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Learning own- and other-race facial identities from natural variability

Simone C. Tüttenberg[1] & Holger Wiese[1]

[1]*Department of Psychology, Durham University, UK*

Author note

Simone C. Tüttenberg, Department of Psychology, Durham University; Holger Wiese, Department of Psychology, Durham University

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Correspondence should be addressed to Simone C. Tüttenberg, Department of Psychology, Durham University, Science Laboratories, South Road, Durham, DH1 3LE, United Kingdom, simone.c.tuettenberg@durham.ac.uk

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Abstract

Exposure to multiple varying face images of the same person encourages the formation of identity representations which are sufficiently robust to allow subsequent recognition from new, never-before seen images. While recent studies suggest that identity information is initially harder to perceive in images of other- relative to own-race identities, it remains unclear whether these difficulties propagate to face learning, i.e., to the formation of robust face representations. We report two experiments in which Caucasian and East Asian participants sorted multiple images of own- and other-race persons according to identity in an implicit learning task and subsequently either matched novel images of learnt and previously unseen faces for identity (Experiment 1) or made old/new decisions for new images of learnt and unfamiliar identities (Experiment 2). Caucasian participants demonstrated own-race advantages during sorting, matching and old/new recognition while corresponding effects were absent in East Asian participants with substantial other-race expertise. Surprisingly, East Asian participants showed enhanced learning for other-race identities during matching in Experiment 1, which may reflect their increased motivation to individuate other-race faces. Thus, our results highlight the importance of perceptual expertise for own- and other-race processing, but may also lend support to recent suggestions on how expertise and socio-cognitive factors can interact.

LEARNING OWN- AND OTHER-RACE FACIAL IDENTITIES FROM NATURAL VARIABILITY

We are able to identify a familiar face from almost any photograph, and this remarkable ability holds even when never-before seen and poor-quality images are used (Burton, Wilson, Cowan, & Bruce, 1999). This has led to the widely held belief that we are "face experts". However, this expertise for faces appears to be far more confined than initially thought, and is, in effect, limited to familiar faces (Young & Burton, 2018). Previous research has shown that we have substantial difficulty recognising unfamiliar faces (Bruce et al., 1999), which appears to be even more pronounced if these faces are from a different ethnic group (Meissner & Brigham, 2001). The difference between familiar and unfamiliar face recognition, and the process that transfers unfamiliar into familiar faces, i.e., face learning, are widely researched, but not yet completely understood. Given the well-documented difficulty in unfamiliar other-race face recognition, the present study investigated whether it is also more difficult to learn other-race facial identities.

Previous studies have shown that unfamiliar face recognition is highly image-dependent and substantially impaired by changes in e.g., viewpoint or expression (e.g., P. J. B. Hancock, Bruce, & Burton, 2000; Longmore, Liu, & Young, 2008). For example, participants make approximately 30% errors when identifying a target face from a different picture in a simultaneously presented array of 10 faces, despite the fact that all photographs depict frontal views and are taken on the same day (e.g., Bruce et al., 1999; Megreya & Burton, 2007). Error rates remain high in matching tasks even when only two different face photographs are presented side-by-side and participants have to decide whether these show the same or different persons (e.g., Burton, White, & McNeill, 2010). Of particular relevance, Jenkins and colleagues presented participants with 20 "ambient" images (i.e., photographs taken from the internet that vary "naturally" in viewing angle, expression, hairstyle, etc.) of each of two unfamiliar identities and asked them to sort the pictures into as many piles as they perceived identities in the set (Jenkins, White, Van Montfort, & Burton, 2011). Participants considerably overestimated the actual number of identities and sorted the pictures into a median of 7.5 piles. Interestingly, corresponding tasks with images of familiar faces resulted in near-perfect performance.

In addition to these well-documented problems with unfamiliar face recognition, people remember faces from a different ethnic group less accurately than faces from their own ethnicity (Meissner & Brigham, 2001). Attempts to explain this own-race bias (ORB) have focused either on perceptual expertise or socio-cognitive factors. Perceptual expertise accounts assume that reduced contact and lack of experience with other-race faces result in reduced configural and/or holistic processing (Hayward, Crookes, & Rhodes, 2013; Michel, Rossion, Han, Chung, & Caldara, 2006; Rhodes et al., 2009) or less precise memory representations (Valentine & Endo, 1992; Valentine, Lewis, & Hills, 2016), ultimately impairing recognition memory. Alternatively, socio-cognitive accounts suggest that other-race faces are categorised into social out-groups. Consequently, processing is thought to be restricted to category-level information while individuating information is assumed to be derived from own-race faces (Hugenberg, Young, Bernstein, & Sacco, 2010; Levin, 1996). However, it is further suggested that, given sufficient motivation, other-race faces can be individuated. Accordingly, increasing motivation to individuate has been reported to eliminate the ORB (Hugenberg, Miller, & Claypool, 2007).

Although typically demonstrated in recognition memory paradigms, an ORB has also been observed in simultaneous matching tasks, suggesting that the effect is, at least partly, related to perceptual deficits and not entirely memory-based (Megreya, White, & Burton, 2011). This conclusion is also in line with evidence from event-related brain potentials, indicating that difficulties at perceptual processing stages are correlated with the ORB in face memory (Wiese, Kaufmann, & Schweinberger, 2014; Wiese & Schweinberger, 2018). At the same time, researchers have only recently begun to investigate differences in the perception of own- and other-race facial identities using multiple ambient images of the depicted persons (e.g., Laurence, Zhou, & Mondloch, 2016; Yan, Andrews, Jenkins, & Young, 2016; Zhou & Mondloch, 2016). These studies report that, in a sorting task similar to Jenkins et al. (2011), participants typically perceive even more other-race than own-race identities, suggesting that identity information is even harder to extract from unfamiliar other-race faces. As sorting tasks arguably encourage individuation of the identities at hand (for a related discussion, see Hayward, Favelle, Oxner, Chu, & Lam, 2017), these findings support an expertise-based account of the ORB and extend difficulties with other-race faces to the recognition of facial identity.

Interestingly, sorting tasks can also be employed for face identity learning. When participants are informed about the correct number of identities in the set subsequent performance for these faces improves substantially (Andrews, Jenkins, Cursiter, & Burton, 2015). Specifically, in a subsequent matching task, previously unseen images of identities seen during sorting are matched more accurately than images of new identities. This suggests that exposure to within-person variability during sorting encourages the formation of so-called robust representations that enable recognition of the face independent of a specific image (Andrews, Burton, Schweinberger, & Wiese, 2017; Andrews et al., 2015; Burton, Kramer, Ritchie, & Jenkins, 2016).

Recently, Matthews and Mondloch (2017) also observed a benefit of exposure to multiple images for other-race identity learning. After extensive training, novel exemplars of the learnt other-race identities were matched more accurately than images of unfamiliar other-race identities. To date, however, only very few studies have directly compared own- and other-race face learning, and have not provided consistent findings. Cavazos and colleagues showed similar benefits of multi-image learning on own- and other-race face recognition although an ORB in recognition memory was still evident (Cavazos, Noyes, & O'Toole, 2018). At variance with this finding, Hayward et al. (2017) provided evidence that it is more challenging to learn other-race as compared to own-race identities from varying images. In this study, a name identification test with new images of the learnt identities revealed higher accuracies for identifying own-race compared to other-race identities. Similarly, Zhou, Matthews, Baker, and Mondloch (2018) showed an own-race advantage in a paradigm where identities were learnt from a single image, a low variability video, or a high variability video. The authors found that, relative to own-race faces, exposure to a higher degree of within-person variability was needed during other-race face learning to subsequently recognise the faces from novel images. Together, the majorities of these studies provide some initial support for an increased challenge to incorporate novel exemplars into newly formed other-race face representations.

