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Recognising other-race faces is more effortful: The effect of individuation instructions on encoding-related ERP Dm effects

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ABSTRACT

Humans are better at recognising faces from their own vs. another ethnic background. Socio-cognitive theories of this own-race bias (ORB) propose that reduced recognition of other-race faces results from less motivation to attend to individuating information during encoding. Accordingly, individuation instructions that explain the phenomenon and instruct participants to attend to other-race faces during learning attenuate or eliminate the ORB. However, it is still unclear how exactly such instructions affect other-race face processing. We addressed this question by investigating encoding-related event-related brain potentials, contrasting neural activity of subsequently remembered and forgotten items (Dm effects). In line with socio-cognitive accounts, individuation instructions reduced the ORB. Critically, instructions increased Dm effects for other-race faces, suggesting that more processing resources were allocated to these faces during encoding. Thus, compensating for reduced experience with other-race faces is possible to some extent, but additional resources are needed to decrease difficulties resulting from a lack of perceptual expertise.

1. Introduction

Face recognition is crucial to our social interactions, and we are remarkably good at it. However, not all faces are recognised equally well. One of the most widely researched phenomena in the face memory literature is the so-called own-race bias (ORB, or other-race effect)[1], the well-documented finding that people more accurately remember faces of their own ethnic group compared to faces of another ethnicity (for a review, see Meissner & Brigham, 2001). Although these difficulties with other-race face recognition can pose substantial challenges for applied contexts, such as passport control and eyewitness testimony, the exact mechanisms underlying the ORB remain an issue of debate. Particularly relevant for the present study, it has been suggested that the ORB results from a lack of motivation to individuate other-race faces and from a failure to attend to individuating information in these faces (Hugenberg, Young, Bernstein, & Sacco, 2010). Accordingly, an explicit instruction to individuate other-race faces has been reported to reduce or even eliminate the effect (e.g., Hugenberg, Miller, & Claypool, 2007). In the present study, we examined the extent to which individuation instructions modulate neural correlates of the ORB. Importantly, previous purely behavioural work has focused exclusively on the effect of giving individuation instructions during learning on memory performance at test, thus providing only indirect evidence of an encoding-based mechanism underlying the effect. Here, we directly investigated whether individuation instructions modulate encoding-related neural processes, and whether they do so selectively for other-race faces.

Theoretical accounts of the ORB generally fall into one of two categories, those highlighting a lack of perceptual expertise with the other-race category, and those emphasising socio-cognitive or motivational aspects. Perceptual expertise accounts assume that face recognition is finely tuned to the faces in our environment, which happen to be own-race faces for the majority of people. For instance, faces are often believed to be processed in a configural and/or holistic manner, and these perceptual processes may be less efficient for other-race faces because most people have only limited experience with them (Hancock & Rhodes, 2008; Tanaka, Kiefer, & Bukach, 2004). In addition, it has been suggested that other-race faces are coded less precisely along

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[1] Please note that the use of the term ‘race’ in neuroscientific research has recently been criticised (see Cubelli & Della Sala, 2018). In this article, we use the term to refer to visually distinctive ethnic groups (see Wiese, 2013, for a similar statement).

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perceptual dimensions in a multidimensional face space (MDFS; Valentine, 1991). These dimensions have been developed to optimally distinguish between the faces we regularly encounter in our environment (i.e., typically own-race faces), but are ill-suited to encode other-race faces (Valentine & Endo, 1992; Valentine, Lewis, & Hills, 2016). Accordingly, deficits during perceptual processing and/or less fine-grained representations of other-race faces are thought to impair subsequent memory for this face category. Crucially, these deficits are thought to result from reduced long-term expertise with other-race faces, and they are therefore unlikely to change substantially when participants are simply given particular instructions.

Alternatively, socio-cognitive accounts propose an initial categorisation of faces into social in- or out-groups (e.g., into own versus other ethnic groups) when certain out-group defining features (e.g., a different skin tone) are detected (Levin, 1996, 2000). Whereas out-group faces are only processed at a categorical level (Rodin, 1987; Sporer, 2001), in-group faces are processed more in-depth, resulting in superior memory. Importantly, however, the Categorization – Individuation Model (CIM; Hugenberg et al., 2010) suggests that, in addition to social categorisation, perceiver motivation can modulate the processing of own- and other-race faces. In particular, perceiver motives can redirect attention to individuating information in other-race faces under certain circumstances, for example, when individual identity of other-race faces becomes particularly relevant. Therefore, while previous socio-cognitive accounts are mainly centred around a social categorisation of faces into in- and out-groups, the CIM assumes that the effect of an initial categorisation can be modulated by situational motives or cues.

In support of this account, the ORB can be reduced or even eliminated when participants are informed about the effect prior to the experiment and are asked to focus on individuating information in other-race faces (Hugenberg et al., 2007; Rhodes, Locke, Ewing, & Evangelista, 2009; Young, Bernstein, & Hugenberg, 2010). These findings suggest that people are in principle able to recognise own- and other-race faces similarly well, but per default do not process other-race faces in sufficient detail (Hugenberg et al., 2010). As a qualification to these initial findings, however, others have found these instruction effects to depend on expertise (Pica, Warren, Ross, & Kehn, 2015; Young & Hugenberg, 2012). In these studies, participants with higher amounts of other-race contact showed a stronger decrease in the ORB after receiving individuating instructions compared to people with more limited other-race contact.

