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Introduction

Empathy refers to the ability to understand and share others' emotion and plays a key role in social behaviors. Perception of others in pain or distress generates empathic concerns that provide a proximate mechanism selected by evolution that motivates altruistic behaviors (Batson, 1991; de Waal, 2008). Empathy may influence social behaviors by changing people's attitudes toward a target (Batson et al., 1997a), which sometimes produces serious consequences such as when making judicial decisions on a defendant (Johnson et al., 2002).

The perception–action model of empathy proposes that empathic responses do not require conscious and effortful processing and often occur automatically (Preston and de Waal, 2002). Consistent with this, neuroimaging studies have shown that perception of others in pain activates the neural circuit consisting of the anterior cingulate cortex (ACC) and insula that mediate first-person pain experience (Singer et al., 2004; Botvinick et al., 2005; Jackson et al., 2005; Saarela et al., 2007). However, the empathic neural responses are modulated by affective link between individuals (Singer et al., 2006) and top-down attention to painful cues in stimuli (Gu and Han, 2007; Fan and Han, 2008). In addition, empathy may be influenced by social relationship between individuals such that empathic concerns increase if a perceiver and a target share common membership in a social category (Hornstein, 1978). The evidence supporting this hypothesis comes from research that measured subjective reports of empathic concern. Johnson et al. (2002) asked White university students to read a passage involving a Black or a White man who was charged with a criminal act. Participants were induced to feel no empathy, low empathy, or high empathy for the defendant and then evaluate punishments applied to the defendant. Johnson et al. (2002) found that White participants reported greater feelings of empathy for and assigned more lenient punishments to the White than the Black defendant, suggesting an empathic bias toward racial in-group members.

The current work investigated the neural mechanism underlying modulations of empathic neural responses by racial group membership between individuals. We scanned Caucasian and Chinese participants using functional magnetic resonance imaging (fMRI) while they watched video clips of Caucasian or Chinese faces receiving painful stimulation (needle penetration) or non-painful stimulation (cotton Q-tip touch). Automatic categorization of others by race defines the intragroup or intergroup relations between a perceiver and the target. Our recent research (Han et al., 2009) found that, relative to Q-tip touch, needle penetration applied to faces of Chinese models with neutral expressions induced increased activations in the ACC and bilateral frontal cortices of Chinese participants. The present study further tested the hypothesis that the empathic neural responses are weakened by race-defined intergroup relationship and such effect is independent of perceivers' own race.

Materials and Methods

Subjects. Seventeen Chinese (8 males, mean = 23 years, SD = 2.0 years, all right handed) and 16 Caucasian healthy college students (8 males, mean = 23 years, SD = 3.7 years, 10 Americans, 2 Dutch, 1 Italian, 1 German, 1 Russian, 1 Israeli, 12 right handed, 4 left handed) were paid for participation. All had normal or corrected-to-normal vision and reported no abnormal neurological history. Informed consent was obtained from all participants before scanning. This study was approved by a local ethics committee.

Stimuli and procedure. The stimuli consisted of 48 video clips showing faces of six Chinese (3 males) and six Caucasian models (3 males). Each clip, subtending a visual angle of 21° × 17° (width × height) at a viewing distance of 80 cm, lasted 3 s and depicted a face with neutral expressions

