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Racial bias in neural response to others' pain is reduced with other-race contact

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ABSTRACT

Observing the pain of others has been shown to elicit greater activation in sensory and emotional areas of the brain suggested to represent a neural marker of empathy. This modulation of brain responses to others' pain is dependent on the race of the observed person, such that observing own-race people in pain is associated with greater activity in the anterior cingulate and bilateral insula cortices compared to other-race people. Importantly, it is not known how this racial bias to pain in other-race individuals might change over time in new immigrants or might depend on the level and quality of contact with people of the other-race. We investigated these issues by recruiting Chinese students who had first arrived in Australia within the past 6 months to 5 years and assessing their level of contact with other races across different social contexts using comprehensive rating scales. During fMRI, participants observed videos of own-race/other-race individuals, as well as own-group/other-group individuals, receiving painful or non-painful touch. The typical racial bias in neural responses to observed pain was evident, whereby activation in the anterior cingulate cortex (ACC) was greater for pain in own-race compared to other-race people. Crucially, activation in the anterior cingulate to pain in other races increased significantly with the level of contact participants reported with people of the other race. Importantly, this correlation did not depend on the closeness of contact or personal relationships, but simply on the overall level of experience with people of the other race in their every-day environment. Racial bias in neural responses to others' pain, as a neural marker of empathy, therefore changes with experience in new immigrants at least within 5 years of arrival in the new society and, crucially, depends on the level of contact with people of the other race in every-day life contexts.

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1. Introduction

Our ability to vicariously experience the emotional and mental states of others, allowing us to better understand and predict their behaviour, is suggested to be an important aspect of empathy (Singer & Lamm, 2009). Neurologically, this vicarious representation of others' states is associated with distinct anatomical areas of the brain for shared emotional and cognitive representation of the self and other (Shamay-Tsoory, 2011). One very well studied phenomenon is the neural response to observed pain of others, in which activation in emotional-motivational areas of the brain, including the anterior cingulate cortex (ACC) and insula cortex, is increased when seeing others experiencing pain compared to a neutral or non-painful state (Fan, Duncan, de Greck, & Northoff, 2011; Lamm, Decety, & Singer, 2011). This heightened neural response to observed pain in others has been found to be correlated with measures of trait empathy and helping behaviour towards the other (Singer et al., 2004; Hein, Silani, Preuschoff, Batson, & Singer, 2010). This response is generally referred to as a marker of empathy for pain in others (Lamm et al., 2011), although it is debated whether the specific underlying cause is linked to vicarious feelings of pain per se or the detection of salient negative events (Legrain, Iannetti, Plaghki, & Mouraux, 2011). Here we refer to this vicarious activity in response to others' pain as a neural empathic response.

This neural response to observed pain in others is found to depend on the relationship between the observer and the other (Hein, Silani, Preuschoff, Batson, & Singer, 2010; Lamm, Nusbaum, Meltzoff, & Decety, 2007). For example, people included in a social "in-group" (supporters of the same football team) elicit greater neural empathy when in pain compared to those in an "out-group" (Hein et al., 2010). Crucially, neural empathic responses are much larger when observing a person of the same race in pain as when observing a person of a different race in pain (Xu, Zuo, Wang, & Han, 2009). In their study, Xu et al. (2009) presented Caucasian and Chinese participants with video clips of Caucasian and Chinese actors receiving a painful touch by a needle or a non-painful touch by a cotton-tip on their cheek. They found significantly greater neural responses in the ACC in response to painful compared to non-painful touch, but *only* if the actor was of the same race as the observer (Xu et al., 2009). Subsequent studies using EEG have shown that this racial bias in neural empathy is evident as early as 100 ms–180 ms after viewing the person in pain (Sheng & Han, 2012; Contreras-Huerta, Hielscher, Sherwell, Rens, & Cunnington, 2014) and TMS evidence suggests that racial bias can occur even in sensorimotor processing (Avenanti, Sirigu, & Aglioti, 2010).

It is not known how such race or group biases in neural empathy may develop or change with experience with other-group or other-race members. Interestingly, individuals who have been born and lived their entire life in a predominantly other-race society have been found to show equal neural responses to pain in own-race and the other-race people (Zuo & Han, 2013). Zuo and Han (2013) adopted the same experimental paradigm as Xu et al.'s original experiment (Xu et al., 2009), but recruited participants who were all Chinese and had been born in or immigrated as a child (between 1 and 9 years of age) to a Western country populated predominantly by Caucasian people. These participants demonstrated equal empathic activation to both Chinese and Caucasian actors in pain (Zuo & Han, 2013).

Crucially, it is not known how and even whether *new immigrants* in a predominantly other-race society show changes in neural empathic responses to people of the other (majority) race and what factors may be important in mediating any change in neural empathy. The present study examines these important issues by investigating neural empathy of *recent* migrators to a predominantly other-race country and examining how the amount of contact or experience with people of the other race in different daily-life social contexts influences neural empathy towards people of the other race. We assessed the *quantity* or amount of contact, representing the level of experience with people of the other race, by asking participants to rate the proportion of own-race or other-race people that they typically see day-to-day in their neighbourhood, in their university/school, amongst their classmates, amongst their workmates, and amongst their friends. We also assessed the importance of personal closeness or *quality* of contact, by comparing neural empathic responses depending on the level of other-race contact amongst friends compared with the broader neighbourhood or university/school. Behavioural studies using longitudinal survey have found that people with interracial friendships were significantly more likely to have greater affective empathy for other-race people over time than people without interracial friendships (Swart, Hewstone, Christ, & Voci, 2011). Neurologically, this has never been studied for empathy, although one EEG study on general face processing found that both the quality and quantity of contact with other-race people reduced the difference in neural processing for own-versus other-race faces (Walker, Silvert, Hewstone, & Nobre, 2008). No studies have examined how neural responses to observed pain in others, as a neural marker of empathy, may change over time in recent immigrants or depend on the quantity or quality of contact with other-race people.

