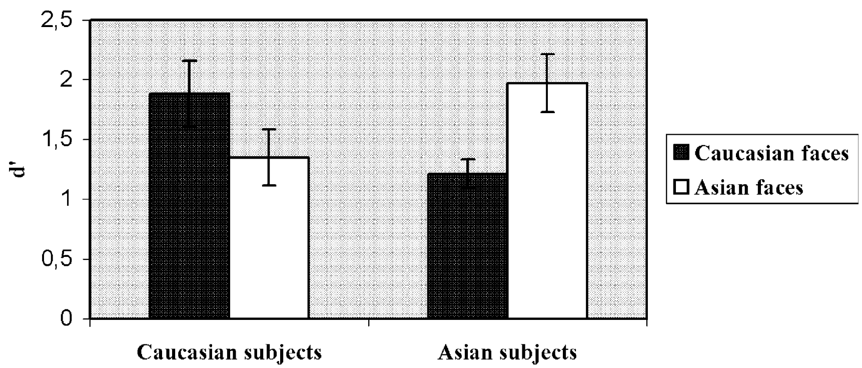

Figure 2. d′ scores for the old/new face recognition test of Caucasian and Asian faces in Caucasian and Asian participants. Error bars represent standard errors of the mean.

were 1.88 (*SE:* ± .28) and 1.35 (*SE:* ± .23) for Caucasian and Asian faces, respectively, post hoc $t(20) = 3.048$, $p < .05$. Asian participants presented the opposite pattern, with scores of 1.97 (*SE:* ± .26) for Asian faces and 1.21 (*SE:* ±.13) for Caucasian faces, $t(20) = -2.73$, $p < .05$. The magnitude of the other-race face effect that is, the difference between d′ for SR and d′ for OR faces) was not different between the two groups of participants, $t(40) = 0.728$.

Response times. The mean response times for correct responses was computed for each participant in each race of faces. There was no main effect of face race or participant's race, Fl(l, 40) = 3.02 and 1.1, respectively) and the interaction between the two factors did not reach significance, $F(1,40) = 3.02$.

Holistic processing test

Accuracy. There was a highly significant effect of condition, $F1(1, 40) = 48.67$, $p < .001$; $F2(1, 38) = 70.64$, $p < .001$, features being recognized better in the context of the whole face than in isolation (= whole/part advantage; Figure 3). There was also a main effect of face race, $F1(1, 40) = 24.68$, $p < .001$; $F2(1, 38) = 7.55$, $p < .01$, Asian faces being recognized better than Caucasian faces overall (Figure 3). However, this effect was qualified by a significant interaction between condition and face race, $F1(1, 40) = 10.34$, $p < .001$; $F2(1, 38) = 5.59$, $p < .05$. Asian participants were better with Asian faces, both in the part, $t1(20) = 4.31$, $p < .01$; $t2(19) = 2.29$, $p < .05$, and in the whole, $t1(20) = 4.01$, $p < .001$; $t2(19) = 2.12$, $p < .05$, conditions. Caucasian participants displayed equal performance for Asian and Caucasian whole faces, $t1(20) = -1.35$; $t2(19) = 0.88$, but were better at recognizing Asian than Caucasian parts, $t1(20) = 3$, $p < .01$; $t2(19) = 2.56$, $p < .05$, showing the expected larger drop of performance for the part condition with SR faces.