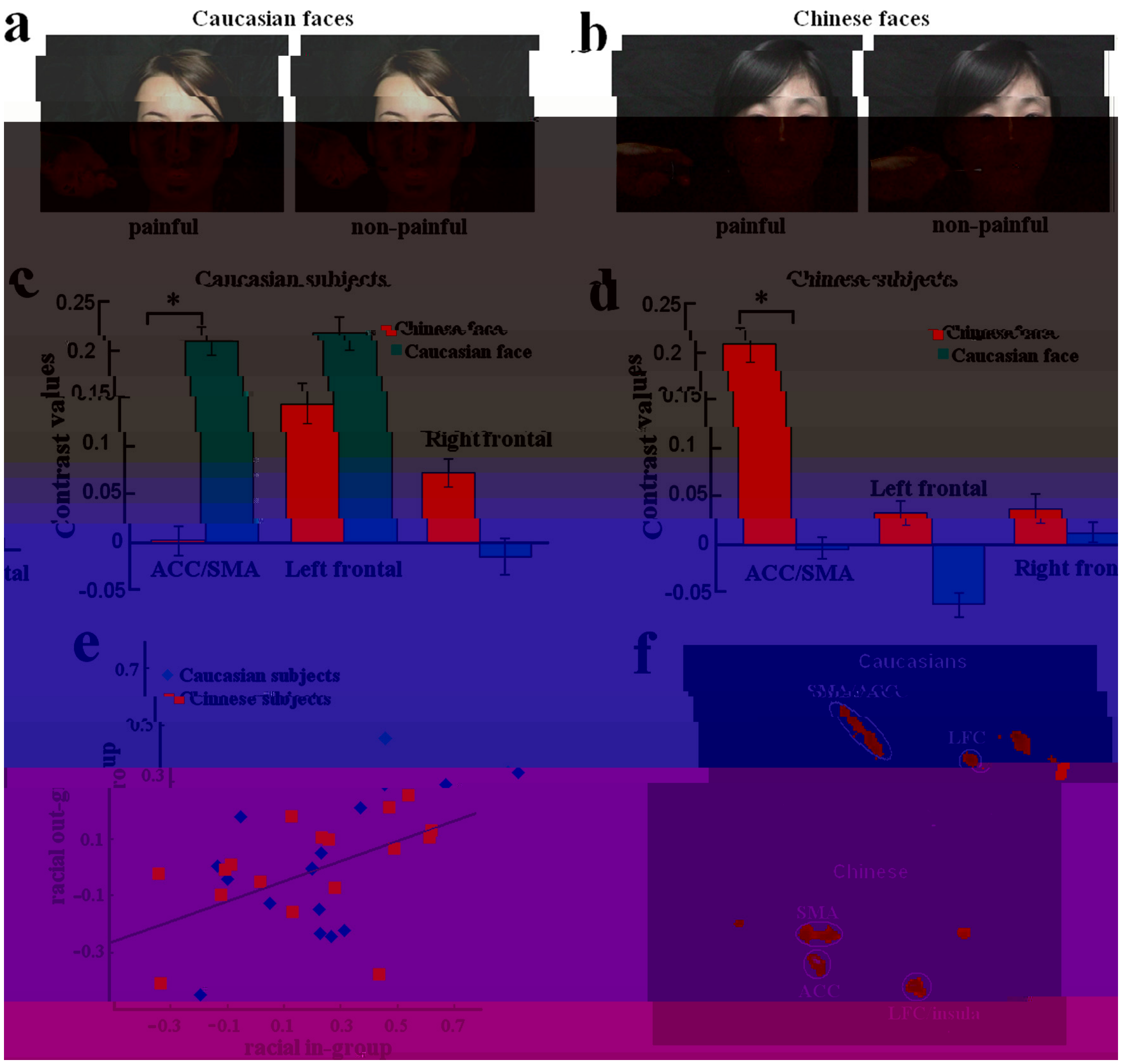

Figure 1. ***a***, Illustration of Caucasian faces receiving painful and non-painful stimuli. ***b***, Illustration of Chinese faces receiving painful and non-painful stimuli. ***c***, Contrast values of the parameter estimates of signal intensity in the ACC and the frontal cortex that differentiated painful and non-painful stimuli in Caucasians. ***d***, Contrast values of the parameter estimates of signal intensity in the ACC and the frontal cortex that differentiated painful and non-painful stimuli in Chinese. ***e***, Correlation between ACC empathic neural responses to racial in-group and out-group members. *X* and *Y* axes respectively indicate ACC empathic responses to racial in-group and racial out-group members indexed in contrast values of painful versus non-painful stimulation. ***f***, Increased activations in the ACC and the frontal/insula cortex shown in whole-brain statistical parametric mapping analyses when participants perceived racial in-group faces. The upper figures show the results from Caucasian subjects and the lower figures show the results from Chinese subjects.

feeling pain by pressing a button using the right index or middle finger. Six functional scans of 204 s were obtained from each subject. Each scan consisted of 16 video clips (8 Chinese and 8 Caucasian faces, half with painful and half with non-painful stimulations in a random order). The interstimulus interval between two successive clips lasted 9 s during which participants fixated at a central cross. The last clip in each scan was followed by a fixation of 12 s.