When examining neural responses to observed pain and possible changes with contact with other-race people, it is also important to consider effects of broader social group association that can also influence neural empathic responses (Hein et al., 2010). Recent studies have investigated whether establishing other forms of social group identity as "in-group" and "out-group" members can overcome the racial bias in neural empathy. The results have been conflicting. One study on Chinese participants found that incorporating Caucasian people into the participants' own in-group (manipulated by T-shirt colour) eliminated the racial bias in neural empathy (Sheng & Han, 2012). Our own previous studies found that the racial bias remained, even towards in-group members, despite participants showing strong association on both implicit and explicit behavioural measures with racially mixed in-group members compared with out-group members (Contreras-Huerta, Baker, Reynolds, Batalha, & Cunnington, 2013, 2014).

The current study aimed to further examine how these factors of level of contact with people of other races and broader social group association could influence the racial bias in neural empathy for pain. Crucially, we recruited Chinese students who had recently arrived in Australia (over a range from 1 month to up to 5 years) and assessed their reported level of contact with Caucasian people across different social contexts, including in their local neighbourhood, at University, amongst their classmates, and amongst their friends. We therefore examined how neural empathy towards other-race people changed with the level of contact recent migrants had with people of the other-race across different social contexts in their every-day life.

2. Materials and methods

2.1. Participants

Thirty right-handed Chinese students (18 females, 12 males; age $M = 23.17$, $SD = 1.80$) from the University of Queensland participated in the study. All participants had lived in Australia for less than five years, including eleven new arrivals (residential time shorter than six months). All participants were born in Mainland China, had two Chinese parents, and finished primary and secondary schooling in China. They had normal or corrected-to-normal vision and did not report any neurological or psychiatric conditions. Correctly completed questionnaires on contact with other races were obtained from 23 of the participants (including all 11 new arrivals); therefore, correlation analyses between fMRI and questionnaire data were conducted on a subset of 23 participants. All participants gave written informed consent for their voluntary participation and were reimbursed $30 for their time. This study was approved by the Medical Research Ethics Committee and the School of Psychology, University of Queensland.

2.2. Procedure

2.2.1. Group assignment

Participants attended two sessions, each conducted 3–6 days apart. In the first session, participants were randomly assigned to one of two arbitrary groups to establish in-group and out-group social identity. Participants completed a 10-item authoritarian and moral attitude questionnaire (Verkuyten & Hagendoorn, 1998) and were then told that their scores on this questionnaire would be used to assign them to a group of people with the most similar beliefs and attitudes to them, and most different from members of the other group. A photo was then taken of the participant to be shown amongst in-group members in the group learning task in the second session.

2.2.2. Group learning and recognition

In the second session, participants completed a 10-min group learning and recognition task, followed by the fMRI task, exactly as described in our previous study (Contreras-Huerta et al., 2013). For the group-learning task, participants viewed photos of faces of 8 actors with text below the face indicating "Your Group" or "Other Group" (each photo shown for 2 sec duration, with 3 sec inter-stimulus interval; 3 blocks with each face presented once per block). Participants were told they should learn to recognise each person so that they could later identify who belonged to their group and who belonged to the other group. Crucially, both the own-group and other-group faces consisted of 2 Chinese actors (1 male, 1 female) and 2 Caucasian actors (1 male, 1 female), with own-group/other-group, Chinese/Caucasian, and male/female balanced in a 2 x 2 x 2 factorial design. The participants' own photograph was additionally included amongst the set of own-group photos for the group-learning task, to enhance group association, but was not included for the fMRI study later. The actors assigned as own-group and other-group members were pseudo-randomised and counter-balanced across participants to avoid any bias that could be associated with particular actor identities.

Following the learning phase, participants' recognition performance for the faces was tested. Each face was presented once per block in randomised order, without the text indicating group membership, and participants were required to verbally report each face as "My Group" or "Other Group". Verbal report was used rather than button-press responses to avoid participants forming any association between own/other groups and left/right responses which could have created a confound in the later affective priming task (see below). The participants' verbal responses were coded by the experimenter and feedback was given by text displayed beneath the photo: ''Your Group'' or ''Other Group'' displayed in red-font for incorrect responses and in green font for correct responses. Blocks were repeated until participants reached over 90% accuracy in 3 consecutive blocks and 100% accuracy in the final block. A further 4 blocks of the recognition task were performed again inside the MRI scanner immediately prior to the fMRI task.

2.2.3. fMRI task

Inside the MRI scanner, participants viewed video clips of actors receiving a painful touch with a syringe needle or a non-painful touch with a cotton-tip to either the left or right cheek of their face, following exactly the procedure of our previous study (Contreras-Huerta et al., 2013) and based on the original design of Xu et al. (2009). The video stimuli were each 3 sec duration and showed one of the 8 actors (balanced Chinese/Caucasian, own-group/other-group, and male/female) with a neutral facial expression and a hand holding either the syringe or cotton-top reaching in to the left or right of the image and touching the syringe/cotton-top to the actors' cheek (see Fig. 1). The video clips were cut to end immediately when the syringe needle or cotton-tip made contact with the actor's cheek so that no emotional expression or reaction to the touch stimulus was portrayed. Participants viewed videos on a projection screen at a distance of 80 cm, via a mirror mounted on the MRI head coil. Following each video clip, participants rated how painful they thought the stimulus looked by pressing one of four buttons on a 4-choice button-box held in their right hand, rating from no pain (1, left button) to considerable pain (4, right button). There were 32 video clips in total (the 8 actors, with balanced needle/cotton-tip stimuli and and left/right cheek touches), each presented once in random order (3 sec video clip, with 9 sec inter-stimulus interval) in each 6 min 40 sec fMRI scan run. Four fMRI runs were repeated, with video stimuli presented in a different random order for each run.

