Original Article

A Modifying Effect of Trait Empathy on Frustration-Related Attentional Processing of Aggression-Related Words

An ERP Study

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Abstract: This study describes two experiments conducted to investigate the modifying effect of trait empathy on attentional processing of emotionally laden (i.e., aggression-related) words in frustrating situations. A dot-probe task was used in the first experiment. The results showed that low-empathy individuals exhibited attentional bias toward aggressive words under both frustrating and nonfrustrating conditions. High-empathy individuals demonstrated attentional bias only under frustrating conditions. In the second experiment, the effect of frustration on high-empathy individuals' aggression was reflected by N200, P300, and late positive potential amplitudes. It was discussed that these amplitudes might indicate that frustrating situations caused high-empathy individuals to show attentional bias toward aggressive words. Our findings suggested that high-empathy individuals were sensitive to emotionally laden (i.e., aggression-related) stimuli under frustrating conditions.

Keywords: trait empathy, aggressive tendency, frustrating conditions, event-related potentials (ERPs)

Psychologists define empathy as a personality trait or general ability that enables one to deeply understand or experience the inner lives or emotions of others (Feshbach & Feshbach, 1969). Trait empathy is regarded as a stable ability to understand emotional messages and to produce a reasonable response (Decety & Jackson, 2004). It is considered an essential factor required for reducing individuals' aggressive tendencies and behavior (Lovett & Sheffield, 2007; Miller & Eisenberg, 1988; van Langen et al., 2014; White et al., 2015). High levels of trait empathy are associated with low levels of violence and aggression, while insufficient levels of trait empathy have been described as a primary characteristic and cause of aggression (Ordoñez et al., 2010). Other studies have shown that individuals with lower trait empathy may exhibit more aggression and higher delinquency (Galán et al., 2017; Hyde et al., 2010).

Although most research supports the protective effect of empathy against aggression, some studies found that high-empathy individuals exhibit aggressive tendencies and behavior under certain types of circumstances (Baron-Cohen & Wheelwright, 2003; Gantiva et al., 2021; Vukosavljevic-Gvozden et al., 2015; Vachon et al., 2014; Vachon & Lynam, 2016). For instance, when high-empathy individuals experience a negative emotional state, their empathy for others may increase their level of emotional arousal. They subsequently pay more attention to their negative emotions, and it becomes difficult for them to pay attention to others (Baron-Cohen & Wheelwright, 2003; Eisenberg & Strayer, 1987).

According to the General Aggression Model (Anderson & Bushman, 2002), environmental factors may influence aggressive behavior by increasing aggressive tendencies, which represent the desire to act with aggression (Efrat-Treister et al., 2020), which is an important predictor of aggressive behavior (Efrat-Triester et al., 2021; Reijntjes et al., 2013). A frustrating condition, as a negative situation, may cause high trait empathy individuals to pay more attention to their own circumstances of frustration and become insensitive to the feelings of others (Vukosavljevic-Gvozden et al., 2015). This is manifested as attentional bias toward aggression-related stimuli (Song, 2011). Several

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studies suggest that attentional bias toward aggressive words can be an effective measurement of individuals' aggressive tendencies (Dodge, 2006; Putman et al., 2004; Smith & Waterman, 2003). Therefore, different from the results of previous studies that showed inhibitory effects of trait empathy on aggression, this study examined the modifying effect of trait empathy on frustration-related attentional processing of aggression-related words.

To further explore the mechanism of the modifying effect, it is necessary to explore the cognitive processes involved in trait empathy under frustrating conditions. Some studies have found that experiencing frustration elicits negative emotions along with specific physiological stress responses (Gentry, 1970). Such negative emotions or stresses may significantly diminish the individual's cognitive and emotional resources (Zhu, 2015); thus, the individual's cognitive resources are limited under frustrating conditions, causing increased sensitivity to aggression-related stimuli due to weakening the inhibitory effect. Therefore, understanding the effects and cognitive processes involved in trait empathy, and its modifying effects on aggressive tendencies induced by frustration, has important implications for development of interventions and public policy addressing individual risk for aggressive behavior.

Event-Related Potential Components Related to Aggression and Empathy

Few cognitive neuroscience studies have discussed the relationship between trait empathy and aggression. Therefore, in addition to investigating behavioral results, based on previous studies of aggression using event-related potentials (ERPs; Li & Zheng, 2014), this research selected N200, P300, and late positive potential (LPP) as three ERP components to explore the neural mechanisms of how frustration affects high-empathy individuals.

N200

The N200 is a negative wave that appears about 200–300 ms after a stimulus, reflecting preliminary cognitive processing of the stimulus in the brain (Johnstone & Galletta, 2013). A large number of studies have shown that N200 reflects response inhibition, mainly related to cognitive conflict monitoring, and also reflects the process and intensity of conflict monitoring and suppression (Enriquez-Geppert et al., 2010). When individuals were asked to suppress a dominant, frequently occurring response, the amplitude of N200 would consistently increase (Folstein & Van Petten, 2008). To elaborate, since high-empathy individuals are supposed to have a lower aggression level, their cognitive control of aggressive and nonaggressive words should be significantly different. This may result in a corresponding significant difference in N200 amplitude.

P300

One of the most widely researched ERP components, P300, is associated with emotional arousal (Dufey et al., 2011) and cognitive processing ability (Gao & Raine, 2009). Additionally, evidence has been presented that lower P300 amplitude is associated with higher aggression (Gao & Raine, 2009; Venables et al., 2011). Patrick et al. (2006) found that P300 amplitudes might indicate neurobiological vulnerability related to certain abnormal behaviors (e.g., aggressive behavior). Given that P300 is associated with emotional arousal, it may also reflect an individual's empathetic ability. High-empathy individuals show a significantly higher P300 amplitude when observing injury or harm befalling others (Bartholow et al., 2006) as opposed to when observing a neutral stimulus. High-empathy individuals, therefore, tended to show higher levels of emotional arousal under these circumstances (Gao et al., 2015). Stimuli associated with aggression or harm may arouse high-empathy individuals more powerfully (i.e., showing a higher P300 amplitude) than do those with neutral connotations.

LPP

LPP is a sustained positive potential that appears about 400 and 1,000 ms after a stimulus appears (Hajcak et al., 2009, 2011). The LPP is the main component of attention induced by emotional stimuli (Hill et al., 2019; Weinberg & Sandre, 2018), which also reflects top-down processes, such as emotion regulation (Schupp et al., 2000). Therefore, as related to this study, increased LPP may reflect increased attention to emotional stimuli (Schupp et al., 2000; 2003). Compared with neutral stimuli, aggressive stimuli may induce higher LPP amplitudes in high-empathy individuals.

