Electro-cortical implicit race bias does not vary with participants' race or sex

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Abstract

Previous research found evidence for electro-cortical race bias towards black target faces in white American participants irrespective of the task relevance of race. The present study investigated whether an implicit race bias generalises across cultural contexts and racial in- and out-groups. An Australian sample of 56 Chinese and Caucasian males and females completed four oddball tasks that required sex judgements for pictures of male and female Chinese and Caucasian posers. The nature of the background (across task) and of the deviant stimuli (within task) was fully counterbalanced. Event-related potentials (ERPs) to deviant stimuli recorded from three midline sites were quantified in terms of mean amplitude for four components: N1, P2, N2 and a late positive complex (LPC; 350-700 ms). Deviants that differed from the backgrounds in sex or race elicited enhanced LPC activity. These differences were not modulated by participant race or sex. The current results replicate previous reports of effects of poser race relative to background race on the LPC component of the ERP waveform. In addition, they indicate that an implicit race bias occurs regardless of participant's or poser's race and is not confined to a particular cultural context.

Keywords: Race bias, event related brain potentials, implicit race bias

Categorisation is a fundamental process that helps to structure the large amount of information with which we are confronted. It contributes to the prioritized processing of information that is essential for physical survival (Öhman & Mineka, 2001) and successful navigation of our social environments (Fiske & Neuberg, 1990). In the latter context, the expedient processing of human faces is of crucial importance, both in regards to the determination of personal identity and in the determination of the potential intentions of other humans (Calder & Young, 2005). The expedient processing of facial expressions of emotion is of particular relevance in the determination of others' intentions and has attracted considerable attention in research (see Adolphs, 2002; Palermo & Rhodes, 2007). In research on personal identity and on the processing of in-group and out-group related surface features, such as race, there is evidence that faces belonging to a racial out-group are categorized faster in a simple sorting procedure, recognized less well in a forced choice recognition test, and detected faster among an array of in-group faces (Levin, 1996, 2000; Meissner & Brigham, 2001; Sporer, 2001; but see Lipp, Terry, Smith, Tellegen, Kuebbeler, & Newey, 2009). A fear learning bias to racial out-group faces – as indexed by resistance to extinction of electrodermal responding – has been demonstrated in white and black American (Olsson, Ebert, Banaji & Phelps, 2005; Navarrete, Olsson, Ho, Mendes, Thomsen & Sidanius, 2009), and Caucasian-Australian (Mallan, Sax & Lipp, 2009) samples. However, little is known about the component processes that mediate these differences in response time, recognition performance or preparedness to form associations with threat.

Current research using methods from cognitive neuroscience has begun to elucidate the component processes reflected in behavioural measures of race bias. Studies employing fMRI have identified areas in the human brain that respond differently to racial in-group and out-group faces. Golby, Gabrieli, Chiao, and Eberhardt (2001) found less activation of the fusiform face area (Kanwisher, McDermott, & Chun, 1997) in response to racial out-group faces than to in-group faces in a sample of black and white American participants. This suggests that differential processing of in- and out-group faces occurs within the initial stages of face processing (Bruce & Young, 1986). Cunningham, Johnson, Raye, Gatenby, Gore, and Banaji (2004) demonstrated that presentation of racial out-group faces led to increased amygdala activation in a sample of white American participants, a finding that was explained in the context of negative evaluation of out-group race individuals.

Studies of the neuro-anatomical basis of out-group face processing are complimented by studies using event-related brain potentials (ERPs), derived from the human electroencephalogram (EEG). ERPs permit the mapping of the time course of the differential processing of both static and dynamic facial features indicative of sex, race, age, and emotional expression. In this tradition, Ito and Urland (2003) used an odd-ball paradigm to present two groups of white American participants with pictures of black and white male and female faces. Across four tasks, participants were presented with a series of five picture sequences drawn either from the same category (i.e., all black females) or with one deviant among them (e.g., a white male among black females). One group of participants was asked to classify the pictures by race whereas the second was asked to classify them by sex. Evidence for explicit race bias was present in larger N1 and P2 amplitudes and smaller N2 amplitudes to black faces than to white faces in the race task (and in larger P3, but that is likely to reflect the task requirements of the race task). Implicit race bias was evident in larger P3 to black faces regardless of sex in the sex task.

Ito and Urland (2005) extended these findings by assessing the effects of processing objectives (individualized vs. non social feature oriented processing: Macrae & Bodenhausen, 2000) on the processing of black versus white faces in a sample of white participants. They replicated some of their earlier findings, larger N1 and P2 to black faces, larger N2 to white faces, although some of the differences were modulated by the processing objectives. Moreover they found, across two experiments, an enhancement of the N170 component, a component that is selectively sensitive to human faces (Bentin, Allison, Puce, Perez, & McCarthy, 1996), to white in-group faces (see also Herrmann, Schreppel, Jäger, Koehler, Ehlis, & Fallgatter, 2007; Stahl, Wiese, & Schweinberger, 2008; Walker, Silvert, Hewstone, & Nobre, 2007).

