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Differences in holistic processing do not explain cultural differences in the recognition of facial expression

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ABSTRACT

The aim of this study was to investigate the causes of the own-race advantage in facial expression perception. In Experiment 1, we investigated Western Caucasian and Chinese participants' perception and categorization of facial expressions of six basic emotions that included two pairs of confusable expressions (fear and surprise; anger and disgust). People were slightly better at identifying facial expressions posed by own-race members (mainly in anger and disgust). In Experiment 2, we asked whether the own-race advantage was due to differences in the holistic processing of facial expressions. Participants viewed composite faces in which the upper part of one expression was combined with the lower part of a different expression. The upper and lower parts of the composite faces were either aligned or misaligned. Both Chinese and Caucasian participants were better at identifying the facial expressions from the misaligned images, showing interference on recognizing the parts of the expressions created by holistic perception of the aligned composite images. However, this interference from holistic processing was equivalent across expressions of own-race and other-race faces in both groups of participants. Whilst the own-race advantage in recognizing facial expressions does seem to reflect the confusability of certain emotions, it cannot be explained by differences in holistic processing.

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The question of whether a small number of facial expressions correspond to basic emotions with a long evolutionary history and are hence universally recognized has elicited considerable debate since Darwin (1872) put forward the suggestion in the nineteenth century. From the research stimulated by this debate, two consistent findings stand out. First, recognition of facial expressions of basic emotions is substantially above-chance in all cultures tested to date (Biehl et al., 1997; Ekman, 1972; Izard, 1971); this finding is consistent with the universality hypothesis. Second, although always above-chance, there are nonetheless some cultural differences, and people are often better at recognizing expressions posed by their own race than those of other-race members (Elfenbein & Ambady, 2002; Jack, Caldara, & Schyns, 2012; Yan, Andrews, & Young, 2016; Yan, Andrews, Young, & Jenkins, 2016); these findings of cross-cultural differences and own-race advantages set limits on the extent of universality.

A key unresolved issue concerns what causes cultural difference in facial expression recognition. A novel hypothesis proposed by Jack and colleagues (2012) suggests that the differences between cultural groups are driven by people from different cultural backgrounds paying attention to different facial signals when processing facial expressions. For example, in a study that used reverse correlation methods to estimate the internal representation of static facial expressions, Jack et al. (2012) maintained that East Asian participants use mainly information from the eye region when processing facial expressions, whereas Western Caucasian participants rely more evenly on both the eye and mouth regions. From this perspective, the cross-cultural differences reflect underlying differences in mental representations resulting from differences in the attended regions of the face. A recent study by Yan, Andrews, and Young (2016) therefore systematically

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investigated cross-cultural similarities and differences in the perception as well as the recognition of facial expressions of five basic emotions (anger, fear, happiness, disgust, and sadness). By asking Western Caucasian and Chinese participants to make similarity ratings to pairs of expressions or to identify the emotion from facial expressions, Yan, Andrews, and Young (2016) showed that there was actually considerable consistency in the way each group of participants perceived facial expressions, but there was a small cross-cultural difference in recognizing facial expressions, which was driven in part by an own-race advantage in recognizing anger and disgust.

Although their findings offered at best limited support for Jack et al.'s (2012) claim of an underlying difference in perceptual representations, one limitation of Yan, Andrews, and Young's (2016) study was that the most confusable expressions they used were anger and disgust, so that it was unclear whether the own-race advantage Yan, Andrews, and Young (2016) found for recognizing anger and disgust reflected something to do with expressions of these emotions *per se*, or simply the fact that they were the most confusable expressions in the set investigated (happiness, sadness, fear, anger, disgust). In the present Experiment 1, we therefore added facial expressions of surprise to the set used by Yan, Andrews, and Young (2016). In studies of facial expression recognition, surprise is confused with fear more often than anger is confused with disgust (Calvo & Lundqvist, 2008; Ekman & Friesen, 1976; Palermo & Coltheart, 2004; Wiggers, 1982). Hence including expressions of surprise as well as fear allows us to test whether the own-race advantage is driven by overall confusability (in effect, by task difficulty). Moreover, facial expressions of surprise were also included in Experiment 1 because Jack et al. (2012) have argued that surprise plays an important role in driving the group differences in expression perception.

Jack et al.'s (2012) hypothesis that East Asian participants use mainly information from the eye region to recognize facial expressions also predicts that holistic processing of expression should be reduced in comparison to Western Caucasian participants. For Western participants it is well established that facial expressions are perceived holistically, with information from the mouth region modifying the interpretation of information from the eye region and vice versa. The best-known demonstration involves a facial expression variant of the face composite paradigm devised by Young, Hellawell, and Hay (1987). Calder, Young, Keane, and Dean (2000) created images that combined the upper half of one expression with the lower half of a different expression. They found that participants were slower at identifying expressions from either the upper or the lower part of these images when these two halves were presented in a face-like aligned composite format than when the same parts were presented in a misaligned format that was not face-like. This effect has been replicated in other studies of Western participants (Flack et al., 2015; Tanaka, Kaiser, Butler, & Le Grand, 2012). It is interpreted as indicating that holistic perception of the face-like aligned composite stimuli makes it difficult for participants to ignore information from the irrelevant part of the image (i.e., to ignore information from the bottom half when classifying the top half, and vice versa). In contrast, the misaligned stimuli do not create a face-like configuration, and so they are not susceptible to this holistic interference.

In Experiment 2 we therefore tested the expression composite effect in Western Caucasian and East Asian participants, using a paradigm modelled on Calder et al. (2000). If the recognition of expressions by East Asian participants is dominated by information from the eye region, we expect either a reduced composite effect overall or to find a reduced effect when it is the part of the face containing the eye region that has to be classified. An additional reason for testing the expression composite effect cross-culturally is that some studies have linked own-race advantages in the recognition of facial identity (rather than expression) to holistic processing (Michel, Caldara, & Rossion, 2006; Michel, Rossion, Han, Chung, & Caldara, 2006; Tanaka, Kiefer, & Bukach, 2004). However, findings of enhanced holistic processing of own-race faces are by no means obtained consistently (Hayward, Crookes, & Rhodes, 2013) and no studies have yet looked at cross-cultural differences in holistic processing of facial expressions.

Experiment 1

This experiment examined cross-cultural similarities and differences in perceiving and recognizing facial expressions of six basic emotions with a full crossover design that included Chinese and Western faces and Chinese and Western participants. Separate perceptual similarity and emotion categorization tasks were used, with the perceptual task asking participants to rate the similarity of facial expressions across pairs of face photographs and the categorization task involving forced-choice recognition of the facial expressions. This experiment also aimed to investigate whether the own-race advantages in expression recognition found by Yan, Andrews, and Young (2016) was driven by certain confusable emotion categories. Studies have found that there is confusion among certain emotion categories, such as anger and disgust, and fear and surprise (Calvo & Lundqvist, 2008; Ekman & Friesen, 1976; Palermo & Coltheart, 2004; Wiggers, 1982). We were interested in whether cultural differences in expression recognition might be driven largely by confusion between these emotions. In addition, the inclusion of facial expressions of surprise is of interest because, according to Jack et al. (2012), there are particularly clear cultural differences in the mental representation of surprise.