The Present Study and Hypotheses

The main goal of the present research is to examine the modifying effect of trait empathy on attentional processing of emotionally laden (i.e., aggression-related) words under frustrating situations. We also explored ways in which neural mechanisms might indicate this effect. Specifically, we hypothesized that under nonfrustrating conditions, low-empathy individuals will show significant attentional bias toward aggressive words, whereas high-empathy individuals will not show this bias. We also hypothesized that both low-empathy and high-empathy individuals will demonstrate attentional bias toward aggressive words under frustrating conditions. From a neuroscientific perspective, we predicted that the influence of frustration on high-empathy individuals' aggression would be reflected by differences in N200, P300, and LPP amplitudes. We used the dot-probe task (Macleod et al., 1986) and the emotional Stroop task (Eckhardt & Cohen, 1997; Matthews & Mackintosh, 1998) as reliable paradigms of attentional bias to explore the hypotheses.

In Study 1, a dot-probe task was used to measure attentional bias toward aggression-related stimuli with the following aims: (1) to verify under nonfrustrating conditions that high-empathy individuals do not exhibit attentional bias toward aggressive words while low-empathy individuals demonstrate significant attentional bias toward such words and (2) to investigate whether high-empathy individuals demonstrate attentional bias toward aggressive words under frustrating conditions.

After obtaining behavioral results, we also needed to determine how frustration affects high-empathy individuals' aggression from a neuroscientific perspective. The inhibitory effect of empathy may diminish under frustrating conditions, so even highly empathetic individuals, when frustrated, cannot make full use of their empathy for maintaining low levels of attentional bias toward aggression-related stimuli. Therefore, in Study 2, using the emotional Stroop task, we explored the neural mechanisms by which the modifying effect of trait empathy works on frustration-related attentional processing of aggression-related words. The focus was on three different ERP components: the N200, the P300, and the LPP.

Study 1: Evidence From the Dot-Probe Task

Method

Materials

Interpersonal Reactivity Index Questionnaire

The Interpersonal Reactivity Index (IRI) has been used in previous studies (Ardenghi et al., 2020; Koller & Lamm, 2015). It was translated into Chinese (IRI-C) by Tang (1987). The IRI-C questionnaire uses a 5-point Likert scale (0 = *not appropriate at all* to 4 = *very appropriate*) with 22 items covering four dimensions (fantasy, perspective taking, empathic concern, and personal distress). The questionnaire has good reliability (Cronbach's $\alpha = .53–.78$).

Dot-Probe Task

We based the dot-probe task paradigm used in this study on that used by MacLeod et al. (1986). We used 20 aggressive (e.g., hurt, attack) and 20 nonaggressive verbs (e.g., wear, arrive). All verbs were in Chinese and had the same word lengths. The verbs were chosen from Song's (2013) research and were peer-reviewed by psychology professors and postgraduates for suitability.

The procedure was programmed by E-prime 2.0 and underwent 90 trials (80 formal and 10 practice), which were excluded from further analysis. A pair of words (one aggressive and one nonaggressive verb, e.g., attack-wear, destruct-arrive, insult-dress) appeared in each trial.

Participants and Design

We used G*power 3.1 to determine our sample size. Using a medium effect size of $f = 0.25$, medium correlation within measurements of $r = .30$, and a significance value of $p = .05$, a sample size of 120 participants was required to attain an 80% power level. Our final sample consisted of 310 college students.

We used the IRI-C to measure the college students' trait empathy. The highest and lowest 20% on the empathy score were selected as the high-empathy ($N = 60$, 6 men and 54 women, mean age = 21.6 ± 2.63 years) and low-empathy ($N = 60$, 17 men and 43 women, mean age = 21.2 ± 2.16 years) groups. An independent t-test showed a significant difference in trait empathy scores between the high-empathy ($M = 55.38$, $SD = 7.54$) and low-empathy ($M = 32.98$, $SD = 6.21$) groups, $t(122) = 17.97$, $p < .001$, Cohen's $d = 3.24$.

Study 1 examined three independent variables: (1) situation (frustrating, nonfrustrating), (2) empathy level (low, high), and (3) target location (consistent, inconsistent). A consistent target had the aggressive word and the target appearing on the same side while an inconsistent target had the nonaggressive word and target on the same side. Situation and empathy levels were between-group factors while target location was the within-group factor. The dependent variables were correct response rate and reaction times.

Procedure

Participants underwent the experimental procedure in a quiet laboratory. After signing a written consent form, the participants were directed to finish a mental rotation task (the frustration manipulation). In the nonfrustrating condition, all the questions were easy. In the frustrating condition, three of the questions were easy and the remaining seven answers were marked as incorrect whether the test-taker solved them. After experiencing the frustration situation, the participants' positive emotions decreased significantly ($t = 3.40$, $p = .002$, and Cohen's

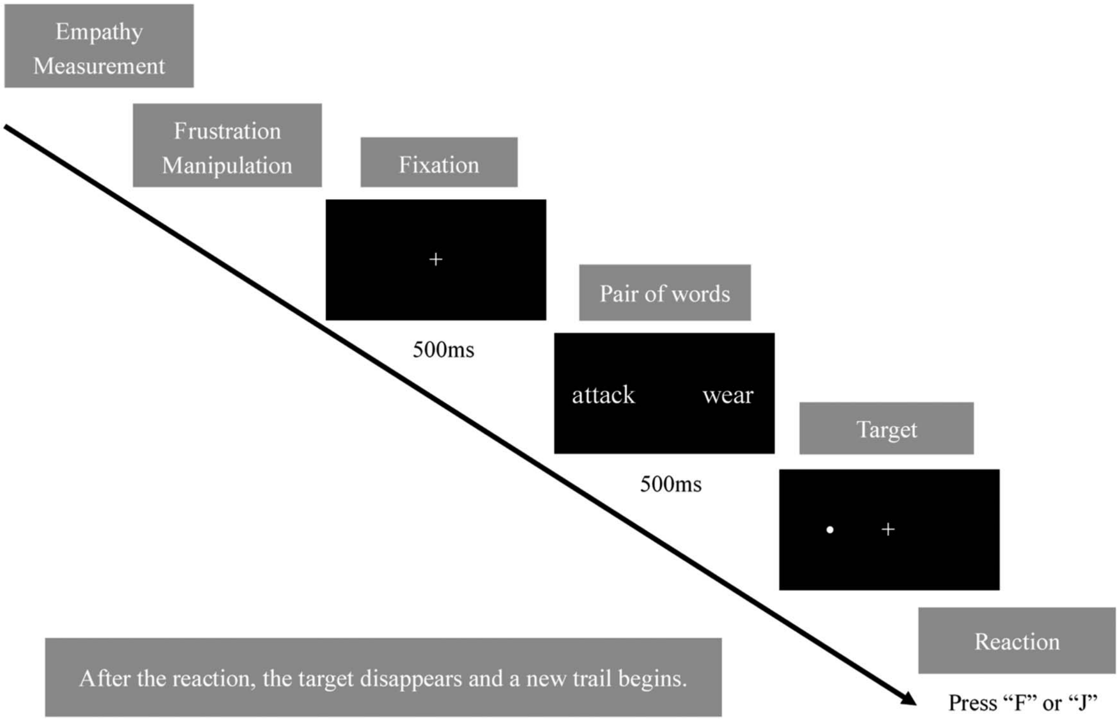

Figure 1. Experiment flow for dot-probe task.

