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Electrocortical effects of detachment and reinterpretation on the regulation of negative emotion

Lele Chen [a,b], Fangfang Long [b], Lei Chang [c], Renlai Zhou [b,d,e,*]

[a] School of Education Science, Nantong University, Nantong 226019, China
[b] Department of Psychology, Nanjing University, Nanjing 210023, China
[c] Department of Psychology, Faculty of Social Sciences, University of Macau, Macau, China
[d] Department of Radiology, The Affiliated Drum Tower Hospital, Medical School of Nanjing University, No. 321 Zhongshan Road, Nanjing 210008, China
[e] State Key Laboratory of Media Convergence Production Technology and Systems, Beijing 100803, China

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ABSTRACT

Research has suggested a contradictory effect between detachment and reinterpretation, two distinct tactics of cognitive reappraisal, in the regulation of negative emotion. The reasons for this contradictory effect remain unclear. The present study explored the differences between these tactics in terms of potential early processes and neural mechanisms, comparing psychophysiological differences using event-related potentials (ERPs) in the regulation of negative emotion. Thirty college students were required to perform an emotion regulation task, in which they naturally viewed or applied a given emotion regulation strategy towards negative pictures. The results demonstrated that both tactics reduced emotional experiences (decrease of arousal and increase of valence). Reinterpretation was associated with reductions in the late positive potential (LPP) in the late time window, while detachment was not. Detachment showed a lower amplitude in the N1 and N2 ERP components and a higher P2 amplitude than reinterpretation. The differences in early ERP components (N1, N2, and P2) predicted the reduction of LPP amplitude. These findings reveal the differential effects of these tactics on emotional experience and neural responses and highlight the significance of early processes on emotion across the time course of cognitive reappraisal.

1. Introduction

The failure to regulate negative emotion has been linked to various psychopathologies (Hajcak et al., 2010), including depression (Gross and Muñoz, 1995), anxiety disorders (Cisler et al., 2010), and bipolar disorders (Gruber et al., 2012). The ability to regulate one's emotions plays a crucial role in cognitive, social, and psychological well-being (Gross, 2002; Nyklíček et al., 2011). A variety of strategies, such as situation selection, situation modification, attentional deployment, cognitive change, and response modulation, can be selected to achieve emotion regulation (Gross, 2015). Among these strategies, cognitive reappraisal, a method for focusing on cognitive change, aims to alter one's appraisal of emotional events (Buhle et al., 2014; Foti and Hajcak, 2008; Hajcak and Nieuwenhuis, 2006) and has been demonstrated to be a more effective strategy for decreasing negative emotion than other strategies, including suppression and distraction (John and Gross, 2004; Richards and Gross, 2000; Webb et al., 2012). According to a recent taxonomy by Powers and LaBar (2019), cognitive reappraisal can be implemented through the tactics of detachment and reinterpretation. Detachment involves detaching or distancing oneself from an emotional event in a noninvolved observer way (Ochsner et al., 2012), and reinterpretation refers to reinterpreting an emotional stimulus in a positive way (Ochsner et al., 2012). Conceptually, the difference between these two tactics is that reinterpretation focuses on the stimulus content, whereas detachment focuses on how the stimulus is viewed (Powers and LaBar, 2019). To better support clinical treatment or psychological intervention, it will be important to understand the nuance in cognitive processing of these two tactics.

The different neural mechanisms between these two tactics reveal the lateralization of brain function. Studies have associated detachment with the activation of the right prefrontal cortex (PFC) and inferior parietal cortex, whereas reinterpretation activates the left lateral PFC (Dörfel et al., 2014; Powers and LaBar, 2019). These results reveal that greater spatial and attentional processing is possibly associated with

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[*] Corresponding author at: Department of Psychology, Nanjing University, Room 418, Heren Hall, 163 Xianlin Avenue, Nanjing 210023, China.
E-mail address: rlzhou@nju.edu.cn (R. Zhou).

