Neuroscience Letters 578 (2014) 85–89

Contents lists available at ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Sex differences in affective response to different intensity of emotionally negative stimuli: An event-related potentials study

Pinchao Luo[a,b], Xiaochun Zheng[b], Xiaoying Chen[b], Yue Li[b], Junfang Wang[b], Lin Deng[b], Xifu Zheng[a,b,*]

[a] Center for Studies of Psychological Application, South China Normal University, Guangzhou 510631, PR China
[b] School of Psychology, South China Normal University, Guangzhou 510631, PR China

HIGHLIGHTS

- Sex differences in affective response are related to different emotional intensity.
- Both sexes showed affective response to highly and moderately negative stimuli at N2.
- Both sexes showed affective response to highly negative stimuli at LPP.
- Affective response to moderately negative stimuli at LPP was present only in females.

ARTICLE INFO

Article history:
Received 30 April 2014
Received in revised form 6 June 2014
Accepted 14 June 2014
Available online 23 June 2014

Keywords:
Affective response
Different emotional intensity
Event-related potentials
Empathy
Sex

ABSTRACT

Previous studies have extensively reported an advantage of females in empathy as compared with males. It remains to be clarified, however, whether these sex differences are associated with sex specific neural processes underlying empathic response to different intensity of emotional stimulus. The present study examined sex differences in empathy for suffering persons by recording event-related potentials (ERP) to different emotional intensity. We compared affective response in males and females, who were exposed to a series of highly negative (HN), moderately negative (MN), and neutral pictures. The results revealed that both males and females showed a short-latency affective response, as indexed by frontal–central N2, to HN and MN stimuli. Moreover, both sexes showed a long-latency affective response, as indexed by central–parietal LPP, to HN stimuli. However, long-latency affective response to MN stimuli was present only in females, and sex differences were localized to the parietal sites. This suggests that the well-known female advantage in empathy may be attributable to the unique sensitivity of females to the affective state of persons in moderate suffering. Our results provide neuroscientific evidence for differences in affective response to different intensity of emotionally negative stimuli between the two sexes.

1. Introduction

Empathy has been a hot area of research for several years in psychology for its important role in human intercourse [1,2]. It is widely acknowledged that females are more empathic than males. This notion has been proved by many behavior studies which demonstrated that there was a female advantage in empathy [3,4]. For example, studies on reflexive crying among infants showed that baby girls were more sensitive to another's distress [5]. Studies making use of self-report scales found that females obtained higher empathy scores [6–8]. Additionally, females were specifically rated as being more empathic than males when other-report measures were used to assess empathy [9,10].

Recently, sex differences in empathy have been studied by functional neuroimaging. One study examined sex differences in neural substrates underlying empathy for pain. Males and females were given an economic game to play, in which two confederates played fairly or unfairly with them. The results revealed similar activation patterns for empathic neural response in ACC and insula to fair and unfair confederates' pain in females. Males showed a response in pain-related areas only to fair confederates [11]. Another study investigated sex differences of empathy

* Corresponding author at: Center for Studies of Psychological Application, South China Normal University, Guangzhou 510631, PR China.
Tel.: +86 020 8521 6386; fax: +86 020 8521 0369.
E-mail address: zhengxf@scnu.edu.cn (X. Zheng).

http://dx.doi.org/10.1016/j.neulet.2014.06.032

in an emotion attribution task. Participants either focused on their own emotional response to emotion expressing face (SELF-task) or evaluated the emotional state expressed by the face (OTHER-task). The results demonstrated that females recruit areas containing mirror neurons to a higher degree than males during both SELF- and OTHER-task [12]. Researchers also assessed three core components of empathy (emotion recognition, perspective taking and affective responsiveness) and clarified to which extent sex affects the neural correlates of empathic abilities. Analyses of functional data revealed that females exhibited an overall stronger activation of the amygdala than males, an effect that was most pronounced for affective responsiveness [13].

ERP has also been used to examine the neural mechanisms underlying sex differences of empathy. Groen et al. investigated sex differences in the temporal dynamics of experiencing empathy. They found females showed increased anterior N2 and parietal LPP amplitudes to humans contrasted with scenes (independent of emotional valence) and to negative contrasted with neutral emotions (independent of human presence) compared to males [14]. In another study [15], participants were presented with pictures of hands that were in painful or neutral situations and were asked to perform a pain judgment or a counting task. The results showed that pain effect was stronger for females than males when participants performed the pain judgment task. Proverbio et al. investigated whether males and females differed in their cerebral response to affective pictures portraying humans in different positive or negative contexts compared to natural or urban scenarios [16]. The study found that orbitofrontal N2 was greater in response to positive than negative human pictures in women but not in men, and not to scenes. A late positivity (LP) to suffering humans far exceeded the response to negative scenes in women but not in men.