Most interestingly for our hypothesis, three-way interaction between participant's race, face race, and condition reached significance, $F1(1, 40) = 4.895$, $p < .05$; $F2(1, 38) = 2.94$, $p = .09$. A two-way ANOVA conducted in each racial group independently revealed a significant Face race × Condition interaction in Caucasian participants, $F1(1, 20) = 17.26$, $p < .001$; $F2(1, 19) = 7.02$, $p < .05$, but not in Asian participants, $F1(1, 20) = 0.603$; $F2(1, 19) = 0.26$. Caucasian participants were significantly better at recognizing Caucasian parts in the facial setting (81.43%; *SE:* ±2.89) than in isolation (66.78%; *SE:* ±2), post hoc $t1(20) = 7.77$, $p < .001$; $t2(19) = 4.67$, $p < .001$. However, they did not show this whole/ part advantage for Asian faces (79.04%, *SE:* ±2.74; 75.35%, *SE:* ±1.91; respectively), $t1(20) = 1.27$; $t2(19) = 1.69$ (see Figure 3). Performance of Asian partici-

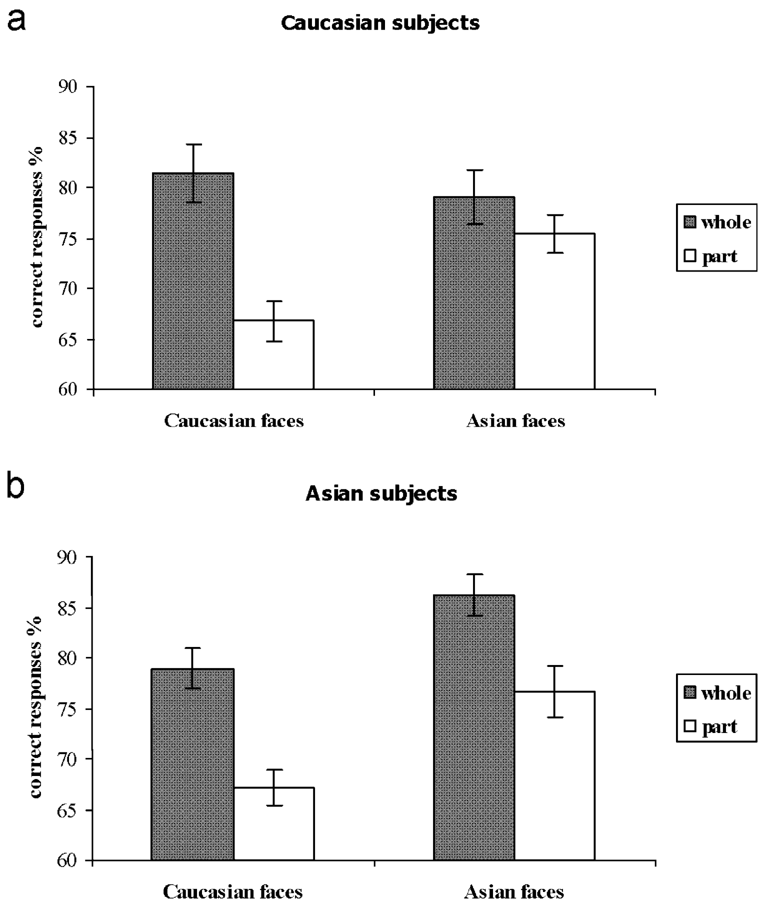

Figure 3. Recognition accuracy of (a) Caucasian and (b) Asian participants for whole faces and isolated features in the 2AFC matching test. Error bars represent standard errors of the mean.

pants was better for whole faces than for isolated parts, whether they were presented with Asian faces (86.19%, *SE:* ±2; and 76.67%, *SE:* ±2.55 for whole and parts, respectively), $t1(20) = 4.09$, $p < .01$; $t2(19) = 6.24$, $p < .001$, or with Caucasian faces (78.93%, *SE:* ±2; and 67.14%, *SE:* ±1.7, respectively), $t1(20) = 4.61$, $p < .001$; $t2(19) = 5, p < .001$.

Response times. On response times (RTs), the main effect of condition, $F1(1, 40) = 32.64$, $p < .001$; $t2(1, 38) = 8.64$, $p < .01$, was significant, indicating that whole faces were processed more quickly than isolated parts (Table 1). However, the three-way interaction of interest did not reach significance, $F1(1, 40)$, $p < 1$; $F2(1, 38)$, $p < 1.09$.