The results reported by Ito and Urland (2003, 2005) are intriguing in that they support the notion that race is used as a feature during the early stages of face processing. However, they also raise a number of interesting questions which have been explored by other researchers. First, it was not clear whether a processing bias for black faces would generalize to other racial out-groups. Caldara, Rossion, Bovet, and Hauert (2004) presented Caucasian participants with pictures of Caucasian and Asian faces in a race categorization task whereas Caldara, Thut, Servoir, Michel, Bovet, and Renault (2003) employed pictures of Caucasian and Asian faces, butterflies, cars, and furniture in a picture identification task. Both studies found differences between racial in- and out-group faces evident at later ERP components. On the other hand, Herrmann et al. (2007) and Stahl et al. (2008) found larger N170 to pictures of Asian faces in Caucasian participants. The latter study however, failed to replicate the larger P2 to out-group race faces, which has emerged consistently in other studies (Ito & Urland, 2003, 2005).

Second, it was unclear whether the findings of Ito and Urland (2003, 2005) were indicative of the manner in which all persons process out-group race faces as no black participants were included. Dickter and Bartholow (2007) included white and black participants in their study of attentional race bias. Using an Eriksen flanker task Dickter and Bartholow found larger P2 and P300 and smaller N2 to out-group face targets in both participant groups (see also Golby et al., 2001, who employed a mixed race sample). Thus, the results reported by Dickter and Bartholow suggest that Ito and Urland’s findings are indeed indicative of a general processing bias for out-group race faces and are not limited to a particular sample.

Taken together, these studies suggest that evidence for an electro-cortical race bias is not restricted to white participants nor is it restricted to black out-group faces. Nevertheless, these ERP studies were conducted within the context of race-relations in the United States, where, by and large, most studies on racial bias are conducted using pictures of white and black Americans. Thus, the generality of these findings to different cultural contexts remains to be established. The demonstration that an implicit bias to racial out-group faces extends beyond the North American cultural context is an important step toward a better understanding of the potential universality of the effect and the mechanism that it reflects (Ito & Bartholow, 2009).

The aim of the present study was to replicate Ito and Urland's (2003, 2005) findings of a processing bias for out-group race faces in a different cultural context (Australia) with female and male Caucasian-Australian and Chinese/Chinese-Australian participants using Caucasian and Chinese faces as relevant racial in-/out-group stimuli. We presented all participants with four odd-ball tasks in which ERPs on deviant face trials were recorded in backgrounds of all Chinese female, Chinese male, Caucasian female or Caucasian male faces. Our primary focus was modulation of the late positive complex (LPC) on deviant trials that varied as a function of background race, however, modulation of early components of the ERP waveform (N1, P2 and N2) was also examined in light of previous findings. Explicit biases as assessed previously can be confounded with task requirements in that larger ERP components are obtained to out-group race faces in tasks that require a judgement and response based on race. It seems more instructive for our understanding of race biases if they can be observed under conditions in which race is de-emphasized and another characteristic of the face, such as sex, is the task relevant feature.

Method

Participants

Fifty-six students from the University of Queensland voluntarily participated in the study either for course credit or for $20 remuneration. Prior to commencing the experiment, all participants provided informed consent. Based on their sex and self-identification as Caucasian or Chinese, participants fell into one of four groups: Chinese Females (n = 16, mean age = 21.44 years [range = 19-27]; 15 right-handed [RH],1 left-handed [LH]); Chinese Males (n = 13, mean age = 21.75 years [range = 18-27]; 12 RH, 1 LH); Caucasian Females (n = 14, mean age = 22.71 years [range = 18-29]; all RH), and Caucasian Males (n = 13, mean age = 24.50 years [range = 20-36]; 11 RH, 2 LH). All participants had normal or corrected-to-normal vision, reported no history of mental illness, head injury, epilepsy or illicit drug use and were not currently taking medication (other than the contraceptive pill).

Stimuli

Pictorial stimuli consisted of a set of 36 greyscale (72 dpi) photographs 260 x 195 pixels in size of male and female faces in frontal pose and displaying a neutral expression. There were nine photographs each of Chinese females, Chinese males, Caucasian females, and Caucasian males. The Caucasian faces were sourced from the Matsumoto and Ekman database (Matsumoto & Ekman, 1988). The Chinese faces were provided by Dr William Hayward, Hong Kong University. Faces were edited using Jasc Paint Shop Pro, version 6.00 to remove any excess hair and all hair was coloured black. Pictures were set on a grey scale and dropped in a grey background of 260 x 195 pixels (7.52° x 5.97° of visual angle). Pictures were matched for brightness and contrast and presented in the centre of a 17” CRT (Samsung Multisync) computer screen with a resolution of 1280 x 1024 pixels.

Procedure

Each participant read and signed an informed consent form and completed the Edinburgh Handedness Inventory (Oldfield, 1971) and a custom-designed medical history questionnaire. The age, sex, and race of each participant were recorded. The participant was seated facing a 17” CRT monitor in a sound-attenuated room adjacent to the control room. Participants were prepared for EEG collection with the application of the electrode cap (32 channel Quick Cap, sintered Ag/AgCl electrodes, Neuroscan). Participants read a standard instruction sheet and completed a short set of practice trials that were the same as the experimental trials detailed below. They were presented with four experimental tasks in a counterbalanced order and allowed brief 1-5 minute breaks between tasks. Each task comprised 400 pictures of faces, broken down into 80 sets of five pictures each, and took about 20 minutes to complete. Participant were asked to classify the face on display as male or female by pressing one of two buttons on a four button button-box. Participants were asked to respond at their own pace and to ensure that they classified the faces correctly. Within each set of five pictures, a face was presented for 1000 ms followed by an inter-face interval of 1000 ms. After each set of five faces, an instruction asked the participant to press the spacebar to start the next set. Prior to the experiment participants were advised to use these periods to blink, cough, or stretch and to remain as still as possible during the trials. Presentation of the face stimuli in the experimental tasks and recording of behavioural data was controlled by DMDX (Forster & Forster, 2003).