In sum, previous work has shown difficulties to cohere ambient images of unfamiliar faces into distinct identity representations (Jenkins et al., 2011) which are even more pronounced for other-race faces (Laurence et al., 2016). Although sorting of unfamiliar own-race identities has been shown to result in incidental learning (Andrews et al., 2015), no study investigating differences in the perception of own- and other-race identities from ambient images has yet addressed whether difficulties during sorting propagate to subsequent matching and recognition of novel exemplars of the learnt identities. This question is arguably of particular relevance, given that in daily life people presumably learn new facial identities from exposure to variability. Moreover, as noted above, the paradigms and findings of previous studies on own- and other-race face identity learning are somewhat mixed. While Cavazos et al. (2018) found that own- and other-race identification benefits similarly from exposure to variability during learning, others found an advantage for own-race identity learning (Hayward et al., 2017; Zhou et al., 2018). Of note, Cavazos et al. (2018) used a relatively limited number of images with restricted variability. Moreover, Hayward et al. (2017) used a naming task. Accordingly, any reduced performance for other-race faces could in principle result from increased difficulty of accessing new name-face associations rather than from face recognition per se. Put differently, it is possible in such tasks that participants recognise the face, but do not remember the correct name.

Here, we report two experiments investigating own- and other-race identity learning. In both experiments, Caucasian and East Asian participants sorted own- and other-race faces according to identity in separate blocks. To promote learning, participants were informed that only two identities were present. Following each sorting task, they engaged in a matching task (Experiment 1) or an old/new recognition task (Experiment 2) in which previously unseen images of the identities seen during sorting (learnt identities) and of unfamiliar (novel) identities were presented. We expected a differential pattern of results for own- and other-race faces across the sorting and matching/recognition tasks. Given the particular difficulties to extract identity-diagnostic information from other-race faces when presented with ambient images (e.g., Laurence et al., 2016), we expected better performance during sorting for own- relative to other-race identities. We also predicted more difficulties with other-race faces in the subsequent matching and old/new recognition tasks. In Experiment 1, we expected a general benefit of prior familiarisation with the identities (Andrews et al., 2015), which would be reflected in better matching for learnt when compared to novel identities. We further hypothesised that previous exposure would be particularly beneficial for own-race identities, resulting in larger learning effects for own- relative to other-race faces. In Experiment 2, a similar learning advantage for own-race identities was expected which would be reflected in more accurate recognition of own- compared to other-race identities. Finally, we note that our East Asian participants were tested while attending a UK university, which likely enabled them to acquire substantial expertise with Caucasian faces. We therefore expected differences between own- and other-race faces to be attenuated in East Asian relative to Caucasian participants.

Experiment 1

Method

Participants

The sample comprised 24 Caucasian (22 female, 18-42 years, M_{age} = 21.5, SD_{age} = 5.1) and 24 East Asian undergraduate and postgraduate students (21 female, 19-31 years, M_{age} = 21.5, SD_{age} = 2.9) at Durham University. East Asian participants had been living in the UK for 2 to 48 months. All participants gave written informed consent to take part in the study and received course credit or £5. The study was approved by the local ethics committee.

Stimuli and Design

40 images of each of four Caucasian and four East Asian male models unfamiliar to the participants were collected via Google image search (for more detailed information, see Andrews et al. (2017)). Rectangles around the face were cut out of the original pictures, re-sized to 190 x 285 pixels, and converted to grey scale. All images were also printed at 3 x 4 cm, laminated and cut out to create stimuli for the sorting task (see below). Following the main experiment, participants were asked to judge the quality of contact with Caucasian and East Asian people on a scale from 1 (very superficial) to 4 (very intense) (Wiese, 2012).

For each identity, images were randomly divided into two sets (A, B) of 20 images each. The identities within each ethnic group were paired (ID1/2, ID3/4), resulting in four different image sets for each ethnic group (A and B for ID1/2 and ID3/4, respectively).

Participants completed a sorting and a matching task, once with Caucasian and once with East Asian identities in separate blocks. The order of blocks (Caucasian first, East Asian first) was counterbalanced across participants. For the sorting task, one of the image sets for the respective ethnic group was used. The identity set presented in the sorting task (ID1/2A, ID1/2B, ID3/4A or ID3/4B) was counterbalanced across participants.

In the subsequent matching task, two face images were presented side-by-side on a computer screen on grey background. 80 trials, i.e., 20 match and 20 mismatch trials each for the learnt identities encountered in the sorting task, and the two previously unseen (novel) identities, were completed. The two images were presented at 7 x 11.2 cm, separated by a 4.3 cm gap. Each image was presented twice, once in a match and once in a mismatch trial. Within the respective categories (match or mismatch trials for learnt or novel identities, respectively), the two images contributing to each stimulus pair were selected randomly. All presented images of learnt identities were novel exemplars to test for identity learning independent of a specific image set (e.g., if participants sorted set 1A, images presented during matching were those of set 1B).

Procedure

After providing consent, participants completed the first sorting task. They received a pile of shuffled cards and were informed that the cards depicted two different persons with 20 images per identity. They were asked to sort the images into two clusters, one for each identity, without time restriction. They were told to arrange images of the same person next to one another, so that all images could be seen simultaneously. Participants were then seated in front of a computer monitor to participate in the first matching task. They were told that they would see a pair of face images on the screen and that their task was to judge as accurately as possible whether the two faces presented in each trial depicted the same or two different identities. Images remained on the screen until participants keyed in their response. Finally, participants completed the second sorting and matching task, using stimuli from the ethnic group not used in the first block.

Sorting errors were calculated by determining the number of images of one identity (e.g., ID1) incorrectly sorted into a pile containing a majority of images of the second identity in the set (e.g., ID2). Statistical analyses were performed using mixed-model analyses of variance (ANOVA). Quality of contact (reported in Table 1) and sorting task errors were analysed using the within-subjects factor contact/stimulus ethnicity (Caucasian, East Asian) and the between-subjects factor group (Caucasian, East Asian). Analysis of matching task performance involved the additional within-subjects factors familiarity (learnt, novel) and trial type (match, mismatch). Post-hoc comparisons were performed using paired samples t-tests. Additionally, we tested our a priori hypothesis of larger learning effects in the matching task for own- relative to other-race identities with planned contrasts (learnt minus novel for both Caucasian and East Asian identities in Caucasian and East Asian participants, respectively) using t-tests. To further explore whether sorting facilitated subsequent performance with these recently learnt identities, we computed Pearson correlations between sorting errors and the learning effect (learnt - novel) during matching for own- and other-race identities in Caucasian and East Asian participants, respectively. Following an estimation approach, estimates of effect sizes (Cohen's *d*) and 95% confidence intervals (CIs) for Cohen's *d* and Pearson's *r* are reported, which were calculated using ESCI (Cumming & Calin-Jageman, 2017). As suggested by Cumming and Calin-Jageman (2017), Cohen's *d* for paired samples t-tests was corrected for bias and calculated by using the mean SD (and not the SD of the difference) as the denominator (Cohen's d_{unb}).

Results

For the sake of conciseness, we only report those results that directly relate to our hypotheses in the main text. A complete list of all significant effects is presented in Table 1.

A mixed-model ANOVA on sorting errors (Figure 1A) with the within-subjects factor stimulus ethnicity and the between-subjects factor group revealed a significant interaction, $F(1,46) = 12.75$, $p = .001$, $\eta^2_p = .217$. Post-hoc contrasts conducted for each participant group separately revealed fewer sorting errors for own- relative to other-race identities in Caucasian, $t(23) = 4.03$, $p = .001$, $M_{\text{diff}} = 2.208$, 95% CI [1.07, 3.34], $d_{\text{unb}} = 0.901$, 95% CI [0.40, 1.45], but not in East Asian participants, $t(23) = 0.90$, $p = .375$, $M_{\text{diff}} = -0.458$, 95% CI [-1.51, 0.59], $d_{\text{unb}} = -0.207$, 95% CI [-0.68, 0.26].