d = 0.57), while negative emotions significantly increased (t = −2.52, p = .017, and Cohen's d = 0.52), indicating that the frustration manipulation was effective.

Then, participants were required to sit 90 cm in front of a computer screen. They received instructions for the task. After a 500 ms fixation time, a pair of words briefly flashed on the screen (500 ms) followed by a dot (the target) in the position formerly occupied by one of the words. Participants were required to press the left ("F") or right ("J") response key as quickly and accurately as possible to indicate the position of the target. The target disappeared immediately after participants pressed the response key. The next trial began automatically. The accuracy rate of correct responses and the reaction times were recorded. Figure 1 shows the experiment flow.

After hearing the instructions, participants underwent 10 practice trials. When the accuracy rate was over 90%, the participants continued with the formal experiments. The experiments comprised four blocks with 20 trials in each block. To avoid sequence effects (confounding influences due to exposure to multiple conditions), we balanced the order of aggressive words and the probe dot. Half of the word pairs in each block represented aggressive words consistent with the targets, while the other half represented nonaggressive words consistent with the targets. The four blocks appeared in a fixed order to all participants. The trial order within each block was randomly determined per participant using E-Prime 2.0.

Results

We used SPSS 21.0 to conduct repeated-measures ANOVA. Trials with incorrect responses and reaction times shorter than 100 ms or longer than 1,000 ms were excluded (Fox et al., 2002). We used only reaction times as the dependent variable in experiment one, deviating from the original proposal, because the average accuracy rate was too high (99.3%) to obtain a meaningful result. Table 1 presents the average reaction times for the different empathy levels and frustrating conditions.

The results of the ANOVA showed a main effect of the target location. The reaction time for the consistent location (409 ± 57 ms) was significantly lower than that for the inconsistent location ([412 ± 57 ms], $F(1, 116) = 12.143$, $p < .001$, and $\eta_p^2 = 0.095$). No other main effect or two-way interaction attained significance ($p > .10$). The triple interaction effect among frustration, empathy, and target location was also significant [$F(1, 116) = 4.039$, $p = .047$, and $\eta_p^2 = 0.034$]. Figure 2 illustrates the distributional properties using the boxplots.

The results indicated that participants with low-empathy levels had lower reaction times under frustrating conditions for consistent locations (409 ± 50 ms) than for inconsistent locations (413 ± 49 ms). These findings reached a marginal-significance level ($p = .057$, $\eta_p^2 = 0.031$). Under nonfrustrating conditions, participants with low-empathy scores had a significantly lower reaction time for consistent

Table 1. Average reaction times of different empathy levels and frustrating situations (ms)

		Empathy	
Situation	Target location	High	Low
Frustrating	Consistent	413 ± 57	409 ± 50
	Inconsistent	419 ± 58	413 ± 49
Nonfrustrating	Consistent	417 ± 69	398 ± 53
	Inconsistent	416 ± 69	402 ± 53

locations (398 ± 53 ms) than for inconsistent locations ([402 ± 53 ms], p = .019, and η_p^2 = 0.046). This result indicated that low-empathy participants demonstrated attentional bias toward aggressive words under both frustrating and nonfrustrating conditions. The simple effect analysis suggested that, under frustrating conditions, high-empathy participants' reaction times were significantly lower (413 ± 57 ms) for consistent locations than for inconsistent locations ([419 ± 58 ms], p = .002, and η_p^2 = 0.082). No statistically significant results were obtained for participants under the nonfrustrating condition (p = .640), indicating that high-empathy participants only exhibited attentional bias toward aggressive words under frustrating conditions.

Discussion

The results supported our hypotheses. The results suggested that under nonfrustration conditions, low-empathy individuals showed significant attentional bias toward aggressive words, while high-empathy individuals did not. At the same time, we found that under frustrating conditions, both low-empathy and high-empathy individuals showed significant attentional bias toward aggressive words.

For the low-empathy participants, the interaction between frustration and word types was not statistically significant. Higher empathy levels resulted in lower attentional bias toward aggressive words under nonfrustrating conditions (Blair, 2018). When facing a frustrating situation, however, even high-empathy participants showed attentional bias toward aggressive stimuli (van Langen et al., 2014; White et al., 2015). The results supported our hypotheses that empathy not only influences emotional processing but also cognitive processing, which indicates that empathic response to others also depends on the situation at the time.

Study 2: Evidence From ERPs

Although previous studies have shown that high-empathy individuals may show fewer aggressive tendencies (Jolliffe & Farrington, 2004; Lovett & Sheffield, 2007), the results of Study one showed that high-empathy participants exhibited attentional bias toward aggressive words under frustrating conditions. Furthermore, how cognitive