Across the four tasks, the nature of the background stimuli was varied (Chinese female, Chinese male, Caucasian female, Caucasian male) and deviants were drawn from each of the four categories. In each task, a random subset of five pictures from the background category was presented on 20 of the 80 five-picture-sets. On the remaining 60 sets, a deviant picture from one of the three different categories was presented in positions three, four or five in 20 of the sets. On sets of background pictures only, one of the pictures presented in positions three, four or five was declared the deviant. The average serial position of the deviants was constant across conditions. Trial sets were presented in four different pseudo-random orders which ensured that no more than two consecutive sets were of the same nature. Thus, pictures from all four categories served as deviants within a task and pictures from all categories served as backgrounds across tasks. The sequence in which the tasks were completed was counterbalanced across participants.

EEG Recording and ERP Analysis

EEG activity was recorded from nine scalp electrodes (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4) using SynAmps 1 amplifiers according to the International 10-20 system of electrode placement (Jasper, 1958). A Quik-cap was used to collect the EEG data using Neuroscan 4.3.1 software. All electrode sites were referenced to the mastoids, horizontal electro-oculargraphic (EOG) activity was recorded from electrodes placed at the outer canthi of both eyes, and vertical EOG activity was recorded from electrodes above and below the left eye. Electrode impedance was kept below 10KΩ. EEG activity was sampled continuously at 1000 Hz, and amplified with a high pass filter of 0.15, and low pass filter of 100Hz. Reaction time and accuracy data were recorded for each target trial. EEG data were merged with behavioural files following which artifact reduction was conducted. Bad blocks were marked if: (a) EOG activity was larger than 160 μV; (b) excessive noise was present due to EMG activity, EKG activity, alpha waves, or skin potentials, or (c) different-to-usual EOG activity was observed. Ocular artefact corrections based on VEOG were performed using the SCAN 4.3.1 software. Continuous data files were then low pass filtered at 30 Hz, epoched offline for a 1000 ms epoch commencing 100 ms before stimulus onset and baseline corrected. High and low voltage cut-offs for artifact rejections were set at 100 μV and -100 μV respectively.

Grand mean average ERPs elicited by the four types of deviants were averaged across the groups using Scan 4.3.1. Based on the grand mean average ERP waveforms (at the nine scalp electrode sites) two negative-going components – N1 and N2 – and two positive-going components – P2 and a late positive complex (LPC) – were identified. Mean amplitude for each of the four components was calculated as the average voltage in the following latency windows: 50-130 ms (N1); 150-200 ms (P2); 200-250 (N2); 350-700 ms (LPC). Latency windows were defined based on inspection of the grand mean average ERP waveforms across midline electrode sites (i.e., Fz, Cz, and Pz). The latency window for the LPC in the present study is similar to that used by Ito and Urland (2003) for the component they labelled P300 (350–900 ms after stimulus onset). Following Ito, Thompson and Cacioppo (2004) and Kubota and Ito (2007) the current report is limited to the average voltages recorded under the midline electrodes (Fz, Cz, and Pz).

The ERP mean amplitude data for each of the four components were calculated for correct classifications of the deviant faces from all four tasks. Preliminary analyses[1] of the mean amplitude data for each component were conducted via a 2 (Participant race [Chinese, Caucasian]) × 2 (Participant sex [female, male]) × 2 (Background race [Chinese, Caucasian]) × 2 (Background sex [female, male]) × 2 (Deviant race [Chinese, Caucasian]) × 2 (Deviant sex [female, male]) × 3 (Electrode [Fz, Cz, Pz]) factorial ANOVA. In order to not only detect differences between Chinese and Caucasian participants, but also to confirm that the overall pattern of differences that emerged in the full analyses is reliable in each group, the results reported here are based on separate 2 (Participant sex) × 2 (Background race) × 2 (Background sex) × 2 (Deviant race) × 2 (Deviant sex) × 3 (Electrode) factorial ANOVAs of each component for Chinese and Caucasian participants. It was anticipated that this approach would not only be more sensitive and conservative, but would increase the ease with which the results can be interpreted. Main effects and interactions are reported based on the multivariate solution (Pillai's Trace). Follow-up t-tests were calculated using

[1] Results of the full omnibus solution for each component are presented in the Supplementary Section.

Greenhouse-Geisser error values and degrees of freedom to protect against violation of the assumption of sphericity, and critical t-values were sourced from Sidak's tables (Howell, 1997).

Results

Figure 1 (a and b) shows the grand mean ERP waveforms recorded at Cz elicited by the four deviant types in the four background conditions, for Chinese participants (Figure 1a) and Caucasian participants (Figure 1b).

N1 Mean Amplitude (50-130ms)

Chinese participants

Chinese participants showed maximal (i.e., more negative) N1 mean amplitude at Fz (*M* = -2.037 µV) and Cz (*M* = -2.035 µV) compared with at Pz (*M* = .216 µV); main effect for Electrode, $F(2, 26) = 21.940$, $p < .001$, ηp2 = .628 [Fz vs Pz, $t(31.127) = 7.268$, $p < .05$; Cz vs Pz, $t(31.127) = 7.261$, $p < .05$; Fz vs Cz, $t < 1$, *ns*]. No other effects or interactions reached significance, all *p* values > .05, *ns* (see Figure 2, upper panel).