During matching, a mixed-model ANOVA with the within-subjects factors stimulus ethnicity and familiarity as well as the between-subjects factor group yielded a significant main effect of familiarity with overall better performance for learnt relative to novel identities, $F(1,46) = 22.40$, $p < .001$, $\eta^2_p = .327$. Furthermore, a stimulus ethnicity x group interaction was observed (Figure 1B), $F(1,46) = 29.00$, $p < .001$, $\eta^2_p = .387$, revealing better matching of own- versus other-race identities in Caucasian, $t(23) = 10.21$, $p < .001$, $M_{\text{diff}} = 0.148$, 95% CI [0.12, 0.18], $d_{\text{unb}} = 1.879$, 95% CI [1.27, 2.61], and comparable matching of own- and other-race faces in East Asian participants, $t(23) = 0.31$, $p = .760$, $M_{\text{diff}} = -0.007$, 95% CI [-0.05, 0.04], $d_{\text{unb}} = -0.066$, 95% CI [-0.50, 0.37]. In addition, a significant stimulus ethnicity x familiarity interaction was obtained (Figure 2), $F(1,46) = 7.14$, $p = .010$, $\eta^2_p = .134$. Post-hoc contrasts revealed better matching for learnt relative to novel identities for

Caucasian, $t(23) = 3.93$, $p = .001$, $M_{\text{diff}} = 0.116$, 95% CI [0.06, 0.18], $d_{\text{unb}} = 1.036$, 95% CI [0.45, 1.68], but not for East Asian identities, $t(23) = 1.64$, $p = .116$, $M_{\text{diff}} = 0.030$, 95% CI [-0.01, 0.07], $d_{\text{unb}} = 0.351$, 95% CI [-0.09, 0.81]. The stimulus ethnicity x familiarity x group interaction failed to reach significance, $F(1,46) = 0.53$, $p = .472$, $\eta^2_p = .011$.

Additional analyses to test our a priori hypothesis of more pronounced learning effects (learnt – novel) for own- compared to other-race identities (Figure 1C) revealed only numerically larger learning effects for own- relative to other-race identities in Caucasian participants, $t(23) = 1.50$, $p = .148$, $M_{\text{diff}} = 0.045$, 95% CI [-0.02, 0.11], $d_{\text{unb}} = 0.337$, 95% CI [-0.12, 0.81]. Surprisingly, East Asian participants demonstrated significantly larger learning effects for other- than for own-race identities, $t(23) = 2.69$, $p = .013$, $M_{\text{diff}} = -0.127$, 95% CI [-0.23, -0.03], $d_{\text{unb}} = -0.749$, 95% CI [-1.38, -0.16].

Correlational analyses to investigate whether sorting facilitated performance during the subsequent matching task revealed significant correlations for own-race identities in Caucasian, $r(22) = -.397$, 95% CI [-.69, .01], $p_{\text{one-tailed}} = .027$, as well as East Asian participants, $r(22) = -.546$, 95% CI [-.78, -.18], $p_{\text{one-tailed}} = .003$. No corresponding correlations were observed for other-race identities, neither in Caucasian, $r(22) = .242$, 95% CI [-.18, .59], $p_{\text{one-tailed}} = .127$, nor in East Asian participants, $r(22) = -.113$, 95% CI [-.49, .30], $p_{\text{one-tailed}} = .300$ (Figure 3).

The matching task results were additionally confirmed in a by-item analysis. While the stimulus ethnicity x familiarity x group interaction was not significant, $F(1,304) = 0.49$, $p = .484$, $\eta^2_p = .002$, separate one-way ANOVAs comparing learning effects (learnt – novel) for own- and other-race items in Caucasian and East Asian participants respectively, revealed a trend for larger learning effects for own- relative to other-race identities in Caucasian participants, $F(1,318) = 3.29$, $p = .071$, $\eta^2_p = .010$, but significantly larger learning effects for other- relative to own-race faces in East Asian participants, $F(1,318) = 6.58$, $p = .011$, $\eta^2_p = .020$.

Experiment 2

Experiment 1 revealed better sorting for own- than other-race identities in Caucasian participants while East Asian participants showed comparable sorting for own- and other-race identities, which is in line with our predictions. In a subsequent matching task, however, we found only limited support for our hypothesis of more pronounced learning effects for own-race identities in Caucasian participants. Unexpectedly, East Asian participants showed learning effects for *other*-race identities. In Experiment 2, we investigated learning of own- and other-race facial identities using a recognition instead of a matching task.

Method

Participants

24 Caucasian (22 female, 18-25 years, $M_{age} = 19.0$, $SD_{age} = 1.8$) and 24 East Asian students (20 female, 18-21 years, $M_{age} = 18.7$, $SD_{age} = 0.8$) participated in the experiment in exchange for course credit. None of them had taken part in Experiment 1. A further 3 participants were excluded as they failed to follow task instructions. At the time of testing, East Asian participants had been living in the UK (or another country with a predominant Caucasian population) for an average of 8.9 months (SD = 7.4, 1-27 months). None of the Caucasian participants reported having lived in a country with a predominant East Asian population prior to attending university. The study was approved by the ethics committee at Durham University's Psychology department.

Stimuli and Design

The stimulus set was identical to that used in Experiment 1. All aspects of the design were identical to Experiment 1 except that the matching task was replaced by an old/new recognition task. A sequence of 80 single face images was shown on a computer screen. Images were presented at 7 x 11.2 cm on grey background. These images were identical to those presented during the matching task in Experiment 1 (i.e., 40 novel images of identities seen during sorting and 40 images of two previously unseen identities) and presented in random order.

Procedure

The sorting task was performed as described in the procedure section of Experiment 1. For the old/new recognition task, participants were told that they would see a single face image on the screen and that their task was to decide as accurately as possible whether each picture represented a *different* image of one of the two people seen during the sorting task or an unfamiliar person. Stimuli were presented in random order until participants keyed in their response and were separated by a fixation cross presented for 1,000ms.

Statistical analysis of quality of contact (reported in Table 2) and sorting task errors was conducted as described in the respective section of Experiment 1. For the recognition task, following a signal detection theory approach, we calculated the sensitivity measure *d*' (z-standardised hit rate minus z-standardised false alarm rate, Wickens, 2002). *d*' data as well as hits and correct rejections (CR) were analysed using a mixed-model ANOVA with the within-subjects factor stimulus ethnicity (Caucasian, East Asian) and the between-subjects factor group (Caucasian, East Asian), and post-hoc comparisons were performed using paired samples t-tests. In addition, we calculated Pearson correlations between sorting errors and *d'*.

Results

For the sake of conciseness, only those results that directly relate to our hypotheses are reported below. A full list of all significant effects is presented in Table 2.

A mixed-model ANOVA with the within-subjects factor stimulus ethnicity and the between-subjects factor group on sorting errors yielded a significant interaction, $F(1,46) = 5.11$, $p = .029$, $\eta_p^2 = .100$ (Figure 4A). Post-hoc comparisons revealed fewer sorting errors for own- compared to other-race identities in Caucasian participants, $t(23) = 4.55$, $p < .001$, $M_{\mathrm{diff}} = 2.583$, 95% CI [1.41, 3.76], $d_{\mathrm{unb}} = 1.108$, 95% CI [0.54, 1.73]. East Asian participants made numerically fewer errors sorting other- compared to own-race faces, although this difference was not significant, $t(23) = 1.06$, $p = .301$, $M_{\mathrm{diff}} = -0.708$, 95% CI [-2.09, 0.68], $d_{\mathrm{unb}} = -0.272$, 95% CI [-0.81, 0.25].

A corresponding ANOVA on *d*' (Figure 4B) revealed a significant stimulus ethnicity x group interaction, $F(1,46) = 18.41$, $p < .001$, $\eta_p^2 = .286$. Post-hoc contrasts indicated higher sensitivity to own- relative to other-race identities in Caucasian participants, $t(23) = 4.68$, $p < .001$, $M_{\mathrm{diff}} = 1.028$, 95% CI [0.57, 1.48], $d_{\mathrm{unb}} = 1.146$, 95% CI [0.57, 1.78], and comparable sensitivity for own- and other-race identities in East Asian participants, $t(23) = 1.50$, $p = .147$, $M_{\mathrm{diff}} = 0.353$, 95% CI [-0.13, 0.84], $d_{\mathrm{unb}} = 0.301$, 95% CI [-0.11, 0.72].