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detachment, whereas evaluating stimulus salience and semantic processes may be involved in reinterpretation (Buhle et al., 2014; Dörfel et al., 2014; Kohn et al., 2014; Powers and LaBar, 2019). Dörfel et al. (2014) also noted that detachment resulted in greater attenuation of left amygdala activity than reinterpretation. However, other researchers have associated both tactics with the attenuation of amygdala activity (Kanske et al., 2011a; Ochsner et al., 2004). The reasons for these particular patterns are unclear. Technology with the high temporal resolution, such as the electroencephalogram (EEG), may provide a valuable reference in explaining these particular patterns in time course.

Studies using event-related potentials (ERP), an electrophysiological response to a stimulus, to study cognitive reappraisal have shown inconsistent result in late positive potential (LPP) (Qi et al., 2017; Willroth and Hilimire, 2016), especially the centroparietal LPP (Hajcak et al., 2010), which evolves from approximately 400 ms and persists for several seconds following stimulus onset (MacNamara et al., 2022). For example, Willroth and Hilimire (2016) revealed that reinterpretation was a more effective method for reducing the amplitude of LPP than distancing. Reinterpretation reduced the LPP amplitude at the PO8 electrode with a time window of 300–1000 ms, whereas no effects were identified in detachment. However, Qi et al. (2017) noted that LPP amplitude at the centroparietal site was attenuated for both reinterpretation and detachment, with detachment eliciting earlier (700–900 ms) and greater attenuation than reinterpretation. Reinterpretation began to decrease the LPP amplitude from 1100 ms. In Qi's research, the differences between these two tactics were explained through the conceptual framework of emotion regulation choice proposed by Sheppes (Sheppes, 2014), which suggested that disengagement strategy operated earlier and more efficiently than engagement strategy. Notably, Sheppes (2014) referred to disengagement strategy primarily as distraction but not detachment. Distraction involves directing attention away from a stimulus to alter its emotional impact and does not involve self-projection (Powers et al., 2020), which is different from detachment. However, the detachment was regarded as distraction in explaining the differences between detachment and reinterpretation in Qi's study (Qi et al., 2017). In summary, previous studies showed the contrary findings about which tactic was more effective. It is noticed that the electrode site (PO8) in Willroth's study was not typical area related to LPP. Thus, it is emergent and significant to repeat the previous study to reveal the effect of these two tactics.

It is noteworthy that neither the studies by Qi et al. (2017) nor Willroth and Hilimire (2016) discussed the differences in the early ERP components of cognitive reappraisal or the confounding factors related to reappraisal success or failure. Previous studies have demonstrated that negative stimuli result in a higher P2 amplitude than neutral stimuli (Delplanque et al., 2004; Foti and Hajcak, 2008). The differences in P2 were observed to fall between failed and successful cognitive reappraisal (Cao et al., 2020), which meant that successful cognitive reappraisal may reduce the P2 amplitude. In addition, the N1 and N2 components in the early ERP time window have been observed in some emotion-related studies (Foti and Hajcak, 2008; Gan et al., 2015). Thus, the early ERPs including N1, N2, and P2 may differentiate the effect of reinterpretation and detachment in an early time window and predict successful cognitive reappraisal indexed by the decrease of LPP amplitude.

To repeat the previous study, according to the Willroth's study (Willroth and Hilimire, 2016), the differences between reinterpretation and detachment rather than distraction were introduced for participants before starting the formal emotion regulation task. The decrease of LPP amplitude was expected to located at centroparietal site. To further explore the possible reason resulting in the inconsistencies and contradictory results, the early ERPs including N1, N2, and P2 were computed in the current study. Based on findings associating successful reappraisal with a decrease in LPP amplitude and early ERP components (e.g., P2) (Cao et al., 2020; Hajcak and Nieuwenhuis, 2006; Qi et al., 2017), we hypothesized that the early ERP components (N1, N2, and P2) might associate with the LPP during successful cognitive reappraisal.