Caucasian participants

N1 mean amplitude shown by Caucasian participants was also more negative at Fz (*M* = -2.521 µV) and Cz (*M* = -2.435 µV) than at Pz (*M* = -.070 µV); main effect for Electrode, $F(2, 24) = 17.495$, $p < .001$, $\eta_p^2 = .593$ [Fz vs Pz, $t(28.197) = 7.427$, $p < .05$; Cz vs Pz, $t(28.197) = 7.167$, $p < .05$; Fz vs Cz, $t < 1$, *ns*] . A significant interaction of Electrode × Deviant race × Participant sex, $F(2, 24) = 3.449$, $p = .048$, $\eta_p^2 = .223$ can be seen in Figure 2 (lower panel) if we consider that Caucasian men show larger N1 mean amplitude to Chinese deviant faces than Caucasian deviant faces at all sites (Fz, $t(45.858) = 5.849$; Cz, $t(45.858) = 3.559$; Pz, $t(45.858) = 3.179$, all *p* values < .05) – a finding consistent with previous research that reports larger N1 amplitude to racial out-group faces. Caucasian women, however, show this difference at Pz, $t(45.858) = 2.812$, $p < .05$, but not at Fz or Cz (*t* values < 2.7, *ns*). A number of interactions involving the factors Background sex and Deviant sex were significant. A significant Background sex × Deviant sex × Participant sex interaction [$F(1, 25) = 4.405$, $p = .046$, $\eta_p^2 = .150$] did not reflect an interpretable pattern of results; That is, follow-up t-tests to compare N1 mean amplitude to male and female deviants in male or female backgrounds for Caucasian female and male participants did not reveal any significant differences (all p values > .05). Similarly, investigation of the significant interaction Background race × Background sex × Deviant race × Deviant sex [$F(1, 25) = 23.775$, $p < .001$, $\eta_p^2 = .487$] did not produce consistent and interpretable patterns of differences (p values > .05). However, the significant Electrode × Background sex × Deviant sex interaction [$F(2, 24) = 4.644$, $p = .020$, $\eta_p^2 = .279$] indicated an odd-ball type effect at Pz whereby N1 mean amplitude to female deviants was larger than to male deviants in male backgrounds, $t(31.038) = 3.676$, $p < .05$. However, all other follow-up comparisons of this interaction were non-significant (p values > .05). Thus the single significant difference found here may only represent a spurious result in the absence of future replication.

P2 Mean Amplitude (150-200 ms)

Chinese participants

For Chinese participants, P2 mean amplitude was larger at Pz (M = 2.913 μV) than Fz [M = -.479 μV; $t(31.165) = 6.937$, $p < .05$] or Cz [M = -.080 μV; $t(31.165) = 6.120$, $p < .05$]; main effect for Electrode, $F(2, 26) = 15.482$, $p < .001$, $\eta_p^2 = .544$. Previous studies have revealed a larger P2 to racial out-group faces. Figure 3 shows that in the present study Chinese participants showed larger P2 mean amplitude to out-group (Caucasian) deviants presented during in-group (Chinese) backgrounds. This observation was confirmed by a significant Electrode × Background race × Deviant race × Participant sex interaction, $F(2, 26) = 3.497$, $p = .045$, $\eta_p^2 = .212$, which subsumed a number of lower-order interactions including Electrode × Background race [$F(2, 26) = 4.895$, $p = .016$, $\eta_p^2 = .274$], Electrode × Deviant race [$F(2, 26) = 8.394$, $p = .002$, $\eta_p^2 = .392$], and Background race × Deviant race [$F(1, 27) = 10.586$, $p = .003$, $\eta_p^2 = .282$]. A number of other interactions[1] reached significance but were not investigated further due to a lack of theoretical justification to do so.

Follow-up t-tests of the significant four-way Electrode × Background race × Deviant race × Participant sex interaction indicated that at Pz both female and male Chinese participants showed larger P2 mean amplitude to out-group (Caucasian) deviants (*Ms* = 3.083 μV and 3.446 μV, respectively) than to in-group (Chinese) deviants (*Ms* = 2.216 μV and 2.456 μV, respectively) in backgrounds of in-group (Chinese) faces, [$t(39.988) = 4.447$ and 5.07, respectively, p values < .05] but did not show differential P2 mean amplitude to Caucasian and Chinese deviants in backgrounds of Caucasian faces (t values < 2.1, *ns*). A similar pattern of larger P2 to out-group deviants in the in-group contexts emerged for Chinese female and male participants at Cz [$t(39.988) = 3.691$ and 4.015, $p < .05$, respectively] and for Chinese female participants, but not male participants at Fz [$t(39.988) = 3.565$, $p < .05$ and $t < 1.7$, *ns*, respectively].