As a further qualification, a more recent study has not observed any effects of individuation instructions (Wan, Crookes, Reynolds, Irons, & McKone, 2015). Importantly, although participants in this study reported having put more effort into individuating other-race relative to own-race faces, this did not translate into better memory. Similarly, Crookes and Rhodes (2017) showed that participants spent more time studying other- than own-race faces during a self-paced learning phase. However, this increased effort again did not reduce the ORB (see also Tullis, Benjamin, & Liu, 2014). These results are hard to reconcile with CIM, as they suggest that increased motivation is not sufficient to compensate for a lack of long-term experience with other-race faces. To summarise, the behavioural findings available at present are mixed and show somewhat inconsistent effects of individuation instructions on the ORB in recognition memory.

As outlined in the previous paragraphs, the ORB appears to be based on a number of different perceptual, cognitive, and motivational factors, which are assumed to become effective during learning. Yet, behavioural measures of memory performance can only indirectly inform about the specific processing stage at which a particular factor influences perceptual and/or mnestic processing. By contrast, event-related brain potentials (ERPs) offer a fine-grained analysis of the various subprocesses involved in stimulus processing and memory encoding. In the present study, we therefore used ERPs to examine the neural mechanisms underlying own- and other-race face learning. Specifically, we analysed difference due to memory (Dm) effects (e.g., Friedman & Johnson, 2000; Paller, Kutas, & Mayes, 1987), which, as discussed in more detail below, provide a direct and sensitive measure of successful versus unsuccessful memory encoding.

Dm effects contrast brain activity recorded during the learning phase of a recognition memory experiment for items that are subsequently remembered with items that are subsequently forgotten. In ERP studies, items that are later correctly remembered (subsequent hits) typically elicit more positive amplitudes during learning than subsequent misses. These effects have a centro-parietal scalp distribution, start approximately 300 ms after stimulus onset, and their magnitude has been found to predict subsequent memory performance (Paller et al., 1987). While Dm effects have originally been reported for words (Paller et al., 1987), they have also been observed for faces (Sommer, Schweinberger, & Matt, 1991; Sommer, Heinz, Leuthold, Matt, & Schweinberger, 1995; Sommer, Komoss, & Schweinberger, 1997; Wolff, Kemter, Schweinberger, & Wiese, 2014; Yovel & Paller, 2004).

However, to date, only very few studies have investigated Dm effects for own- and other-race faces. Lucas, Chiao, and Paller (2011) observed more pronounced Dm effects for own- than for other-race faces, which they interpreted to reflect more elaborate processing of own-race faces. Other studies have focused on the different contributions of familiarity and recollection (see Yonelinas, 2002) to own- and other-race face recognition (e.g., Herzmann, Minor, & Adkins, 2017; Herzmann, Minor, & Curran, 2018; Herzmann, Willenbockel, Tanaka, & Curran, 2011). Overall, these studies suggest that successful memory encoding is more effortful for other- compared to own-race faces. For example, Herzmann et al. (2011) found recollection-related Dm effects to be more pronounced for other- relative to own-race faces, which was interpreted to reflect less efficient encoding (see also Herzmann et al., 2017). A more recent study further showed that encoding-related activity contributing to Dm effects is sensitive to task difficulty (Herzmann et al., 2018). The authors observed overall more positive amplitudes during a divided attention compared to a focused attention task during encoding, suggesting the recruitment of additional neural resources when the task is more difficult. This modulation did neither affect the behavioural ORB nor its neural correlates (for related findings, see also Stahl, Wiese, & Schweinberger, 2010), which was interpreted to reflect that differences in own- and other-race face processing were unaffected by an attentional manipulation. Importantly, however, this study demonstrates that neural activity underlying Dm effects is susceptible to task difficulty and the allocation of attentional resources.

The present experiment examined the effect of individuation instructions on the ORB in recognition memory and encoding-related neural processes. Participants were randomly assigned to one of two groups (standard instruction, individuation instruction). Participants in the individuation instruction group were informed about the ORB and asked to pay particular attention to other-race faces during encoding, while participants in the standard instruction group did not receive this information. Participants then completed an old/new recognition memory experiment containing own- and other-race face stimuli while their EEG was recorded. To directly investigate the mechanisms underlying successful encoding in the two instruction conditions, we compared Dm effects that contrast neural activity during encoding for subsequently remembered and forgotten items for own- and other-race faces in both groups. Previous research has suggested that the magnitude of Dm effects reflects the amount of effort put into individuating items during learning (e.g., Herzmann et al., 2011, 2017). Therefore, if successful learning of other-race faces as a consequence of enhanced motivation in the individuation instruction condition also required additional effort, we would expect more pronounced Dm effects for other-race faces in the individuation instruction relative to the standard instruction condition.

2. Method

2.1. Participants

36 participants (26 female, 18–36 years, $M_{age} = 21.7$, $SD_{age} = 4.1$) with a Caucasian ethnic background took part in the study. None of them reported having lived in an Eastern Asian country. All participants had normal or corrected-to-normal vision and were right-handed according to the Edinburgh Handedness Questionnaire (Oldfield, 1971). In addition, none of the participants reported to suffer from any skin or neurological conditions or taking any psychoactive medication. Participants gave written informed consent and received £15 or course credit for participating. The study was approved by the Department of Psychology's ethics committee at Durham University.

2.2. Stimuli and apparatus

A total of 384 photographs of unfamiliar faces were used as stimuli. Photographs depicted full frontal views of faces with neutral expression and were taken from various face databases (for origin of images, see Wiese & Schweinberger (2018), and for details regarding ratings of ethnic typicality for approximately 50 % of the images, see Wiese, Kaufmann, & Schweinberger, 2014). Half of the photographs depicted Caucasian faces, the other half showed East Asian faces (50 % female, respectively). Using Adobe Photoshop (CS4 Extended, 11.0.2), faces were cut from the original images, pasted to a uniform black background and converted to greyscale. Stimuli were then resized, framed within an area of 170 × 216 pixels (10.55 × 13.41 cm), resulting in a visual angle of 6.7° × 8.5° at a viewing distance of 100 cm. All stimuli were presented in the centre of a computer monitor with a screen resolution of 1024 × 768 pixels. The experiment was created and run using E-Prime 2.0 (Psychology Software Tools).

