2010; Ma et al., 2011; Mathur et al., 2010; Luo et al., 2015). Therefore, it is likely that MS may modulate the cognitive and neural underpinnings of empathy so as to in uence in-group favoritism in social behavior. The current research tested this hypothesis by examining racial in-group bias in empathic neural responses to racial in-group and out-group members' suffering.

Behavioral research has revealed that, when being asked to make judicial decisions, white university students reported greater feelings of empathy for a white than a black defendant and assigned more lenient punishments to the white defendant (Johnson et al., 2002). White participants also exhibited pro-white empathy bias to patients' pain expressions and showed remarkable pro-white bias in pain treatment (Drwecki et al., 2011). These behavioral observations provide evidence for racial in-group bias in empathy and racial in-group favoritism

intervened with 0.5 s. The priming and calculation tasks were nished before EEG recording or fMRI scanning.

During the electroencephalography (EEG) recordings in Experiment 1, each photograph was presented in the center of a gray background on a 21-inch color monitor, subtending a visual angle of 3.8° × 4.7° at a viewing distance of 120 cm. Each trial consisted of a face stimulus with a duration of 200 ms, which was followed by a xation cross with a duration varying randomly between 800 and 1400 ms (Fig. 1). Each participant nished 4 blocks of 128 trials (each of the 64 photographs was presented twice in a random order in each block) during which they performed judgments on facial expression (pain vs. neutral) of each stimulus.

During fMRI scanning in Experiment 2, stimuli were presented through an LCD projector onto a rear projection screen, which were viewed with an angled mirror positioned on the head-coil. Each photo was presented at the center of a gray background, subtending a visual angle of 4.0° × 5.0° at a viewing distance of 100 cm. On each trial an Asian or Caucasian face with pain or neutral expression was presented with a duration of 2 s, which was followed by a cross xation with a duration of 2, 4, 6, or 8 s. In an event-related design participants were instructed to identify facial expression of each face (pain vs. neutral) by a button press using the right index and middle ngers. In order to increase perceptual duration of each stimulus, participants were instructed to respond after the stimuli had disappeared. Each participant conducted 4 functional scans. Each functional scan started with a 4 s prompt screen with an instruction followed by 32 trials. The 64 pictures of faces were presented in a random order in every two functional scans.

To assess participants' feelings of closeness to death and fear of death during the priming procedure, after EEG recording in Experiment 1 and fMRI scanning in Experiment 2, participants were asked to rate feelings about the priming task (e.g. How close do you feel to death after reading all the sentences and making your judgments?, How unpleasant do you feel after reading all the sentences and making your judgments?, How fearful do you feel about death after reading all the sentences and mak-

fMRI data acquisition and analysis

Imaging data that covered the whole brain were acquired using a 3-T GE Signa MR750 scanner (GE Healthcare; Waukesha, WI) with a standard head coil. Head motion was minimized using foam padding. Anatomical images were obtained using a standard 3D T1-weighted sequence (512 × 512 × 180 matrix with 0.47 × 0.47 × 1.0 mm ^{3} spatial resolution, TR = 8.204 ms, TE = 3.22 ms, ip angle = 12°). Functional images were acquired using T2-weighted, gradient-echo echo-planar imaging (EPI) sequences sensitive to BOLD contrast (64 × 64 × 32 matrix with 3.75 × 3.75 × 5 mm ^{3} spatial resolution, repetition time (TR) = 2000 ms, echo time (TE) = 30 ms, ip angle = 90°, eld of view (FOV) = 24 × 24 cm).

The fMRI data were analyzed using SPM8 (the Wellcome Trust Centre for Neuroimaging, London, United Kingdom). The functional images were corrected for differences in acquisition time between slices for each whole-brain volume and realigned within and across runs to correct for head movement. Six movement parameters (translation: x, y, z and rotation: pitch, roll, yau1(n)-28420(oTTmro)-m325(g)t9mron