After the scanning procedure, participants were shown half of the video clips again and had to rate the pain intensity felt by the model ("How painful do you think the model feels?") and the unpleasantness felt by the onlooker ("How unpleasant do you feel when observing the video clip?") using a Likert-type scale where 0 indicated no effect and 10 indicated maximal effect (e.g., extremely painful, extremely unpleasant). Individuals' attitudes of ethnic identity were assessed using the Multigroup Ethnic Identity Measure (Phinney, 1992) (1 = strongly disagree; 4 = strongly agree). The degree of endorsement of individualistic and collectivistic values was estimated using a 7-point Likert-type scale (Triandis and Gelfand, 1998) (1 = strongly disagree; 7 = strongly agree). Individual differences in empathy ability were measured using the Empathic Concern Scale (Davis, 1996).

fMRI image acquisition and analysis. Scanning was performed at Peking University First Hospital, using a GE 3-T scanner with a standard head coil. Thirty-two transverse slices of functional images covering the whole brain were acquired using a gradient-echo echo-planar pulse sequence [64 × 64 × 32 matrix with a spatial resolution of 3.75 × 3.75 × 4 mm, repetition time (TR) = 3000 ms, echo time (TE) = 30 ms, field of view (FOV) = 24 × 24 cm, flip angle = 90°]. Anatomical images were obtained using a 3D FSPGR T1 sequence (256 × 256 × 128 matrix with a spatial resolution of 0.938 × 0.938 × 1.4 mm, TR = 7.4 ms, inversion time (TI) = 450 ms, TE = 3.0 ms, flip angle = 20 °).

SPM2 (the Wellcome Trust Centre for Neuroimaging, London, UK) was used for fMRI data analysis. The functional data were first time-corrected to compensate for delays associated with acquisition time differences between slices during the sequential imaging. The functional images were then realigned to the first scan to correct for head motion between scans. The anatomical image was coregistered with the mean functional image produced during the process of realignment. All images were normalized to a 2 × 2 × 2 mm^3 Montreal Neurological Institute (MNI) template. Functional images were spatially smoothed using a Gaussian filter with the full-width/half-maximum parameter (FWHM) set to 8 mm and temporally filtered using a cutoff of 128 s. The event-

Table 1. Mean rating scores (SD) of pain intensity and self-unpleasantness

	Chinese face		Caucasian face	
Video types	Needle	Q-tip	Needle	Q-tip
Pain intensity				
Chinese participants	8.78 (1.12)	0.96 (1.21)	8.58 (1.64)	1.13 (1.12)
Caucasian participants	4.56 (3.11)	0.55 (0.54)	4.26 (3.13)	0.29 (0.39)
Self-unpleasantness				
Chinese participants	7.73 (1.89)	1.32 (1.69)	7.68 (1.82)	1.25 (1.40)
Caucasian participants	4.88 (2.98)	0.42 (0.56)	4.56 (3.15)	0.30 (0.47)

related neural activity was modeled using a canonical hemodynamic response function.

Region-of-interest (ROI) analyses were conducted to test our hypothesis. The ROIs were defined based on an entirely independent data set that also compared needle penetration with Q-tip touch applied to neutral faces (Han et al., 2009). The ROI of the ACC was defined as a sphere with a radius of 10 mm centered at $x/y/z = 4/40/38$ [MNI coordinates, Brodmann area (BA) 32/9]. ROIs of the left and right frontal cortices were defined as spheres with a radius of 10 mm centered at $-52/16/16$ (BA 44/45) and 52/22/20 (BA 45). The parameter estimates of signal intensity in association with the needle penetration and Q-tip touch applied to faces of the same or other races were calculated using Marsbar from both racial groups and subject to a repeated-measures ANOVA with Pain (painful vs nonpainful) and Group Membership (same vs other race) as within-subjects independent variables and Ethnicity (Caucasian vs Chinese participants) as a between-subjects variable.

Whole-brain statistical parametric mapping analyses were also performed to examine any other brain areas linked to the painful and non-painful stimulation. Effects at each voxel were estimated and regionally specific effects were compared using linear contrasts in individual participants using a fixed effect analysis. One contrast (painful vs non-painful stimulation) was calculated to define pain specific neural activations. Random effect analyses were then conducted across each participant group based on statistical parameter maps from each individual participant to allow population inference. Whole-brain statistical parametric mapping analyses were also calculated to confirm the interaction between Pain and Group Membership in each subject group by calculating the contrast $1\ -1\ -1\ 1$ (needle penetration applied to same-race faces, Q-tip applied to same-race faces, needle penetration applied to other-race faces, Q-tip applied to other-race faces). Given the previous hypothesis of brain activation related to empathy, significant activations were defined using a voxel threshold of $p < 0.001$ and a spatial extent threshold of $k = 50$.