Method

Participants

Eighteen Chinese students brought up in China with Chinese parents (13 females; mean age, 21.4 years) and 18 Caucasian students brought up in Western countries with Caucasian parents (14 females; mean age, 20.8 years) were recruited from the University of York. All participants gave their written consent prior to the experiment. The University of York Department of Psychology Ethics Committee approved the study.

Stimuli

Photographs of facial expressions of six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) were selected from two face sets: the Chinese Facial Affective Picture System (CFAPS) (Gong, Huang, Wang, & Luo, 2011; Wang & Luo, 2005), posed by Chinese models, and the Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt, & Öhman, 1998), posed by Caucasian models. In total, 120 Chinese and 120 Caucasian faces (with 20 exemplars of each of the six emotions) were used for the categorization task, and 18 Chinese and 18 Caucasian images (3 exemplars of each of the six emotions) were used for the perceptual similarity task.

All images were converted to greyscale and cropped to remove hairstyles and background as far as possible. When viewed in the experiment, each image subtended a visual angle of approximately $7 \times 8°$. Figure 1 shows examples of images used in the experiment. The images for five of the basic emotions (anger, disgust, fear, happiness, and sadness) were the same as those previously used by Yan, Andrews, and Young (2016).

Procedure

Participants viewed expression images using a computerized task programmed with PsychoPy software (www.psychopy.org). All participants completed the perceptual similarity rating task first, and then the forced-choice expression categorization task.

In the perceptual similarity task, participants saw two facial expressions posed by different actors presented simultaneously side by side for 1.5 s. Their task was to rate the similarity of the expression pairs on a 7-point scale, with 1 indicating not very similar expressions and 7 very similar expressions. There were 15 different types of expression pairings in which a photograph showing one expression was always paired with a photograph showing a different expression (e.g., anger with disgust, anger with fear, anger with surprise, and so on; resulting in 15 possible types of combination). Same expression pairs (e.g., anger with anger, disgust with disgust) were not included because Yan, Andrews, and Young (2016) found that these always generated high-rated similarities. We therefore chose to focus on the perceived similarity of between-expression pairs, which offer a stronger test of whether differences between expressions are perceived equivalently across cultures. Because each emotion expression was posed by 3 actors, there were a total of 9 possible combinations for each of the 15 expression pairs, leading to a total of 135 trials for each set of faces. Ten additional practice trials were included to familiarize the participants with the task prior to the formal experiment. The trial order was random across participants.

In the categorization task, participants only saw one face at a time, and they had to perform a 6-alternative forced-choice task (6AFC) to identify each facial expression as happiness, sadness, anger, disgust, fear, or surprise. Each face was presented for 1 s, and the participants were asked to make their responses as quickly and as accurately as possible. Responses were made via keypresses 1–6 for the expressions, and the mapping between emotion labels and keys was counterbalanced across participants. The code for keypresses was always visible on screen. There were a total of 120 trials with Chinese faces and 120 trials with Caucasian faces, with each set split randomly into two blocks. Participants saw the face images in a block order of either

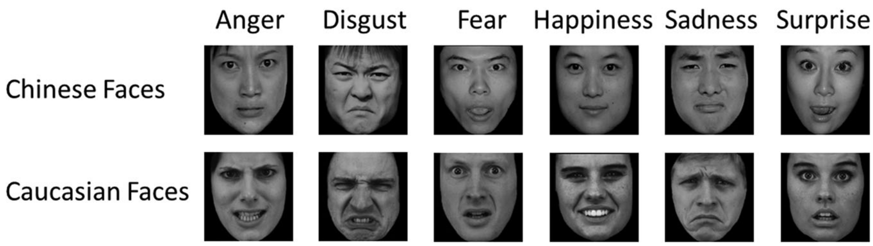

Figure 1. Example face images for six emotions posed by different models from the Chinese Facial Affective Picture System (CFAPS; Gong et al., 2011; Wang & Luo, 2005) © [Y. J. Luo]. Reproduced by permission of Y. J. Luo. Permission to reuse must be obtained from the rightsholder. and the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998). The IDs of the KDEF images shown here are AF07ANS, AM03DIS, AM10AFS, AF08HAS, AM23SAS, AF08SUS.

"Chinese–Caucasian–Chinese–Caucasian" or "Caucasian–Chinese–Caucasian–Chinese", which was counterbalanced across participants. There was also a 10-trial practice session at the beginning.

After these two tasks, all Chinese participants were asked to write down the Chinese names of the six emotion labels used in the categorization task, to check comprehension of the English words. Two native Chinese speakers verified that the labels were all correctly understood by the Chinese participants. They were also asked to fill in a short questionnaire reporting how long they had been in the UK (see Yan, Andrews, and Young, 2016, for details).

Results

The experiment involved perceptual similarity rating and forced-choice categorization tasks. We consider each in turn, looking separately at both accuracies and patterns of confusion in the categorization task.

Perceptual similarity task

To analyse the similarity ratings for the perceptual similarity task, we followed Yan, Andrews, and Young's (2016) procedure of calculating the average similarity ratings for each pair of emotions for each participant (i.e., the average rated similarity of anger–disgust pairs, anger–fear pairs, etc.). The resulting 15 averaged ratings across participants were then used to create perceptual similarity matrices for both the Caucasian faces and the Chinese faces in each group of participants. By correlating the values in these similarity matrices across the different participant cultures, we could then measure the degree of cross-cultural agreement.

Figure 2 shows the similarity rating matrices for Caucasian and Chinese faces and Caucasian and Chinese participants. The correlations between the similarity rating matrices between Chinese and Caucasian participants for both Caucasian faces ($r = .98$, $p < .001$) and for Chinese faces ($r = .97$, $p < .001$) indicate that the perception of the expressions was highly consistent between Caucasian and Chinese participants. These results were consistent with the results found with only five emotions by Yan, Andrews, and Young (2016).

Categorization task

Caucasian participants were more accurate in judging facial expressions from Caucasian faces (77% ± 1%) than from Chinese faces (69% ± 1%). In contrast, there was no difference in overall accuracy for Chinese participants judging Caucasian (72% ± 1%) or Chinese (72% ± 2%) faces. A mixed ANOVA was conducted on the arcsine-transformed percentage recognition accuracies with group (Caucasian participants, Chinese participants) as a between-subject factor and face ethnicity (Caucasian faces, Chinese faces) and emotion (anger, disgust, fear, happiness, sadness, surprise) as within-subject factors. This showed an own-race advantage in the form of a significant interaction of Face Ethnicity × Group, $F(1, 34) = 20.8$, $p < .001$, $\eta_p^2 = .38$, as shown in Figure 3A. Further analyses to decompose this interaction revealed that for the Caucasian participants, there were significant recognition accuracy differences between Caucasian and Chinese faces, $F(1, 34) = 40.1$, $p < .001$, while for the Chinese participants the differences between the two sets of faces were nonsignificant, $F(1, 34) = 0.02$, $p > .1$. This interaction was also moderated by a three-way interaction of Emotion × Face Ethnicity × Group, $F(5,170) = 6.1$, $p < .001$, $\eta_p^2 = .15$.