After the main experiment, participants completed two questionnaires. The first (see Hancock & Rhodes, 2008) assessed contact towards Caucasian and Chinese individuals, and participants were required to answer 15 items (e.g., "I interact with Caucasian/Chinese people on a daily basis", "I know lots of Caucasian/Chinese people") on a 6-point scale ranging from "very strongly disagree" to "very strongly agree". The second questionnaire (Wan et al., 2015) contained two items where participants had to indicate how much special effort they put into telling apart the faces of Caucasian and Chinese people on a 7-point scale, with endpoints labelled as "just normal effort, nothing special" and "a lot of special effort".

2.3. Design

Participants were randomly assigned to one of two experimental groups. Similar to the procedure reported by Hugenberg et al. (2007), all participants were told that they would take part in a face recognition experiment consisting of six learning and test phases. They were asked to closely attend to the faces presented during the learning phase as they would be asked to later recognise them. Participants in the individuation instruction condition were additionally informed about the own-race bias and instructed to put extra effort into learning other-race faces and pay close attention to individual characteristics in them. Note that we utilised the original instructions employed by Hugenberg et al. (2007) with only minor adaptations resulting from the specific own- and other-race categories used in the current experiment (i.e., the ethnic categories "Caucasian" and "East Asian" instead of "White" and "Black").

2.4. Procedure

After providing written informed consent, participants were prepared for EEG recording and seated in an electrically shielded and sound attenuated chamber, with their head in a chin rest approximately 100 cm from a computer screen. The experiment comprised six blocks, each consisting of a learning and test phase, and with self-paced breaks between blocks. Each learning phase consisted of 32 trials, with an equal number of Caucasian and East Asian faces (50 % female, respectively). All trials were presented in random order. Each trial began with a fixation cross presented for 1000 ms on average (jittered between 750 and 1250 ms), which was replaced by the face stimulus shown for 3000 ms. During each test phase, all items presented during the learning phase along with an equivalent number of new items (again, 50 % Caucasian, 50 % female; 64 trials in total) were shown in random order. Trials started with the presentation of a fixation cross (again, 1000 ms on average, jittered between 750 and 1250 ms). The subsequent face image remained on the screen for 2000 ms during which participants were required to make old/new judgements via key presses (left and right index finger). Assignment of key presses and stimuli to first appear in the learning or test phase were counterbalanced across participants.

2.5. EEG recording and data analysis

EEG was recorded from 64 sintered Ag/Ag-Cl electrodes using an ANT Neuro system (Enschede, Netherlands) with a sampling rate of 512 Hz (DC to 120 Hz) and electrode sites corresponding to an extended 10–20 system. An electrode on the forehead served as ground and Cz as the recording reference. Correction of blink artefacts was carried out using the algorithm implemented in BESA 6.3 (Gräfelfing, Germany). For analysis of Dm effects, each learning task trial of each participant was manually sorted into "subsequent hits" or "subsequent misses" based on the participant's response at test. EEG was then segmented from -200 until 1000 ms relative to stimulus onset. The first 200 ms served as baseline. Artefact rejection was performed using an amplitude threshold of 100 μV and a gradient criterion of 75 μV. All remaining trials were recalculated to average reference, digitally low-pass filtered at 40 Hz (12 dB/oct, zero phase shift), and averaged according to experimental conditions. The average number of trials was 58.0 (SD = 9.0) for subsequent hits and 30.3 (SD = 10.3) for subsequent misses for own-race faces and 49.9 (SD = 12.6) for subsequent hits and 37.7 (SD = 13.4) for subsequent misses for other-race faces in the standard instruction group, and 57.2 (SD = 11.9) for subsequent hits and 31.7 (SD = 9.9) for subsequent misses for own-race faces and 55.3 (SD = 11.3) and 33.5 (SD = 7.6) for subsequent misses for other-race faces in the individuation instruction group. All participants had a minimum of 17 artefact-free trials in each experimental condition.

In the averaged ERP waveforms, Dm effects were calculated by subtracting subsequent misses from subsequent hits for own- and other-race faces for the two participant groups, respectively. For all experimental conditions, mean amplitudes were derived from the resulting difference waves for an early (300–600 ms) and late (600 – 1000 ms) time window at electrodes F3, F1, Fz, F2, F4; FC3, FC1, FCz, FC2, FC4, C3, C1, Cz, C2, C4, CP3, CP1, CPz, CP2, CP4, P3, P1, Pz, P2, and P4. Time windows were selected based on visual inspection of the grand averages, but corresponded to those used in previous studies (e.g., Herzmann et al., 2011).

To examine memory performance, we analysed the sensitivity measure d' (z-standardised hits minus z-standardised false alarm rates) and the criterion measure C (negative sum of z-standardised his and z-standardised false alarms, divided by 2) following signal detection theory (see e.g., Wickens, 2002). In addition, we analysed hits and correct rejection (CR) rates. Statistical analyses of self-reported own- and other-race contact and effort to individuate, as well as recognition memory performance were performed using mixed-model Analyses of variance (ANOVAs) using the within-subjects factor contact/face ethnicity (own-race, other-race) and the between-subjects factor participant group (individuation instruction, standard instruction). Pairwise comparisons were performed using paired-samples t-tests. Statistical analyses of Dm effects (difference between subsequent hits and misses) were carried out using mixed-model ANOVAs with the within-subjects factors face ethnicity (own-race, other-race), laterality (five factor levels; left, mid-left, midline, mid-right, right) and anterior/posterior (five factor levels; frontal, fronto-central, central, centro-parietal, parietal), as well as the between-subjects factor participant group (individuation instruction, standard instruction). When appropriate, degrees of freedom were adjusted according to the Greenhouse-Geisser procedure.