Results

Behavioral results

Relative to Chinese participants, Caucasian participants scored higher on the Triandis individualism subscale (4.86 ± 0.48 vs 4.38 ± 0.51, $t_{(31)} = 2.762$, $p < 0.01$) but lower on the collectivism subscale (5.03 ± 0.43 vs 5.74 ± 0.69, $t_{(31)} = 3.521$, $p < 0.001$). The mean ethnic identity scores were higher for Chinese than for Caucasians (3.10 ± 0.38 vs 2.69 ± 0.43, $t_{(31)} = -2.874$, $p < 0.01$). Relative to Chinese participants, Caucasian participants showed higher rating scores of empathic concern (25.6 ± 3.26 vs 22.6 ± 3.42, $t_{(31)} = 2.553$, $p = 0.016$), perspective-taking (27.0 ± 4.25 vs 20.2 ± 3.43, $t_{(31)} = 5.083$, $p < 0.001$), and fantasy (26.8 ± 5.77 vs 19.6 ± 3.44, $t_{(31)} = 4.359$, $p < 0.001$). No significant difference on the personal distress scale was observed between the two racial groups (16.4 ± 3.89 vs 18.5 ± 2.47, $t_{(31)} = -1.852$, $p = 0.074$).

Response accuracy of the identification of painful and non-painful stimuli during scanning was high and did not differ between the two racial groups (Caucasians: 94.0%; Chinese: 93.2%, $t = 0.246$; $p > 0.5$). Rating scores of pain intensity and self-unpleasantness were higher for painful than non-painful stimulations ($F_{(1,31)} = 156.82$ and 107.544, both $p < 0.001$ (see Table 1). Chinese scored higher in both pain intensity and self-unpleasantness than Caucasians ($F_{(1,31)} = 35.645$ and 20.187, $p < 0.001$). Differential rating scores (painful vs non-painful stimuli) of pain intensity and self-unpleasantness were higher for Chinese than for Caucasians ($F_{(1,31)} = 15.421$ and 3.915, $p = 0.001$ and 0.057) but did not differ between racial in-group and out-group members (both $p > 0.1$).

fMRI results

The ROI analysis of signal intensity in the ACC confirmed increased activity to painful than non-painful stimulation ($F_{(1,31)} = 7.876$, $p < 0.01$). Moreover, there was a significant interaction of Pain × Group Membership ($F_{(1,31)} = 21.489$, $p < 0.001$), as ACC empathic responses were greater to racial in-group than out-group members. However, the triple interaction of Pain × Group Membership × Ethnicity was not significant ($F_{(1,31)} = 0.005$, $p = 0.946$), suggesting a similar patter of modulation of ACC empathic responses by racial group membership in Caucasian and Chinese participants. *Post hoc* analysis confirmed that, relative to the Q-tip touch, needle penetration increased the ACC activity when applied to racial in-group faces (Chinese: $t_{(16)} = 2.73$, $p = 0.015$; Caucasians: $t_{(15)} = 3.566$, $p = 0.003$) but not when applied to racial out-group faces (Chinese: $t_{(16)} = 0.100$, $p = 0.922$; Caucasians: $t_{(15)} = 0.030$, $p = 0.977$). Figure 1, *c* and *d*, shows contrast values to illustrate the effect of racial group membership on the ACC empathic responses. To assess whether one may predict ACC empathic responses to racial out-group members from ACC empathic responses to racial in-group members across individuals, we calculated correlation between ACC contrast values (painful vs non-painful) in association with racial in-group and out-group members and confirmed significant correlation between ACC empathic responses to racial in-group and out-group remembers ($r = 0.469$, $p = 0.006$, Fig. 1*e*).

ANOVAs of the signal intensity in the left frontal cortex showed a significant main effect of Pain ($F_{(1,31)} = 4.847$, $p = 0.035$), suggesting enhanced left frontal activity to perceived painful than non-painful stimulation. Moreover, the empathic responses in the left frontal cortex was stronger in Caucasians than in Chinese, resulting in a reliable interaction of Pain × Ethnicity ($F_{(1,31)} = 6.908$, $p = 0.013$). However, the left frontal empathic responses did not show reliable modulations by racial group membership ($F_{(1,31)} = 2.353$, $p = 0.135$). Similar analyses of the right frontal activity failed to show any significant effect (all p values >0.1).