To further investigate the potential group differences in each emotion category, we decomposed

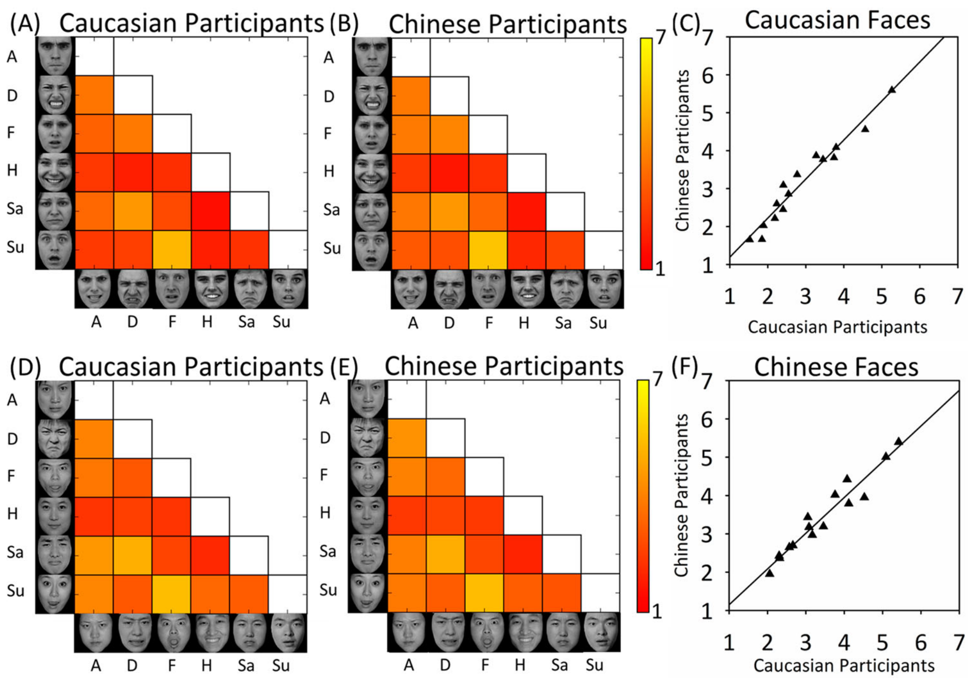

Figure 2. Correlation analyses of similarity rating patterns between Western Caucasian and Chinese participants. Perceptual similarity matrices for (A) Western Caucasian and (B) Chinese participants with Western Caucasian faces (A: anger, D: disgust, F: fear, H: happiness, Sa: sadness, Su: surprise) © [Lundqvist, D.]. Reproduced by permission of Lundqvist, D. Permission to reuse must be obtained from the rightsholder. (C) Scatterplot of correlations between two groups of participants with Western Caucasian faces ($r = .98$, $p < .001$). Perceptual similarity matrices for (D) Western Caucasian and (E) Chinese participants with Chinese faces. © [Luo, Y. J.]. Reproduced by permission of Luo, Y. J. Permission to reuse must be obtained from the rightsholder. (F) Scatterplot of correlation between two groups of participants with Chinese faces ($r = .97$, $p < .001$). To view this figure in colour, please visit the online version of this Journal.

the three-way interaction to look for a Face Ethnicity × Group interaction separately for each emotion (Figure 3B and 3C). Our analyses found that the interaction of Face Ethnicity × Group was only significant for anger, $F(1, 34) = 36.1$, $p < .001$, $\eta_p^2 = .51$, and disgust, $F(1, 34) = 5.2$, $p < .05$, $\eta_p^2 = .13$. In these significant two-way interactions, there were significant differences between Caucasian and Chinese anger faces for both the Caucasian participants (who were better at recognizing Caucasian expressions, $F(1, 34) = 28.5$, $p < .001$, and the Chinese participants (who were better at recognizing Chinese expressions, $F(1, 34) = 9.7$, $p < .01$, while the differences between Caucasian and Chinese disgust faces only reached significance for Chinese participants, $F(1, 34) = 8.6$, $p < .01$.

In addition to the above results, which reflect our main focus of interest, the ANOVA also found significant main effects of face ethnicity, $F(1, 34) = 19.3$, $p < .001$, $\eta_p^2 = .36$, and emotion, $F(5, 170) = 74.4$, $p < .001$, $\eta_p^2 = .69$. These main effects were qualified by the interaction of Face Ethnicity × Emotion, $F(5, 170) = 17.3$, $p < .001$, $\eta_p^2 = .34$, with the Caucasian sadness expressions being easier to recognize than Chinese sadness expressions in the sets used, $t(35) = 8.6$, $p < .001$.

We also conducted an equivalent mixed ANOVA on the median reaction times (RTs) for the correct responses in the categorization task. This did not find significant interactions of face ethnicity and group [Face Ethnicity × Group: $F(1, 34) = 1.3$, $p > .1$; Face Ethnicity × Emotion × Group: $F(5, 170) = 1.5$, $p > .1$], indicating that there were no cultural differences in response time to facial expressions posed by own- and other-race members, and that there was no speed–accuracy trade-off in the categorization task.

As well as examining categorization accuracies, we also looked at the confusion on the part of the two groups of participants when identifying facial expressions of the six basic emotions in the categorization task. To do this, we created separate confusion matrices for each set of faces (Caucasian and Chinese) for each group of participants. These are shown in Figure 4. Each matrix represents the

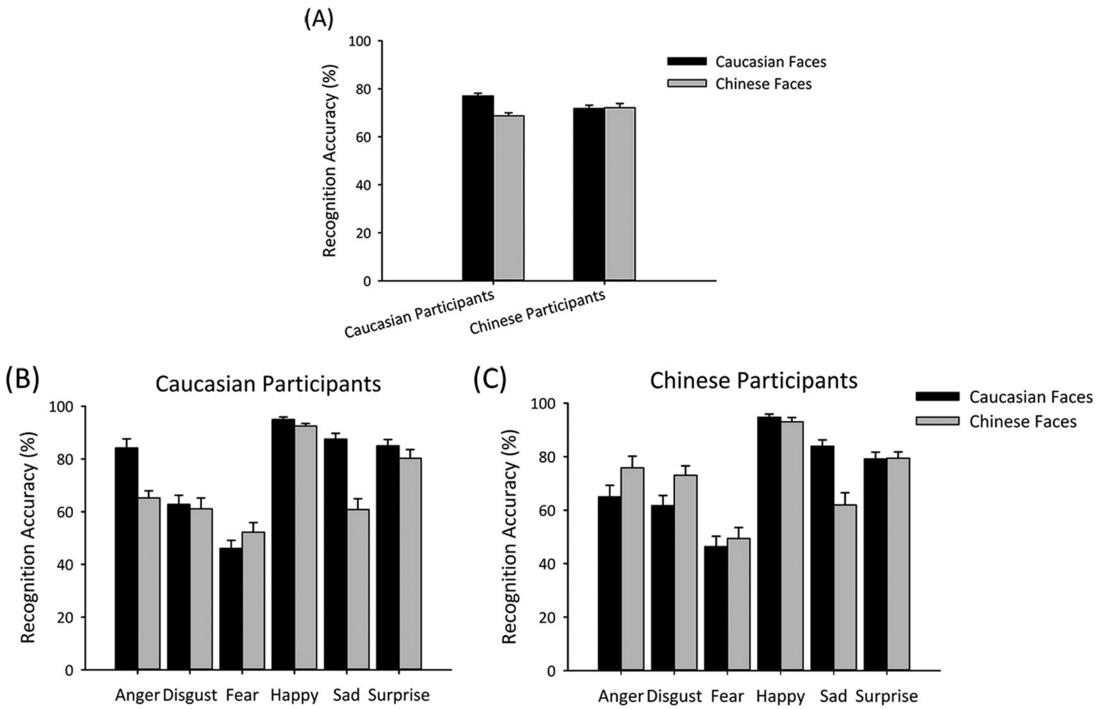

Figure 3. (A) Overall percentage recognition accuracies (with standard error bars) for Western Caucasian and Chinese participants from the Western Caucasian and Chinese facial expressions in the categorization task. (B) (C) Percentage recognition accuracies (with standard error bars) for the six basic emotions by Western Caucasian and Chinese participants presented with Western Caucasian and Chinese facial expressions.