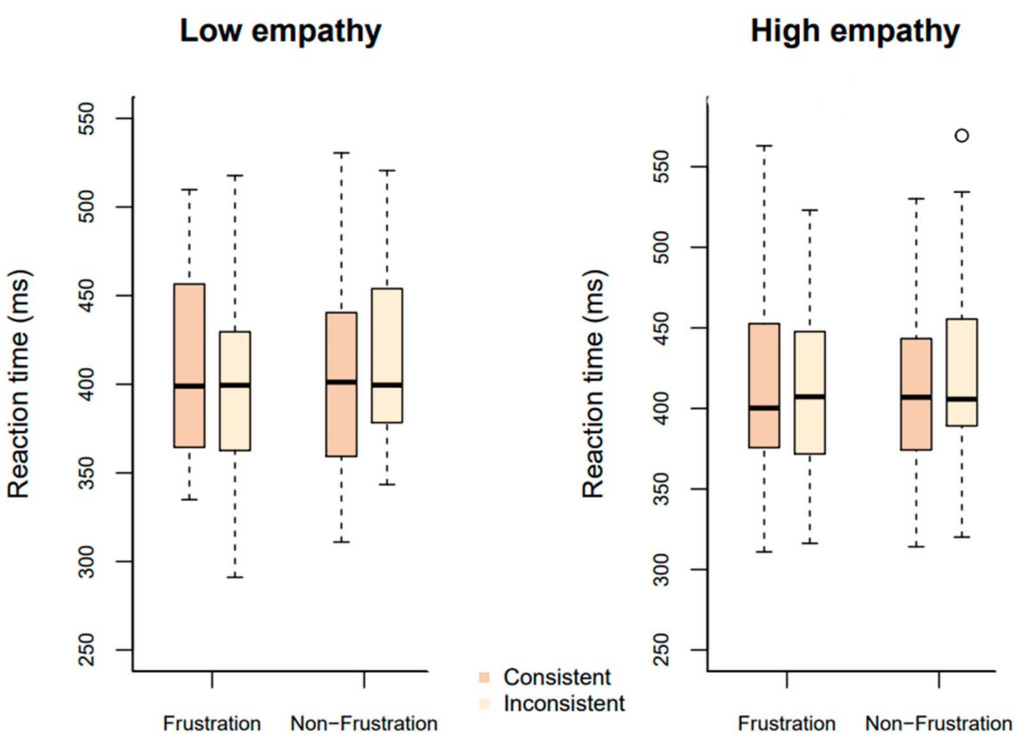

Figure 2. The distributional properties among frustration, empathy, and target location.

resources or emotions affect high-empathy individuals needs the method of cognitive neuroscience to verify the mechanism of the modifying effect we found in Study 1. Thus, we use the emotional Stroop paradigm to examine the cognitive neural mechanism of high-empathy individuals under frustrating situations in Study 2. As mentioned above, we chose the N200, P300, and LPP as three ERP components to explore the neural mechanisms of how frustration affects high-empathy individuals.

Method

Participants and Design

Study 2 was a two-factor within-group experiment examining word type (aggressive or nonaggressive) and situation (frustrating or nonfrustrating). Calculations using G*power showed that 46 participants were needed to obtain 80% power. Due to restrictions on the eligibility of the participants, we recruited 27 participants to take part in the ERP experiment. Again, we used the IRI-C to measure 140 college students' trait empathy. The highest 20% of empathy scores were selected as participants (N = 27, 21 women and six men, mean age = 21.83 ± 1.55 years). Although the final sample size was smaller than our target sample size, *post hoc* tests for the interaction effect of interest (behavior results) and the ANOVA for the ERP results showed that the power of the study was over 80%.

Materials

Emotional Stroop Paradigm

Study 2 was an ERP study using an emotional Stroop paradigm (Eckhardt & Cohen, 1997). The procedure was programmed by E-prime 2.0. Twenty aggressive and 20 nonaggressive words (see Study 1) were written in red and green, respectively. Each word was displayed three times during the procedure. The procedure included 240 trials making up four blocks. All the aggressive and nonaggressive words fit the selection requirements of attentional cue words in the emotional Stroop task (Smith & Waterman, 2003).

Procedure

To start, the participants completed the first two blocks of the emotional Stroop task without any manipulations. After a 30 minute break, participants engaged in the mental rotation task set that comprised the frustrating situation (see Study 1) and then completed the last two blocks.

Figure 3 demonstrates the experimental flow. In each trial, there was a 500 ms fixation and then participants saw a red or green word in the center of the screen for another 500 ms. Participants pressed "F" for red and "J" for green as quickly as possible, depending on the color of the presented word. As soon as the participants made their selection, the next trial automatically began. We allowed participants 20 practice trials to ensure familiarity with the task.

Recording and Data Analysis

We used NeuroScan Synamps 2 to collect ERP data. The EEG of 62 electrodes on the scalp, horizontal electro-ophthalmography (HEOG), and vertical electro-ophthalmography (VEOG) were recorded by a 64-conductor Ag/AgCl electrode cap. All 62 electrodes were arranged based on the national standard of 10–20. HEOG recording electrodes were placed 1.5 cm from the lateral canthus of both eyes, and VEOG recording electrodes were placed 1 cm above and below the left ocular rim. The forehead was grounded. The left mastoid process was the reference electrode, and the contralateral mastoid process was the recording electrode. The Analog-to-Digital Converter (AD) sampling frequency was 500 Hz and the filter bandpass was 0.05–100 Hz. The scalp resistance was kept at less than 5 kΩ.

We used the Linear Modeling of Electroencephalographic toolbox (Pernet et al., 2011) to analyze evoked responses over all space and time dimensions (Figure 4a, b, c). The results showed a significant difference between frustration and nonfrustration in 250–600 ms. There was a

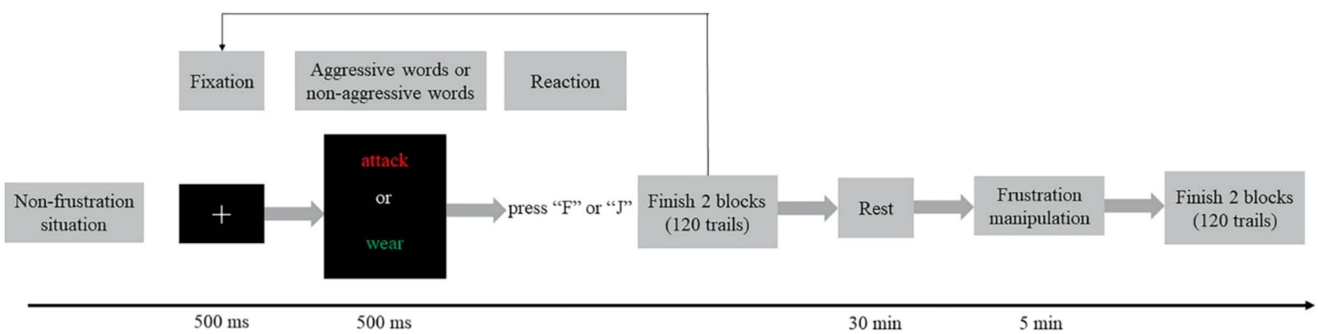

Figure 3. Experiment flow for emotional stroop task.