Caucasian participants

Like Chinese participants, Caucasian participants showed greater P2 mean amplitude at Pz ($M = 3.193$ μV) compared to at Fz [$M = .137$ μV; $t(27.754) = 6.601$, $p < .05$] and Cz [$M = .636$ μV; $t(27.754) = 5.522$, $p < .05$]; main effect for Electrode, $F(2, 24) = 13.132$, $p < .001$, $\eta_p^2 = .523$. As seen in Figure 3, Caucasian participants, like Chinese participants, showed larger P2 mean amplitude to out-group deviants embedded in in-group contexts. A significant Background race × Deviant race interaction supported this observation, $F(1, 25) = 8.812$, $p = .007$, $\eta_p^2 = .261$. Follow-

[1] Deviant race × Deviant sex [$F(1, 27) = 5.363$, $p = .028$, $\eta_p^2 = .166$]; Electrode × Background sex × Deviant sex [$F(2, 26) = 5.972$, $p = .007$, $\eta_p^2 = .315$], and Background race × Deviant race × Deviant sex × Participant sex [$F(1, 27) = 4.797$, $p = .037$, $\eta_p^2 = .151$].

up t-tests confirmed that the pattern of P2 modulation for Caucasian participants was the inverse of that shown by Chinese participants; that is, P2 mean amplitude was larger to Chinese (*M* = 1.658 μV) than to Caucasian deviant faces (*M* = .860 μV) in Caucasian backgrounds, $t(25.00) = 4.899$, $p < .05$, but did not differ significantly to Chinese and Caucasian deviants faces in Chinese backgrounds, $t < 1.1$, *ns*.

There were several other interactions which were statistically significant, but were of no theoretical interest and as such were not investigated further; namely, Electrode × Participant sex [$F(2, 24) = 8.887$, $p = .001$, $\eta_p^2 = .425$], Electrode × Background sex × Participant sex [$F(2, 24) = 5.557$, $p = .010$, $\eta_p^2 = .317$], Background sex × Deviant sex × Participant sex [$F(1, 25) = 4.862$, $p = .036$, $\eta_p^2 = .164$], Deviant race × Deviant sex [$F(1, 25) = 4.597$, $p = .042$, $\eta_p^2 = .155$], and Electrode × Background sex × Deviant sex [$F(2, 24) = 6.374$, $p = .006$, $\eta_p^2 = .347$].

N2 Mean Amplitude (200-250 ms)

Chinese participants

Chinese participants showed the greatest (i.e., most negative) N2 mean amplitude at Fz (*M* = -2.037 μV) and Cz (*M* = -2.035 μV) compared with Pz (*M* = .216 μV); main effect for Electrode, $F(2, 26) = 19.366$, $p < .001$, $\eta_p^2 = .598$ [Fz vs Pz, $t(31.127) = 7.219$, $p < .05$; Cz vs Pz, $t(31.127) = 7.213$, $p < .05$; Fz vs Cz, $t < 1$, *ns*]. Previous research has shown N2 facilitation to racial in-group faces (Ito & Urland, 2003, 2005; Willadsen-Jensen & Ito, 2006). However, Willadsen-Jensen and Ito (2008) found an interaction between context race and target (deviant) race such that Asian participants showed a larger N2 to white targets in a white context, but a larger N2 to Asian targets in an Asian context. Thus, the presence of a significant interaction between Background race and Deviant race, $F(1, 27) = 4.696$, $p = .039$, $\eta_p^2 = .148$ was investigated to see whether the pattern of results was similar to that reported by Willadsen-Jensen and Ito (2008). This was not the case, however, as none of the follow-up t-test comparisons were significant (all *p* values > .05). Rather, the results can be best interpreted according to the significant Electrode × Deviant race interaction which revealed that at Pz, N2 mean amplitude was greater (i.e., more negative) to in-group deviant faces than to out-group deviant faces (see Figure 4). Differences did not reach significance at Fz or Cz. Nevertheless, the in-group effect found at Pz is in accord with the earlier findings of Ito and Urland (2003, 2005).

Other interactions that reached significance included: Electrode × Background race [$F(2, 26) = 7.774$, $p = .002$, $\eta_p^2 = .374$]; Electrode × Background race × Participant sex [$F(2, 26) = 3.526$, $p = .044$, $\eta_p^2 = .213$]; Electrode × Background sex × Deviant sex [$F(2, 26) = 12.271$, $p < .001$, $\eta_p^2 = .486$]; Background race × Background sex × Deviant race [$F(1, 27) = 4.586$, $p = .041$, $\eta_p^2 = .145$]; Background race × Deviant race × Deviant sex × Participant sex [$F(1, 27) = 4.757$, $p = .038$, $\eta_p^2 = .150$], and Background sex × Deviant race × Deviant sex [$F(1, 27) = 6.185$, $p = .019$, $\eta_p^2 = .186$]. Follow-up comparisons of these interactions showed no significant differences except for the Electrode × Background sex × Deviant sex interaction which reflected facilitated N2 mean amplitude to female deviants at Fz and Cz in both male backgrounds [Fz, $t(45.390) = 4.089$, $p < .05$, Cz, $t(45.390) = 3.642$, $p < .05$, and Pz $t < 1.3$, *ns*] and female backgrounds [Fz, $t(45.390) = 3.320$, $p < .05$, Cz, $t(45.390) = 3.559$, $p < .05$, and Pz, $t < 1.9$, *ns*].

Caucasian participants

The N2 mean amplitudes for Caucasian participants are shown in Figure 4. N2 mean amplitude was maximal at Fz ($M = -2.521$ µV) and Cz ($M = -2.435$ µV) compared with Pz ($M = -.070$ µV); main effect for Electrode, $F(2, 24) = 27.616$, $p < .001$, $\eta_p^2 = .697$ [Fz vs Pz, $t(28.197) = 7.294$, $p < .05$; Cz vs Pz, $t(28.197) = 7.038$, $p < .05$; Fz vs Cz, $t < 1$, *ns*]. Overall, Caucasian male participants exhibited a larger N2 than Caucasian female participants with a significant main effect for Participant sex, $F(1, 25) = 7.623$, $p = .011$, $\eta_p^2 = .234$. This effect was qualified by an Electrode

× Participant sex interaction, $F(2, 24) = 9.648$, $p = .001$, $\eta_p^2 = .446$, that indicated the difference was only significant at Pz [$t(28.197) = 2.696$, $p < .05$; t values for comparisons at Fz and Cz < 1.2, *ns*].