pattern of participants' responses, with the *y*-axis indicating the intended emotion categories and the *x*-axis indicating participants' responses as the intended or different emotions. In order to compare participants' confusion matrices in the categorization task with their similarity rating matrices from the perceptual similarity task, we averaged the two cells of the same expression pairs (e.g., anger mistaken for disgust and disgust mistaken for anger) in each confusion matrix to create a generic confusion matrix, and we also removed the accuracies for intended expressions that fall along the diagonal (i.e., the accuracies for recognizing fear as fear, disgust as disgust, and so on). In this way we arrived at representations of categorization confusion (Figure 4) that were similar in structure to the way we represented the perceptual similarity data (Figure 2).

We were then able to measure the similarity between these different confusion matrices using correlations, in the same way as we had measured the similarity between the perceptual ratings matrices. Again, the correlation between Chinese and Caucasian participants for each set of faces was very high for Caucasian faces ($r = .96$, $p < .001$) and for Chinese faces ($r = .95$, $p < .001$), indicating that the overall patterns of confusion between expressions for both Caucasian and Chinese participants were very consistent.

As a further step, we also compared the correspondence between the patterns of perceptual similarity ratings shown in Figure 2 and the categorization confusion matrices shown in Figure 4. Once again we found substantial consistencies between patterns across these two different tasks, indicating that the higher the similarity perceived by the participants for each pair of expressions, the more recognition confusion there was among those expression pairs. The correlations of response patterns between two tasks were: Caucasian faces for Caucasian participants ($r = .85$, $p < .001$), Caucasian faces for Chinese participants ($r = .78$, $p < .001$), Chinese faces for Caucasian participants ($r = .76$, $p < .001$), and Chinese faces for Chinese participants ($r = .82$, $p < .001$).

A noticeable feature of Figure 4 is that the main confusion between expressions involves fear with surprise and anger with disgust. In other studies of facial expression recognition, surprise is confused with fear more often than anger is confused with disgust (Calvo & Lundqvist, 2008; Ekman & Friesen, 1976;

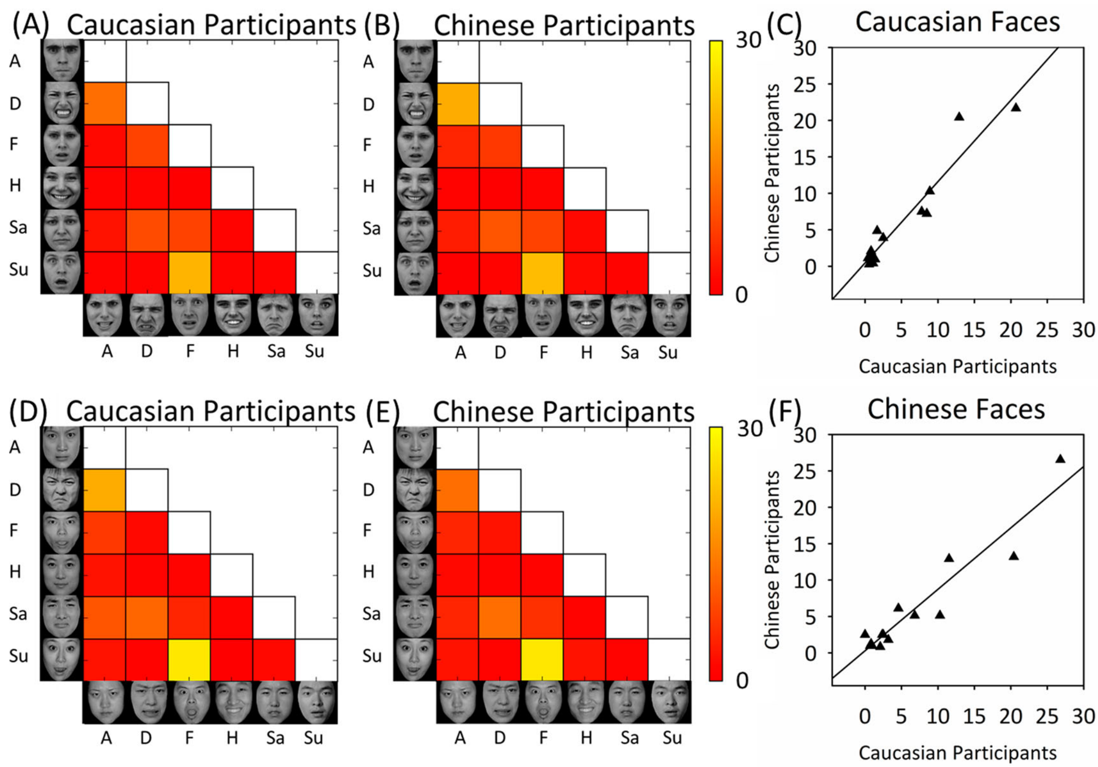

Figure 4. Confusion matrices for (A) Western Caucasian and (B) Chinese participants categorizing Western Caucasian faces (A: anger, D: disgust, F: fear, H: happiness, Sa: sadness, Su: surprise). © [Lundqvist, D.]. Reproduced by permission of Lundqvist, D. Permission to reuse must be obtained from the rightsholder. (C) Scatterplot of correlation of the confusion patterns between the two groups of participants with Western Caucasian faces ($r = .96$, $p < .001$). Both the *x*- and *y*-axes indicate the percentage confusion rates of different pairs of expressions. Confusion matrices for (A) Western Caucasian and (B) Chinese participants categorizing Chinese faces © [Luo, Y. J.]. Reproduced by permission of Luo, Y. J. Permission to reuse must be obtained from the rightsholder. (F) Scatterplot of correlation of the confusion patterns between the two groups of participants with Chinese faces ($r = .95$, $p < .001$). To view this figure in colour, please visit the online version of this Journal.

Palermo & Coltheart, 2004; Wiggers, 1982). To confirm that this was the case in the present data and explore the impact of face and participant ethnicity, we conducted a further ANOVA with group (Caucasian participants, Chinese participants) as a between-subject factor, and face ethnicity (Caucasian faces, Chinese faces) and emotion (the 15 possible emotion pairings, e.g., anger–disgust, anger–fear) as within-subject factors. This revealed a significant three-way interaction of Group × Face Ethnicity × Emotion, $F(14, 476) = 6.1$, $p < .001$, $\eta_p^2 = .15$. In this interaction the confusion between fear and surprise and anger and disgust were more frequent than for other emotion pairs (with $ps < .001$), and there was confusion between fear and surprise significantly more frequently than confusion between anger and disgust, $t(35) = 5.9$, $p < .001$. However, this greater confusability of fear and surprise than of anger and disgust held only when faces were recognized by participants from the same cultural background: Caucasian participants for Caucasian faces: $t(17) = 3.0$, $p < .05$; Caucasian participants for Chinese faces: $t(17) = 2.4$, $p > .1$; Chinese participants for Chinese faces: $t(17) = 6.9$, $p < .001$; Chinese participants for Caucasian faces: $t(17) = 0.6$, $p > .1$.