We additionally conducted mixed-model ANOVAs with factors stimulus ethnicity and group to analyse hits and CR. For hits (Figure 4C), a significant stimulus ethnicity x group interaction was observed, $F(1,46) = 9.02$, $p = .004$, $\eta_p^2 = .164$. Post-hoc comparisons yielded significantly higher hit rates for own- compared to other-race identities in Caucasian participants, $t(23) = 2.78$, $p = .011$, $M_{\text{diff}} = 0.112$, 95% CI [0.03, 0.20], $d_{\text{unb}} = 0.701$, 95% CI [0.17, 1.27], but comparable hit rates for own- and other-race identities in East Asian participants, $t(23) = 1.39$, $p = .179$, $M_{\text{diff}} = 0.049$, 95% CI [-0.02, 0.12], $d_{\text{unb}} = 0.275$, 95% CI [-0.13, 0.69]. Similarly, for CR (Figure 4D), a significant stimulus ethnicity x group interaction was obtained, $F(1,46) = 12.95$, $p = .001$, $\eta_p^2 = .220$, reflecting higher CR rates for own- when compared to other-race identities in Caucasian participants, $t(23) = 4.84$, $p < .001$, $M_{\text{diff}} = 0.121$, 95% CI [0.07, 0.17], $d_{\text{unb}} = 0.849$, 95% CI [0.44, 1.31], while no corresponding difference was detected in East Asian participants, $t(23) = 1.06$, $p = .299$, $M_{\text{diff}} = 0.040$, 95% CI [-0.04, 0.12], $d_{\text{unb}} = 0.234$, 95% CI [-0.21, 0.69].

Correlational analyses revealed a significant correlation for own-race identities in East Asian participants, $r(22) = -.416$, 95% CI [-.70, -.15], $p_{\text{one-tailed}} = .022$, but not in Caucasian participants, $r(22) = -.220$, 95% CI [-.57, .20], $p_{\text{one-tailed}} = .151$. For other-race identities, no significant correlations were detected, neither in Caucasian, $r(22) = -.103$, 95% CI [-.49, .31], $p_{\text{one-tailed}} = .316$, nor in East Asian participants, $r(22) = -.277$, 95% CI [-.61, .14], $p_{\text{one-tailed}} = .096$ (Figure 5).

As in Experiment 1, a by-item analysis was conducted on hit rates during old/new recognition. This analysis confirmed the pattern obtained in the by-subjects analysis. In particular, we observed a significant stimulus ethnicity x group interaction, $F(1,304) = 41.88$, $p < .001$, $\eta^2_p = .121$. Separate one-way ANOVAs conducted post-hoc revealed significantly higher hit rates for own- than other-race identities in Caucasian participants, $F(1,318) = 15.97$, $p < .001$, $\eta^2_p = .048$, and a trend for higher hit rates for own- compared to other-race identities in East Asian participants, $F(1,318) = 3.85$, $p = .051$, $\eta^2_p = .012$,

General Discussion

The present experiments investigated differences in perceiving own- and other-race facial identities using images containing natural variability. We further tested whether exposure to within-person variability facilitates identity learning more strongly for own- relative to other-race identities. Participants initially learned own- and other-race faces while sorting ambient images according to identity. In both experiments, Caucasian participants were significantly more accurate when sorting own- relative to other-race identities. In contrast, East Asian participants demonstrated comparable performance. In Experiment 1, we found overall better performance for learnt relative to unfamiliar identities in a subsequent matching task, which replicates previous findings (Andrews et al., 2015). In addition, Caucasian participants showed overall superior matching performance for own- compared to other-race identities while East Asian participants revealed similar performance for the two ethnicities. However, contrary to our hypothesis, East Asian participants demonstrated more pronounced learning effects for other-race faces during the matching task. In Experiment 2, as predicted, Caucasian participants were more accurate at recognising novel instances of own- than of other-race identities previously seen during sorting. By contrast, East Asian participants showed comparable performance for both face categories. These results are discussed in more detail below.

In line with our predictions, Caucasian participants made significantly more errors when sorting other- as compared to own-race faces. This is in line with previous work that used a sorting task in which the number of identities in the set was unknown and demonstrated that participants typically created more other- than own-race identity piles (Laurence et al., 2016; Yan et al., 2016). Together with the present results, these experiments suggest that it is more difficult to perceive identity information from ambient other-race images and to cohere these into identity representations. A similar own-race advantage was also obtained during subsequent matching (Experiment 1). Caucasian participants again showed significantly better matching performance for own- relative to other-race faces, independent of whether the identities were learnt or novel, which is in line with previous work (Kokje, Bindemann, & Megreya, 2018; Megreya et al., 2011). Interestingly, a markedly different pattern was obtained for East Asian participants. In both experiments, East Asian participants showed comparable performance for own- and other-race identities during the initial sorting task, and this pattern was also observed subsequently during matching (Experiment 1). The absence of a clear own-race advantage in this group presumably resulted from their increased experience with Caucasian people while living in the UK. This interpretation is in line with previous findings of reduced or even absent own-race biases in participants with enhanced expertise for other-race faces (Chiroro & Valentine, 1995; K. J. Hancock & Rhodes, 2008; Wiese et al., 2014). These findings are also in accordance with a perceptual expertise explanation of the ORB, as they reveal that it is more difficult to extract identity information from a set of other-race compared to own-race face images, unless participants have had extensive other-race contact.

As detailed in the introduction, a particular motivation for the present study was to investigate whether it is harder to learn novel other-race facial identities. Therefore, in Experiment 1, we directly compared learning effects for own- and other-race faces in both participant groups. As predicted, Caucasian participants showed numerically larger learning effects for own- relative to other-race faces. Although the direct statistical comparison of own- and other-race learning effects did not result in a significant effect, inspection of Figure 1C reveals that only the confidence interval for the other-race condition includes zero (and is therefore not significantly different from zero). Unexpectedly, however, East Asian participants yielded clearly larger learning effects for *other*- relative to own-race faces.

Therefore, the analysis of learning effects in Experiment 1 only partly supported our hypothesis of more pronounced own- relative to other-race identity learning. In addition, the finding of clear learning effects for Caucasian but not East Asian identities, irrespective of participant group (see Figure 2), might suggest that the East Asian identities presented in the current study were generally perceived as more similar than the Caucasian identities. Such differences in perceived similarity may have made it particularly difficult for both Caucasian and Asian participants to learn the East Asian identities. While we cannot entirely rule out this possibility, we do not think that it can fully account for the present findings. As discussed in more detail below, learning effects for East Asian identities in East Asian participants were obtained in Experiment 2, and these learning effects were highly similar to those detected for Caucasian identities in Caucasian participants (see Figure 4 B-D). In addition, in Experiment 1, we observed significant correlations between sorting errors and the learning effect during matching for own-race identities in both Caucasian and East Asian participants. At the same time, corresponding correlations were not detected for other-race identities. Accordingly, the initial sorting task seems to have facilitated later performance with own-race identities during matching, which is difficult to reconcile with the suggestion that no learning of East Asian faces took place. We acknowledge, however, that the evidence is not clear-cut at present, and that future research on own- and other-race face learning may investigate the issues discussed in this paragraph more systematically.

In Experiment 2, we further investigated our hypothesis of larger learning effects for own- compared to other-race identities using an old/new recognition memory procedure. In line with our predictions, we observed a clear own-race advantage in face identity learning in Caucasian participants. More specifically, Caucasian participants were more accurate at recognising novel instances of recently learnt own-race than other-race faces, which is also in line with previous work (e.g., Zhou et al., 2018). In contrast, East Asian participants again showed comparable performance for both face categories, which, as discussed above, might reflect their increased contact with Caucasian people. Similarly, as in Experiment 1, a significant correlation between sorting errors and *d*' was observed for own-race identities in East Asian participants, suggesting that the initial sorting task promoted identity learning. At some variance with Experiment 1, a corresponding correlation was not detected for own-race identities in Caucasian participants. While the reason for this discrepancy is not entirely clear at present, it could simply reflect sampling variability. Confidence intervals for *r* were quite wide, which is unsurprising considering that medium-sized correlations require much larger samples than those of the present experiments for more precise estimates (see Cumming & Calin-Jageman, 2017). We note, however, that significant correlations were consistently observed for own-race identities in East Asian participants. In sum, while Caucasian participants showed an own-race advantage in both experiments, a corresponding own-race advantage was absent in East Asian participants. Surprisingly, this participant group demonstrated an other-race learning advantage in Experiment 1. As Experiment 2 used a different testing procedure, we are at present unable to offer further insights into this unexpected finding, and it remains to be established whether it can be replicated.