TABLE 1
Mean response times (ms) for Caucasian and Asian stimuli (whole faces and isolated features) in Caucasian and Asianparticipants, standard errors of the means are reported in parenthesis

	Caucasian participants	*Asian participants*
Caucasian faces		
Whole faces	1071 (65.19)	1122 (37.15)
Isolated features	1159 (57.02)	1268 (39.89)
Asian faces		
Whole faces	1108 (63.29)	1064 (35.60)
Isolated features	1152 (53.04)	1156 (40.70)

Correlation analyses

Although Asian participants showed an equally large whole/part advantage for Asian and Caucasian faces (Figure 3), they presented a significant other-race effect in the old/new recognition task, at least as large as the effect observed in Caucasian participants (Figure 2). The relationship between the two measures (whole/part advantage and other-race effect) was tested by a correlation analysis. The other-race effect was calculated for each participant by subtracting the d' for OR faces from the d' for SR faces. The whole/part advantage was calculated for each participant by subtracting the score in the part condition from the score in the whole condition. Thus, a large score reflects an important whole/ part advantage. The result of the subtraction between the whole/part advantage for OR and SR faces was not correlated with the amplitude of the other-race effect, in none of the two groups (Pearson's correlation coefficient = $-.059$, n.s., in Asian and $-.061$, n.s., in Caucasian participants, respectively).

Interracial experience

The questionnaire on interracial experience measured the amount of experience each subject had with OR faces. For Asian participants, experience was quantified as the number of months that they had spent in Europe. For Caucasian participants (who had no experience in an Asian country) the experience with Asian faces was quantified as the number of Asian people that the participants knew personally. Correlations between the magnitude of the other-race effect and the amount of interracial experience were performed on both groups of participants. Interestingly, the correlation between the magnitude of the other-race effect in Asian participants and the number of months (range: 1.5 month; max. 30 months) that they had spent in

Europe was marginally significant (Pearson's correlation coefficient = − .357, $p = .056$). However, in Caucasian participants, the magnitude of the other-race effect was not correlated with the number of Asian acquaintances (range: min. 0; max. 9; Pearson's correlation coefficient = .052, n.s.).

Correlations between the amount of interracial experience and the magnitude of the holistic processing for OR faces revealed that in Caucasians, the amount of experience with Asian faces was significantly correlated with the amount of holistic processing of these faces (Pearson's correlation coefficient = .519, $p = .008$). However, in Asian participants, the amount of interracial experience was not correlated with the magnitude of the holistic processing for OR faces (Pearson's correlation coefficient = .226, $p - .162$).

DISCUSSION

The purpose of the present study was to test the hypothesis of a differential configural processing for same- and other-race faces in the theoretical framework of the other-race effect. In a nutshell, our results support the hypothesis of a larger holistic processing for same-race faces. However, Asian subjects with a limited living experience among Caucasian faces were able to process these faces holistically, and yet presented a robust other-race effect as measured independently. This last observation questions the nature of the relationship between the other-race effect and the differential ability to process same- and other-race faces holistically.