2. Methods

2.1. Participants

Thirty undergraduate students participated in the study (mean age = 21.83 ± 2.29 years, 15 women). All the participants were non-psychology students and completed the Beck Anxiety Inventory (BAI) and Beck Depression Inventory (BDI) (Cheng et al., 2002; Wang et al., 2011), and none of them met the criteria for anxiety (mean BAI = 23.73 ± 3.17, <45) or depression (mean BDI = 4.07 ± 3.51, <21). All the participants were right-handed, had normal or corrected-to-normal vision, reported no history of psychiatric or neurological disorders, and were fluent Chinese speakers. They all gave their written informed consent prior to the experiment. Each participant received 50 Chinese Yuan for finishing the study. The experiment procedures were approved by the Ethics Committee of the Department of Psychology in the author's university and the experiment was conducted in accordance with approved guidelines.

Gpower software was used in the present study to calculate the minimum requisite sample size. A repeated measures analysis of variance (ANOVA: within factors) with effect size (f = 0.25), power (0.8), correlation among repeated measures (0.5), and four measurements in one group was used to estimate the number of participants required in the experiment. Consequently, 24 participants were required. The sample size were larger in the present study than in other similar studies (Qi et al., 2017; Thiruchselvam et al., 2011; Willroth and Hilimire, 2016).

2.2. Stimulus materials

We selected 160 images (120 negative and 40 neutral) from the International Affective Picture System (IAPS) (Lang, 2005). According to the valence and arousal ratings in the IAPS datasets, when compared with the neutral images, the negative images had lower normative valence ($t[119.71] = -24.07$, $P < 0.001$; negative: mean [M] = 2.73, standard deviation [SD] = 0.83; neutral: M = 5.27, SD = 0.47) and higher arousal ($t[92.85] = 14.57$, $P < 0.001$; negative: M = 5.51, SD = 0.57, neutral: M = 4.28, SD = 0.41) levels. These levels of image valence and arousal are similar to those in other emotion regulation studies (Thiruchselvam et al., 2011; Willroth and Hilimire, 2016). The 120 negative images were divided into three condition groups (40 detachment, 40 reinterpretation, and 40 negative view), which did not differ in valence and arousal levels ($Ps > 0.35$). The task was presented using E-prime 2 stimulus presentation software (Schneider et al., 2002). Participants were seated comfortably approximately 70 cm away from a 21-inch screen in a separate room.

2.3. Procedures

Upon arriving at the lab, participants received both a verbal and written description of the experiment. They then consented and were directed to the EEG chamber. A researcher explained the differences between the two emotion regulation strategies, reinterpretation and detachment, in detail. Participants were then guided through eight practice trials for each strategy before participating in the experiment proper. During these practice trials, the participants were told they should begin implementing each emotion regulation strategy when the images appeared on the screen. In each trial, the participants verbally reported the precise manner in which they were implementing each regulation strategy. The researcher ensured that the participants fully understood the experiment and could implement each strategy without difficulty. Following the training, EEG sensors were attached to the participants and the formal emotion regulation task began.

2.4. Emotion regulation task

The emotion regulation task comprised 160 trials, divided into 4 blocks of 40 trials each. Four types of trials were conducted: viewing a neutral image (View-neutral), viewing a negative image (View-negative), reinterpreting a negative image in a positive way (Reinterpretation), and detachment from the negative image (Detachment). To decrease the likelihood that participants mixed the two different strategies, a block structure was used, as detailed in previous studies (Qi et al., 2017; Thiruchselvam et al., 2011). Each block contained 10 View-neutral trials, 10 View-negative trials, and 20 Reinterpretation or 20 Detachment trials. The sequence of the 40 trials within each block was randomized for each condition, and the order of the blocks was counterbalanced. In the View-neutral and View-negative trials, participants were told to look at an image directly and allow themselves to feel emotions. In the Reinterpretation trials, participants were told to reinterpret the image in a positive way to decrease the negative feelings that they experienced. In the Detachment trials, participants were told to look at an image directly but try to take the position of a neutral, noninvolved observer. The detailed instruction of detachment and reinterpretation would be found in supplemental materials.

The trial structure for the emotion regulation task was based on that of (Thiruchselvam et al., 2011), as presented in Fig. 1. Each trial began with a white fixation cross in the center of a black screen for 2 s. Following this, an instruction cue (View, Reinterpret, or Detach) was displayed in white text on a black background for 2 s, followed by a negative or neutral image for 5 s. After the image had disappeared, participants rated their level of valence (until response), followed by their level of arousal (until response). A Self-Assessment Manikin 9-point scale was used to rate the valence and arousal of each image (Lang, 1980). Higher numbers indicated more arousing images and a more pleasant valence.