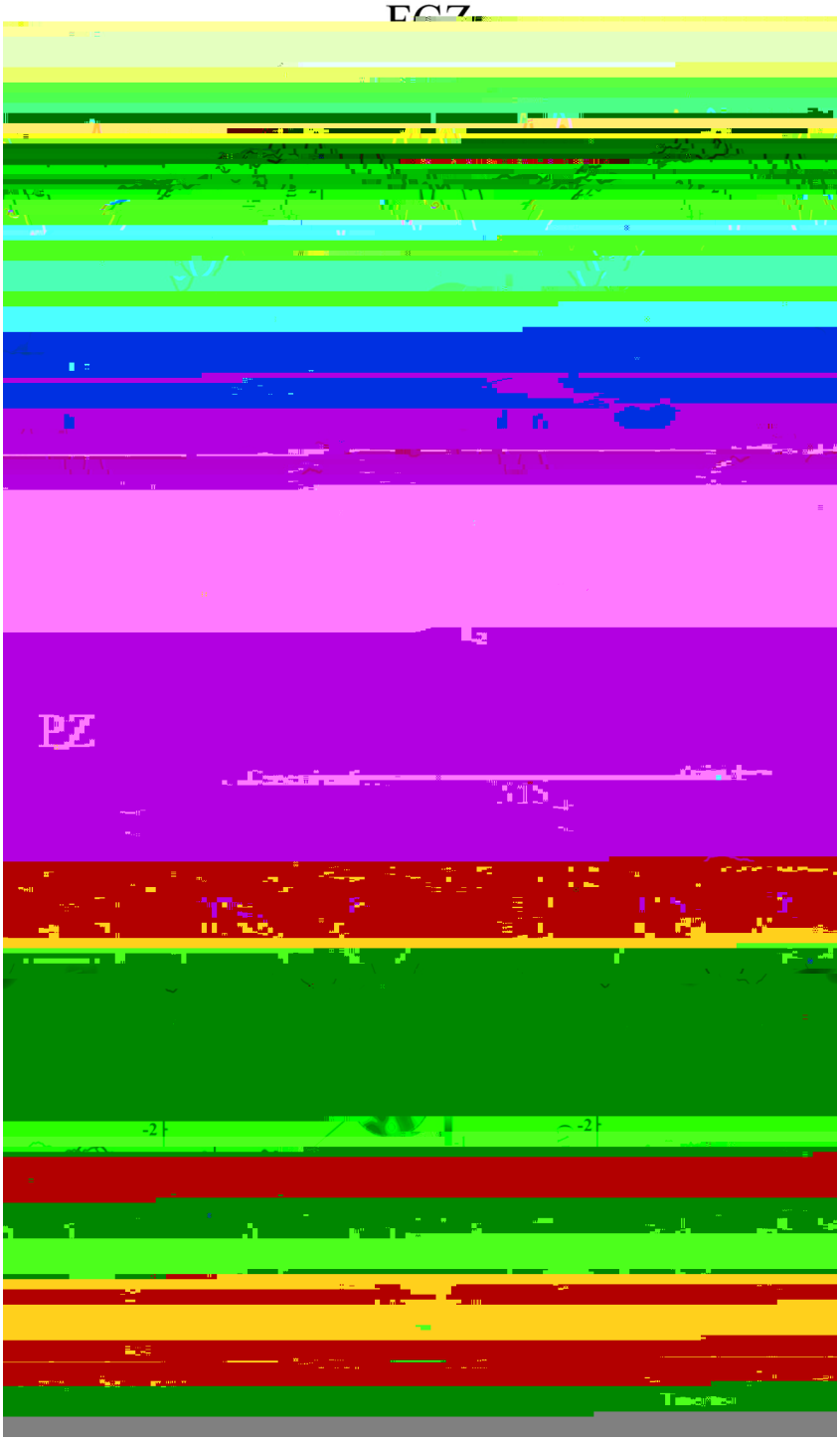

Fig. 2. Illustration of ERPs at electrodes FCZ and PZ in response to pain and neutral expressions of Asian and Caucasian faces in Experiment 1. ERPs are plotted separately for MS and NA

Asian than Caucasian faces (Fig. 3A). However, the interaction of Race × Expression was not signi cant for NA group ($F(1,15) = 0.00$ … 0.85, $ps > 0.5$). Therefore, relative to NA group, MS showed stronger racial in-group bias in P3 amplitudes to perceived pain in others and, as illustrated in Fig. 3, these effects occurred due to that MS priming compared to NA priming increased the P3 amplitude to pain expression of Asian faces. We further conducted sLORETA to estimate the sources of the racial in-group bias in empathic neural responses in the P3 time window in MS group. This revealed two potential sources in the mid-cingulate cortex and the left anterior insula (Figs. 3B and C).