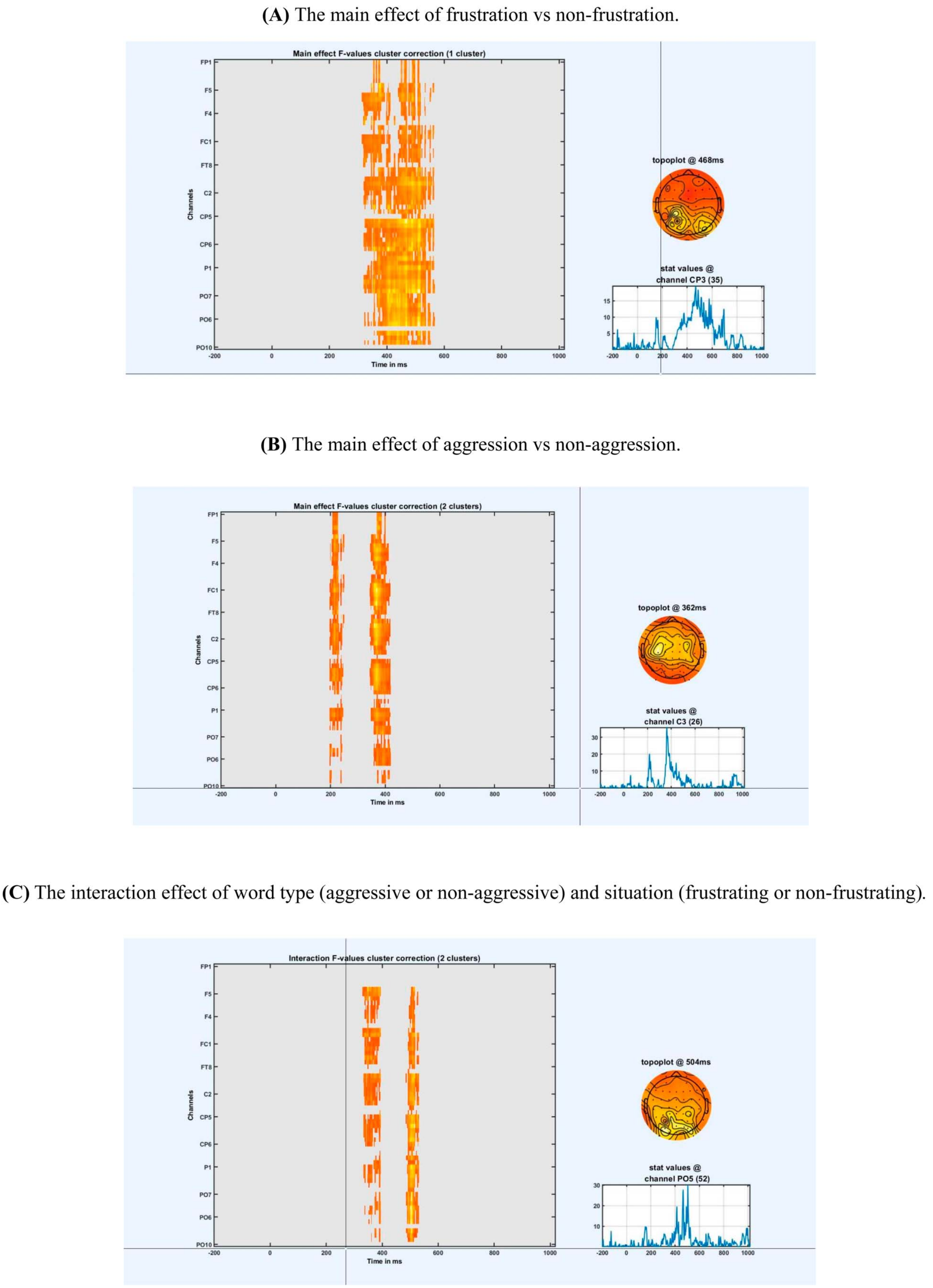

Figure 4. Exploratory analysis for ERP results. (Panel A) The main effect of frustration versus nonfrustration. (Panel B) The main effect of aggression versus nonaggression. (C) The interaction effect of word type (aggressive or non-aggressive) and situation (frustrating or non-frustrating). ERP = event-related potential.

significant difference between aggression and nonaggression in 200–250 ms and 350–420 ms, and a significant interaction effect of word type (aggressive or nonaggressive) and situation (frustrating or nonfrustrating) in 300–400 ms and about 500 ms. Thus, we chose the N200, P300, and LPP as three ERP components.

We selected 15 approximately equidistant located electrodes from the 62 measured ones (Figure 5a). We then constructed a topographic map for N200, P300, and LPP (Figure 5b).

The EEG data were analyzed offline by EEGLAB toolbox (Delorme & Makeig, 2004), and the influence of eye or muscle movement on EEG data was excluded. The whole-brain average was used as a reference electrode. We filtered the data with a cut-off of 0.1–50 Hz. Portions of EEG containing large muscle artifacts or extreme voltage offsets were removed by visual inspection. Independent component analysis was then performed for each subject to identify and remove components associated with eyeblink activity (Jung et al., 2000). We used 1,000 ms as our analysis duration (epoch) and set the first 200 ms as the baseline. Baseline correction was performed using the 200 ms before the onset of the images. After adjusting the baseline and removing the effects of eye movement, those readings with amplitudes larger than ± 100 V were automatically removed as artifacts. Then, we selected F3, FZ, F4, FC3, FCZ, FC4, C3, CZ, C4, CP3, CPZ, CP4, P3, PZ, and P4 as the 15 electrode areas and 200–250 ms (N200), 300–400 ms (P300), and 420–600 ms (LPP) as the three periods during which to analyze the ERP results.

For the behavioral results, we conducted repeated-measures ANOVA using situation (frustrating or nonfrustrating) and word type (aggressive or nonaggressive) as the two independent variables. For the ERP results, we conducted three repeated-measures ANOVAs for the three different components using situation (frustrating or nonfrustrating), word type (aggressive or nonaggressive), and electrode area (F3, FZ, F4, FC3, FCZ, FC4, C3, CZ, C4, CP3, CPZ, CP4, P3, PZ, or P4) as the three independent variables.

Results

Behavioral Results

The accuracy rate of the Stroop task was too high (98%) for further analysis, as was the case in Study 1. We used reaction time as the only dependent variable for the analysis of behavioral results. Table 2 displays the average reaction times of different frustration situations and word types. A repeated measures ANOVA showed that the main effect of word type was not significant, $F(1, 26) = 0.24$, $p = .626$. The main effect of situation was also not significant, $F(1, 26) = 0.75$, $p = .393$. The interaction effect between word type and situation was not significant, $F(1, 26) = 0.13$, $p = .721$. This results showed that there was no significant difference between aggressive and non-aggressive words under frustrating conditions in reaction times.