2.5. Electroencephalographic recording and analysis

Continuous EEG recordings were taken from 32 scalp electrodes based on an Ag–AgCl 10–20 system (bandpass: 0.01–100 Hz, sampling rate: 1000 Hz). The data were collected using Curry 7 software and Neuroscan (USA) amplifiers. The impedances were set at ≤10 KΩ for all apparatuses. For data collection, the ground lead and reference electrode were located at AFz. The data from the left (A1) and right (A2) mastoids were also recorded during the experiment. During the offline data processing, the EEG was rereferenced to the average activities of the left and right mastoids.

EEG data were processed offline using EEGLAB (Delorme and Makeig, 2004), an open access toolbox running in a Matlab environment. EEG data were filtered with a 0.1-Hz high-pass filter and 30-Hz low-pass filter. The data were segmented into epochs with a time window from −300 to 1500 ms. Baseline correction was performed by subtracting the mean of the 500 ms before image onset. Trials with a large drift were manually removed, and trials contaminated by eye movement or eyeblinks were corrected using an independent component analysis algorithm (Delorme and Makeig, 2004). The mean rejection rate was 4.2 % (SD = 4.7 %), and it did not vary by task type ($P = 0.93$).

Consistent with other research (Gardener et al., 2013; Moser et al., 2010; Walker et al., 2011) and based on the visual inspection of ERP waveforms, the N1 amplitude was quantified as the negative amplitude at the frontal sites (Fz and FCz) between 70 and 170 ms after image onset and the N2 amplitude as the negative mean amplitude at Fz and FCz between 260 and 300 ms after image onset. The P2 amplitude was quantified as the positive amplitude at posterior sites (P3, Pz, and P4) between 190 and 250 ms after image onset. Similar to the approach adopted in previous studies demonstrating that LPP is typically the highest at the centroparietal sites (Foti and Hajcak, 2008; Paul et al., 2013; Thiruchselvam et al., 2011), LPP was quantified as the average signal amplitude collapsed across three sensors within the centroparietal region (CP3, CPz, and CP4) between 400 and 1500 ms after image onset. Considering the functional differences cross the course of LPP may be existed (Weinberg and Hajcak, 2011), the waveform was split into early LPP (400–900 ms) and late LPP (900–1500 ms) following previous LPP studies (MacNamara et al., 2022).