Following an estimation approach in data analysis (see e.g., Cumming, 2012; Cumming & Calin-Jageman, 2017), effect sizes and appropriately sized confidence intervals (CI) are reported throughout. As suggested by Cumming (2012), Cohen's d for paired samples t-tests[2] was bias-corrected and calculated using the mean SD rather than the SD of the difference as the denominator (Cohen's d_{unb}) using ESCI (Cumming & Calin-Jageman, 2017). 90 % CIs for partial eta squared (η_p^2) were calculated using scripts provided by M.J. Smithson (http://www.michaelsmithson.online/stats/CIstuff/CI.html).

3. Results

3.1. Rating data

The mixed-model ANOVA revealed no difference in contact with own- and other-race people between the individuation instruction and standard instruction group, $F(1,34) = 0.09$, $p = .769$, $\eta_p^2 = .003$, 90 % CI [.00, .08]. A paired-samples t-test on the combined data from both groups revealed that participants reported substantially higher contact with own- ($M = 5.397$, 95 % CI [5.09, 5.70]) when compared to other-race people ($M = 2.472$, 95 % CI [2.17, 2.78]), $t(35) = 11.62$, $p < .001$, $M_{diff} = 2.925$, 95 % CI [2.41, 3.44], $d_{unb} = 3.168$, 95 % CI [2.30, 4.16].

The mixed-model ANOVA on ratings of effort yielded a significant main effect of ethnicity, $F(1,34) = 18.86$, $p < .001$, $\eta_p^2 = .357$, 90 % CI [.14, .51], indicative of more effort put into individuating other- ($M = 4.972$, 95 % CI [4.55, 5.40]) compared to own-race faces ($M = 3.722$, 95 % CI [3.16, 4.52]). Neither the main effect participant group, $F(1,34) = 0.58$, $p = .451$, $\eta_p^2 = .017$, 90 % CI [.00, .14], nor the face ethnicity x participant group interaction, $F(1,34) = 1.13$, $p = .296$, $\eta_p^2 = .032$, 90 % CI [.00, .17], reached significance.

3.2. Memory performance

A mixed-model ANOVA on d '(Fig. 1a) yielded a significant main effect of face ethnicity, $F(1,34) = 146.28$, $p < .001$, $\eta_p^2 = .811$, 90 % CI [.70, .86], indicating higher sensitivity to own- ($M = 1.402$, 95 % CI [1.25, 1.55]) relative to other-race faces ($M = 0.837$, 95 % CI [0.68, 1.00]). The main effect of participant group did not reach statistical significance, $F(1,34) = 0.78$, $p = .383$, $\eta_p^2 = .022$, 90 % CI [.00, .15]. Interestingly, the face ethnicity x participant group interaction approached significance, $F(1,34) = 4.04$, $p = .052$, $\eta_p^2 = .106$, 90 % CI [.00, .27]. However, additional comparisons carried out to test the a priori prediction of no ORB in the individuation instruction condition revealed significantly higher sensitivities for own- when compared to other-race faces both in the individuation instruction, $t(17) = 7.06$, $p < .001$, $M_{diff} = 0.471$, 95 % CI [0.33, 0.61], $d_{unb} = 1.051$, 95 % CI [0.62, 1.57], as well as in the standard instruction group, $t(17) = 10.07$, $p < .001$, $M_{diff} = 0.659$, 95 % CI [0.52, 0.80], $d_{unb} = 1.053$, 95 % CI [0.67, 1.52].

A corresponding ANOVA on C indicated a significant main effect of face ethnicity, $F(1,34) = 11.65$, $p = .002$, $\eta_p^2 = .255$, 90 % CI [.07, .43], with overall more conservative responses to own-race ($M = -0.299$, 95 % CI [-0.40, -0.20]) compared to other-race faces ($M = -0.181$, 95 % CI [-0.30, -0.07]). Neither the main effect of participant group, $F(1,34) = 1.62$, $p = .211$, $\eta_p^2 = .046$, 90 % CI [.00, .19], nor the face ethnicity x participant group interaction, $F(1,34) = 1.86$, $p = .182$, $\eta_p^2 = .052$, 90 % CI [.00, .20], reached significance (Fig. 1b).

A corresponding analysis on hits (Fig. 1c) revealed significant main effects of face ethnicity, $F(1,34) = 16.43$, $p < .001$, $\eta_p^2 = .326$, 90 % CI [.12, .49], which further interacted with participant group, $F(1,34) = 5.99$, $p = .020$, $\eta_p^2 = .150$, 90 % CI [.01, .32]. Post-hoc comparisons showed higher hit rates for own-race compared to other-race faces in the standard instruction group, $t(17) = 4.32$, $p < .001$, $M_{diff} = 0.097$, 95 % CI [0.05, 0.14], $d_{unb} = 0.738$, 95 % CI [0.33, 1.20]. Critically, no comparable difference was detected in the individuation instruction group, $t(17) = 1.22$, $p = .240$, $M_{diff} = 0.024$, 95 % CI [-0.02, 0.07], $d_{unb} = 0.231$, 95 % CI [-0.16, 0.64].

For CR (Fig. 1d), a significant main effect of face ethnicity, $F(1,34) = 79.07$, $p < .001$, $\eta_p^2 = .699$, 90 % CI [.53, .78], indicated significantly higher CR rates to own-race ($M = 0.813$, 95 % CI [0.78, 0.85]) compared to other-race faces ($M = 0.704$, 95 % CI [0.65, 0.76]). Neither the main effect of participant group, $F(1,34) = 1.00$, $p = .324$, $\eta_p^2 = .029$, 90 % CI [.00, .16], nor the face ethnicity x participant group interaction, $F(1,34) = 0.63$, $p = .434$, $\eta_p^2 = .018$, 90 % CI [.00, .14], reached significance.