To estimate the relationship between trait empathy ability and racial in-group bias in empathic neural responses, we rst subtracted the differential amplitude to pain vs. neutral expressions of Caucasian faces from the differential amplitude to pain vs. neutral expressions of Asian faces. We then examined the correlation of this measure and IRI scores. This analysis revealed a signi cant negative correlation between racial

in-group bias in the P3 amplitude and the ability of perspective taking in MS group ($r = -.36$ to -0.42, $ps < 0.05$, Fig. 4, see Table S4 for details) but not in NA group ($ps > 0.05$), suggesting that individuals with better perspective taking ability showed weaker racial in-group bias in P3 amplitude after MS priming.

Experiment 2

Behavioral results

fMRI results

We first examined the priming effect on racial in-group bias in empathic neural responses by calculating a whole-brain ANOVA of the contrast of pain vs. neutral expression with Race (Asian vs. Caucasian) as a within-subjects variable and Group (MS priming vs. NA priming) as a between-subjects variable. This analysis revealed significant activations in the anterior and mid-cingulate cortex (−6/20/28, k = 80, Z = 3.11) and the right precentral gyrus (54/2/37, k = 38, Z = 3.75, Fig. 5A). We then conducted whole-brain interaction analyses of the contrast of (pain ..neutral) $_{\text{Asian faces}}$ vs. (pain ..neutral) $_{\text{Caucasian faces}}$ in MS and NA groups, respectively. This contrast revealed significant activations in the dorsal portion of the anterior cingulate cortex that extended into the mid-cingulate cortex (−6/20/40, k = 38, z = 3.33) and in the right precentral gyrus (57/−1/34, k = 78, Z = 3.56, Fig. 5B) in MS group. NA group, however, showed a significant activation in the right inferior parietal cortex (36/−73/43, k = 55, Z = 3.35). These results suggest that, relative to NA priming, MS priming significantly enhanced the racial bias in empathic neural response in the cingulate cortex and the right precentral gyrus.

To further examine how MS vs. NA priming modulated empathic neural response to pain versus neutral expressions of Asian and Caucasian faces, we conducted separate whole-brain interaction analyses of the contrast of (pain ..neutral) $_{\text{MS priming}}$ vs. (pain ..neutral) $_{\text{NA priming}}$ for Asian and Caucasian faces. The results indicated that MS vs. NA priming significantly increased activity in the right posterior temporal cortex (57/−61/4, k = 103, Z = 4.00) and the mid-cingulate cortex (3/32/25, K = 28, Z = 3.47, Fig. 5C) in response to pain expression of Asian faces. In contrast, MS vs. NA priming increased the activity in the right posterior temporal cortex (60/−58/4, k = 139, Z = 3.96) but decreased the activity in the right precentral gyrus (57/−4/37, k = 84, Z = 3.45) in response to pain vs. neutral expression of Caucasian faces.

Finally, to examine the main effect of facial expression, we calcu7212-6(a)-4icf-9(am)32((m)-9(42.0(N)-11(an)19(aly)19(se38(Z)-27938(Z)-1tpa)-221t39m(m)-9b

priming induced stronger feelings of closeness to death in our participants, indicating enhancement of death awareness in MS compared to NA groups.

these brain imaging results jointly demonstrate a key role of MS priming in modulation of the cognitive component of empathy for racial in-group members' suffering.

Interestingly, MS compared to NA priming activated the right precentral gyrus during perceiving pain vs. neutral expression of Asian faces but decreased the activity in the right precentral gyrus in response to pain vs. neutral expression of Caucasian faces. The precentral gyrus showed enhanced activity not only during motor execution but also during attention to action (Binkofski et al., 2002) and motor preparation (Kawashima et al., 1994; Simon et al., 2002). This brain region was likewise engaged during imagining motor acts and the activity in the region was associated with accuracy of imagery task performances (Hanakawa et al., 2003). Therefore, besides promoting helping behavior toward racial in-group members (e.g., Johnson et al., 2002; Drwecki et al., 2011), MS vs. NA priming might also facilitate motor preparation that helps to

Harris, R.J., Young, A.W., Andrews, T.J., 2012. Morphing between expressions dissociates continuous from categorical representations of facial expression in the human brain. Proc. Natl. Acad. Sci. U. S. A. 109, 21164–21169.