A significant four-way interaction of Background race × Background sex × Deviant race × Deviant sex [$F(1, 25) = 4.403$, $p = .046$, $\eta_p^2 = .150$] subsumed significant two-way interactions between Background race and Deviant race [$F(1, 25) = 8.133$, $p = .009$, $\eta_p^2 = .245$] and between Deviant race and Deviant sex [$F(1, 25) = 4.622$, $p = .041$, $\eta_p^2 = .156$]. Follow-ups of the four-way and the two-way interactions failed to yield any systematic pattern of significant differences. An Electrode × Background sex × Deviant sex interaction [$F(2, 24) = 10.647$, $p < .001$, $\eta_p^2 = .470$] was similarly non-instructive, reflecting only a differences at Pz whereby N2 mean amplitude was larger to female than male deviants in male backgrounds [$t(45.390) = 3.976$, $p < .05$; all other p values > .05].

LPC Mean Amplitude (350-700 ms)

Chinese participants

LPC mean amplitude was larger at Cz ($M = 4.608$ μV) and Pz ($M = 4.042$ μV) compared to Fz ($M = 2.478$ μV) [Fz vs Cz, $t(35.776) = 6.868$, $p < .05$; Fz vs Pz, $t(35.776) = 5.043$, $p < .05$; Cz vs Pz, t < 1.9, *ns*], with a significant main effect for Electrode, $F(2, 26) = 52.481$, $p < .001$, $\eta_p^2 = .801$. Chinese participants showed the predicted "odd-ball" effects on LPC mean amplitude. Thus, the expected Background race × Deviant race and Background sex × Deviant sex interactions were both significant, $F(1, 27) = 19.330$, $p < .001$, $\eta_p^2 = .417$, and $F(1, 27) = 52.525$, $p < .001$, $\eta_p^2 = .660$, respectively. As predicted, Chinese participants showed a greater LPC response when the deviant race differed from the background race (Figure 5, upper panel), and also when the deviant sex differed from the background sex (Figure 5, lower panel). More precisely, LPC mean amplitude was larger to Caucasian than Chinese deviants in Chinese backgrounds, $t(27.000) = 5.078$, $p < .05$, and larger to Chinese than Caucasian deviants in Caucasian backgrounds, $t(27.000) = 3.786$, $p <$

.05. Furthermore, LPC mean amplitude was larger to female than male deviants in male backgrounds, $t(27.000) = 8.282$, $p < .05$, and larger to male than female deviants in female backgrounds, $t(27.000) = 6.271$, $p < .05$.

These two key interactions were each qualified by a significant three-way interaction: Electrode × Background race × Deviant race [$F(2, 26) = 4.099$, $p = .028$, $\eta_p^2 = .240$] and Electrode × Background sex × Deviant sex [$F(2, 26) = 16.132$, $p < .001$, $\eta_p^2 = .554$]. Follow-up comparisons of these interactions showed significant odd-ball effects at Fz, Cz and Pz for background and deviant race [all $t(38.235)$ values exceeded 5.2, $p < .05$] and background and deviant sex (all $t(35.734)$ values exceeded 6.3, $p < .05$]. Other interactions that reached significance but were of no theoretical interest in the present context included: Electrode × Deviant sex [$F(2, 26) = 4.643$, $p = .019$, $\eta_p^2 = .263$]; Background sex × Deviant sex × Participant sex [$F(1, 27) = 4.391$, $p = .046$, $\eta_p^2 = .140$]; Deviant race × Deviant sex [$F(1, 27) = 19.216$, $p < .001$, $\eta_p^2 = .416$], and Background race × Deviant race × Deviant sex × Participant sex [$F(1, 27) = 11.652$, $p = .002$, $\eta_p^2 = .301$].

Caucasian participants

The results for the LPC analyses for Caucasian participants mirrored those for Chinese participants (see Figure 5, right panel). LPC mean amplitude was maximal at Cz ($M = 4.359$ µV) and Pz ($M = 4.338$ µV) relative to Fz ($M = 1.903$ µV); main effect for Electrode, $F(2, 24) = 73.380$, $p < .001$, $\eta_p^2 = .859$ [Fz vs Cz, $t(35.952) = 8.618$, $p < .05$; Fz vs Pz, $t(35.952) = 8.544$, $p < .05$; Cz vs Pz, $t < 1$, *ns*]. Importantly, Caucasian participants also showed the predicted "odd-ball" effects of facilitated LPC mean amplitude to deviants that differed from the background context according sex or race. Hence, significant interactions between Background race and Deviant race, $F(1, 25) = 15.696$, $p = .001$, $\eta_p^2 = .386$, and between Background sex and Deviant sex, $F(1, 25) = 58.153$, $p < .001$, $\eta_p^2 = .699$, were obtained. LPC responses were larger to (a) Chinese deviants than Caucasian deviants in Caucasian backgrounds, $t(25.000) = 4.212$, $p < .05$, and (b) Caucasian deviants than

Chinese deviants in Chinese backgrounds, $t(25.000) = 3.718$, $p < .05$ (see Figure 5, upper panel). In addition to this effect of race, LPC responses were larger to (a) female deviants than male deviants in male backgrounds, $t(25.000) = 10.023$, $p < .05$, and (b) male deviants than female deviants in female backgrounds, $t(25.000) = 5.231$, $p < .05$ (see Figure 5, lower panel).