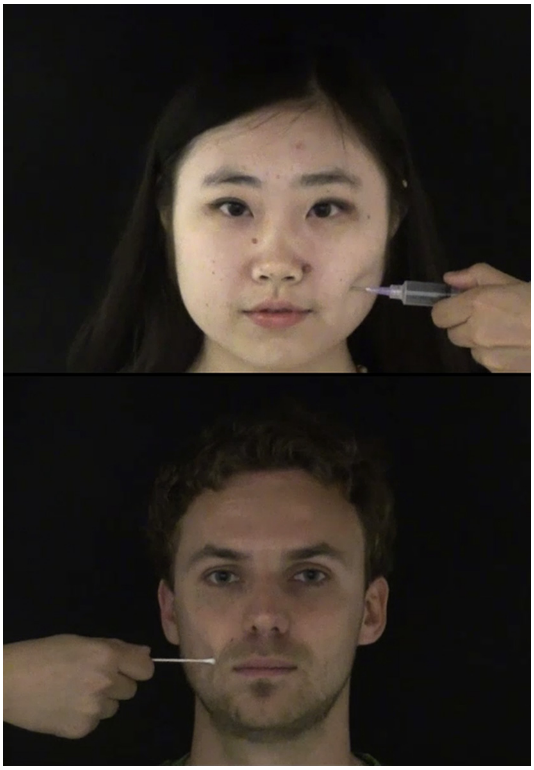

Fig. 1 – Examples of stimuli used in the main fMRI task. Participants viewed video clips of Chinese or Caucasian actors who were either in-group or out-group members receiving either painful touch with a syringe needle or non-painful touch with a cotton-tip.

2.2.4. *Implicit association with Race and Group: affective priming task*

Immediately after the fMRI scan, participants performed an Affective Priming task to assess implicit associations with own-race compared with other-race members and with own-group compared with other-group members, exactly as described in Contreras-Huerta et al. (2013). Briefly, photos of the 8 actors were presented as primes and paired with words of either positive or negative valence. Participants were required to respond as quickly as possible, by left or right button press, to classify words as pleasant or unpleasant and then verbally report whether the prime face was an in-group or out-group member. In this task, implicit associations are typically revealed as slower reaction times to classify negative-valence words when primed by in-group members and to classify positive-valence words when primed by out-group members. Each trial began with a blank screen (1000 ms duration) followed by a fixation cross as a warning cue (500 ms). The prime photo was then presented centrally (200 ms duration), followed by 100 ms blank screen, and then the target word of either positive or negative valence was presented until participants responded by button-press (or timed-out after 3000 ms). Participants performed 96 trials in randomized order, consisting of each of the 8 photos of actors paired once with each of 6 positive-valence words (‘charming’, ‘nice’, ‘friendly’, ‘happy’, ‘desirable’, ‘kind’) and 6 negative-valence words (‘repulsive’, ‘nasty’, ‘evil’, ‘angry’, ‘disturbing’, ‘annoying’). Priming scores were calculated by subtracting reaction times for pleasant words from unpleasant words, with positive scores therefore representing stronger association between the prime face and “pleasant”, and negative scores representing stronger association between the prime face and “unpleasant”. Similar priming scores for accuracy were calculated by subtracting % correct for unpleasant words from pleasant words. These priming scores were analyzed by 2-way repeated measures ANOVA with factors of Race (Chinese/Caucasian) and Group (Own/Other).

2.2.5. *Level of contact with other-race: questionnaire*

Participants also completed a questionnaire to assess their level of contact with Caucasian people. Firstly, participants completed a questionnaire that asked participants to estimate the percentage of people who were Caucasian or Asian across different daily-life social contexts and across different life stages. Specifically, they were asked to rate the percentage split for people in their neighbourhood, in their university/school, amongst their classmates, amongst their workmates, and amongst their friends, rated for their situation during primary school age, secondary school age, and university/work age. All participants were current university students in Australia who had completed all primary and secondary schooling in China, and their ratings for University/work age reflected their current situation in Australia. As such, all participants rated very low contact with Caucasians during primary and secondary school years, and we took only their percentage scores for “Caucasians” in their current situation (University/work age) for each of the different daily-life contexts to correlate with fMRI results.

2.2.6. *Explicit identification with own and other group*

Finally, participants were asked to explicitly rate the degree to which they identified with their own group and with the other group from the arbitrary (minimal) group assignment. They gave ratings on a 5-point scale to the questions: “How similar do you see yourself to be to members of your group?” and “How similar do you see yourself to be to members of the other group?” (1, not similar at all; 5, very similar). Ratings for Own and Other group were compared by Wilcoxon signed-ranks test.

2.3. *fMRI image Acquisition and analysis*

Functional MRI scans were conducted on a 3 Tesla Siemens Trio MRI scanner with 32-channel head coil. Gradient-echo echo-planar images were acquired with 38 axial slices from the top of the vertex covering most of the brain with parameters: 64 x 64 voxels at 3×3 mm resolution, 3 mm slice thickness with 10% inter-slice gap, repetition time (TR) = 2.5 sec, echo time (TE) = 35 ms, flip angle (FA) = 90°. For each participant, 636 volumes were obtained (4 runs $\times$ 159 scans each). High-resolution anatomical images were acquired using 3D T1-weighted image and 1 mm isotropic voxel resolution.

Data preprocessing and analysis was performed with SPM8 (The Wellcome Trust Center for Neuroimaging, London, UK). Slice timing correction was used first to correct images for inter-slice timing differences (Sladky et al., 2011). Images were then spatially realigned to correct for head movement during the scans and spatially normalised to standard MNI space, using parameters derived from the SPM "Segment" procedure applied to the participant's co-registered T1 anatomic image. Finally, images were spatially smoothed using a 3D isotropic Gaussian filter of 6 mm full-width/half-maximum. For first-level data analysis, event-related neural responses to the videos were modelled as 8 separate conditions (all factorial combinations of Needle/Cotton-tip, Chinese/Caucasian, Own-group/Other-group) convolved with the canonical hemodynamic response function. Contrasts of Needle minus Cotton-tip touch were calculated for each of the 4 types of faces, therefore representing the level of activation for observed painful compared with non-painful touch for actors of own versus other race and own versus other group.

For group level analysis, these contrasts of painful versus non-painful touch were entered into a 2 x 2 Factorial design with factors of Race (Own/Other) and Group (Own/Other). Within this design, we specifically compared activation to observed painful versus non-pain touch overall, averaged across Race and Group (Main effect), and activation differences for painful versus non-painful touch to Chinese faces versus Caucasian faces and to Own-group faces versus Other-group faces (Interaction effects). Results from these whole-brain analyses were reported at a cluster-level threshold of $P_{FWE} < .05$, corrected for multiple comparisons, with clusters formed by the voxel-level height threshold of $P_{uncorrected} < .001$. Anatomical names for brain areas showing significant effects were identified using the Automated Anatomical Labelling toolbox of SPM8 (Tzourio-Mazoyer et al., 2002).