3.3. ERP results

Grand average ERPs for subsequent hits and subsequent misses for own- and other-race faces are depicted in Fig. 2 (standard instruction group) and 3 (individuation instruction group).

A mixed-model ANOVA on the early Dm time window (300–600 ms) yielded a significant main effect of anterior/posterior, $F(4,136) = 8.12$, $p = .003$, $\eta_p^2 = .193$, 90 % CI [0.08, 0.27], reflecting a gradual increase in Dm effects from anterior to posterior sites. Crucially, a significant laterality x face ethnicity x participant group interaction was observed, $F(4,136) = 2.92$, $p = .024$, $\eta_p^2 = .079$, 90 % CI [0.01, 0.14]. Post-hoc comparisons revealed significantly larger Dm effects for other-race faces in the individuation instruction relative to the standard instruction group at midline, $F(1,34) = 5.94$, $p = .020$, $\eta_p^2 = .149$, 90 % CI [0.01, 0.32], and mid-right hemispheric electrodes, $F(1,34) = 4.81$, $p = .035$, $\eta_p^2 = .124$, 90 % CI [0.00, 0.29], all other $Fs \leq 2.32$, $ps \geq .137$, $\eta_p^2 \geq .064$ (Fig. 4). Corresponding differences between Dm effects in the individuation instruction and standard instruction group were not detected for own-race faces, all $Fs \leq 0.66$, $ps \geq .422$, $\eta_p^2 \leq .019$.

A corresponding mixed-model ANOVA on the late Dm time window (600−1000 ms) again revealed a significant main effect of anterior/posterior, $F(4,136) = 12.51$, $p < .001$, $\eta_p^2 = .269$, 90 % CI [0.15, 0.35], reflecting more pronounced Dm effects over posterior relative to anterior sites. No other significant effects were observed, all $Fs \leq 2.12$, $ps \geq .081$, $\eta_p^2 \leq .059$ (Fig. 3).

4. Discussion

The aim of the present study was to investigate whether more accurate memory for own- relative to other-race faces results from reduced effort and motivation to attend to the latter category during learning - a key proposition put forward by socio-cognitive theories of the ORB. We therefore compared a group of participants who received explicit instructions to closely attend to other-race faces during learning prior to the experiment with a control group that did not receive comparable instructions. Importantly, to directly investigate whether such instructions modulate how faces are encoded into memory, we analysed neural activity during the learning phases of the experiment. In line with socio-cognitive accounts, individuation instructions eliminated the ORB in hit rates but not in correct rejections, and analysis of d' revelaed a trend for an interaction of participant group by instruction condition. Moreover, more pronounced early difference due to memory (Dm) effects contrasting activity for subsequently remembered vs. forgotten items were found for other-race faces in the individuation instruction relative to the standard instruction group, suggesting that individuation

[2] Please note that although our experimental design contained the between-subjects factor participant group, no independent samples t-tests were carried out. Accordingly, we only report repeated-measures d scores.

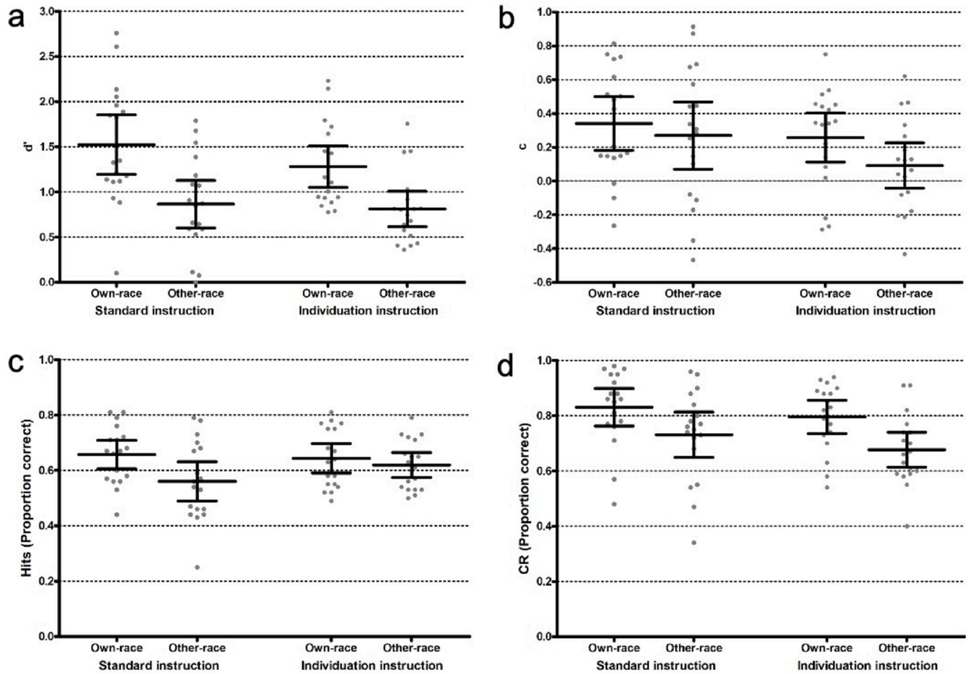

Fig. 1. Behavioural results. (a) *d'* and (b) *c* as well as (c) hit and (d) correct rejection (CR) rates for own- and other-race faces in the standard instruction and individuation instruction group.