In these previous studies mentioned above, the intensity of negative stimulus is not considered. However, emotional intensity is important in real life. Compared with moderately negative events, highly negative events usually mean greater threat to survival. Highly negative events but not moderately negative events can severely affect memory and lead to unwise decision making [17]. Moreover, the adoption of different intensities of facial emotion expression in patients studies already proved valuable [18]. As a result, variations in emotional intensity have differential effects. To date, data on sex effects on empathic response to different intensity of emotional stimulus are not available. It remains to be clarified, however, whether these sex differences are associated with sex specific neural processes underlying empathic response to different intensity of emotional stimulus.

Empathy is a multidimensional psychological construct and can be described as a reaction to observed emotional states in other people which may include (1) affective response to another person, which some believe entails sharing that person's emotional state; (2) cognitive capacity to take the perspective of the other person or self-other distinction [13,19]. Here, we focused on sex differences in affective response to different intensity of emotional stimulus. Due to the human brain's especial sensitivity to emotionally negative events [20], only negative emotions were explored. The current study used ERP to compare affective response in males and females, who were exposed to a series of highly negative (HN), moderately negative (MN), and neutral pictures depicting humans. On the basis of female advantage in emotional tasks [21–23] and the emotional salience of HN and MN stimuli, we hypothesized that: (1) relative to males, females would be more sensitive to MN stimuli and showed stronger affective response under MN condition; (2) affective response for suffering persons would be comparable between males and females under HN condition.

2. Methods

2.1. Participants

Thirty-four college students (17 females, 17 males) aged 19–22 years (mean age, 21.3 years) participated in the study. All participants were healthy, right-handed, with normal or corrected to normal vision, and reported no history of mental illnesses. Each participant signed an informed consent form and received a compensation of RMB40 for the experiment. The study was approved by the Academic Committee of the School of Psychology at South China Normal University. The experimental procedure was in accordance with the ethical standards of the Declaration of Helsinki [24].

2.2. Visual stimuli

The stimulus set comprised 34 HN, 34 MN and 34 neutral color pictures taken from the International Affective Picture System (IAPS) [25]. The HN pictures showed humans in highly negative contexts. Persons depicted in the contexts were visibly anguished, at risk of their lives or dead. The MN pictures showed humans in moderately negative contexts. Persons depicted in the contexts were visibly sad, distressed or pain. The neutral pictures showed humans in the serenities of everyday life. The three groups of pictures differed significantly from one another according to their IAPS normative valence ($M_{HN} = 1.73 \pm 0.26$, $M_{MN} = 3.36 \pm 0.61$, $M_{neutral} = 5.00 \pm 0.57$; $F(2,99) = 356.66$, $p < 0.001$) and arousal ratings ($M_{HN} = 6.43 \pm 0.62$, $M_{MN} = 4.89 \pm 0.75$, $M_{neutral} = 3.61 \pm 0.89$; $F(2,99) = 126.36$, $p < 0.001$). The stimuli were presented in the center of a 17-in. color monitor with a white background. Each stimulus was a 13 cm × 10 cm (width × height) picture, subtending a visual angle of 7.44° × 5.72° at a viewing distance of 100 cm.

2.3. Experimental procedure

Before the ERP recording, each participant completed a training block to familiarize the experimental procedure. The ERP recording consisted of four blocks. Each block included 51 trials. The order of the trial condition (HN, EN, neutral) was randomized within each block. To mitigate the effects of familiarity, stimuli were presented only 2 times each. Each trial started with a black fixation cross for 500 ms against a white screen followed by a blank screen with a duration varying randomly between 300 and 500 ms. Then IAPS pictures appeared 1500 ms. The trial ended in a blank screen varied between 2300 and 2500 ms randomly. The order of the blocks was randomized and counterbalanced across participants.

To ensure that participants were paying attention to the stimuli, a judgment task was randomly interspersed among trials. In 24 trials (8 for each condition) the blank screen after the picture presentation was replaced by a question mark, in which participants were asked to identify the emotional content of the pictures (negative or neutral). These trials were excluded from Section 2.4.

After the ERP recording, participants were instructed to rate the intensity of distress supposedly felt by the person in the pictures (other-distress). They were also asked to evaluate their own distress induced by the suffering person in the pictures (self-distress). The evaluations were measured using a 6-point scale (1 = no distress, 6 = great distress).

2.4. ERP recording and analysis

Electroencephalograph (EEG) was recorded with 32 scalp electrodes mounted on an elastic cap (Brain Products) in accordance to the extended 10–20 system. All recordings were initially referenced to a Tp10 electrode and re-referenced off-line against the average reference. Vertical electrooculogram (EOG) was monitored with