In order to examine correlations between the level of neural empathic activation (i.e. difference in response between painful and non-painful touch) and the level of contact that our Chinese participants reported with Caucasian people, we performed additional region of interest analysis only in those brain regions that showed significant neural empathic responses. We identified the peaks of the clusters showing significantly greater activation overall for painful versus non-painful touch or showing significant race differences in activation to painful versus non-painful touch (racial bias in empathy). We extracted the mean contrast parameter estimates (i.e. levels of activation) from 5 mm radius spheres centred on those peaks for neural empathic responses (i.e. painful minus non-painful touch) to Caucasian actors only. We then used SPSS to examine the correlation between neural empathic activation to the Caucasian actors and the level of contact with Caucasians that participants reported in the questionnaires, considering only their current situation in Australia. Using SPM8, we also performed voxel-wise whole-brain regression analysis between activation for painful versus non-painful touch to Caucasian faces and the overall level of contact participants reported with Caucasians. This allowed us to examine whether any other regions, outside those generally showing neural empathic activation, showed any correlation between activation level and contact reported with Caucasians in daily life.

3. Results

3.1. *Implicit association with Race and Group: affective priming task*

Results of the affective priming task clearly indicated that participants formed implicit associations with their own group compared with the other group from the arbitrary (minimal) group assigment. As evident in Fig. 2, participants' Priming Scores were significantly more positive (indicating faster reaction times to classify positive compared with negative words) when primed by Own-Group faces compared with Other-Group faces. This was assessed by 2-way ANOVA showing a significant main effect of Group, $F(1,29) = 42.05$, $p < .001$. Overall, there was no significant main effect of Race, but there was a significant interaction between Race and Group, $F(1,29) = 5.16$, $p = .031$, indicating that the association participants formed with own and other group members differed depending on the race of the actor. Interestingly, post hoc tests showed that the negative associations participants had with Other-Group members were significantly stronger (more negative) to the Chinese (own-race) actors compared with the Caucasian actors, $p = .019$. This is possibly a type of "traitor" effect, whereby people who could be considered in-group members on the highly salient dimension of Race were identified as members of the out-group on the other minimal-group dimension. Nonetheless, participants clearly identified with Own-Group members more positively that with Other-Group members overall.

Accuracy on the affective priming task showed the same strong effect of group membership [main effect: $F(1,29) = 15.75$, $p < .0001$], whereby the Priming Score was significantly more positive (greater accuracy to classify positive words than negative words) for Own-Group members

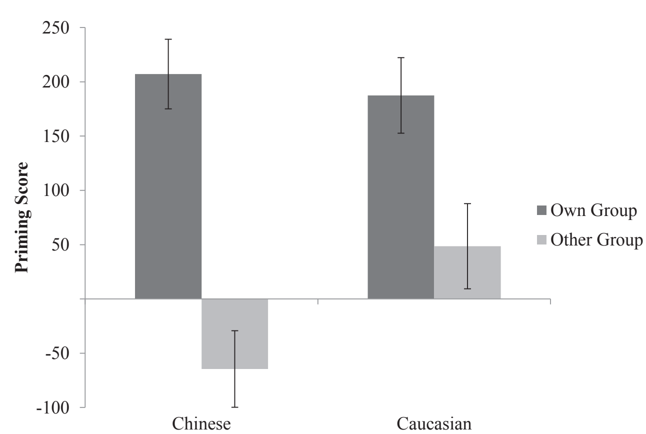

Fig. 2 – Priming Scores for the affective priming task, indicating implicit associations with the Chinese/Caucasian and Own-Group/Other-Group actors. Positive priming scores reflect faster reaction times to classify positive compared with negative words, indicating greater positive associations of the actors. Conversely, negative priming scores reflect slower reaction times to positive compared with negative words, indicating greater negative association with the actors.

compared with Other-Group members. For accuracy, there was no significant main effect of Race or interaction between Race and Group ($p > .05$).

3.2. *Explicit identification with own and other group*

Participants were also asked to explicitly rate how similar they saw themselves to members of their Own-Group or the Other-Group from the arbitrary (minimal) group assignment. Participants gave significantly higher ratings for similarity with their Own-Group ($M = 3.30$ $SE = .21$) compared to Other-Group members ($M = 2.17$ $SE = .14$; Wilcoxon signed ranks test $Z = 3.98$, $p < .0001$). Overall, results from the affective priming task (implicit association) and this explicit rating scale of group identification clearly showed that our group assignment and learning/recognition tasks were successful in leading to greater association with Own-Group compared with Other-Group members.

3.3. *Level of contact with other-race: questionnaire*

Only 23 of the 30 participants correctly completed the questionnaire to assess level of contact with other-race people (5 people did not complete any items, and 2 were incomplete). Data for these analyses was therefore based on a subset of 23 participants, including all 11 of the new arrivals (in Australia for less than 6 months) and 12 with longer duration in Australia (up to 5 years). As would be expected, the overall level of contact participants reported with Caucasians in daily life was significantly correlated with their duration of stay in Australia ($r = .60$, $p = .003$). There was a wide range of daily contact with Caucasian people reported across the different daily-life social contexts. The largest percentage experience with Caucasians was reported in the Neighbourhood (mean: 57%; range: 97%), followed by University (mean: 47%; range: 85%). For closer contact, percentage experience with Caucasians was overall lower, with a mean of 33% as Classmates (range: 85%) and mean of 13% as Friends (range: 50%). Only 6 students had part-time jobs and reported contact for Workmates (mean: 25%; range: 89%); however, as most participants did not complete this item it was not further analysed.