If replicable, the results from the current experiments do not sit easily with an explanation of the ORB that solely relies on perceptual expertise. Instead, increased learning of other-race identities could reflect a combination of East Asian participants' considerable expertise with the other-race category and increased motivation to individuate other-race faces. At the time of testing, East Asian participants had acquired substantial experience with Caucasian faces due to living in the UK, and most likely had also realised that Caucasian faces are hard to recognise for them. Therefore, they may have put more effort into processing other-race faces (for related empirical evidence, see Wan, Crookes, Reynolds, Irons, & McKone, 2015).

Importantly, however, the extent to which motivation to individuate modulates performance at test seems to depend on specific task characteristics. More specifically, in the matching task of Experiment 1, the influence of previous learning is indirect, as a decision about two simultaneously presented stimuli is affected by a face representation established during learning. In other words, all information necessary for the task is in principle available in the display, but previous learning about within-person variability improves performance. Under these conditions, increased motivation or attention to other-race faces appears to be particularly beneficial, which may in turn enhance the benefit from previous learning. The lack of a significant correlation between East Asian participants' sorting performance and the learning effect during subsequent matching for other-race identities may offer some support for this proposition. In particular, this finding suggests that the other-race learning advantage in East Asian participants is not strongly related to the initial learning phase, and may instead reflect this group's increased motivation to individuate faces from the other-race category during matching. By contrast, explicit old/new recognitions (as used in Experiment 2) require a familiarity decision to a single face stimulus, and an "old" response is made whenever the stimulus sufficiently activates a recently formed representation. Our data suggest that this process of directly comparing a face with a memory representation is harder to modulate by increased motivation relative to the matching task. In line with this suggestion, we observed a correlation between sorting errors and *d'* for own-race identities in East Asian participants. We would like to emphasise, however, that this interpretation is speculative at present and needs to be tested in future studies.

If motivation modulated performance of East Asian participants, it appears reasonable to ask whether the clear own-race advantages in Caucasian participants might have been related to *reduced* motivation to individuate other-race faces (Hugenberg et al., 2010). While this possibility cannot be completely ruled out based on the present data, we do not think that reduced motivation is a likely explanation for the present findings in this participant group. The experimental tasks used in the present experiments, i.e., sorting, matching and recognition from novel images, explicitly ask for the processing of individual identity, and processing of other-race faces at a categorical level, as suggested by socio-cognitive accounts, would not have been sufficient to reach the overall high performance levels observed here. We also note that own- and other-race faces were presented in separate blocks, further stressing the importance of individuating both ethnic groups. We therefore suggest that Caucasian participants were not *able* to sort, match and recognise other-race faces as accurately as own-race faces, and that this reduced ability resulted from their reduced perceptual expertise. In line with this suggestion, Short and Wagler (2017) did not observe differences in performance in a sorting task when the faces belonged to social in- or out-groups but did not differ with respect to expertise.

Finally, we note that in the present study, all images were presented in greyscale rather than in colour. This decision was practical rather than driven by theoretical considerations. The image sets from this study have also been used in experiments using event-related brain potentials (ERPs). Using greyscale images allows to more easily control basic physical stimulus properties, such as luminance and contrast, which can be important for ERP experiments. Previous work has shown that performance in matching tasks with own-race faces is unaffected by whether images are shown in greyscale or colour (e.g., Bruce et al., 1999). Moreover, a systematic literature review suggested that perceptual processing of own- and other-race faces is not affected by colour versus greyscale format (see Wiese, 2013). We therefore do not think that our choice of using greyscale images substantially affected our results.

In conclusion, the present study offers some support for the idea that individual other-race faces are harder to learn than own-race faces. This own-race advantage, however, was observed only in Caucasian participants who had limited contact with other-race individuals. In contrast, East Asian participants with substantial other-race contact were able to learn individual other-race faces as well as own-race faces. Quite surprisingly, in this participant group, we observed initial evidence suggesting that increased motivation to learn other-race identities may even result in more pronounced learning effects. While this finding needs to be replicated in future experiments, it is in line with recent propositions that perceptual expertise and socio-cognitive factors can interact in specific settings (Wan et al., 2015). Finally, our findings may inform further research in applied contexts, such as eyewitness testimony or passport control. Whereas participants without specific other-race expertise are likely to be less accurate in such applied situations, a combination of increased motivation and expertise may, under certain conditions, not only overcome but potentially even overcompensate any disadvantage for other-race faces.

References

Andrews, S., Burton, A. M., Schweinberger, S. R., & Wiese, H. (2017). Event-related potentials reveal the development of stable face representations from natural variability. *Quarterly Journal of Experimental Psychology, 70*(8), 1620-1632. doi:10.1080/17470218.2016.1195851

Andrews, S., Jenkins, R., Cursiter, H., & Burton, A. M. (2015). Telling faces together: Learning new faces through exposure to multiple instances. *Quarterly Journal of Experimental Psychology, 68*(10), 2041-2050. doi:10.1080/17470218.2014.1003949

Bruce, V., Henderson, Z., Greenwood, K., Hancock, P. J. B., Burton, A. M., & Miller, P. (1999). Verification of face identities from images captured on video. *Journal of Experimental Psychology-Applied, 5*(4), 339-360. doi:10.1037//1076-898x.5.4.339

Burton, A. M., Kramer, R. S. S., Ritchie, K. L., & Jenkins, R. (2016). Identity From Variation: Representations of Faces Derived From Multiple Instances. *Cognitive Science, 40*(1), 202-223. doi:10.1111/cogs.12231

Burton, A. M., White, D., & McNeill, A. (2010). The Glasgow Face Matching Test. *Behavior Research Methods, 42*(1), 286-291. doi:10.3758/brm.42.1.286

Burton, A. M., Wilson, S., Cowan, M., & Bruce, V. (1999). Face recognition in poor-quality video: Evidence from security surveillance. *Psychological Science, 10*(3), 243-248. doi:10.1111/1467-9280.00144

Cavazos, J. G., Noyes, E., & O'Toole, A. J. (2018). Learning context and the other-race effect: Strategies for improving face recognition. *Vision Research*. doi:10.1016/j.visres.2018.03.003

Chiroro, P., & Valentine, T. (1995). An Investigation of the Contact Hypothesis of the Own-race Bias in Face Recognition. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 48*(4), 879-894.

Cumming, G., & Calin-Jageman, R. (2017). *Introduction to the New Statistics: Estimation, Open Science, and Beyond*. New York: Routledge.

Hancock, K. J., & Rhodes, G. (2008). Contact, configural coding and the other-race effect in face recognition. *British Journal of Psychology, 99*, 45-56. doi:10.1348/000712607x199981

Hancock, P. J. B., Bruce, V., & Burton, A. M. (2000). Recognition of unfamiliar faces. *Trends in Cognitive Sciences, 4*(9), 330-337. doi:10.1016/s1364-6613(00)01519-9

Hayward, W. G., Crookes, K., & Rhodes, G. (2013). The other-race effect: Holistic coding differences and beyond. *Visual Cognition, 21*(9-10), 1224-1247. doi:10.1080/13506285.2013.824530

Hayward, W. G., Favelle, S. K., Oxner, M., Chu, M. H., & Lam, S. M. (2017). The other-race effect in face learning: Using naturalistic images to investigate face ethnicity effects in a learning paradigm. *Quarterly Journal of Experimental Psychology, 70*(5), 890-896. doi:10.1080/17470218.2016.1146781

Hugenberg, K., Miller, J., & Claypool, H. M. (2007). Categorization and individuation in the cross-race recognition deficit: Toward a solution to an insidious problem. *Journal of Experimental Social Psychology, 43*(2), 334-340. doi:10.1016/j.jesp.2006.02.010