Our Chinese participants had all been raised in China by Chinese parents, but they were all living in the UK at the time. We therefore used the data from the questionnaire concerning how long the Chinese participants had been in the UK to explore whether contact with Western Caucasian people might have influenced their performance to the Western Caucasian facial expressions. The time our Chinese participants had been in the UK ranged from 18 months to 9 years and 3 months. To investigate whether contact with Western Caucasian people might have influenced the Chinese participants' performance with Western Caucasian expressions, we calculated the averaged similarity ratings for each set of faces for each of our Chinese participants, and then calculated the difference in similarity ratings between the two sets of faces (i.e., similarity ratings of Chinese faces minus those of Caucasian faces) and correlated these differences with time in the UK. From social contact theories (Furl, Phillips, & O'Toole, 2002; Tanaka et al., 2004; Walker, Silvert, Hewstone, & Nobre, 2008) we might expect that the longer Chinese participants have lived in a Western country, the less would be the perceptual difference between the Western Caucasian and Chinese faces. However, our results (Figure 5A) were not consistent with this idea. Instead, they showed a significant positive relationship between rating differences and time spent in the UK ($r = .47$, $p = .05$); this result is in the opposite direction to the social contact hypothesis.

We also applied the same approach to the recognition accuracy data. A correlation analysis was also used to evaluate the relationship between each Chinese participant's time spent in the UK and their recognition difference between Chinese and Western Caucasian faces. The result showed a trend indicating that the longer the Chinese participants had been living in the UK, the smaller was the identification difference between the Chinese and Western Caucasian faces. This is in line with the social contact hypothesis, but the trend did not reach a reliable level ($r = -.32$, $p = .20$) (Figure 5B).

Discussion

In this experiment, we extended Yan, Andrews, and Young's (2016) study by investigating cross-cultural similarities and differences in perceiving and recognizing facial expressions of six basic emotions. We found a large amount of cross-cultural consistency in participants' similarity ratings of expression pairs, and also in the patterns of confusion from the categorization task.

Despite this general background of cross-cultural consistency, we found that a small own-race advantage for recognizing facial expressions is driven by the overall confusability of emotion categories. Our results only found a full cross-over interaction of Participant Group × Face Ethnicity for recognizing anger, some evidence of differences in recognition of disgust, and also a group difference between Caucasian and Chinese faces for Caucasian participants. These results showed that the cross-cultural differences in expression processing were mainly centred on the recognition of anger and disgust.

Previous studies have shown that some pairs of facial expressions are more likely to be confused with each other; especially surprise with fear, and anger with disgust (Calvo & Lundqvist, 2008; Ekman & Friesen, 1976; Palermo & Coltheart, 2004; Wiggers, 1982). In our emotion categorization task, confusion between anger and disgust or fear and surprise was much higher than those of other expression pairs, and our two groups of participants showed a high consistency in the confusion patterns. However, as has been noted in other studies, although our participants confused fear and surprise expressions more than they did anger and disgust; nevertheless, despite this, only anger and disgust recognition were linked to an own-race advantage. These results indicate that the own-race advantage in expression recognition cannot be explained simply by the degree of confusability of the expressions. We return in the General Discussion to the question of how it might therefore originate.

In this experiment, we also investigated cross-cultural differences for surprise because Jack et al. (2012) reported that the surprise expression plays an important role in driving the own-race advantage in expression perception. This conclusion was linked by Jack et al. (2012) to a more general idea that East Asian participants rely considerably on the eye region and comparatively little on the mouth region in their mental representations of facial expressions. Although our findings from Experiment 1 did not lend support to the particular importance of surprise, we decided to further investigate Jack et al.'s more general position on the importance of the eye region in Experiment 2, by investigating whether there are cross-cultural differences in the holistic processing of facial expressions.

Experiment 2

We used the composite-expression paradigm devised by Calder et al. (2000) to investigate the holistic processing of own-race and other-race facial expressions by Caucasian and Chinese participants. From Jack et al.'s (2012) findings we predicted that if Chinese participants mainly use the eye region to internally represent facial expressions, there should be a correspondingly reduced holistic processing of facial expressions. To test this prediction, we asked participants to identify facially expressed emotions from

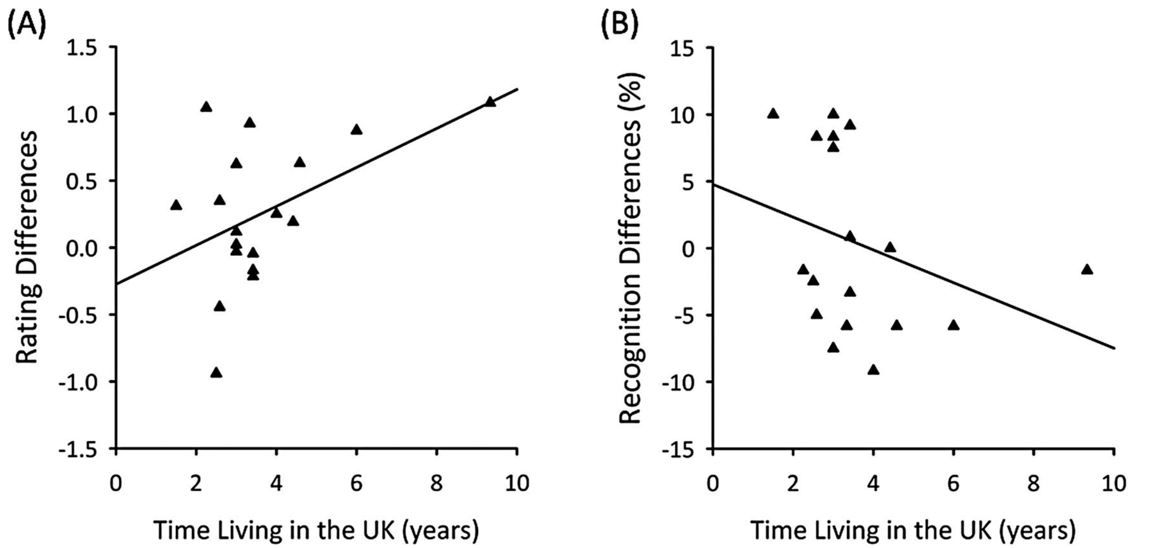

Figure 5. Scatterplots of Chinese participants' time living in the UK with their performance differences between Chinese and Western Caucasian faces in the perceptual similarity task (A) and the categorization task (B).

the upper (eye region) or lower (mouth region) parts of stimuli arranged in aligned composite (face-like) or misaligned (not face-like) formats.