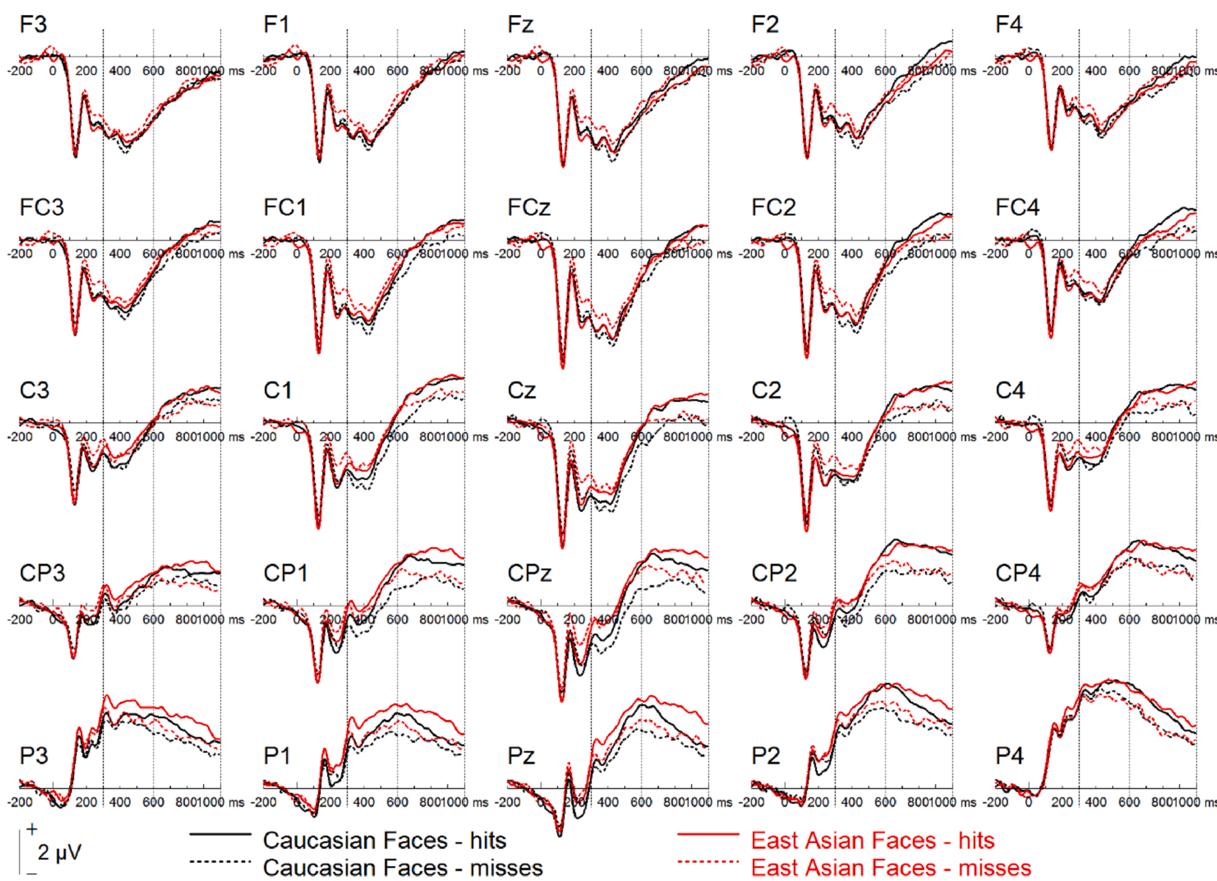

Fig. 2. Grand average ERPs from the standard instruction group. Dotted lines denote time ranges selected for analysis of Dm (difference due to memory) effects.

instructions encouraged more effortful processing of other-race faces. These findings are discussed in more detail below.

In line with previous work (Hugenberg et al., 2007; Rhodes et al., 2009; Young et al., 2010), the ORB in recognition memory was attenuated for participants in the individuation instruction group. This was clearly evident in hit rates, which revealed a significant ORB in the