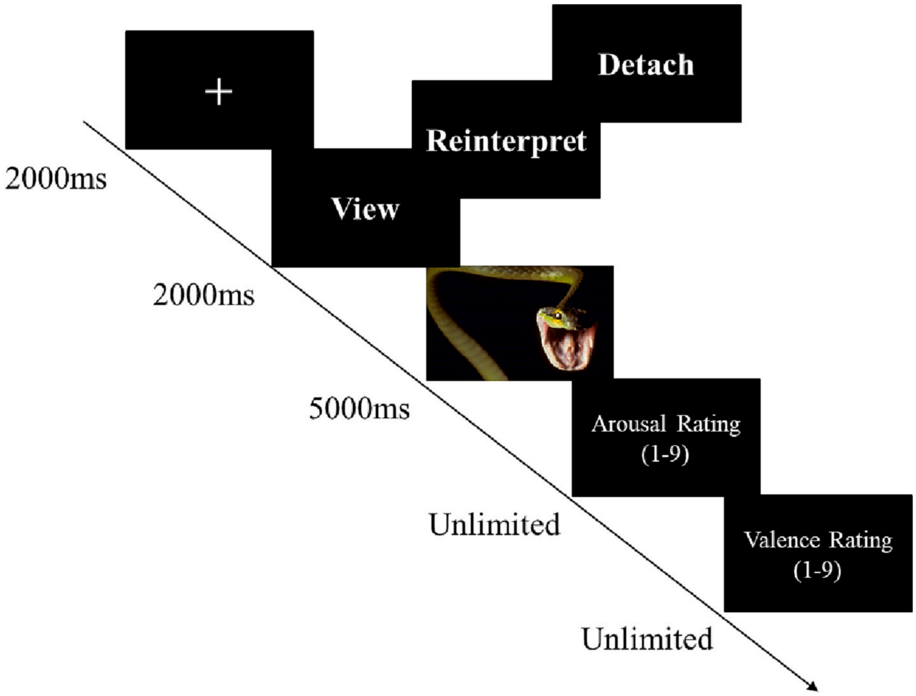

Fig. 1. Trial structure for the emotion regulation task. Participants regulated their emotion according to the cue, after which they reported their emotional experience.

2.6. Statistical analysis

Statistical analysis was conducted in R (version 3.6.2) (R Core Team, 2019) for Windows. The level of significance was set to $\alpha = 0.05$. To examine the effect of ER strategies, linear mixed models were performed for emotional ratings, early ERPs (N1, N2, and P2), different stages of LPP. To control the individual differences, individual (subject-specific) variation was accounted for by considering *Subjects* as random effect. In addition, we controlled covariates including gender, age, BAI, and BDI in regression models. Multiple comparisons were adjusted using the Hommel correction (Hommel, 1988). Effect sizes are presented as partial eta-squared (η_p^2) and Cohen's *d*. Effect sizes for planned comparisons were computed with the *effectsize* package (Ben-Shachar et al., 2020). To further explore whether the early ERPs predict the decrease of LPP, the amplitude differences between reinterpretation (reinterpretation minus view-negative) and detachment (detachment minus view-negative) were calculated when compared to view-negative, then Pearson correlations were computed to explore the relationship between early ERPs (N1, N2, and P2) and LPP.

3. Results

3.1. Emotional ratings

The results revealed that task type had a significant primary effect on arousal ratings (F (3, 87) = 70.80 , $P < 0.001$, $\eta_p^2 = 0.71$). Post-hoc tests indicated that View-negative ($M = 6.35$, $SD = 1.10$, $P < 0.001$, $d = 2.96$), Reinterpretation ($M = 5.13$, SD = 1.09, $P < 0.001$, $d = 1.54$) and Detachment ($M = 4.40$, $SD = 1.22$, $P = 0.002$, $d = 0.69$) elicited greater arousal than View-neutral ($M = 3.80$, SD = 1.49). Relative to View-negative, both Reinterpretation ($P < 0.001$, $d = -1.43$) and Detachment ($P < 0.001$, $d = -2.27$) had decreased arousal ratings elicited by the negative image. Furthermore, Detachment ($P < 0.001$, $d = 0.84$) was associated with reduced emotional arousal compared with Reinterpretation (Fig. 2a, sTable 1). For the valence ratings, a significant main effect of task type was also observed (F (3, 87) = 119.94 , $P < 0.001$, $\eta_p^2 = 0.81$). Post-hoc tests revealed that View-negative ($M = 2.86$, SD = 0.62) exhibited lower valence than View-neutral ($M = 5.53$, SD = 0.59, $P < 0.001$, $d = -3.91$). Reinterpretation ($P < 0.001$, $d = -1.02$) and Detachment ($P < 0.001$, $d = -1.94$) were also associated with lower valence ratings than View-neutral. Compared with View-negative, both Reinterpretation ($M = 4.83$, SD = 0.91, $P < 0.001$, $d = 2.88$) and Detachment ($M = 4.20$, SD = 0.64, $P < 0.001$, $d = 1.96$) increased the pleasantness of the negative image. In addition, Reinterpretation had higher valence ratings than Detachment ($P < 0.001$, $d = 0.92$).