Again, these two key interactions of interest were each qualified by significant three-way interactions: Electrode × Background race × Deviant race, $F(2, 24) = 6.362$, $p = .006$, $\eta_p^2 = .346$, and Electrode × Background sex × Deviant sex, $F(2, 24) = 20.985$, $p < .001$, $\eta_p^2 = .636$. Follow-up comparisons of the odd-ball effects involving background and deviant race in all instances at Fz, Cz and Pz with one exception at Fz with Chinese backgrounds ($t < 1.4$, *ns*, all other $t(31.270)$ values exceeded 3.6, $p < .05$). All follow-up comparisons of odd-ball effects involving background and deviant sex at Fz, Cz and Pz were significant (all $t(41.634)$ values exceeded 7.3, $p < .05$).

The following significant main effects and interactions that reached significance were either subsumed under the interactions already considered, or were of no theoretical interest: Background sex, $F(1, 25) = 9.817$, $p = .004$, $\eta_p^2 = .282$.; Deviant sex, $F(1, 25) = 7.483$, $p = .011$, $\eta_p^2 = .230$; Background sex × Deviant race [$F(1, 25) = 5.051$, $p = .034$, $\eta_p^2 = .168$]; Electrode × Background sex × Deviant race [$F(2, 24) = 4.910$, $p = .016$, $\eta_p^2 = .290$], and Background race × Background sex × Deviant race [$F(1, 25) = 5.745$, $p = .024$, $\eta_p^2 = .187$].

Discussion

The aim of the present study was twofold. First, determine whether an implicit out-group race bias as documented by Ito and Urland (2003, 2005) can be replicated in a sample of participants drawn from a cultural context (Australia) that extends the scope of this area of research beyond the United States. Second, demonstrate that an implicit race bias as reflected in LPC facilitation to out-group faces is reciprocal, i.e., shown by Caucasian participants to Chinese faces and by Chinese participants to Caucasian faces. The current results provide concise evidence in relation to these aims. In accord with Ito and Urland's previous findings, an implicit race bias was found to modulate the LPC thereby providing support for the significance of race categorization in face processing regardless of cultural context. Moreover, these effects were observed in all participant groups – Caucasian and Chinese females and males. Both these findings are discussed in more depth following an overview of the results pertaining to earlier components of the ERP, specifically, the N1, P2 and N2 components.

The N1 is an early negative-going perceptual component of the ERP waveform that has previously been associated with initial stages of perceptual processing of stimuli. In studies looking at processing of racial in-group and out-group faces, facilitated N1 to out-group faces as compared to in-group faces has typically been reported (e.g., Ito & Urland, 2003). Nonetheless, exceptions to this out-group effect have also been reported. For example, Willadsen-Jensen and Ito (2006) found minimal, if any, differential N1 modulation to Asian and white faces in a group of white participants. Similarly, Willadsen-Jensen and Ito (2008) did not report an out-group effect on N1 for Asian participants viewing Asian and white faces. Given these discrepancies in the existing literature the complexity of the results of the present study is not surprising. On the one hand, Chinese participants did not show differential N1 mean amplitude to Chinese and Caucasian deviant faces regardless of background context (in-group or out-group faces). On the other hand, Caucasian participants showed evidence for facilitated N1 mean amplitude to out-group deviants. Caucasian males showed larger N1 mean amplitude at all 3 midline electrode sites (Fz, Cz and Pz) to Chinese deviant faces, whereas Caucasian females showed larger N1 mean amplitude to Chinese deviant faces at Pz only (the site at which N1 mean amplitude was maximal). Thus, the out-group facilitation effect on the N1 component as shown by Caucasian participants replicates previous demonstrations of this effect in similar studies (Ito & Urland, 2003, 2005). Similarly, the absence of such an effect in Chinese participants is consistent with Willadsen-Jensen and Ito's (2006, 2008) results. Given that N1 is known to be associated with early attentional processing of stimuli based on perceptual qualities, the discrepancies in the literature with regard to N1 modulation by racial group membership may be accounted for by between-experiment variations in task demands, perceptual characteristics of the facial stimuli used, and/or participants' level of engagement with the task. Clearly, to make a specific claim as to the reason for the discrepancies is not possible based on the available data and further research is required.

The P2 component, like the N1, has demonstrated sensitivity to racial group membership, whereby racial out-group faces elicit a larger P2 than racial in-group faces (e.g., Ito & Urland, 2003, 2005). Our results are partially consistent with these previous findings. For both Chinese and Caucasian participants, P2 mean amplitude was maximal at Pz and was generally larger to out-group deviant faces presented during in-group contexts. However, for both Chinese and Caucasian participants, P2 mean amplitude to in-group and out-group deviant faces did not differ when the background context consisted of out-group faces. This suggests that P2 may be sensitive to out-group faces particularly when they are presented in the context of in-group faces. On this point, Willadsen-Jensen and Ito (2008) speculated that "the social context in which racial perception occurs may influence response" (p. 183). Although a context effect on P2 has not previously been reported, the particular demands of the present experiment – to attend only to sex of the face – may have resulted in a diluted out-group effect on P2 when the background faces were exclusively out-group faces as well.