The hypothesis of a differential configural coding between SR and OR faces was tested in previous studies using the "face inversion effect" (FIE; Yin, 1969) but has led to inconsistent results (Buckout & Regan, 1988; Rhodes et al., 1989; Sangrigoli & de Schonen, 2004; Valentine, 1991; Valentine & Bruce, 1986), which may be due in part to the different methods used in these studies. For instance, Valentine and Bruce (1986) tested only Caucasian participants with two races of faces and equated the performance at processing SR and OR faces by presenting the latter for longer times, whereas Rhodes et al. (1989) tested two groups of participants of different races and presented them in the same conditions. More generally, as stated in the introduction, the FIE may not be adequate to test the hypothesis of a better configural processing in SR faces, as upside-down inversion disrupts all types of configural processing (Maurer et al., 2002), as well as local shape cues (e.g., Rhodes et al., 1993). Here, we tested directly the hypothesis of a differential configural processing between SR and OR faces by using the whole/part advantage paradigm (Davidoff & Donnelly, 1990; Tanaka & Farah, 1993). We replicated the whole/part advantage effect in accuracy rates and response times (see Figure 3 and Table 1): Participants were better and faster at discriminating facial features presented in a whole context than the same features presented in isolation. Previous studies reporting the whole/part advantage (for faces or other objects) either did not measure or report response times (Davidoff & Donnelly, 1990; Donnelly & Davidoff, 1999; Joseph & Tanaka, 2002; Palermo & Rhodes, 2002; Tanaka & Farah, 1993; Tanaka & Sengco, 1997) or demonstrated the whole/part advantage only in accuracy, with a possible speed-accuracy tradeoff (participants faster with isolated parts; e.g., Gauthier & Tarr, 1997; Gauthier, Williams, Tarr, & Tanaka, 1998; Tanaka et al., 2004).

Most interestingly, in agreement with our hypothesis, a significant interaction was observed between the whole/part advantage effect in accuracy, the race of participant and the race of face. That is, Caucasian participants processed Caucasian faces more holistically than Asian faces. However, Asian participants presented a comparable whole/part advantage for Asian and Caucasian faces, indicating that they processed *both* race of faces as holistically.

The larger holistic processing observed for SR faces in Caucasian participants supports the hypothesis of a relationship between the ORE and an inability to process other-race faces holistically (Rhodes et al., 1989). A similar conclusion was drawn in a recent study, which also used the whole/part advantage paradigm (Tanaka et al., 2004). However, in this last study, the authors tested Asian participants who had been living amongst Caucasian populations for their entire life and reported a larger amount of interactions with Caucasians than with Asians. Here, our two groups of participants had significantly more experience with same-race faces. Most importantly, Tanaka and colleagues (2004) did not measure the other-race effect, and could thus not test the relationship between this effect and the differential holistic processing observed. The general goal of the present study was to contribute to an explanation of the other-race effect. To this aim, we measured the holistic processing in two groups of participants who showed an equally large advantage in processing same-race faces as compared to other-race faces.

The pattern of results observed in the present study with Caucasian participants fits perfectly with the holistic or configural account of the ORE (Rhodes et al., 1989), but the results observed with Asian participants cannot be accounted so easily in this framework. Indeed, these participants processed both races of faces as holistically, and yet presented an equally large other-race effect as Caucasian subjects. How can this paradox be resolved? First, let us consider why Asian participants in our study process Caucasian faces holistically, before addressing the question of why this ability does not appear to help them overcoming their impairment in recognizing other-race faces.