3.4. *fMRI task*

3.4.1. *Behavioural measures: perceived painfulness*

During the fMRI task, participants rated the perceived painfulness of each video clip on a 4-point scale (1, no pain; 4, considerable pain). As expected, participants rated the perceived painfulness significantly higher to videos showing touch with the syringe needle ($M = 3.31$, $SE = .12$) compared with the cotton-tip ($M = 1.15$, $SE = .04$, Wilcoxon signed rank test, $Z = 4.78$, $p < .0005$). We further analysed the perceived painfulness for the syringe needle videos only, comparing ratings for painful stimuli across the 4 types of faces (Fig. 3). These scores appeared all very similar across conditions; however, statistical analysis revealed that perceived painfulness ratings given for Chinese actors ($M = 3.36$, $SE = .12$) were significantly higher than those for Caucasian actors ($M = 3.25$, $SE = .12$; Wilcoxon signed-ranks test, $z = 3.51$, $p < .0005$). Mean

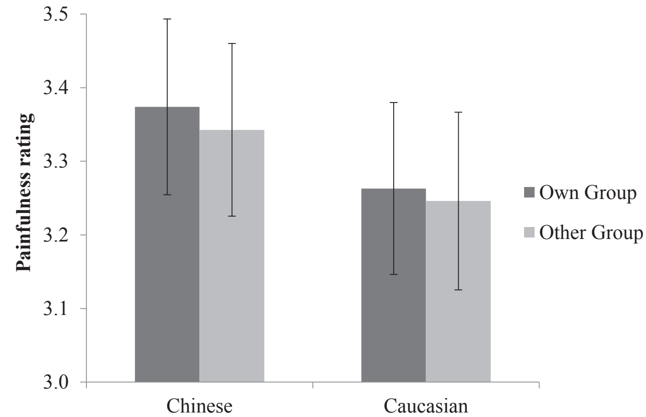

Fig. 3 – Mean ratings of Perceived Painfulness on a 4-point scale for the video clips depicting touch with the syringe needle. Mean ratings were relatively high for the painful stimuli for all actors (4 = "considerable pain"), and were significantly higher for Chinese actors compared to Caucasian actors.

ratings for Own-Group compared to Other-Group actors were not significantly different.

In order to examine whether perceived painfulness to Caucasians actors changed with the level of contact reported with Caucasians, we calculated a racial bias score by subtracting the ratings given for Caucasian actors minus Chinese actors receiving painful touch. We then performed a Spearman's rank correlation analysis between these racial bias scores and the overall level of contact with Caucasians reported in daily life; however, this was not significant ($rho = -.15$, $p = .50$). Finally, we also divided the participants into groups of High versus Low contact, by median-split on the overall contact scores, and compared the two groups using a Mann–Whitney Test. This also showed no significant difference between the groups ($U = 49.50$, $p = .31$). This lack of significant findings should be interpreted cautiously, as the 4-point scale used for painfulness ratings may not have had the sensitivity needed to detect subtle changes in perceived painfulness with level of contact.

3.4.2. *Whole-brain fMRI analysis*

3.4.2.1. NEURAL EMPATHY: PAINFUL VERSUS NON-PAINFUL TOUCH. Overall, significantly greater activation for painful compared with non-painful touch averaged across all conditions was found in the typical regions of the core pain matrix as reported in many previous studies (see Fig. 4, Table 1). This neural empathic activation included: the left insula cortex, extending to the left inferior frontal gyrus, pars orbitalis and pars triangularis; the right insula cortex, extending to the right inferior frontal gyrus, pars orbitalis and pars triangularis; the supplementary motor area; the medial frontal gyrus, and the left somatosensory cortex, including the left postcentral gyrus, extending also to the precentral gyrus (see Table 1 for all peak co-ordinates and statistical values). Activation in the region of the secondary sensory cortex, around the left supramarginal gyrus, was also present but did not reach the corrected statistical threshold (co-ordinates: −60, −22, 34; z-score: 4.44; Cluster-size, 97 voxels; Cluster-level $P_{FWE} = .09$).