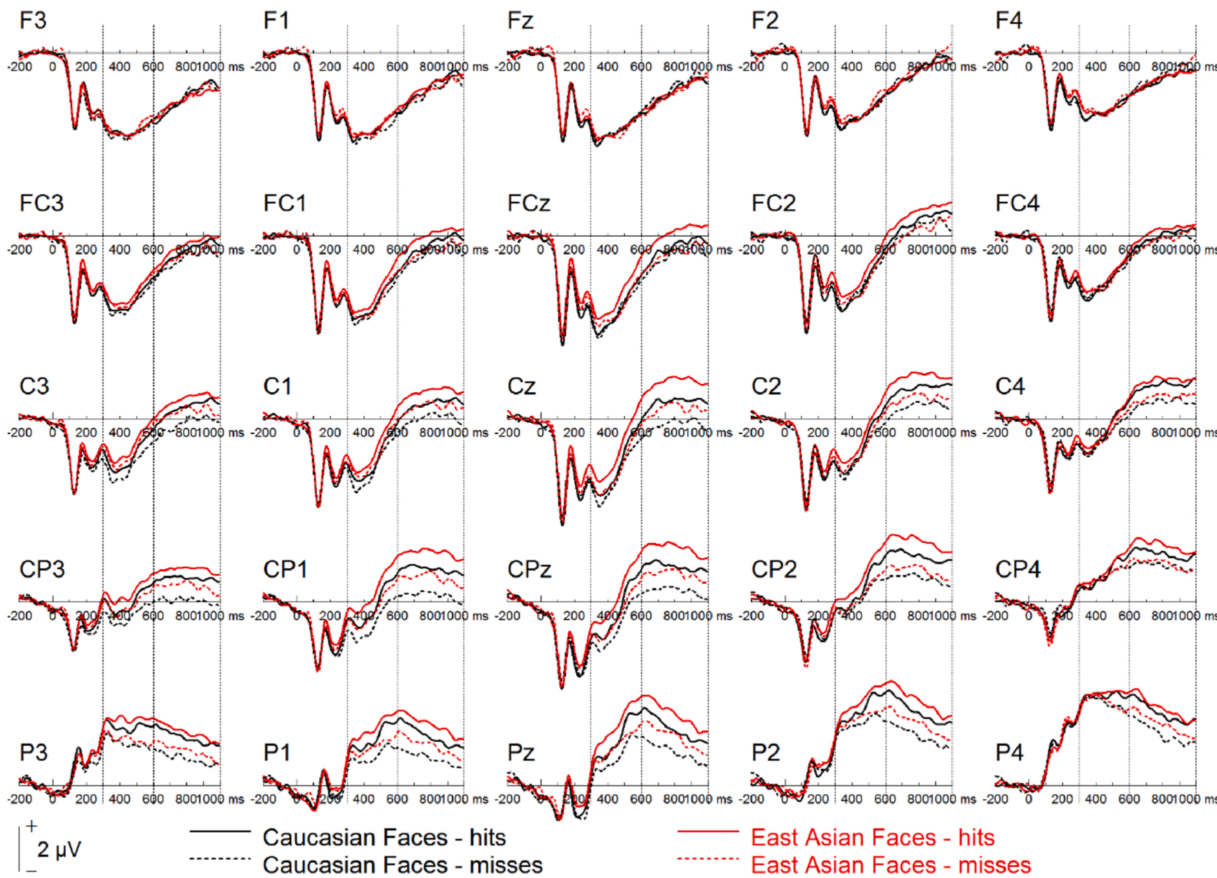

Fig. 3. Grand average ERPs from the individuation instruction group. Dotted lines denote time ranges selected for analysis of Dm (difference due to memory) effects.

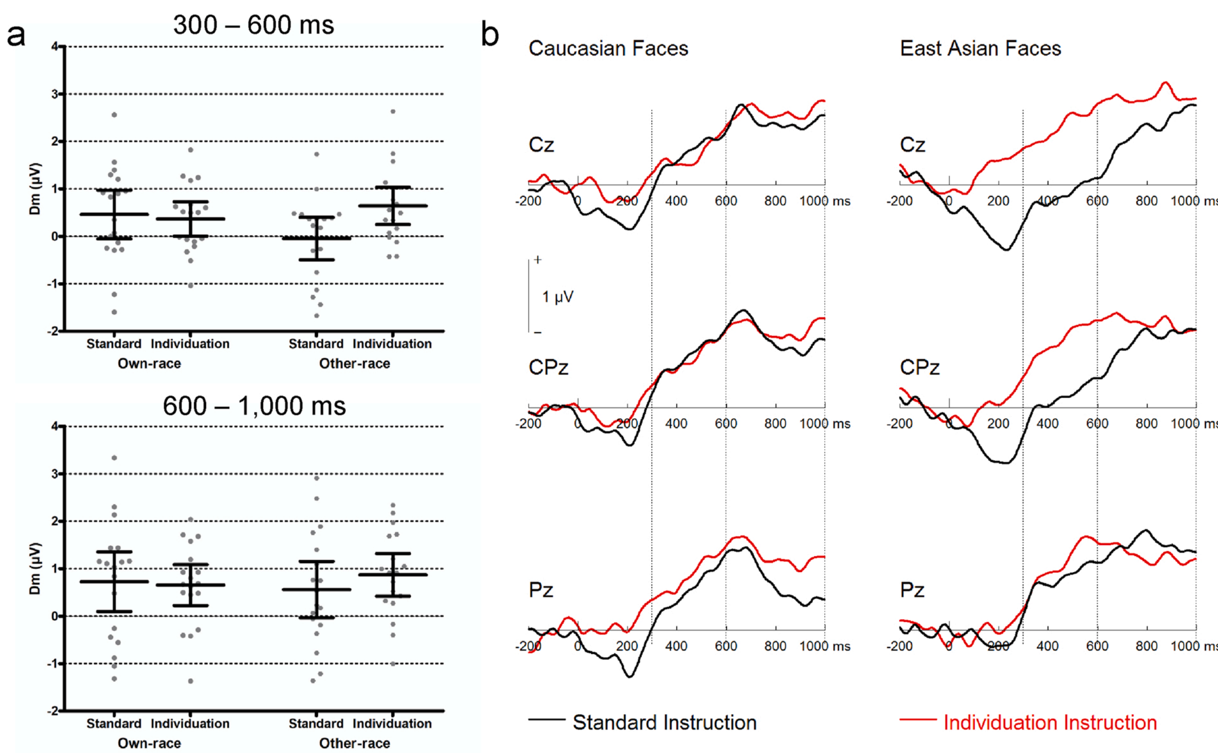

Fig. 4. Dm effects (i.e., the difference in µV between subsequent hits and misses). (a) Early (top) and late (bottom) Dm effects averaged across midline electrode sites for own- and other-race faces in the standard instruction and individuation instruction group. (b) ERP difference waves (subsequent hits minus subsequent misses) for own- and other-race faces in the standard instruction and individuation instruction condition at electrodes Cz, CPz, and Pz.

standard instruction but not in the individuation instruction group. Moreover, as evident from Fig. 1 c, the absence of a significant effect in the latter group resulted from improved recognition of other-race faces. A trend towards a reduced ORB in the individuation instruction condition was also observed in *d*'. However, the ORB was still significant in both groups. Thus, in the present study, individuation instructions most directly affected participants' 'old' responses to other-race faces, without a comparable benefit in sensitivity (or correct rejection rates). While it thus appears plausible that this increase in hit rates for other-race faces was at least partly based on a change in criterion between the groups, the analysis of *C* did not reveal a corresponding effect. Accordingly, our findings appear to be best interpreted as reflecting an increase in memory performance for other-race faces in the individuation instruction group, which is most clearly observed for those items that were presented during learning.