There are at least three possible explanations for the holistic processing of Caucasian faces observed in our Asian participants. First, the short adult visual experience that these participants had with OR faces (they had been living amongst Caucasians for about 1 year on average) may have helped them develop the ability to process these faces as a gestalt (holistic processing). The role of visual experience in leading to holistic processing of (face) stimuli is still debated. On the one hand, holistic processing is observed in young children (e.g., Carey & Diamond, 1994; Cohen & Cashon, 2001; Pellicano & Rhodes, 2003; Tanaka, Kay, Grinnell, Stansfield, & Szechter, 1998) and does not appear to increase between 6 and 10 years old (Carey & Diamond, 1994; Joseph & Tanaka, 2002; Tanaka et al., 1998). Further, it can be observed for nonface objects such as chairs, houses, Greebles, or cars in novices (Davidoff & Don nelly, 1990; Donnelly & Davidoff, 1999; Gauthier & Tarr, 1997; Tanaka & Gauthier, 1997). Accordingly, it has been suggested that holistic processing depends more on the complexity of the stimulus than on the amount of visual experience: We would naturally process holistically stimuli belonging to visually homogeneous categories (Gauthier & Tarr, 1997; Tanaka & Gauthier, 1997). On the other hand, several sources of evidence suggest a role of visual experience in the development of the holistic processing, since the effect is not observed for faces between 2 and 5 years (Schwarzer, 2002) but appears at 6 years old (Tanaka et al., 1998), and is usually larger in experts compared to novices for nonface object categories (Gauthier & Tarr, 1997; Gauthier et al., 2002). A recent study using the composite paradigm (Young et al., 1987) also suggests that early (before 6 months) visual experience is necessary for the normal development of holistic processing in adults (Le Grand et al., 2004). Regarding the data of this paper, the link between visual experience with other-race faces and holistic processing of these faces is reinforced several observations. First, as a group, Caucasian subjects did not process Asian faces holi-stically. Second, for these subjects, there was a significant correlation between holistic processing for Asian faces and the number of their Asian acquaintances. The absence of the relationship between holistic processing and the amount of interracial experience in our sample of Asian people may be explained by the nature of the measure of the interracial experience in these participants: The number of months they had spent in Europe may reflect more the quantity than the quality of contact with other-race faces. To sum up, our results suggest that a short amount of adult visual experience may be sufficient to apply holistic mechanisms to other-race faces, a result that extends previous findings of holistic processing for other-race faces in subjects presenting a lifelong visual experience with these faces (Tanaka et al., 2004).

An alternative account to the proposal that visual experience subtends holistic processing of Caucasian faces in Asian participants would be that our observations are due to a stimulus effect: We would process SR faces more holi-stically than OR faces, but Caucasian faces would be processed by default more holistically than Asian faces. Several factors may account for such a stimulus difference, such as the larger exposure to Caucasian faces in the media (e.g., widespread diffusion of western movies), or differences in our particular face set that would make the Caucasian faces more prone to be perceived holistically. Although this alternative explanation is highly unlikely, it could only be completely ruled out by conducting the same experiment in Asian people who do not present any living experience amongst Caucasians.

Finally, an interesting alternative supported by several studies is that Asian people are generally more "holistic" (i.e., influenced by the context) than Westerners, as evidenced both in cognitive (Nisbett, Peng, Choi, & Norenzayan, 2001; Peng & Nisbett, 1999) and perceptive tasks (Ji, Peng, & Nisbett, 2000; Kitayama, Duffy, Kawamura, & Larsen, 2003) on nonface stimuli. For example, it has been shown that Easterners rely more on "dialectical reasoning" than Westerners (Nisbett et al., 2001; Peng & Nisbett, 1999). At the perceptual level, Kitayama and colleagues (2003) highlighted a difference between Easterners and Westerners in the degree of attention paid to objects versus the context in which the objects were presented. Participants in their study were presented with a line in a surrounding frame and they were required to draw an identical line in a second frame. The line had to be drawn either in absolute length, or in proportion to the height of the surrounding frame. Whereas Westerners' per formances were better in the absolute task, Easterners were more accurate at reproducing the line in the relative task (Kitayama et al., 2003). According to the authors, these differences in processing may be due to the different social systems observed in these two populations (Nisbett et al., 2001). Thus, it may be that even Asian people without visual experience with OR faces process these stimuli more holistically than Caucasian people. Given the absence of correlation between holistic processing and the number of months spent in Europe by the Asian people tested in the present study, one cannot fully rule out this hypothesis.

To summarize, we have identified three hypotheses as to why Asian subjects in our study processed other-race faces holistically. Unlike Caucasian participants, Asian participants presented a visual experience at adult age with other-race faces, supporting the proposal that a short amount of visual experience is sufficient to apply holistic mechanisms to other-race faces.