Method

Participants

Groups of 18 Chinese students brought up in mainland China with Chinese parents (13 females; mean age, 21.9 years) and 18 Caucasian students brought up in Western countries with Caucasian parents (16 females; mean age, 21 years) were recruited from the University of York to participate in this experiment. All participants gave their written consent prior to the experiment and received a small payment or course credit. The University of York Department of Psychology Ethics Committee approved the study.

Stimuli

Based on our previous study (Yan, Andrews, and Young, 2016), we selected facial expressions of the three emotions that could be easily recognized from both the upper and lower part of the face, namely anger, fear, and happiness. The proportional recognition rates for these three emotions were .5, .6, and .9, respectively, for the upper half-faces, while the relative recognition rates for the lower part-faces were .5, .7, and .9, respectively. Four exemplars of each emotion were selected from the stimuli used in Experiment 1. The stimuli were created by combining the upper and the lower halves of different facial expressions. This led in total to six possible upper/lower combinations; anger/fear, anger/happiness, fear/anger, fear/happiness, happiness/anger, and happiness/fear. The upper and lower halves of each stimulus were always taken from photographs posed by different models, because Calder et al. (2000) showed that the identities of the face parts had no effect on the holistic processing of facial expressions. All half-faces were created by arbitrarily dividing each face through the middle of the bridge of the nose.

Stimuli were presented in two different formats: aligned composites and misaligned images (Figure 6). The aligned expressions were presented in a face-like configuration, but (following the recommendation of Rossion & Retter, 2015) a narrow dark band was used to separate the upper and lower halves of each stimulus, so that participants could see that there were distinct top and bottom parts. The misaligned expressions were created from the same face parts as the aligned expressions, except that the upper and lower halves of the misaligned stimuli were misaligned horizontally. For these misaligned stimuli we followed Calder et al. (2000) by aligning the middle of the nose of the upper half-faces with the edge of the lower half-face. For half of the misaligned images, the upper half was shifted to the left side of the lower half, while for the other half of the misaligned stimuli the upper half was shifted to the right side of the lower half.

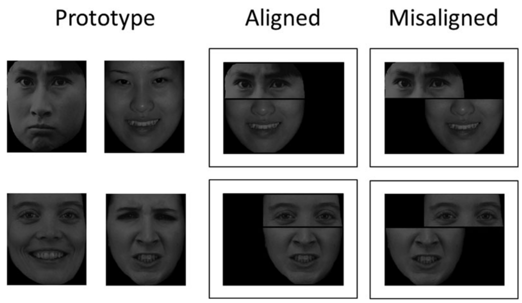

Figure 6. Examples of stimuli used in Experiment 2. The upper and lower halves of different prototype expressions from one of the image sets (left) were combined to create aligned composite (middle) and misaligned (right) stimuli. The two prototype faces in the first row are Chinese models showing expressions of anger and happiness, respectively, from the Chinese Facial Affective Picture System (CFAPS; Gong et al., 2011; Wang & Luo, 2005) (© [Luo, Y. J.]. Reproduced by permission of Luo, Y. J. Permission to reuse must be obtained from the rightsholder) and the two prototype faces in the second row are Western Caucasian models showing happiness and anger expressions from the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998) (© [Lundqvist, D.]. Reproduced by permission of Lundqvist, D. Permission to reuse must be obtained from the rightsholder).

There were 4 stimuli for each of the 6 upper/lower expression combinations, giving a total of 24 aligned stimuli and 24 misaligned stimuli for each race set. When the misaligned faces were presented in the middle of the screen, neither the upper nor the lower half of the faces was centralized on the screen. To match this, half of the aligned faces were presented in the same position as the left half of the misaligned faces and half in the same position as the right half of the misaligned faces (Figure 6). When viewed in the experiment, the aligned images subtended a visual angle of approximately $8° \times 7°$, and the misaligned images were $8° \times 10°$.

Procedure

Participants viewed expression images using a computerized task programmed with PsychoPy software (www.psychopy.org). All participants made a three-alternative forced choice (3AFC) involving judging the facial expression (anger, fear, or happiness) of the upper or lower half of both the Chinese and Western Caucasian faces. Responses were made via keypresses 1–3 for the expressions; the mapping between these emotion labels and response keys was counterbalanced across participants. The code for keypresses was always visible on screen. Each trial began with a central fixation cross for 0.5 s, following which a stimulus was presented on the screen until the participant made a response. Participants were asked to respond as quickly and as accurately as possible.

All participants completed two blocks of trials. In one block, the task was to identify the facial expression of the upper half-face, and in the other block the task was to identify the facial expression from the lower half. The sequence of these two blocks was counterbalanced across participants. The face stimuli for each block were identical, including 24 aligned and 24 misaligned Chinese faces and the same number of Western Caucasian faces. Faces of different races were presented in a block order of "Chinese–Caucasian" or "Caucasian–Chinese", which was counterbalanced across participants. Within each race set the 48 stimuli (aligned and misaligned images) were presented in a random order.

To ensure participants could correctly identify the upper or lower parts of the facial expressions, each block began with the presentation of only the half-faces (upper or lower, as appropriate) that were used to create the aligned and misaligned stimuli. Participants were asked to identify the expression for each half-face, and feedback was given in this part of the experiment only. The appropriate parts (upper or lower) of the 12 faces were each presented twice, making a total of 24 practice trials. After being familiarized with the half-faces, no further feedback was given, and the participants completed 24 practice trials with the aligned and misaligned stimuli before the formal task in each block. These practice stimuli were made from the same part faces but with combinations different from those used in the main experimental trials.

Results

Our primary focus of interest is in reaction times for correct responses, with the expression composite effect being indexed by slower responses to aligned composite than to misaligned images. Slowing of responses to the aligned composites is thought to result from holistic perception of the face-like aligned expressions leading to a novel expression that interferes with identifying the expression in each face part (Calder et al., 2000). We conducted a mixed ANOVA on the median correct reaction times (RTs) with half (upper or lower part judgement), face ethnicity (Caucasian or Chinese faces), and alignment (aligned or misaligned stimuli) as within-subject factors and participant group (Caucasian or Chinese