The second negative-going component of the ERP waveform, the N2, was investigated to see whether an in-group facilitation effect would occur (Ito and Urland, 2003, 2005; Willadsen-Jensen & Ito, 2006). The results for such an effect were mixed. N2 mean amplitude was largest at Fz and Cz for Chinese and Caucasian participants. However, the expected in-group facilitation effect – larger N2 mean amplitude to in-group deviants than to out-group deviants – was shown only at Pz by Chinese participants and not at all by Caucasian participants. The present findings (specifically for Caucasian participants) are not easily accounted for. It may be a reflection of some aspect of the present task used, or may point to the need to more closely examine modulation of the N2 by race. The latter point is somewhat supported by data from Willadsen-Jensen and Ito's (2006) study with Asian participants. It was found that N2 facilitation to in-group members was sensitive to context race and occurred only to targets embedded in in-group contexts, whereas the inverse effect was found to out-group targets embedded in an out-group context.

The influence of facial features indicative of racial group membership appears to extend beyond early perceptual processing stages (Ito & Urland, 2003, 2005) to affect continued processing stages (reflected in LPC; Luck, 2005) even when race is a task irrelevant dimension. Facilitation of the LPC to racial out-group deviants occurred in addition to LPC modulation related to the task relevant dimension of sex. Thus, implicit race bias, as indexed by larger activity during out-group race faces was evident in the latency window around the LPC component on deviant trials embedded in different-race backgrounds; highlighting the implicit attention to race above and beyond the task-demand to attend to sex.

In a recent review paper on the neural correlates of race, Ito and Bartholow (2009) called for replication of a race bias in face processing beyond the North American cultural/racial context. The present study addresses this issue directly and demonstrates that an implicit bias to out-group race individuals is not only found when white Americans are asked to perform tasks with images of black faces (Ito & Urland, 2003, 2005). This seems the more remarkable as the participants in the present study were not selected to have had minimum exposure to persons of the other-race (Caldara et al., 2003, 2004). Caucasian participants would have encountered numerous Chinese persons during both schooling and University life. Australia is a multicultural society with an Asian population of about six percent and the University of Queensland has a foreign student participation of about 20%, many of whom originate from North East Asia. Conversely, our Chinese sample comprised foreign students who had been in Australia for at least one semester as well as Chinese Australians. Thus, both samples had considerable exposure to members of the racial out-group.

Our findings also speak to the universality of other race effects (see also Dickter & Bartholow, 2007). Early explanations for other race biases suggested that preferential processing of Black faces relative to White faces reflected that Black targets were perceived as negative or threatening by White participants, given the negative stereotypes of Black people in the United States. More recent research, however, has suggested that these effects reflect a more general pattern of responding to in-group and out-group targets. For example, Dickter and Bartholow found that both Black and White participants showed an enhanced P2 for faces of out-group targets. Our research, which examined face processing for two racial groups that are not embedded within a socio-historical context of negative intergroup relations, supports the assertion that such effects reflect an underlying in-group/out-group processing bias, present for all groups, rather than an automatic vigilance effect associated with particular social groups.

The present study assessed implicit race bias to pictures of Caucasian/Chinese persons in a sample of Chinese/Caucasian participants and provided evidence that such a bias is not limited to particular in-group/out-group stimuli or persons, nor is it confined to the North American cultural context. In light of previous findings, the current results strongly support the notion that attention to facial features that assist racial categorization is an obligatory component of face processing for all and occurs independently of explicit attention to race.

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Figure captions

Figure 1a: ERP grand mean averages recorded at Cz as shown by Chinese participants to deviants in Chinese female backgrounds (upper left panel), Chinese male backgrounds (upper right panel), Caucasian female backgrounds (lower left panel), and Caucasian male backgrounds (lower right panel). Upward deflections indicate positive amplitude (µV).

Figure 1b: ERP grand mean averages recorded at Cz as shown by Caucasian participants to deviants in Chinese female backgrounds (upper left panel), Chinese male backgrounds (upper right panel), Caucasian female backgrounds (lower left panel), and Caucasian male backgrounds (lower right panel). Upward deflections indicate positive amplitude (µV).

Figure 2: Mean Amplitude (µV) at Fz, Cz and Pz in the N1 latency window (50-130 ms) to Chinese and Caucasian deviants as shown by female and male Chinese participants (upper panel) and female and male Caucasian participants (lower panel). Error bars indicate standard error of the mean.

Figure 3: Mean Amplitude (µV) averaged across Fz, Cz and Pz in the P2 latency window (150-200 ms) to Chinese and Caucasian deviants in Chinese and Caucasian backgrounds as shown by Chinese and Caucasian participants. Error bars indicate standard error of the mean.

Figure 4. Mean Amplitude (µV) averaged across Fz, Cz and Pz in the N2 latency window (200-250 ms) to Chinese and Caucasian deviants as shown by Chinese and Caucasian participants. Error bars indicate standard error of the mean.

Figure 5. Mean Amplitude (µV) averaged across Fz, Cz and Pz in the LPC latency window (350-700 ms) to Chinese and Caucasian deviants in Chinese and Caucasian backgrounds as shown by Chinese and Caucasian participants. Error bars indicate standard error of the mean.