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ABSTRACT

Our recent event-related brain potential (ERP) study disentangled the neural mechanisms of empathy for pain into an early automatic emotional sharing component and a late controlled cognitive evaluation process. The current study further investigated gender difference in the neural mechanisms underlying empathy for pain by comparing ERPs associated with empathic responses between male and female adults. Subjects were presented with pictures of hands that were in painful or neutral situations and were asked to perform a pain judgment task that required attention to the pain cues in the stimuli or to perform a counting task that withdrew their attention from the pain cues. We found that both males and females showed a short-latency empathic response that differentiated painful and neutral stimuli over the frontal lobe at 140 ms after stimulus onset and a long-latency empathic response after 380 ms over the central-parietal regions. However, females were different from males in that the long-latency empathic response showed stronger modulation by task demands and that the ERP amplitudes at 140–180 ms were correlated with subjective reports of the degree of perceived pain of others and of unpleasantness of the self. Our ERP results provide neuroscience evidence for differences in both the early and late components of empathic process between the two sexes.


a
Male
Painful, Pain judgment
Painful, Counting
Neutral, Counting
230-250 ms
50ms
17
100-120 ms
330-350 ms
P320
110-120 ms
310-330 ms
600
800
-200
0
200
400
time
Painful, Pain judgment
230-250 ms
100-120 ms
330-350 ms
-2 T
0
μV

amplitudes in the pain judgment than the counting tasks

[(1,12)=18.351, <0.01], whereas no such difference was observed in males [(1,12)=2.361, >0.1]. Furthermore, there was a significant interaction of Pain×Task×Gender between 420 ms and 540 ms over the occipito-temporal area [(1,24)=6.272, <0.05]. Separate analysis showed a reliable interaction of Pain×Task at 420–540 ms in females [(1,12)=23.061, <0.001], suggesting that the descending phase of the P320 showed larger amplitude to the painful than neutral stimuli in the pain judgment task [(1,12)=15.887, <0.01] but not in the in counting task [(1,12)=0.343, >0.5]. For males, however, the interaction of Pain×Task was not significant [(1,12)=0.069, >0.5], although the main effect of Pain was significant in this time window [(1,12)=19.124, <0.01].

We also observed an interaction of Gender×Pain×Hemisphere at 140–300 ms over the occipito-temporal area [(1,24)=9.042, <0.01]. Separate ANOVAs showed a reliable interaction of Pain×Hemisphere at 160–300 ms for females [(1,12)=8.644, <0.05] but not for males [(1,12)=1.241, >0.1], suggesting a more salient effect of painful contents of the stimuli over the left than right hemispheres for females.

2.3. C ... a ... ... g a E P a .

After the EEG recording procedure, subjects were asked to evaluate the pain intensity felt by the model in painful and neutral stimuli and to report subjective feeling of their own unpleasantness when watching others in pain. The mean scores and standard deviation of the subjective reports are shown in Table 2. The ratings of others' pain were subject to ANOVAs with Pain (painful vs. neutral) and Gender as main effect. There was only a significant main effect of Pain [(1,24)=470.330, <0.001], suggesting higher scores for painful than neutral stimuli.

We calculated the correlation between the mean amplitudes of ERPs elicited by painful stimuli in each time window and the FPS-R scores (see Fig. 3). The mean ERP amplitudes at 140–180 ms associated with the painful stimuli was significantly negatively correlated with both the score of other's pain [F3: (1,13)=−0.748, <0.01; FC3: (1,13)=−0.715, <0.01; C3: (1,13)=−0.616, <0.05; F4: (1,13)=−0.723, <0.01; FC4: (1,13)=−0.623, <0.05; C4: (1,13)=−0.689, <0.01] and the score of self unpleasantness [F3: (1,13)=−0.810, <0.01; FC3: (1,13)=−0.816, <0.01; C3: (1,13)=−0.736, <0.01; F4: (1,13)=−0.804, <0.01; FC4: (1,13)=−0.803, <0.01] for females. The larger the ERP amplitudes in this time window, the lower perceived pain intensity and the weaker ERP amplitudes in this time window.4(low

healthy adults. In particular, we investigated gender difference in the early automatic and late controlled processes of empathy for pain that were indexed by differential neural activity elicited by painful and neutral stimuli (Fan and Han, in press).