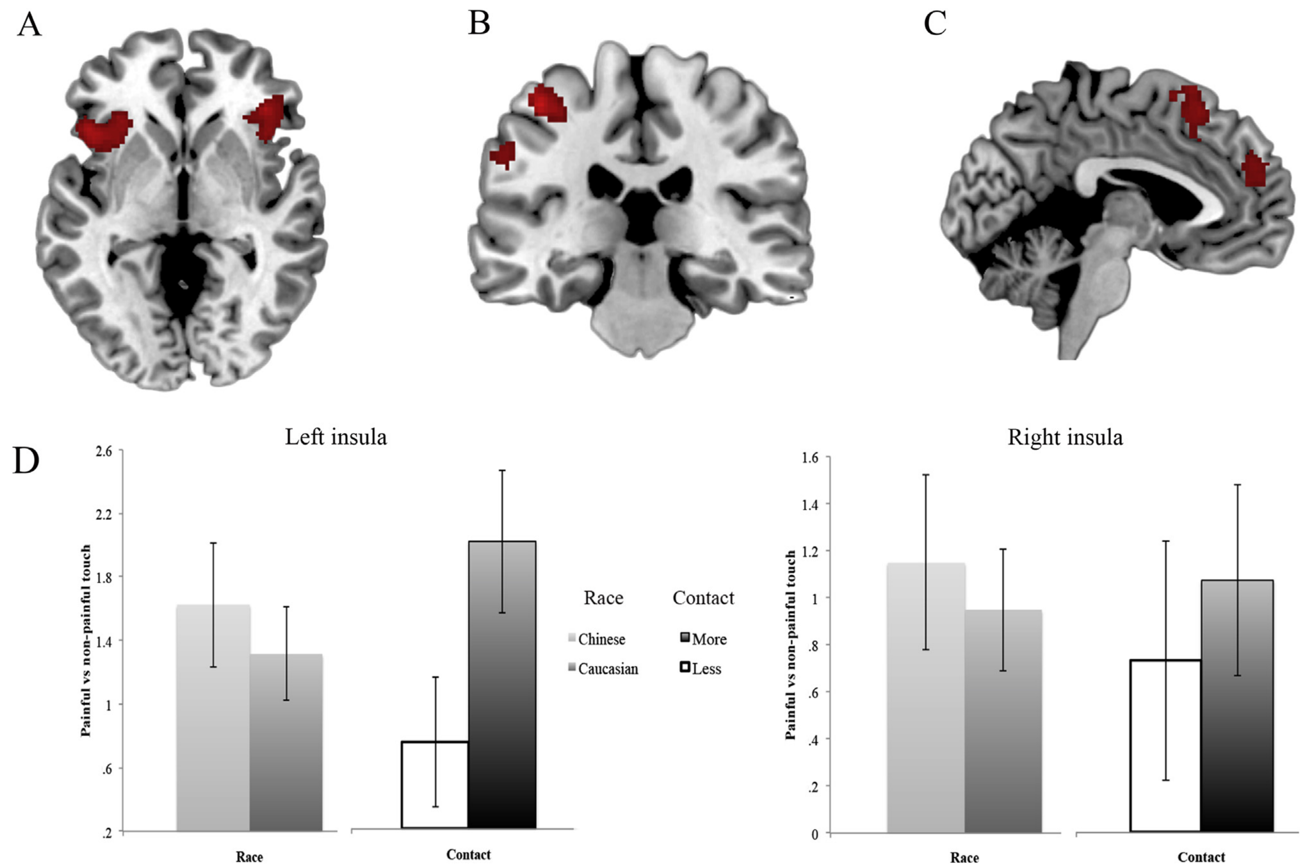

Fig. 4 – Brain activation maps showing areas of greater activation for painful versus non-painful touch, averaged across Race and Group conditions. (A) Activation was found bilaterally in the insula cortex. (B) Activation in left somatosensory cortex (postcentral gyrus) and below the statistical significance threshold in the region of the secondary sensory cortex (supramarginal gyrus; $P_{FWE} = .09$). (C) Activation in the medial frontal cortex, including the supplementary motor area and the medial frontal gyrus. (D) Level of activation (parameter estimates) in the activated regions of the left and right insula cortex separated by Race (Caucasian versus Chinese faces) and the level of Contact (response to Caucasian faces in those participants reporting More versus Less contact with Caucasians, by median-split on summed overall contact scores).

3.4.2.2. Effects of Race and Group on neural empathy. Next, we examined differences in this neural empathic activation (painful versus non-painful touch) for Own-Race compared to Other-Race actors and for Own-Group compared to Other-Group actors (i.e. interaction effects), tested across the whole brain. Only one area, in the ACC, showed significantly greater activation for pain in Own-Race compared to Other-Race actors (Fig. 5A). The peak of this cluster lay in the right ACC, according to the AAL atlas (see Table 1), and extended also to the superior and mid frontal gyri in the right hemisphere. No regions showed significantly greater activation in the reverse contrast, for pain in Other-Race compared to Own-

Table 1 – Brain regions that showed significantly greater activation for painful versus non-painful touch. Shown are both main effects averaged across Group and Race conditions (Chinese + Caucasian) and interaction effects comparing neural empathic activation to Chinese versus Caucasian faces.

Area	Cluster peak co-ordinates	Peak z score	Cluster size	Cluster level P_{FWE}
Chinese + Caucasian (Main effect)				
Left insula cortex	−32 22 −12	5.40	868	.0001
Right insula cortex	40 32 −2	4.69	334	.0001
Supplementary motor area	−2 22 56	4.16	457	.0001
Left postcentral gyrus	−42 −26 56	5.18	154	.015
Medial frontal gyrus	0 58 28	3.84	151	.016
Chinese − Caucasian (Interaction)				
Anterior cingulate cortex	16 42 14	4.05	141	.022

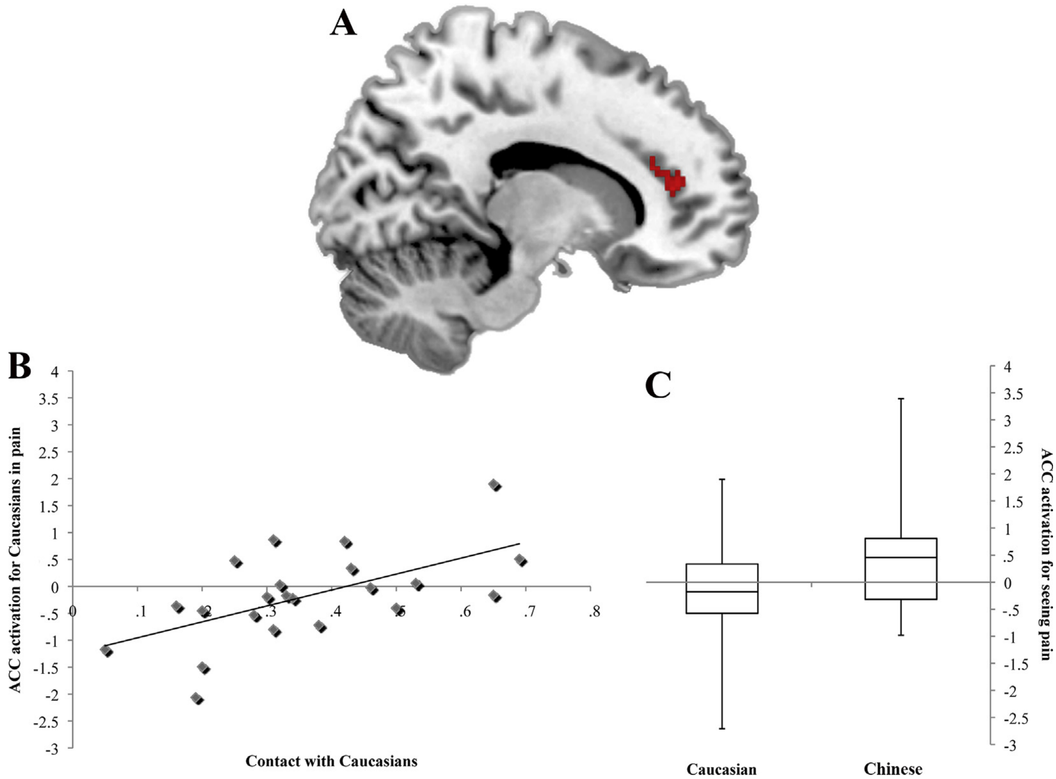

Fig. 5 – Brain activation results showing racial bias in neural empathy. (A) Significantly greater activation was found in the anterior cingulate cortex for painful versus non-painful touch to Chinese (Own-Race) compared to Caucasian (Other-Race) actors. (B) The level of activation in the anterior cingulate cortex for painful versus non-painful touch to Caucasian actors showed a significant correlation with the total level of contact reported with Caucasians averaged across all daily-life social contexts ($r = .60$, $p = .003$). (C) Plotted is the overall activation in the anterior cingulate cortex for painful versus non-painful touch to Chinese compared to Caucasian actors, showing the median value, upper and lower quartiles, and maximum and minimum values.