3.2. Early component of event-related potential

Fig. 3 presents the grand-averaged ERP waveforms at the pooling of Fz and FCz for each of the four conditions. The descriptive statistics of early ERPs were shown in sTable 1. Task type exhibited a significant main effect on N1 amplitude (F (3, 87) = 32.15, $P < 0.001$, $\eta_p^2 = 0.53$). The results of the post-hoc tests are presented in Fig. 5 (left), revealing that both View-negative ($M = -5.07$, SD = 2.29, $P < 0.001$, $d = -0.82$) and Reinterpretation ($M = -5.35$, SD = 2.24, $P < 0.001$, $d = -0.97$) achieved greater N1 amplitude than View-neutral ($M = -3.60$, SD = 1.93), whereas Detachment had a smaller N1 amplitude ($M = -2.00$, SD = 2.07) than View-neutral ($P = 0.002$, $d = 0.89$), View-negative ($P < 0.001$, $d = 1.71$), and Reinterpretation ($P < 0.001$, $d = -1.87$).

For N2 amplitude, task type also had a significant main effect (F (3, 87) = 18.27, $P < 0.001$, $\eta_p^2 = 0.39$). Post-hoc tests revealed that Detachment exhibited a smaller N2 amplitude ($M = -5.51$, SD = 5.28) than View-neutral ($M = -9.04$, SD = 4.68, $P < 0.001$, $d = 1.36$), View-negative ($M = -8.13$, SD = 5.87, $P = 0.030$, $d = 1.01$, and Reinterpretation ($M = -9.11$, SD = 6.00, $P < 0.001$, $d = -1.38$) (Fig. 5, middle). However, there was no significant differences of N2 amplitude between Reinterpretation and View-neutral ($P = 0.912$, $d = -0.02$) as well as View-negative ($P = 0.083$, $d = -0.38$).

Fig. 4 depicts the grand-averaged ERP waveforms at the pooling of P3, Pz, and P4 for each of the four conditions. For P2 amplitude, a significant main effect of task type was observed (F (3, 87) = 9.90, $P < 0.001$, $\eta_p^2 = 0.25$). Post-hoc tests revealed that Detachment exhibited a larger P2 amplitude ($M = 5.15$, SD = 4.82) than View-neutral ($M = 3.05$, SD = 4.24, $P < 0.001$, $d = 1.06$), View-negative ($M = 3.47$, SD = 4.50, $P = 0.014$, $d = 0.85$), and Reinterpretation ($M = 3.37$, SD = 4.25, $P = 0.001$, $d = -0.9$) (Fig. 5, right). No significant differences of P2