Our ERP results indicate that the painful and neutral stimuli were differentiated as early as 140 ms after sensory stimulation over the frontal-central areas. In addition, the tasks of pain judgment or counting did not influence the differentiation between the painful and neutral stimuli until 380 ms over the frontal-central area and 220 ms over the occipito-temporal sites. These ERP results provide evidence for an early neural response at 140–340 ms over the frontal-central area that was elicited by observation of others in pain and independent of the task demand, suggesting an early automatic component of empathy for pain (Fan and Han, in press). In contrast, the later stage of the processing of others' pain depended upon the task demands. The differentiation between the painful and neutral stimuli indexed by the P3 was evident in the task of pain judgment but not in the counting task, suggesting that a controlled process of empathy for pain over the posterior parietal region occurred later than the automatic process of empathy for pain that focused over the anterior frontal-central areas. Our ERP results appear to parallel previous ERP studies that also observed an early fronto-central modulation of ERPs elicited by facial expressions at 120 ms (e.g.,

offspring (Vogel et al., 2003), which requires greater sensitivity to danger signals such as painful stimuli. While previous

Each subject participated in eight blocks of trials. In four blocks of trials subjects were required to judge pain vs. no-pain for hands in painful and neutral pictures. They were asked to count the number of hands in painful and neutral pictures in the other blocks of trials. Each block of trials started with the presentation of instructions for 3 s, which defined the task (i.e., pain judgment or counting the number of hands) for each block. There were 80 trails in each block. On each trial the stimulus display was presented for 200 ms in the center of the screen, which was followed by a fixation cross with a duration varying randomly between 800 ms and 1600 ms. The stimuli in each block of trials and the four tasks were presented in a random order for each subject. Subject responded to each stimulus by a button press using the left or right index finger. The assignment of the left or right index finger to the painful and neutral stimuli was counterbalanced across subjects.

4.3. E P

The electroencephalogram (EEG) was continuously recorded from 62 scalp electrodes that were mounted on an elastic cap according to the extended 10–20 system, with the addition of two mastoid electrodes. The electrode at the right mastoid was used as reference. The electrode impedance was kept at less than 5 kΩ. Eye blinks and vertical eye movement were monitored with electrodes located above and below the left eye. The horizontal electro-oculogram was recorded from electrodes placed 1.5 cm lateral to the left and right external canthi. The EEG was amplified (band pass 0.01–100 Hz) and digitized at a sampling rate of 250 Hz. The ERPs in each condition were averaged separately off-line with an epoch beginning 200 ms before stimulus onset and continuing for 1200 ms. Trials contaminated by eye blinks, eye movements, or muscle potentials exceeding ±50 μV at any electrode were excluded from the average.

ERPs at each electrode were re-referenced to the algebraically computed average of the left and right mastoids before further analysis. The baseline for ERP measurements was the mean voltage of a 200 ms prestimulus interval and the latency was measured relative to the stimulus onset. Mean voltage of ERPs were obtained (a) at 20-ms intervals starting at 80 ms after stimulus onset and continuing until 380 ms post-stimulus and (b) at 40-ms intervals from 380 to 820 ms post-stimulus. Statistical analysis were conducted at electrodes selected from the frontal (Fz, FCz, F3-F4, FC3-FC4), central (Cz, CPz, C3-C4, CP3-CP4), parietal (Pz, P3-P4), temporal (T7-T8, TP7-TP8, P7-P8), occipito-temporal (POz, Oz, PO3-PO4, PO7-PO8) regions.

Reaction times (RTs) and response accuracies were subjected to a repeated measure analysis of variance (ANOVA) with Pain (painful vs. neutral stimuli), Task (pain judgment vs. counting the number of hands) as within-subject independent variables, and Gender (male vs. female subjects) as a between-subject variable. The mean ERP amplitudes were subjected to

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