ERP Results

The ANOVA for the mean amplitude of N200 (200–250 ms negative-stimulus) revealed that the main effect of the word type was statistically significant, $F(1, 26) = 17.25$, $p < .001$, $\eta_p^2 = 0.40$. The aggressive words condition ($M = 3.21$, $SE = 0.70$) had significantly higher amplitude than did the nonaggressive words condition ($M = 2.53$, $SE = 0.68$). The main effect of situation was not significant, $F(1, 26) = 0.47$, $p = .498$. The main effect of the electrode area was statistically significant, $F(14, 364) = 13.28$, $p < .001$, $\eta_p^2 = 0.34$. The interaction effect between situation and word type was not significant, $F(1, 26) = 0.001$, $p = .982$. The interaction effect between situation and electrode area was significant, $F(14, 364) = 1.79$, $p = .038$, $\eta_p^2 = 0.07$. The interaction effect between word type and electrode area was not significant, $F(14, 364) = 1.61$, $p = .073$. The interaction effect among situation, word type, and electrode area was not significant, $F(14, 364) = 1.22$, $p = .258$.

The ANOVA for the mean amplitude of P300 (300–400 ms poststimulus) showed that the main effect of situation was significant, $F(1, 26) = 6.34$, $p = .018$, $\eta_p^2 = 0.20$. The frustrating condition ($M = 7.03$, $SE = 0.73$) was significantly lower than that under the nonfrustrating condition ($M = 7.99$, $SE = 0.70$). The main effect of word type was significant, $F(1, 26) = 10.18$, $p = .004$, $\eta_p^2 = 0.28$, and the amplitude for the aggressive words condition ($M = 7.82$, $SE = 0.68$) was significantly higher than that seen under the nonaggressive words condition ($M = 7.20$, $SE = 0.71$). The main effect of the electrode area was significant, $F(14, 364) = 3.36$, $p < .001$, $\eta_p^2 = 0.11$. The interaction effect between situation and word type was marginally significant, $F(1, 26) = 3.61$, $p = .069$, $\eta_p^2 = 0.12$. The average P300 amplitude for aggressive words under the frustrating condition ($M = 7.13$, $SE = 0.71$) was significantly lower than that produced under the nonfrustrating ($M = 8.50$, $SE = 0.73$) condition ($p = .008$, $\eta_p^2 = 0.24$). The interaction effect between word type and electrode area was significant, $F(14, 364) = 2.69$, $p = .001$, $\eta_p^2 = 0.09$. The interaction effect between situation and electrode area was not significant, $F(14, 364) = 1.08$, $p = .375$. The interaction effect among situation, word type, and electrode area was not significant, $F(14, 364) = 0.835$, $p = .631$.

The ANOVA for the mean amplitude of LPP (420–600 ms poststimulus) showed that the main effect of word type was statistically significant, $F(1, 26) = 8.63$, $p = .007$, $\eta_p^2 = 0.25$. The amplitude under aggressive words condition ($M = 2.47$, $SE = 0.42$) was significantly higher than seen in the nonaggressive words ($M = 2.10$, $SE = 0.44$). The

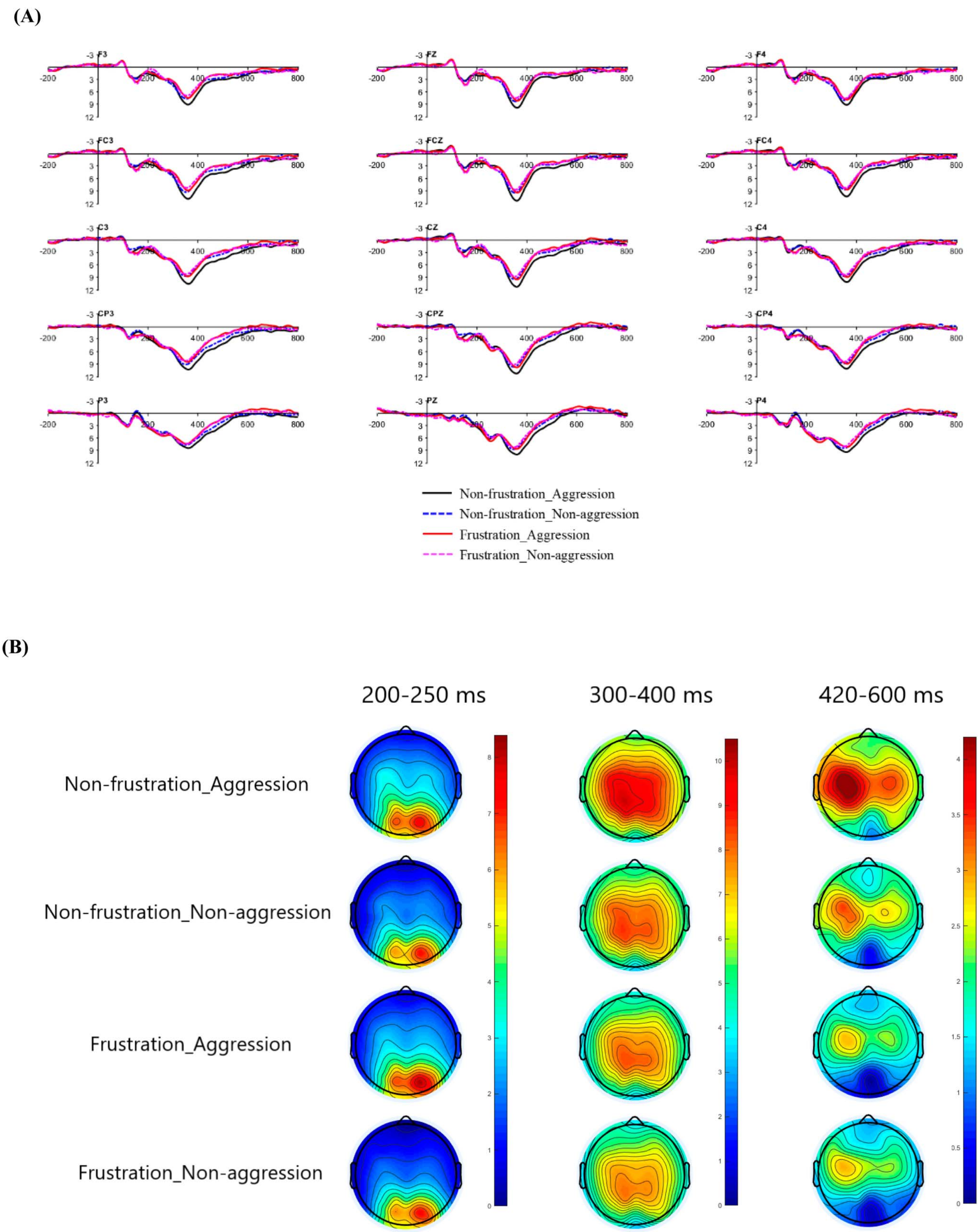

Figure 5. (Panel A) ERP waveform of 15 electrodes. (Panel B) Topographic map of N200 in time window of 200–250 ms, P300 in time window of 300–400 ms, and LPP in time window of 420–600 ms. ERP = event-related potential; LPP = late positive potential.