Hugenberg, K., Young, S. G., Bernstein, M. J., & Sacco, D. F. (2010). The Categorization-Individuation Model: An Integrative Account of the Other-Race Recognition Deficit. *Psychological Review, 117*(4), 1168-1187. doi:10.1037/a0020463

Jenkins, R., White, D., Van Montfort, X., & Burton, A. M. (2011). Variability in photos of the same face. *Cognition, 121*(3), 313-323. doi:10.1016/j.cognition.2011.08.001

Kokje, E., Bindemann, M., & Megreya, A. M. (2018). Cross-race correlations in the abilities to match unfamiliar faces. *Acta Psychologica, 185*, 13-21. doi:10.1016/j.actpsy.2018.01.006

Laurence, S., Zhou, X. M., & Mondloch, C. J. (2016). The flip side of the other-race coin: They all look different to me. *British Journal of Psychology, 107*(2), 374-388. doi:10.1111/bjop.12147

Levin, D. T. (1996). Classifying faces by race: The structure of face categories. *Journal of Experimental Psychology-Learning Memory and Cognition, 22*(6), 1364-1382. doi:10.1037//0278-7393.22.6.1364

Longmore, C. A., Liu, C. H., & Young, A. W. (2008). Learning faces from photographs. *Journal of Experimental Psychology-Human Perception and Performance, 34*(1), 77-100. doi:10.1037/0096-1523.34.1.77

Matthews, C. M., & Mondloch, C. J. (2018). Improving Identity Matching of Newly Encountered Faces: Effects of Multi-image Training. *Journal of Applied Research in Memory and Cognition, 7*(2), 280-290. doi:10.1016/j.armac/2017.10.005

Megreya, A. M., & Burton, A. M. (2007). Hits and false positives in face matching: A familiarity-based dissociation. *Perception & Psychophysics, 69*(7), 1175-1184. doi:10.3758/bf03193954

Megreya, A. M., White, D., & Burton, A. M. (2011). The other-race effect does not rely on memory: Evidence from a matching task. *Quarterly Journal of Experimental Psychology, 64*(8), 1473-1483. doi:10.1080/17470218.2011.575228

Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology Public Policy and Law, 7*(1), 3-35. doi:10.1037/1076-8971.7.1.3

Michel, C., Rossion, B., Han, J., Chung, C. S., & Caldara, R. (2006). Holistic processing is finely tuned for faces of one's own race. *Psychological Science, 17*(7), 608-615. doi:10.1111/j.1467-9280.2006.01752.x

Rhodes, G., Ewing, L., Hayward, W. G., Maurer, D., Mondloch, C. J., & Tanaka, J. W. (2009). Contact and other-race effects in configural and component processing of faces. *British Journal of Psychology, 100*, 717-728. doi:10.1348/000712608x396503

Short, L. A., & Wagler, M. C. (2017). Social Categories Alone Are Insufficient to Elicit an In-Group Advantage in Perceptions of Within-Person Variability. *Perception, 46*(8), 929-940. doi:10.1177/0301006617699226

Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: the effects of race and distinctiveness. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 44*(4), 671-703. doi:10.1080/14640749208401305

Valentine, T., Lewis, M. B., & Hills, P. J. (2016). Face-space: A unifying concept in face recognition research. *Quarterly Journal of Experimental Psychology, 69*(10), 1996-2019. doi:10.1080/17470218.2014.990392

Wan, L. L., Crookes, K., Reynolds, K. J., Irons, J. L., & McKone, E. (2015). A cultural setting where the other-race effect on face recognition has no social-motivational component and derives entirely from lifetime perceptual experience. *Cognition, 144*, 91-115. doi:10.1016/j.cognition.2015.07.011

Wickens, T. D. (2002). *Elementary signal detection theory*. Oxford: Oxford University Press.

Wiese, H. (2012). The role of age and ethnic group in face recognition memory: ERP evidence from a combined own-age and own-race bias study. *Biological Psychology, 89*(1), 137-147. doi:10.1016/j.biopsycho.2011.10.002

Wiese, H. (2013). Do neural correlates of face expertise vary with task demands? Event-related potential correlates of own- and other-race face inversion. *Frontiers in Human Neuroscience, 7*. doi:10.3389/fnhum.2013.00898

Wiese, H., Kaufmann, J. M., & Schweinberger, S. R. (2014). The Neural Signature of the Own-Race Bias: Evidence from Event-Related Potentials. *Cerebral Cortex, 24*(3), 826-835. doi:10.1093/cercor/bhs369

Wiese, H., & Schweinberger, S. R. (2018). Inequality between biases in face memory: Event-related potentials reveal dissociable neural correlates of own-race and own-gender biases. *Cortex, 101*, 119-135. doi:10.1016/j.cortex.2018.01.016

Yan, X. Q., Andrews, T. J., Jenkins, R., & Young, A. W. (2016). Cross-cultural differences and similarities underlying other-race effects for facial identity and expression. *Quarterly Journal of Experimental Psychology, 69*(7), 1247-1254. doi:10.1080/17470218.2016.1146312

Young, A. W., & Burton, A. M. (2018). Are We Face Experts? *Trends in Cognitive Sciences, 22*(2), 100-110. doi:10.1016/j.tics.2017.11.007

Zhou, X., Matthews, C. M., Baker, K. A., & Mondloch, C. J. (2018). Becoming Familiar With a Newly Encountered Face: Evidence of an Own-Race Advantage. Perception. doi:10.1177/0301006618783915

Zhou, X. M., & Mondloch, C. J. (2016). Recognizing "Bella Swan" and "Hermione Granger": No Own-Race Advantage in Recognizing Photos of Famous Faces. *Perception, 45*(12), 1426-1429. doi:10.1177/0301006616662046

Table 1. Full list of significant statistical results for the Quality of contact rating, sorting task errors and matching task performance.

Analysis	Effect	*df*	*F*	*p*	η^2_p	Post-hoc comparison	*df*	*t*	*p*	M_{diff}	95% CI	d_{unb}	95% CI
Quality of contact	Contact ethnicity x group	1,46	169.60	<.001	.787	Cauc. participants: Own- vs. other-race	23	13.16	<.001	2.083	1.76, 2.41	3.578	2.49, 4.89
						Asian participants: Own- vs. other-race	23	6.99	<.001	1.708	1.20, 2.21	2.289	1.40, 3.30
Sorting task errors	Stimulus ethnicity	1,46	5.49	.024	.107								
	Group	1,46	4.44	.041	.088								
	Stimulus ethnicity x group	1,46	12.75	.001	.217	Cauc. participants: Own- vs. other-race	23	4.03	.001	2.208	1.07, 3.34	0.901	0.40, 1.45
						Asian participants: Own- vs. other-race	23	0.90	.375	-0.458	-1.51, 0.59	-0.207	-0.68, 0.26
Matching task performance	Stimulus ethnicity	1,46	34.81	<.001	.431								
	Familiarity	1,46	22.40	<.001	.327								
	Stimulus ethnicity x group	1,46	29.00	<.001	.387	Cauc. participants: Own- vs. other-race	23	10.21	<.001	0.148	0.12, 0.18	1.879	1.27, 2.61
						Asian participants: Own-vs. other-race	23	0.31	.760	-0.007	-0.05, 0.04	-0.066	-0.50, 0.37
	Stimulus ethnicity x familiarity	1,46	7.14	.010	.134	Caucasian IDs: Learnt vs. novel	23	3.93	.001	0.116	0.06, 0.18	1.036	0.45, 1.68
						East Asian IDs: Learnt vs. novel	23	1.64	.116	0.030	-0.01, 0.07	0.351	-0.09, 0.81
	Familiarity x trial type	1,46	20.66	<.001	.310	Leant IDs: Match vs. mismatch	23	0.89	.381	-0.027	-0.09, 0.04	-0.258	-0.86, 0.33
						Novel IDs: Match vs. mismatch	23	1.84	.079	0.088	-0.01, 0.19	0.611	-0.07, 1.32

Table 2. Full list of significant statistical results of Experiment 2 for the Quality of contact rating, sorting task errors and recognition task performance.