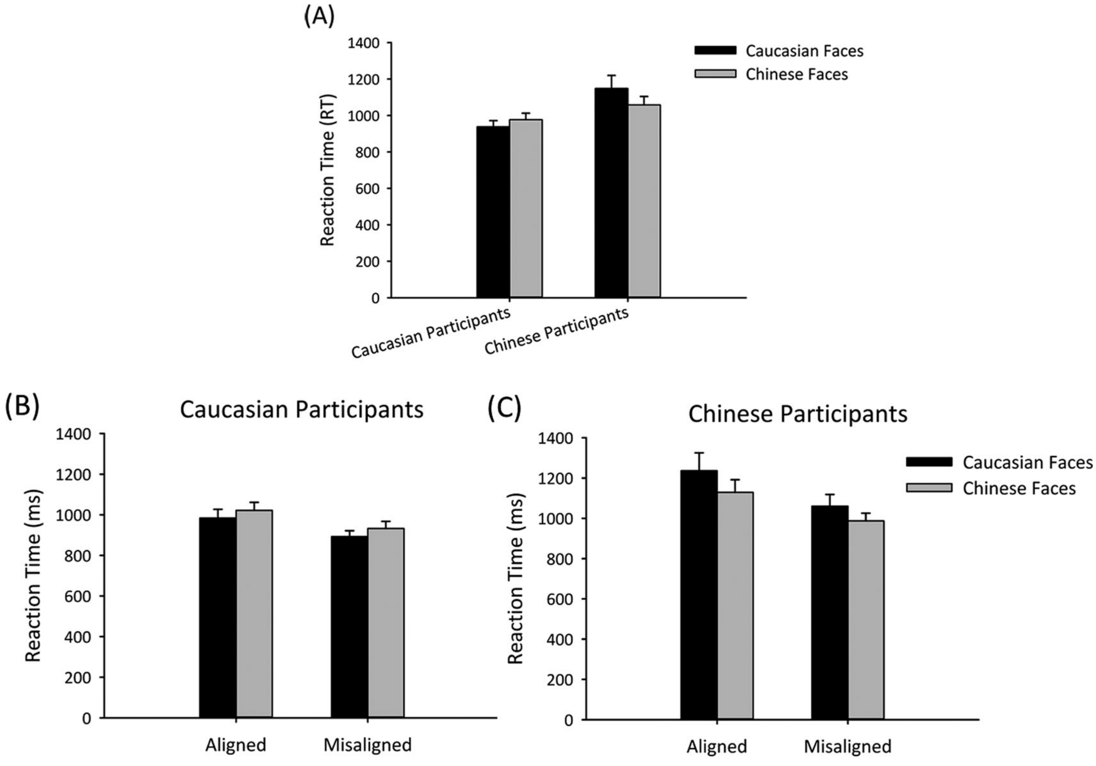

Figure 7. (A) Overall correct reaction times (with standard error bars) for Western Caucasian and Chinese participants with the Western Caucasian and Chinese facial expressions in Experiment 2. (B) (C) Overall correct reaction times (with standard error bars) for Western Caucasian and Chinese participants recognizing parts of aligned and misaligned stimuli created from upper and lower halves of Western Caucasian and Chinese expressions.

participants) as a between-subjects factor. This showed a significant main effect of stimulus alignment, $F(1, 34) = 29.3$, $p < .001$, $\eta_p^2 = .46$. Participants took longer to identify the parts of aligned expressions (1093 ms) than the misaligned expressions (968 ms), consistent with the expression composite effect found in previous studies (Calder et al., 2000; Calder & Jansen, 2005; White, 2000).

There was also a significant Face Ethnicity × Participant Group interaction, $F(1, 34) = 5.9$, $p < .05$, $\eta_p^2 = .15$, indicating an own-race advantage in recognizing facial expressions (Figure 7). Further analyses showed that Chinese participants were faster at recognizing Chinese facial expressions than Caucasian expressions, $F(1, 34) = 5.7$, $p < .05$, while there was no time difference between Western Caucasian and Chinese facial expressions for Caucasian participants, $F(1, 34) = 1.1$, $p > .1$.

The ANOVA also found a significant main effect of face half, $F(1, 34) = 12.0$, $p < .001$, $\eta_p^2 = .26$, and this main effect was moderated by two two-way interactions: Face Ethnicity × Half, $F(1, 34) = 6.1$, $p < .05$, $\eta_p^2 = .15$, and Alignment × Half, $F(1, 34) = 6.2$, $p < .05$, $\eta_p^2 = .15$. Further analyses of these two-way interactions showed that the Chinese lower half-faces were identified more quickly than the Caucasian lower half-faces, while there was no difference for the upper half-faces. Nonetheless, for both the upper and lower half-faces, participants were always faster at recognizing facial expressions from misaligned than from aligned faces. The main effect of participant group was also significant, $F(1, 34) = 5.2$, $p < .05$, $\eta_p^2 = .13$, with Caucasian participants taking less time (958 ms) than Chinese participants (1103 ms) to identify the facial expression parts. No other significant effects were detected.

The most important RT findings, then, were a clear expression composite effect (main effect of alignment) that was not modified either by participant group or by face ethnicity, indicating that the size of the expression composite effect was stable across participant and face ethnicities.

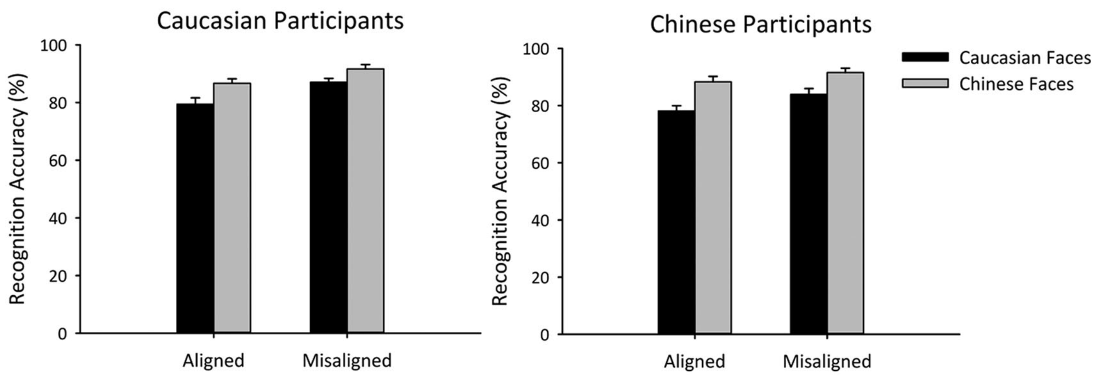

Figure 8. Overall recognition accuracies (with standard error bars) for Western Caucasian and Chinese participants with the Western Caucasian and Chinese aligned and misaligned stimuli in Experiment 2.

We also conducted an equivalent mixed ANOVA on the arcsine-transformed recognition accuracies. The results showed a significant main effect of alignment, $F(1, 34) = 39.7$, $p < .001$, $\eta_p^2 = .54$, indicating that participants were more accurate at recognizing facial expressions from misaligned stimuli than from aligned stimuli (see Figure 8) and demonstrating that there was no speed–accuracy trade-off. The expression composite effect was again detected for both the upper half-faces, $F(1, 34) = 32.6$, $p < .001$, and the lower half-faces, $F(1, 34) = 3.3$, $p = .08$.

There were also significant main effects on accuracy for face ethnicity, $F(1, 34) = 51.6$, $p < .001$, $\eta_p^2 = .60$, and half, $F(1, 34) = 16.8$, $p < .001$, $\eta_p^2 = .33$. Two significant two-way interactions were also detected: Face Ethnicity × Half, $F(1, 34) = 32.4$, $p < .001$, $\eta_p^2 = .49$, and Half × Alignment, $F(1, 34) = 11.5$, $p < .01$, $\eta_p^2 = .25$. Further analyses showed that the accuracy for recognizing Chinese face parts was higher than that for Caucasian face parts for only the lower half-faces, $F(1, 34) = 87.6$, $p < .001$. No other significant effects were revealed.

Because Experiment 1 only found own-race advantages for recognition of certain facial expressions (particularly anger), we carried out a supplementary analysis of the data from Experiment 2 to explore whether holistic processing was evident for each emotion category. We conducted a mixed ANOVA of the correct RTs, which included expression (anger, fear, and happiness) as an additional within-subjects factor. In order to examine the expression composite effect in each emotion category, we looked for significant effects involving the holistic processing of expressions. These were a main effect of alignment, $F(1, 34) = 33.8$, $p < .001$, $\eta_p^2 = .50$, and a three-way Half × Alignment × Expression interaction, $F(2, 68) = 4.9$, $p < .01$, $\eta_p^2 = .13$. The main effect of alignment demonstrated an overall expression composite effect, in which participants needed more time to recognize facial expressions from aligned than from misaligned face parts.