Table 2. Average reaction times of different frustration situations and word types (ms)

	Word type	
Situation	Aggressive	Nonaggressive
Frustration	456 ± 71	455 ± 72
Nonfrustration	448 ± 67	445 ± 68

main effect of situation was statistically significant, $F(1, 26) = 10.30$, $p = .004$, $\eta_p^2 = 0.28$. The amplitude for the frustrating condition ($M = 1.85$, $SE = 0.39$) was significantly lower than that produced under the nonfrustrating condition ($M = 2.71$, $SE = 0.49$). The main effect of the electrode area was statistically significant, $F(14, 364) = 6.587$, $p < .001$, $\eta_p^2 = 0.20$. The interaction effect between word type and situation was statistically significant, $F(1, 26) = 7.24$, $p = .012$, $\eta_p^2 = 0.22$. The average LPP amplitude for aggressive words seen under the frustrating condition ($M = 1.83$, $SE = 0.39$) was significantly lower than that produced under the nonfrustrating ($M = 3.11$, $SE = 0.51$) condition ($p = .001$, $\eta_p^2 = 0.35$). The interaction effect between situation and electrode area was significant, $F(14, 364) = 1.819$, $p = .034$, $\eta_p^2 = 0.065$. The interaction effect between word type and electrode area was not significant, $F(14, 364) = 0.539$, $p = .909$. The interaction effect among situation, word type, and electrode area was not significant, $F(14, 364) = 0.930$, $p = .526$.

Figure 6 showed the distributional character of the respective ERP components N200, P300, and LPP using boxplots.

Discussion

In Study 2, we adopted the emotional Stroop paradigm to examine the cognitive neural mechanism of high-empathy individuals under frustrating situations. At the behavioral level, there was no significant difference between aggressive and non-aggressive words under frustrating conditions in reaction times for the high-empathy individuals. The reasons for this result may be that dot-probe task and emotional Stroop task is different; in the dot-probe task, individuals choose between two stimuli, and the measured attentional bias included many components such as attentional transfer retention and disengagement; however, in the emotional Stroop task, individuals were required to pay attention to the color of words, which involved the processing competition between different attributes of only a single stimulus (word types and colors) (Mogg et al., 2000; Wirth & Schultheiss, 2007). Thus, although the meaning of specific words may effectively catch the individual's attention, it doesn't show up in explicit behavioral outcomes. Therefore, we mainly examined the indicators of ERPs.

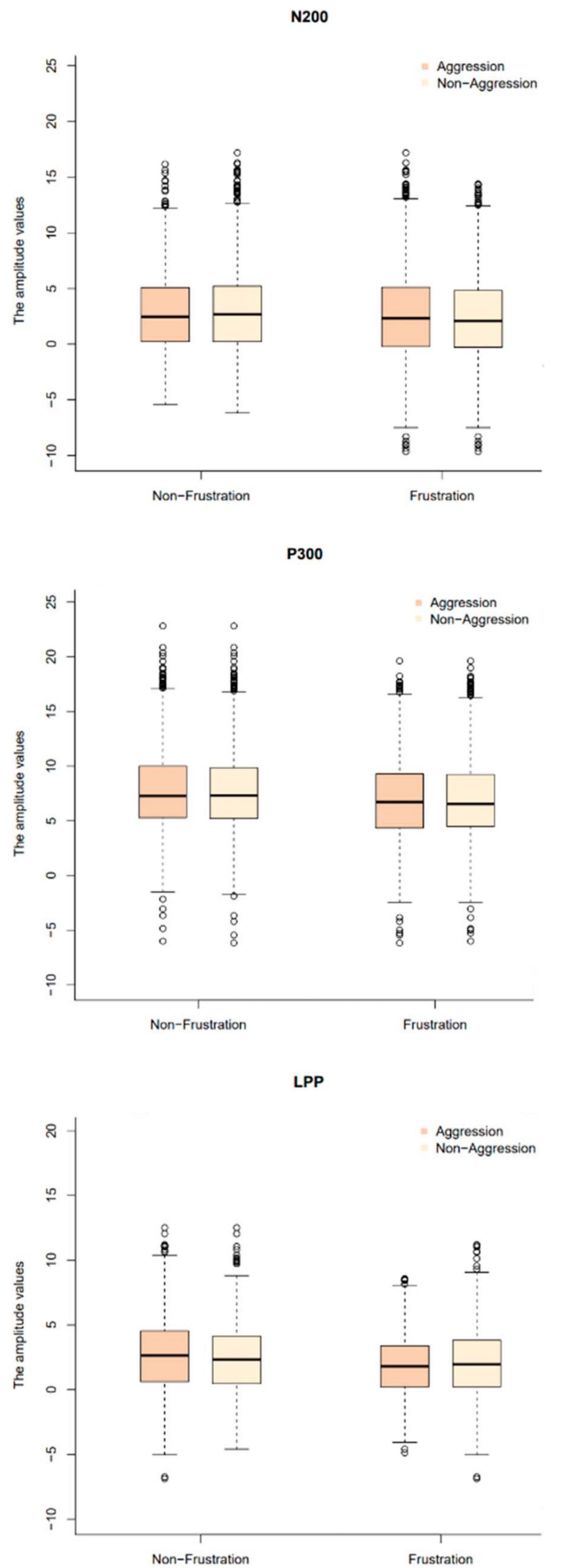

Figure 6. The distributional character of N200, P300, and LPP. LPP = late positive potential.

Interestingly, the results of the ERPs supported our hypothesis. The P300 component is associated with the processing and evaluation of emotional stimuli (Cacioppo et al., 1993). The P300 amplitude value reflects different methods of processing stimulus information (Dufey et al., 2011). The results showed that the high-empathy individuals' average P300 amplitude for aggressive words under the frustrating condition was significantly smaller than that under the nonfrustrating condition, indicating that high-empathy participants showed higher levels of attention arousal toward aggressive words and spent more cognitive resources to process aggressive words under the nonfrustrating condition. P300 was associated with activation of the aversive motivational system (Bartholow et al., 2006). Therefore, under the nonfrustrating condition, high-empathy participants considered aggressive words to be a negative stimulus and their aversive motivational system was activated. Thus, when experiencing frustration, participants tended to process aggressive and neutral words in a similar manner.