Analysis	Effect	*df*	*F*	*p*	η^2_p	Post-hoc comparison	*df*	*t*	*p*	M_{diff}	95% CI	d_{unb}	95% CI
Quality of contact	Contact ethnicity x group	1,46	81.06	<.001	.638	Cauc. participants: Own- vs. other-race	23	8.11	<.001	1.667	1.24, 2.09	2.044	1.31, 3.00
						Asian participants: Own- vs. other-race	23	4.90	<.001	1.167	0.67, 1.66	1.573	0.81, 2.42
Sorting task errors	Stimulus ethnicity	1,46	15.18	<.001	.248								
	Stimulus ethnicity x group	1,46	5.11	.029	.100	Cauc. participants: Own- vs. other-race	23	4.55	<.001	2.583	1.41, 3.76	1.108	0.54, 1.73
						Asian participants: Own- vs. other-race	23	1.06	.301	-0.708	-2.09, 0.68	-0.272	-0.81, 0.25
Recognition task *d'*	Stimulus ethnicity	1,46	4.40	.042	.087								
	Stimulus ethnicity x group	1,46	18.41	<.001	.286	Cauc. participants: Own- vs. other-race	23	4.68	<.001	1.028	0.57, 1.48	1.146	0.57, 1.78
						Asian participants: Own- vs. other-race	23	1.50	.147	0.353	-0.13, 0.84	0.301	-0.11, 0.72
hits	Stimulus ethnicity x group	1,46	9.02	.004	.164	Cauc. participants: Own- vs. other-race	23	2.78	.011	0.112	0.03, 0.20	0.701	0.17, 1.27
						Asian participants: Own- vs. other-race	23	1.39	.179	0.049	-0.02, 0.12	0.275	-0.13, 0.69
CR	Stimulus ethnicity x group	1,46	12.95	.001	.220	Cauc. participants: Own- vs. other-race	23	4.84	<.001	0.121	0.07, 0.17	0.849	0.44, 1.31
						Asian participants: Own- vs. other-race	23	1.06	.299	0.040	-0.04, 0.12	0.234	-0.21, 0.69

Figure Captions

Figure 1. (A) Sorting errors, (B) matching task accuracy and (C) learning effects during matching (difference in accuracy between learnt and novel identities) for Caucasian and East Asian identities in Caucasian and East Asian participants. Error bars denote 95% confidence intervals (CI), grey dots represent individual subject data.

Figure 2. Matching accuracy for Caucasian and East Asian identities in Caucasian (A) and East Asian participants (B). Error bars denote 95% confidence intervals (CI), grey dots represent individual subject data.

Figure 3. Correlational analysis between sorting errors and the learning effect (learnt – novel) during matching for Caucasian and East Asian identities in Caucasian and East Asian participants. Curved dashed lines denote 95% confidence band of the regression line, grey dots represent individual subject data.

Figure 4. (A) Sorting errors, (B) *d*' data as well as (C) hits and (D) correct rejections during old/new recognition for Caucasian and East Asian identities in Caucasian and East Asian participants. Error bars denote 95% confidence intervals (CI), grey dots represent individual subject data.

Figure 5. Correlational analysis between sorting errors and *d*' during old/new recognition for Caucasian and East Asian participants in Caucasian and East Asian participants. Curved dashed lines denote 95% confidence band of the regression line, grey dots represent individual subject data.

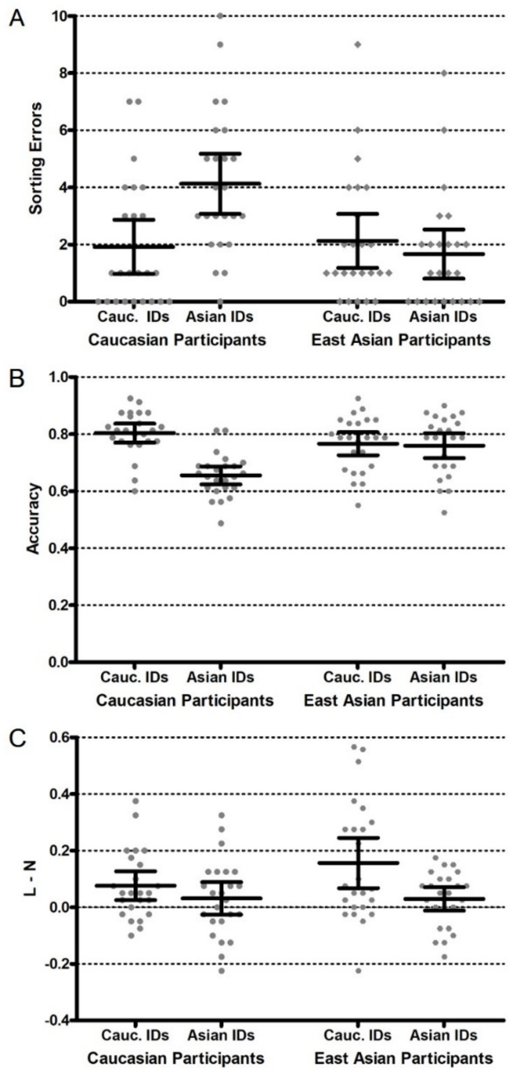
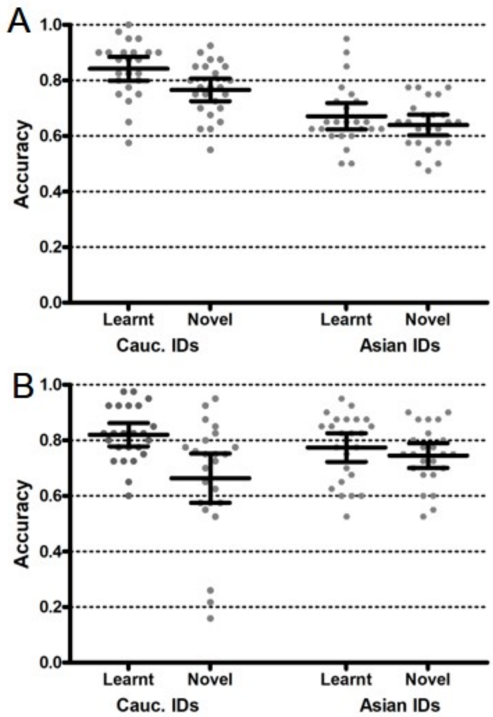

A
Sorting Errors
10
8
6
4
2
0
Cauc. IDs
Asian IDs
Cauc. IDs
Asian IDs
Caucasian Participants
East Asian Participants
B
Accuracy
1.0
0.8
0.6
0.4
0.2
0.0
Cauc. IDs
Asian IDs
Cauc. IDs
Asian IDs
Caucasian Participants
East Asian Participants
C
L - N
0.6
0.4
0.2
0.0
-0.2
-0.4
Cauc. IDs
Asian IDs
Cauc. IDs
Asian IDs
Caucasian Participants
East Asian Participants

