# Empathic brain responses to other's pain was modulated by simple group categorization: An fMRI study

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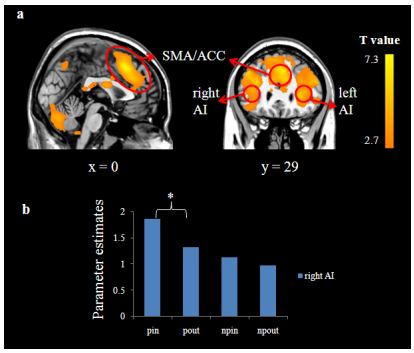
**Introduction:** Empathy is defined as the ability to infer and share other's affective and sensory state. Given that intergroup conflict depending on the categorization of the social world into "us" versus "them" throughout the history of human evolution (1), whether empathy can be influenced by group membership has long been an important topic to investigate. A recent fMRI study showed that the neurobiological mechanism underlying empathy (esp. anterior insula) for other's painful suffering could be modulated by perceived group membership (1). However, it may be more likely the antagonistic attitude towards two groups derived from long period of mutually rival relationship rather than the in-/out-group difference itself that serves as an alternative explanation. Therefore, the current study aimed to investigate whether simple group categorization can modulate the neural correlates of empathy for other's pain.

**Methods:** Thirty healthy Chinese participants attended the study with informed consent. Stimuli were 16 neutral faces naive to participants with half Chinese (4 males) and half Western (4 males), which were divided equally into 2 sets with matched valence and attractiveness. Subjects were assigned into a red or green group with either one of the sets as the same group (in-group) and the other set as the different group (out-group). The assignments were counterbalanced across both subjects and sets. Participants were shown pictures of these faces with red or green cues and were instructed to memorize these faces through repeated learning. To further enhance the effect of group identification, the participants' own photo was used with the group cue assigned into them during the learning procedure. After the learning procedure, a recognition test was employed to measure whether participants could distinguish in-group faces from out-group. Participants with accuracy less than 90% were excluded from the fMRI session to make sure the effect of group categorization.

The subsequent fMRI task adopted a block design including 4 functional runs. Four different conditions (i.e. in-/out-group face with neutral expression touched by a needle/Q-tip) were applied, and each of them was pseudo-randomly presented twice within each run. Each condition consisted of 8 trials of the same category, with four different faces (2 males) receiving painful (needle) or non-painful (Q-tip) stimulation applied to left/right cheeks. In each trial, a face was presented through goggles for 3 seconds in which participants needed to rate the pain intensity felt by the in-/out-group members with right fingers, ranging five levels from "not painful at all" to "severely painful". There was a 20-s inter-block-interval, with a white fixation cross in the middle of the screen. After scanning, participants finished the same recognition test and finally filled out a questionnaire.

The imaging data was collected on a 3-Tesla Siemens Trio MR scanner. Functional data sets (TR = 2000ms, TE = 30ms, flip angle = 90◦) were processed to correct motion, normalized to MNI space, spatially smoothed and then the hemodynamic responses for pin, pout, npin and npout conditions were estimated with a canonical HRF function, with six head motion functions as covariates. Then paired T-test and ANOVA were applied to evaluate group difference.




**Results & Discussion:** fMRI data from 22 participants was valid. Behavioral results showed that faces with needle stimulation were rated significantly more painful that faces touched by Q-tip ($F_{(1, 20)}$=155.083, p<0.001). However, participants didn't felt more pain for in-group faces than out-group faces ($t_{(20)}$= -1.383, p>0.05). The whole-brain analysis revealed that SMA (BA 8), ACC (BA 24/32) along with bilateral AI extending to IFG (BA 13/47) was more recruited by faces with painful rather than non-painful stimulation ($p_{(FDR)}$<0.05; Figure 1a). ROI analysis further confirmed that right AI (based on a coordinate from a recent study; x/y/z=36/29/-3, r=8mm) responded stronger to in-group faces with painful stimulation than that of out-group ($t_{(21)}$=1.767, $p_{(one-tailed)}$=0.046; Figure 1b).

Our paradigm provided an effective way to categorize participants into different groups without evoking different attitudes towards in-/out-group members because of relationship history, conflict of interests and stereotypes. Therefore, the results in AI suggested that despite with no significant behavior difference, an in-group bias in empathy-related brain responses could form through simple group categorization. In summary, our fMRI results firstly demonstrated that empathic neural responses other's pain could be influenced by simple group categorization.

**Figure 1 a:** Increased activations in the ACC and bilateral AI when participants perceived painful versus non-painful faces (p(FDR) < 0.05); SMA/ACC=supplementary motor area/anterior cingulate cortex, AI=anterior insula; **b:** Average activation in right AI [MNI; 36/29/-3] for the pain_in-group (pin), pain_out-group (pout), nopain_in-group (npin), and nopain_out-group (npout) conditions. *p<0.05, one tailed.

**Reference**

1. Hein G, Silani G, Preuschoff K, Batson C, Singer T: Neural Responses to Ingroup and Outgroup Members' Suffering Predict Individual Differences in Costly Helping. Neuron 68:149-160, 2010