In the three-way Half × Alignment × Expression interaction, we found that participants recognized expressions faster from both the upper and lower parts of the misaligned anger and fear faces than from aligned faces, but the composite effect existed only when recognizing happiness from the upper part-faces. This interaction therefore reflected the ease with which the smiling mouth is identified as a signal of happiness, leading to an absence of the expression composite effect for this condition only. No interactions involving alignment or participant group were detected, indicating again that there were no group differences between Caucasian and Chinese participants in holistic processing of the three emotions. This was again inconsistent with the prediction based on Jack et al.'s (2012) study that Chinese participants would show reduced holistic processing for facial expressions.

Discussion

In Experiment 2, we used the composite effect to investigate holistic processing of facial expressions. We found a reliable expression composite effect: participants were faster and more accurate at recognizing facial expressions from half-faces when they were in a misaligned arrangement that was not face-like. When the same half-faces were presented in a more face-like aligned composite format, responses to upper or lower parts slowed, and errors increased. These results indicate that facial expressions are processed in a holistic way. Importantly, this was true for both the Caucasian and Chinese participants, and for the Caucasian and Chinese expressions. The lack of cross-cultural differences in holistic perception of expressions is inconsistent with predictions based on Jack et al.'s (2012) view that Chinese participants focus on the eye region when internally representing facial expressions. Our results showed clearly that both groups of participants recognize facial expressions in a holistic way.

We did nonetheless find a small own-race advantage in overall reaction times, with Chinese participants spending less time recognizing Chinese faces than Caucasian participants, but no difference for Caucasian participants. However, this own-race advantage was not linked to differences in holistic processing of own-race versus other-race expressions. We also found equivalent holistic processing effects for each of the three facial expressions tested (with the minor exception of the lower parts of happy faces) and in both groups of participants.

General discussion

We investigated potential factors that might underlie cultural differences in facial expression recognition. In the first experiment, we replicated and extended Yan, Andrews, and Young' (2016) results by showing that there was substantial cross-cultural consistency in the perception of similarities between different pairs of expressions and in the patterns of confusion when categorizing expressions. The own-race advantage was found only in the categorization (not in the perception) of expressions, and mainly for expressions of anger and disgust. Even though we found more obvious categorization confusion between anger and disgust and also between fear and surprise than between other expressions, which was consistent with the findings of previous studies (Calvo & Lundqvist, 2008; Ekman & Friesen, 1976; Palermo & Coltheart, 2004; Wiggers, 1982), only anger and disgust were linked to the own-race advantage. Therefore, the confusability of expressions cannot fully explain the own-race advantage in expression recognition.

In the second experiment, we explored another possible factor of engagement of holistic processing that might drive cross-cultural differences in expression recognition. We found a reliable expression composite effect for both groups of participants and both face ethnicities; participants were faster and more accurate at recognizing facial expressions from half parts of misaligned than aligned stimuli. These results indicate that for both the Caucasian and Chinese participants, expressions of both own-race and other-race faces are processed in a holistic way. This is inconsistent with the prediction based on Jack et al.'s (2012) hypothesis that Chinese participants use mainly the eye region to represent facial expressions. Moreover, since our results showed comparable magnitudes of holistic processing of expressions across Caucasian and Chinese participants, the own-race advantage in expression recognition cannot be explained by the engagement of holistic processing.

In both experiments, we nonetheless found a reliable own-race advantage in the overall recognition of facial expressions posed by own-race versus other-race members. However, this own-race advantage was small compared with the large amount of cross-cultural agreement, indicating that widely repeated claims that "they all look the same" overestimate the cross-cultural differences (Yan, Andrews, and Young et al., 2016; Yan, Andrews, Young, & Jenkins, 2016).

Even though we did not find group differences in holistic processing of facial expressions, some previous studies have linked the own-race advantages in the recognition of facial identity (rather than expression) to holistic processing, claiming a greater engagement of holistic processing by own-race than other-race faces (Michel, Caldara et al., 2006; Michel, Rossion et al., 2006; Tanaka et al., 2004). Alternatively, however, Hayward et al. (2013) have pointed to inconsistencies between previous findings involving the other-race effect for facial identity and argued that the key feature of own-race face advantages may lie in more effective processing of all types of face information (featural as well as holistic). Our study is the first to investigate potential cross-cultural differences in the holistic perception of facial expression and the discrepancy between our results for facial expression and these previous findings for facial identity processing is consistent with the idea that the underlying processing of facial expression and identity may be different (Bruce & Young, 1986; Calder & Young, 2005; Haxby, Hoffman, & Gobbini, 2000).

Since our results showed that the own-race advantage in facial expression recognition cannot be explained by either the confusability of emotions or the holistic perception of expressions, we can ask what, then, are the factors that cause the own-race advantages? One possible reason is that there are relatively minor cultural "stylistic" differences in the way in which certain emotions are expressed around a common overall template (Yan, Andrews, & Young, 2016), and we note two influences that may contribute to such differences for anger and disgust. First, compared to Western Caucasian individuals, people in Eastern Asian countries learn to avoid expressing negative emotions that might harm interpersonal and social harmony (Matsumoto, 1989; Matsumoto & Ekman, 1989). Second, and possibly linked to this, the meaning of disgust might be different across cultures (Han, Kollareth, & Russell, 2015; Yoder, Widen, & Russell, 2016). Although Darwin (1872) and Rozin, Haidt, and McCauley (1993) have argued that the evolutionary origins of disgust can be traced back to a rejection response to bad tastes and smells, other types of disgust can be added to this core disgust by "an opportunistic accretion of new domains of elicitors, and new motivations, to a rejection system that is already in place" (Rozin et al., 1993). These accretions can include responses to violations of moral or cultural rules and norms (Rozin et al., 1993). So there are clear possibilities for cultural differences. Compared with the Korean and Malayalam words for disgust, for example, Han et al. (2015) found that the English word disgust referred to more mixed emotional reactions to both physical and moral disgust scenarios. Similarly, by asking participants to choose an emotion label that best matched the emotion of several stories, Yoder et al. (2016) found that the facial expression that best described physical disgust stories was more like a "sick face", while the more standard disgust facial expression and sometimes anger were more often chosen for the representation of moral violation stories. These findings coincide with our findings that own-race advantages were mainly evident for anger and disgust expressions, but not the more confusable expressions of fear and surprise.

In summary, the present study shows substantial cross-cultural consistency in perception of facial expressions of six basic emotions and also confusion patterns among emotions in Western Caucasian and Chinese participants. In contrast, cross-cultural differences in the categorization of expressions were real but small and mainly existed for emotions of anger and disgust. Both Caucasian and Chinese participants process facial expressions in a holistic way, and there were no differences in the engagement of holistic processing to own- and other-race faces. The own-race advantage in expression recognition cannot be explained by either the confusability of emotions or the holistic perception of expressions, but may reflect stylistic differences in the way that certain emotions are expressed within a common overall template.

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Disclosure Statement

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