The relationship between holistic processing and the ORE

Asian participants were able to process Caucasian faces holistically, yet this ability did not help them to overcome their impairment in recognizing other-race faces, as shown by their robust other-race effect in the old/new recognition task. Furthermore, there was no correlation between the differential holistic processing observed for the two races of faces and the magnitude of the other-race effect measured independently. Based on this dissociation, one may be tempted to conclude that the greater holistic processing for same-race faces as compared to other-race faces does not have much relevance for the other-race recognition deficit. However, the configural/holistic account of the ORE (Rhodes et al., 1989) is supported here by the observation that Caucasian subjects, who are impaired at recognizing Asian faces, process these faces less holistically than Caucasian faces (see also Tanaka et al., 2004). How can this apparent paradox be reconciled? Bearing in mind that one can only speculate at this state of our knowledge, we refer to the developmental and neuropsychological face literature to suggest that holistic processing of other-race faces is a necessary component to be able to discriminate and recognize these faces adequately, but that it is by no means sufficient.

Even though it is widely acknowledged in the literature that faces are handled holistically, the relationship between such holistic processing and the ability to recognize individual faces is not well documented and usually not discussed in the literature (e.g., Maurer et al., 2002). Impairment in holistic processing of faces, because of a lack of early visual experience (Le Grand et al., 2004) or following brain damage (e.g., Boutsen & Humphreys, 2002; Sergent & Signoret, 1992; Sergent & Villemure, 1989), is associated with individual face recognition impairments (Geldart et al., 2002; Sergent & Signoret, 1992; Sergent & Villemure, 1989), suggesting that the ability to handle faces holistically is a necessary component for face recognition. However, the developmental face literature suggests that the ability to process faces holistically is not sufficient to reach a full level of expertise at individual face recognition. It has been shown that children as young as 6 years old, or perhaps earlier (Pellicano & Rhodes, 2003; but see Schwarzer, 2002), are able to process faces as holistically as adults (Carey & Diamond, 1994; Pellicano & Rhodes, 2003; Tanaka et al., 1998). Yet, young children of 6 years of age are profoundly deficient at matching faces, especially when they differ in viewpoint, lighting or clothing (Benton & van Allen, 1973; Bruce et al., 2000; Carey et al., 1980; Ellis, 1992; Mondloch et al., 2003), even in matching tasks that eliminate memory demands (Bruce et al., 2000). This difficulty appears to be due to a deficit at face encoding (Ellis, 1992), children relying mostly on external features (Campbell et al., 1999; see also Carey & Diamond, 1977), and failing to extract distances between features, the so-called "second order configuration" (Diamond & Carey, 1986), adequately. Holistic processing and second-order configuration sensitivity are thus both impaired following early deprivation (Le Grand et al., 2001, 2004) but the former becomes adult-like much earlier (6 years old) than the latter, which may not be achieved fully until mid-adolescence (Carey, 1992; Carey & Diamond, 1994; Ellis & Ellis, 1994; Mondloch et al., 2002). These last observations have been considered to support the view that holistic processing is a prerequisite for normal processing of second-order configuration, allowing efficient individual recognition (Le Grand et al., 2004).

The developmental face literature provides a good illustration of how holistic processing may be a necessary—and yet not sufficient—component for the ability to recognize individual faces adequately (Geldart et al., 2002; Le Grand et al., 2004). In line with this literature, the findings reported in the present paper on adults processing same- and other-race faces suggest that the ability to process other-race faces holistically is a necessary step in order to be able to discriminate and recognize these faces adequately, but that it is by no means sufficient. More precisely, a short amount of visual experience with Caucasian faces in adults may have helped Asian participants in our study to develop the ability to process Caucasian faces holistically, while they still present a marked deficit at recognizing other-race faces in an individual recognition task.

CONCLUSIONS

In summary, the present study shows that same-race faces are processed more holistically than other-race faces, and suggest that a short amount of experience in adult age may lead to holistic processing of other-race faces. This ability to process other-race faces holistically may be necessary, but is not sufficient to overcome individual face recognition impairments with other-race faces, i.e., the other-race effect.

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