The results of the N200 measurements showed that the average amplitude for nonaggressive words was significantly smaller than that produced in the aggressive words condition. Previous studies have found that the amplitude of N200 was associated with suppression activity (Folstein & Van Petten, 2008). Our studies indicate that the N200 component is associated with the suppression of aggressive words. Aggression words may raise conflicting emotions or cognitions for empathic individuals. In the face of conflict, the monitoring and suppression system would be invoked, increasing N200 amplitude. Thus, when facing aggressive stimuli, these participants may manifest inhibitory responses.

Apart from P300 and N200 values, the average LPP amplitude produced by high-empathy participants for aggressive words under the frustrating condition was significantly smaller than it was in the nonfrustrating condition. LPP reflects individuals' attention to emotional stimuli (Schupp et al., 2000; 2003). In our study, the negative emotions of high-empathy participants were aroused under the frustrating condition. Aggressive words appearing in the emotional Stroop task produced consistently negative emotions, which resulted in the small LPP for aggressive words under the frustrating condition. A smaller LPP amplitude may reflect that high-empathy participants paid more attention to aggressive words and showed attentional bias toward them.

General Discussion

We conducted two experiments to investigate the modifying effect of trait empathy on attentional processing of emotionally laden (i.e., aggression-related) stimuli under frustrating situations. The first study used the dot-probe task to demonstrate that high-empathy participants exhibited attentional bias toward aggressive words under frustrating conditions. The second study employed an emotional Stroop task and used ERPs to investigate the neuro-mechanisms of high-empathy participants' attentional processing of aggression-related words under a frustrating condition.

The behavioral study of the dot-probe task revealed that low-empathy participants demonstrated attentional bias toward aggressive words in both the frustrating and the nonfrustrating conditions, while high-empathy participants did not show this type of attentional bias under the nonfrustrating condition. Our results are consistent with those of previous studies (van Langen et al., 2014; White et al., 2015), suggesting that low-empathy individuals may exhibit higher levels of attentional bias toward aggression-related words than do high-empathy individuals under nonfrustrating conditions.

A possible explanation for the result is that frustration aroused negative emotional responses. Eisenberg and Strayer (1987) suggested that if individuals are experiencing negative emotions, empathy toward others might over-arouse their negative emotions. This response can increase cognitive and emotional loads and interfere with the effects of empathy on aggressive tendencies. Specifically, when individuals experience negative emotions, such as sadness and anger, they attend to their own emotions and find focusing on those of others' strenuous. As a result, these individuals are more likely to show attentional bias toward aggressive words.

High-empathy individuals may be more sensitive to emotion valence (Cui & Luo, 2009). After the frustration manipulation in our study, participants' negative emotions were aroused. Thus, participants were likely to direct their attention to aggression-related stimuli. Therefore, their emotional and cognitive resources were heavily loaded, leading to slower and longer reaction times.

Our findings suggested that frustration played a moderating role in empathy in the early emotional sharing stage, and in the later cognitive evaluation stage. In the early stages of emotional sharing, frustrating situations heavily occupy high-empathy individuals' attention when aggressive words are presented. Under the influence of negative emotions concomitant with frustration, participants may have paid attention to their own emotional experiences and interests rather than empathizing (Vukosavljevic-Gvozden et al., 2015). During the later stages of cognitive evaluation, frustrating situations may have elicited smoother coding and semantic processes in high-empathy participants responding to aggression-related words, resulting in attentional bias.

Implications and Limitations

This study revealed the modifying effects of trait empathy on frustration-related attentional processing of emotionally laden (i.e., aggression-related) words. Frustration is an important factor influencing how empathy affects aggression. Developing methods to reduce and intervene in aggression if necessary is an important concern in modern society related to promoting altruism and cooperation. Although developing empathy may be feasible, we should address possible interventions toward coping with frustration better.

Based on our results, instead of emphasizing the role of empathy alone without regard to their specific aspects, we suggest that governments should pay extra attention to those situations where individuals are more likely to encounter frustration, to develop effective ways to deal with frustration properly. Meanwhile, on an individual level, in addition to promoting empathetic responses, postfrustration intervention may be also worthwhile, for example, implementation of intervention programs promoting insight into what stimuli provoke frustration, and how redirect such reactions into constructive motivation (Alcota et al., 2015). Additionally, directing interventions toward regulating negative emotions after the experience of frustration (e.g., cognitive reappraisal intervention and attributional intervention; Peters et al., 2011) can also be relatively effective strategies for management and reduction of individuals' aggression.

The current study has several limitations. First, since attentional bias is a reliable measurement of aggressive tendencies (Putman et al., 2004; Smith & Waterman, 2003) and aggressive tendencies are strongly positively correlated with aggressive behavior (Efrat-Triester et al., 2021; Reijntjes et al., 2013), our study focused on aggressive tendencies using the dot-probe task and the emotional Stroop task to investigate attentional bias to aggressive stimuli, rather than aggressive behaviors. The differences between aggressive tendencies and aggressive behaviors might need further study. Furthermore, other aggression paradigms might be used in future studies to further test and validate the results of this research.

Second, our stimulus materials were aggressive and nonaggressive words, including only two emotional stimulus categories. Due to the characteristics of aggressive words, it was difficult to control the categories of emotion in a dot-probe task and emotional Stroop task to explain attention bias (Brugman et al., 2015; Chan et al., 2010). Thus, future research may benefit from explicit control for emotional categories. For example, in addition to aggressive words and neutral words, another stimulus material with other types of emotions could be used.

Finally, we used a binary manipulation to categorize frustration (frustrating and nonfrustrating situations). The effects of slight frustration or extreme frustration may differ. For example, it is possible that high-empathy individuals do not show attentional bias toward aggressive words in a slightly frustrating situation because their empathy inhibits its effects. In an extremely frustrating situation, however, they may manifest a different response. We hope that future research will pay more attention to nuances related to degree of frustration experienced, to solve this problem as effectively as possible.

Conclusion

This study concluded that low-empathy individuals exhibited attentional bias toward emotionally laden (i.e., aggression-related) words under both frustrating and nonfrustrating conditions while high-empathy individuals demonstrated it only under frustrating conditions. Under frustrating conditions, high-empathy participants also produced a higher amplitude of N200, P300, and LPP toward aggressive versus nonaggressive words. These findings suggested that high-empathy individuals were sensitive to emotionally laden stimuli, such as aggression-related words as used in the present study, under frustrating conditions.

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There are no conflicts of interest to declare.

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Open Data
The data that support the findings of this study are available from the corresponding author upon reasonable request. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. The data, materials, and analytic codes are available in an open repository: https://osf.io/ubmd9/ (Jiang, 2022).

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