Race actors. Also, no regions showed significantly greater activation for pain in Own-Group compared to Other-Group members or vice-versa.

3.4.3. *Correlation between neural empathy and other-race contact*

We conducted region of interest analysis to examine the correlation between activation level in brain areas showing neural empathic responses (all regions in Table 1) and the level of contact participants reported with Caucasians across different daily-life contexts. Duration of stay in Australia did not show any significant correlation with neural responses to observed pain in Caucasians ($p > .05$). Importantly, however, the region of the ACC that showed a significant racial bias in neural empathy (Section 3.4.2) also showed a significant positive correlation between the level of contact reported with Caucasians and activation to observed pain in Caucasian actors (Fig. 5B; $r = .60$, $p = .003$). Note that this correlation analysis is orthogonal to and not confounded by the differences found in activation to Own-Race compared to Other-Race actors (Section 3.4.2), since we took measures of activation level for observed pain only in Caucasian (Other-Race) actors and not Chinese (Own-Race) actors for this correlation analysis.

Specifically, we found significantly greater neural empathic activation in the ACC in those people reporting greater total contact with Caucasians, averaged across the 5 different social contexts (Fig. 5B; $r = .60$, $p = .003$). Interestingly, the greatest correlations were found for the reported percentage of Caucasians seen in more incidental contexts, in general at the University ($r = .67$, $p < .0001$), and in the participant's Neighbourhood ($r = .51$, $p = .013$). Other measures of closer social contact were not so strong, showing marginally significant correlation for percentage of Caucasians as Classmates ($r = .42$, $p = .044$) and no significant correlation for percentage of Caucasians as friends ($p > .05$). This may reflect the lower percentage reported overall for contact with Caucasians as classmates and as friends.

No other regions showed significant correlations between activation level and measures of contact with Caucasians from the questionnaires. In particular, activation in the left and right anterior insula cortex appeared to show greater activation to observed pain to Caucasian faces in those participants reporting more contact with Caucasians (Fig. 4D); however, correlation analyses between these parameter estimates and the overall level of contact reported in the questionnaires were not significant for either the left ($r = .14$, $p = .51$) or the right insula cortex ($r = .12$, $p = .60$).

3.4.4. *Post-hoc analyses*

3.4.4.1. Region of interest: the anterior insula cortex. As previous studies have implicated the anterior insula cortex as an important site for racial bias in neural responses to observed pain (Contreras-Huerta et al., 2013), we examined activation in the insula in more detail using region-of-interest analysis. We extracted parameter estimates from the bilateral anterior insula clusters that showed significant activation to observed pain overall (Table 1, Main effect) and plotted these separately by Race of the observed face and by level of Contact reported with Caucasians by median-split (Fig. 4D). There is an apparent trend for greater activation to observed pain in Chinese compared with Caucasian faces; however, ANOVA conducted on these parameter estimates showed no significant effects of Race or Group, or any significant interactions, in both the right and left anterior insula regions ($p > .05$).

3.4.4.2. Correlation: own-versus other-group association and neural empathy. We also conducted post-hoc analyses to examine the lack of significant effects of Group from the whole-brain analysis in more detail. Specifically, we examined whether the degree to which participants identified positively with own-group versus other-group members, from the affective priming task, correlated with their neural responses to observed pain in own- or other-group members. We obtained mean parameter estimates from regions-of-interest around the peaks in each of the regions showing significant neural empathic responses (all regions in Table 1) and calculated correlations with Priming scores towards own/other group members on the affective priming task. We found no significant correlations in any of the regions of interest ($p > .05$).

3.4.4.3. Whole-brain regression: neural empathy and other-race contact. In order to determine if any other brain region outside our regions-of-interest might have shown correlations between activation level for painful versus non-painful touch to Caucasian actors and the level of contact reported with Caucasians, we conducted a voxel-wise regression analysis across the whole brain. The peak identified in this whole-brain analysis lay in the same region of the ACC identified in our main analyses (MNI co-ordinates: 16 38 12; z-score: 3.71; $P_{uncorrected} < .001$; cluster size: 37 voxels); however, there were no regions that were significant in this analysis following correction for multiple comparisons (both cluster-level and voxel-level $P_{FWE} > .05$ for every peak). There were also no regions that showed significant negative correlation with contact scores. The peak in the ACC was also the only region with uncorrected cluster-level probability $P_{uncorrected} < .05$ in analyses for positive or negative correlations in the whole brain.

4. Discussion

The current study aimed to determine how exposure to other-race people and the manipulation of social group membership could influence the racial bias in neural empathy for pain. We found the typical neural empathic response to painful versus non-painful touch, involving activation bilaterally in the insula cortex, as found in many previous studies (Singer et al., 2004; Lamm et al., 2011; Fan et al., 2011). This neural empathic response in the ACC showed a racial bias, with greater activation to observed pain in Own-Race compared with Other-Race actors, consistent with previous studies (Contreras-Huerta et al., 2013; Xu et al., 2009). Crucially, we found that this racial bias in empathic activation of the anterior cingulate was reduced by contact with people of the other race, with participants who reported greater contact with Caucasian people showing greater neural empathic activation to pain in Caucasian actors.

Overall, our study shows that racial bias in neural empathy changes rapidly with experience in new immigrants within 5 years of arriving and, crucially, depends on the level of daily-life contact with people of the other race in everyday situations. In a previous study, Zuo and Han (2013) showed that people who were born and lived the majority of their lives in a predominantly other-race country showed equal empathic activation to their own-race and the other-race people. Our findings expand significantly on this prior work, showing that neural empathic responses to other-race people change relatively quickly over time, at least within 5 years of immigrating, and that these changes in racial bias do not rely on closeness of contact or personal relationships but simply on incidental experience with people of the other-race in daily life situations.