Whole-brain statistical parametric mapping analyses further confirmed the results of ROI analyses. The contrast of painful versus non-painful stimulation applied to racial in-group faces indicated increased activations in the ACC/supplementary motor cortex (SMA) (2/34/38, $k = 1205$, $Z = 4.12$), bilateral inferior frontal cortices ($-40/42/4$, $k = 415$, $Z = 3.72$; 34/46/14, $k = 275$, $Z = 3.91$) and the left superior parietal cortex ($-48/-50/52$, $k = 757$, $Z = 5.25$) in Caucasians and in the ACC/SMA ($-2/28/20$;

$k = 200$, $Z = 3.65$; 0/20/38, $k = 105$, $Z = 2.94$) and left inferior frontal/insula cortex (−48/34/−2, $k = 299$, $Z = 3.48$, Fig. 1*f*) in Chinese. The contrast of painful versus non-painful stimulation applied to racial out-group faces did not show any significant activation in both groups of subjects. The interaction analysis that compared the two contrasts (needle penetration vs Q-tip applied to racial in-group and out-group faces) revealed increased activation in the ACC (Caucasians: 4/28/42, $k = 243$, $Z = 3.37$; Chinese: −4/38/40, $k = 488$, $Z = 3.27$). The reverse comparison did not show any significant activation.

Finally, we calculated correlation between the magnitudes of empathic responses in the ACC/bilateral frontal cortex and subjective ratings of self-construals, empathy concern, and ethnic identity. However, we did not find any significant correlation results (p values >0.05).

Discussion

We showed that perception of painful stimulation applied to faces increased activity in parts (e.g., ACC and frontal/insula cortex) of the neural circuits underlying first-person pain experience, consistent with previous observations (Singer et al., 2004; Jackson et al., 2005; Gu and Han, 2007; Lamm et al., 2007; Saarela et al., 2007; Han et al., 2009). More interestingly, we found neuroimaging evidence for modulation of empathic neural responses by racial group membership, i.e., ACC empathic responses to perception of others in pain decreased remarkably when participants viewed faces of racial in-group members relative to racial out-group members. This effect was comparable in Caucasian and Chinese subjects and suggests that modulations of empathic neural responses by racial group membership are similar in different ethnic groups.

Our findings cannot be explained by different affective links between individuals since all models were strangers to our participants. Nor can the racial bias in empathic neural responses be accounted for by in-group advantage in emotion recognition (Elfenbein and Ambady, 2002) because empathic neural responses were defined by contrasting of painful and non-painful stimuli applied to faces with neutral expressions. As race helps defining in-group/out-group members (Cosmides et al., 2003), our fMRI results support the view that shared common membership enhances a perceiver's empathic concerns for others (Hornstein, 1978). Empathy consists of both affective components (e.g., emotional sharing) and cognitive components (e.g., perspective taking) (Decety and Jackson, 2006; Fan and Han, 2008) and the ACC mainly contributes to the affective component of empathy (Singer et al., 2004). Thus the own-race bias in ACC activity linked to empathy for pain may mediate enhanced sharing of feelings and emotions of ethnic in-group members. However, such neural empathic bias toward racial in-group members did not necessarily result in different conscious subjective ratings of others' pain intensity and induced self-unpleasantness related to racial in-group and out-group members, as indicated by measures of subjective ratings in the current work. Thus it is likely that the own-race bias in empathy-related ACC activity observed here reflected unconscious affective response to racial in-group members. In contrast, as the empathy-related lateral frontal activity covaried with task demands [i.e., being present in a pain judgment task but absent in a counting task related to painful stimuli (Gu and Han, 2007)] and co-occurred with subjective reports in the current work, it may be speculated that the lateral frontal cortex is involved in conscious cognitive evaluations of others' pain.

Although our fMRI results suggest own-race bias in empathy-related ACC activity, the results of correlation analysis indicate that empathic neural responses to in-group and out-group members were not independent. Participants who showed greater empathic neural responses to in-group members also showed stronger empathic neural responses to out-group members, reflecting individual differences in general ability of empathy.

It should be noted that not any in-group membership results in enhancement of empathy. For example, university group status (shared vs unshared) does not have an impact on empathetic induction (Batson et al., 1997b). Racial group membership defines coalitions and alliances during evolution (Cosmides et al., 2003) and thus results in strong modulation of the neural substrates of emotional components of empathy. Our questionnaire measurements suggested difference in cultural values, ethnic identity, and empathy ability between the two participant groups. However, they showed similar neural substrates of empathy modulation by racial group membership. It appears that, relative to cultural influence on empathy, if any, the modulation of empathy by racial group membership is more fundamental and plays a more pivotal role in shaping social behaviors.

Our results complement previous observations that empathic neural responses are modulated by affective link between individuals (Singer et all, 2006), personal experience (Cheng et al., 2007), and task demand and stimulus reality (Fan and Han, 2008; Gu and Han, 2007) by showing modulation of empathic neural responses by social relationship. Our findings have significant implications for understanding real-life social behaviors and provide a neurocognitive mechanism for stronger intentions to help racial in-group than out-group members (Gaertner and Dovidio, 1977).

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