Figure 1


A
B
Accuracy
1.0
0.8
0.6
0.4
0.2
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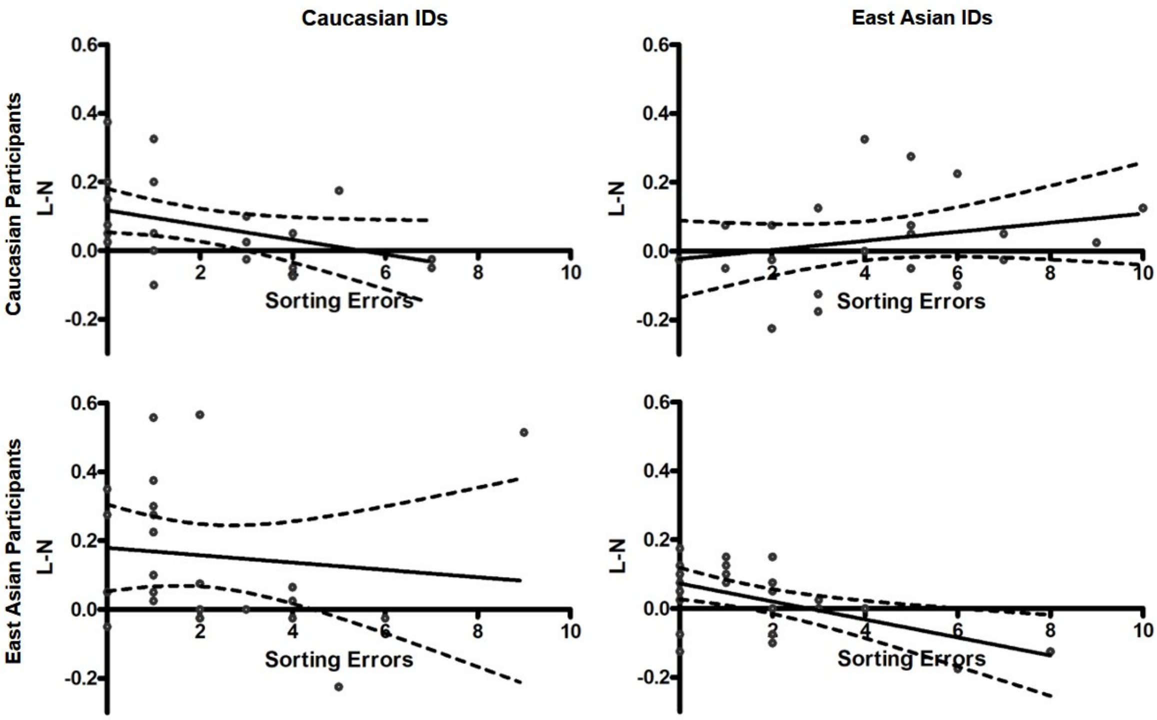
Learnt
Novel
Learnt
Novel
Cauc. IDs
Asian IDs

Figure 2



Caucasian IDs
East Asian IDs
Caucasian Participants
East Asian Participants
L-N
Sorting Errors
0.6
0.4
0.2
0.0
-0.2
2
4
6
8
10

Figure 3

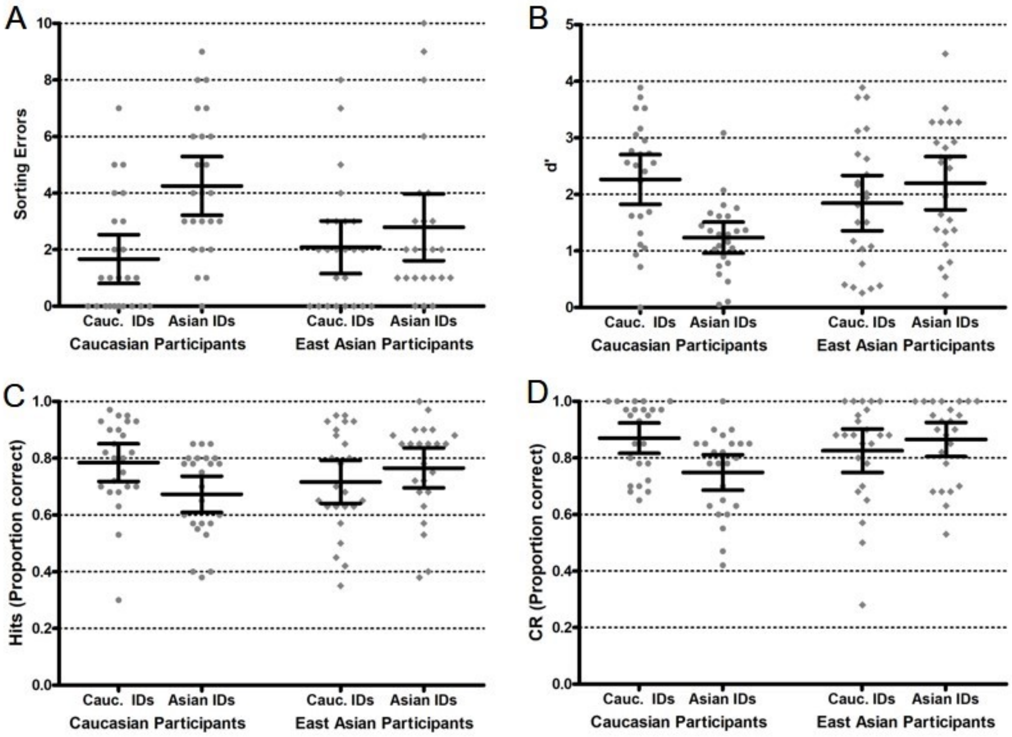

A
Sorting Errors
10
8
6
4
2
0
Cauc. IDs
Asian IDs
Caucasian Participants
Cauc. IDs
Asian IDs
East Asian Participants
B
d'
5
4
3
2
1
0
Caucasian Participants
East Asian Participants
C
Hits (Proportion correct)
1.0
0.8
0.6
0.4
0.2
0.0
D
CR (Proportion correct)

Figure 4

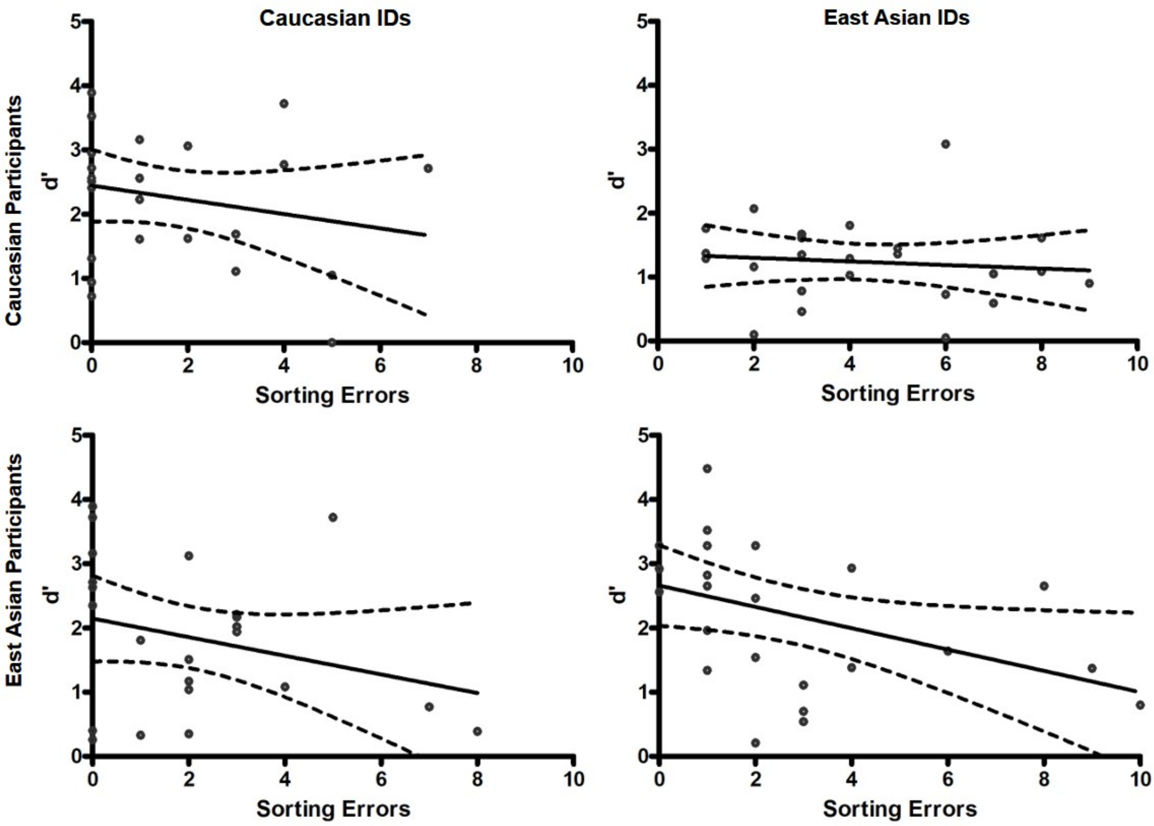

Caucasian IDs
East Asian IDs
Caucasian Participants
East Asian Participants
d'
Sorting Errors
0
1
2
3
4
5
6
8
10

Figure 5