Surprisingly, although individuation instructions improved hit rates for other-race faces, participants in this group did not report having put more effort into individuating other-race faces than participants in the standard instruction group. Indeed, all participants reported more effort for other- relative to own-race faces, irrespective of group. While the reason for this result is somewhat unclear, it may partly reflect a lack of sensitivity of this measure that is based on subjective self-report. More specifically, participants might not be willing or fully able to accurately report effort during learning after the experiment. Interestingly, however, our results are in line with Wan et al. (2015) who also observed more self-reported effort allocated to other- relative to own-race faces, even when participants are not explicitly instructed to do so.

As outlined above, the main aim was to investigate whether individuation instructions encourage more in-depth processing of other-race faces during learning – a suggestion which has been offered in previous behavioural studies (e.g., Hugenberg et al., 2007) but has not been directly tested as of yet. In the present study, other-race faces elicited significantly larger Dm effects between 300 and 600 ms in the individuation instruction relative to the standard instruction group. It has previously been suggested that increased amplitudes for successfully remembered other-race faces in Dm effects reflect more effortful encoding (e.g., Herzmann et al., 2011). Thus, in the present study individuation instructions seem to have encouraged participants to allocate more attentional resources to other-race faces during encoding. This finding supports previous suggestions that, unless instructed to do so, other-race faces are processed in a more superficial manner when compared to own-race faces, possibly because of reduced motivation and attention (e.g., Hugenberg et al., 2010). The finding that Dm effects for own-race faces did not differ between groups might indicate that own-race faces are per default processed in sufficient depth, which is beneficial for subsequent recognition. Thus, the present ERP results show that, when participants are encouraged to individuate other-race faces, additional resources can be selectively recruited for the processing of these faces.

As discussed above, this additional effort allocated to other-race faces during learning was paralleled by improved recognition of other-race faces in the subsequent test phase, which was most clearly evident in increased hit rates for this face category. To the best of our knowledge, this provides the most direct evidence available to date that increased effort put into individuating other-race faces can enhance other-race face recognition. In contrast, previous work focused exclusively on the effect of individuation instructions on the ORB at test (e.g., Hugenberg et al., 2007). As such, these examinations provided rather indirect evidence for the suggestion that instructions promote individuation of other-race faces and offer limited insights into the processes engaged *during learning*. Here, we show that individuation instructions do indeed encourage more elaborate processing, and recruit additional processing resources selectively for other-race faces.

Of note, Dm effects in the present study reflect differences between subsequent hits and misses, while previous studies by Herzmann et al. (2011; 2017; 2018) analysed differences between recollection- and familiarity-based recognition during encoding. These differences between studies make a direct comparison somewhat difficult (see also Herzmann et al., 2011). However, more pronounced Dm effects for other-race faces as observed in the present study may nonetheless suggest that successful recognition is more effortful for other- relative to own-race faces (Herzmann et al., 2011; 2017), irrespective of whether these effects reflect recollection- or familiarity-based recognition. We further note that the only other previous study that examined Dm effects for subsequent hits and misses reported more pronounced effects for own- relative to other-race faces (Lucas et al., 2011). In the present study, however, Dm effects for own- and other-race faces did not differ significantly in the standard instruction condition (which is closer to the experimental manipulation used by Lucas and colleagues). While the reason for these discrepant findings is not entirely clear, it might be related to differences in experimental design. In particular, Lucas et al. (2011) presented faces from different ethnic categories in separate blocks, which may have resulted in less effortful processing of other-race faces, as such designs are presumably particularly sensitive to reducing attention or motivation to individuate.

As discussed above, our behavioural results suggest that the ORB only partly reflects a failure to sufficiently attend to other-race faces during encoding, which can to some extent be compensated by individuation instructions. Importantly, this compensatory increase in other-race face processing comes at the cost of more effortful processing during learning, which is reflected in the more pronounced Dm effects for other-race faces in the individuation instruction relative to the standard instruction group. Moreover, the finding of a clear memory advantage for own-race faces in sensitivity - even though participants preferentially allocated attentional resources to other-race faces during learning - suggests that other factors, such as reduced expertise with the other-race category, likely contributed to the ORB in the present study.

A potential limitation of the present experiment is that the origin of face databases was not matched across ethnic categories. Using images of faces from different ethnic groups that are, at the same time, unbalanced with regard to their origin could in principle introduce systematic differences between these sets that might, in turn, affect the pattern of results. We note that Wiese et al. (2014) who used an image set that substantially overlapped with the one of the present experiment observed an ORB in Caucasian as well as East Asian participants. In this study, participants also rated all images for ethnic typicality, and no significant difference between Asian and Caucasian faces was detected (with Asian faces rated as slightly more typical by both Asian and Caucasian participants). However, while we cannot rule out potential confounds resulting from the unbalanced origin of images with certainty for the present study, it seems unlikely that such potential effects could explain the observed differences between participant groups.

In conclusion, using a neural measure sensitive to motivational and attentional processes, we show that individuation instructions increased Dm effects for other-race faces and, at the same time, attenuated the ORB in recognition memory. These results strongly support previous suggestions that high levels of attention and increased effort put into individuating other-race faces during encoding can reduce the ORB. However, such additional effort appears to come with costs, which is indicated by enhanced neural processing. Moreover, the finding of a clear ORB in sensitivity even in the instruction group suggests that motivational factors can only partly explain the phenomenon and that other factors such as reduced experience with other-race faces play an important role in the generation of the effect.

Link to data

https://osf.io/gd9ac/?view_only=0792f47c8dce49ebbb6433f85bd2b5cb.

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Declaration of Competing Interest

None.

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