We assessed correlations between neural empathic responses and participants' reported contact with Caucasians across five different daily-life social contexts. Interestingly, the strongest relationships between other-race contact and empathic responses were found for the social contexts with more incidental contact or exposure, including the percentage of Caucasians that participants reported seeing in their local neighbourhood and at their university (n.b. All participants were students of The University of Queensland, which is located on a single campus of approximately 40,000 students). Social contexts involving closer personal contact with Caucasians (as friends) appeared to have much less influence in reducing the racial bias in neural empathy observed. Other studies have suggested that the quality or closeness of relationships or friendships with others plays an important role in emotional or empathic responses to their suffering (Beeney, Franklin, Levy, & Adams, 2011; Meyer et al., 2013). It may be that the weaker relationships we found here for closer contact with other-race people simply reflects the lower average contact that our participants reported with Caucasians as classmates (33%) or as friends (13%). Nonetheless, the fact that we found strong relationships between neural empathic responses to Caucasians and reported experience with Caucasians in more incidental contexts, in the general neighbourhood and the university campus, suggests that mere exposure to the other race people in daily-life situations is sufficient to reduce racial bias in neural empathy.

Behaviourally, we also found that participants judged the perceived pain for own-race Chinese actors higher than for other-race Caucasian actors. Interestingly, this behavioural racial bias in empathy has not been found by previous studies (Avenanti et al., 2010; Azevedo et al., 2013; Sessa, Meconi, Castelli, & Dell'Acqua, 2014; Xu et al., 2009). While the difference we found was statistically significant, it is not clear how ecologically or behaviourally relevant this difference really is, as the mean difference in scores was only .11 points on an ordinal scale from 1 to 4. Nonetheless, we do find a very small difference in perceived judgements of painfulness that appears to follow the neural empathic activation for own-race compared with other-race actors.

Our manipulation of group membership, orthogonal to the race of the actors, clearly led to participants identifying more positively with in-group members than out-group members behaviourally, as assessed by the affective priming task and explicit ratings. Group membership, however, had no significant influence on neural empathic activation to in-group compared with out-group members or on judgements of perceived painfulness. This is consistent with and replicates our previous study that used identical methods (Contreras-Huerta et al., 2013), but is at odds with the previous EEG study of Sheng and Han (2012) that showed racial bias could be eliminated by incorporating other-race individuals into the observer's own in-group.

There are a number of factors that could account for these differences between studies, and would be a valuable avenue for further research to examine the basis of group identity processes. Firstly, in-group and out-group members in the study of Sheng and Han (2012) wore different coloured t-shirts, providing a strong physical cue for group identity. This is similar to "Race" in which own-race and other-race individuals are defined only by highly salient differences in the physical characteristics of the actors' faces. In contrast, our own studies have relied on participants learning to recognise individual actors to identify group membership, and no other salient physical cues differentiated in-group from out-group members (Contreras-Huerta et al., 2013, in press). Alternately, in our studies, participants were told that group assignment was based on common shared beliefs and attitudes, whereas participants in Sheng and Han (2012) study were told that group assignment was for a competitive game. Other studies have similarly shown strong effects of group assignment on empathy and neural mirroring processes when groups are defined based on competition (Hein et al., 2010; Singer et al., 2006). It is possible that competition between groups, more than shared beliefs and attitudes, either facilitates empathy or emotion sharing between group members or strengthens and reinforces in-group versus out-group identity generally. This would be in line with theories on the relationship between inter-group prejudice and competition (Sumner, 1940; Taylor & Moriarty, 1987) and its possible evolutionary basis (Kurzban, Tooby, & Cosmides, 2001).

We found no significant racial bias in activation to observed pain in the anterior insula cortex, although we observed trends in that direction. Previous findings in this area have been mixed, with our own previous study (Contreras-Huerta et al., 2013) reporting racial bias in the anterior insula, but Xu et al. (2009) not reporting any such racial bias in the insula cortex. Interestingly, when considering insula activation to observed pain in Caucasians *only* in those participants reporting low contact with Caucasians (Fig. 4D, white bars), this appears much less than activation to observed pain in own-race Chinese faces (Fig. 4D, light grey bars). Although neither of these effects of Race or Contact were statistically significant, we certainly do not rule out that neural empathic responses in the anterior insula cortex may be sensitive to the race of the observed person and level of contact with people of the other race.

Finally, we must consider possible underlying mechanisms of this change in neural empathic responses with other-race contact. While we found that the level of exposure to other-race people in more incidental daily-life contexts had the most influence in reducing the racial bias in neural empathic responses, the underlying cause of this effect is still not clear. It may be simply that greater visual exposure to other-race people is sufficient to change the neural response of the brain to seeing other-race people, and that this effect of visual experience flows on to influence higher-order neural responses when observing other-race people in other situations. Such effects of visual experience or expertise have been used to explain the "other race effect", whereby facial recognition performance is better for the types of faces with which we have greatest visual experience (Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005; de Heering, de Liedekerke, Deboni, & Rossion, 2010). Alternately, the increased neural empathic response that we find here increasing with experience with people of the other race may still arise from underlying changes in group social identity, whereby the immigrants develop greater group association with the types of people they encounter in their new social environment over time.

We also cannot rule out that more general group processes may play a role in changing racial bias in neural empathic responses. In our study, the strongest correlation we found was for contact with Caucasians in the university population in general. Our participants were all students of The University of Queensland and were led to believe that the actors in the video clips were other participants in the study (reinforced by inclusion of the participant's photo amongst in-group members) who would therefore be considered students of the same university. It has long been known that university allegiance is a strong basis for intergroup biases and prejudice (Hastorf & Cantril, 1954; Bourhis & Hill, 1982). Developing in-group relations with other-race people, for example as fellow students of the same university, or simply through everyday contact in the local neighbourhood or around the university campus, may therefore contribute to the changes in racial bias in neural empathy we find here. This complex issue of what specific factors underlie these changes in neural empathy towards people of other races with experience and contact is a crucial direction for future research and of profound importance to our modern-day multi-cultural society.

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