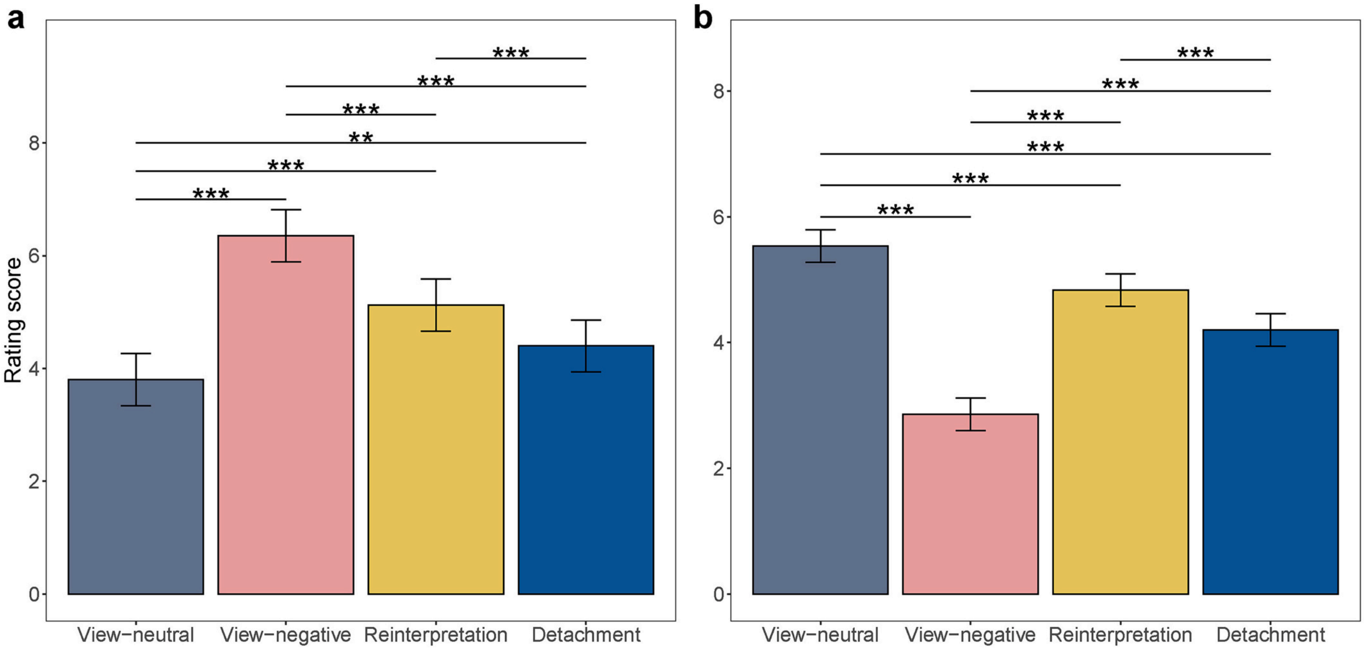

Fig. 2. The estimated mean arousal (a) and valence (b) ratings across four task types in linear mixed models after controlling gender, age, anxiety, and depression scores. Error bars represent 95 % confidence intervals of means. ** $P < 0.01$, ***$P < 0.001$.

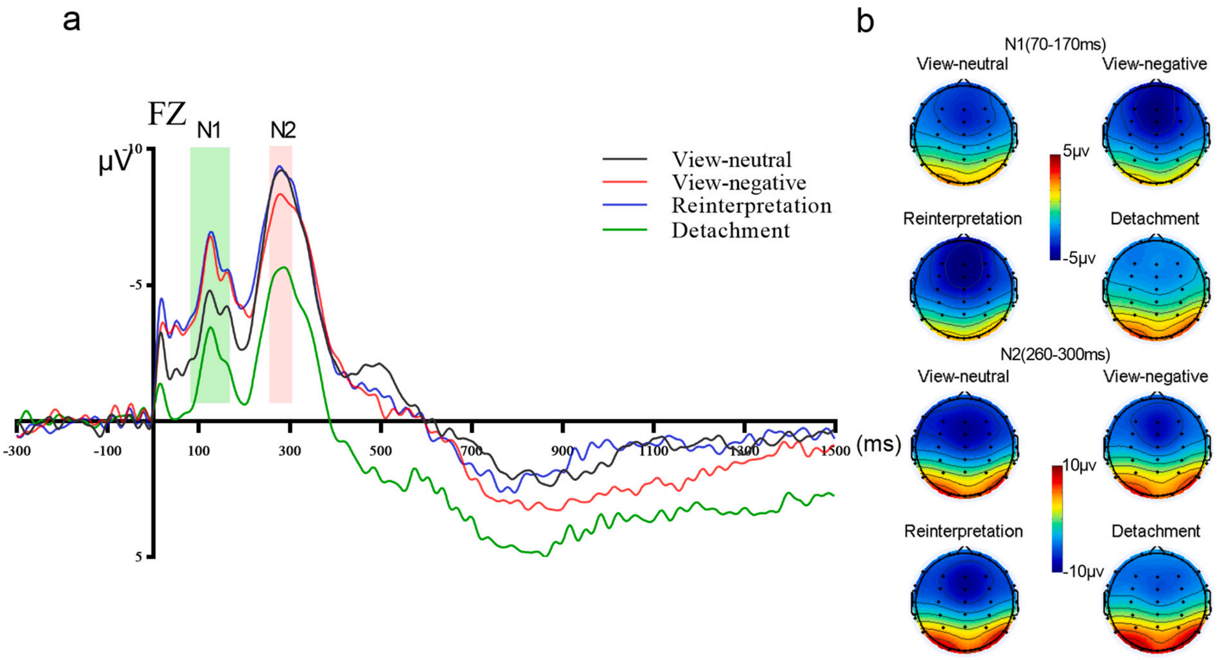

Fig. 3. Grand-average N1(a) and N2 (a) and the topographical distribution of wave N1 (b) and N2 (b) for the four task types in the regulation task at frontal sites (Fz and FCz).

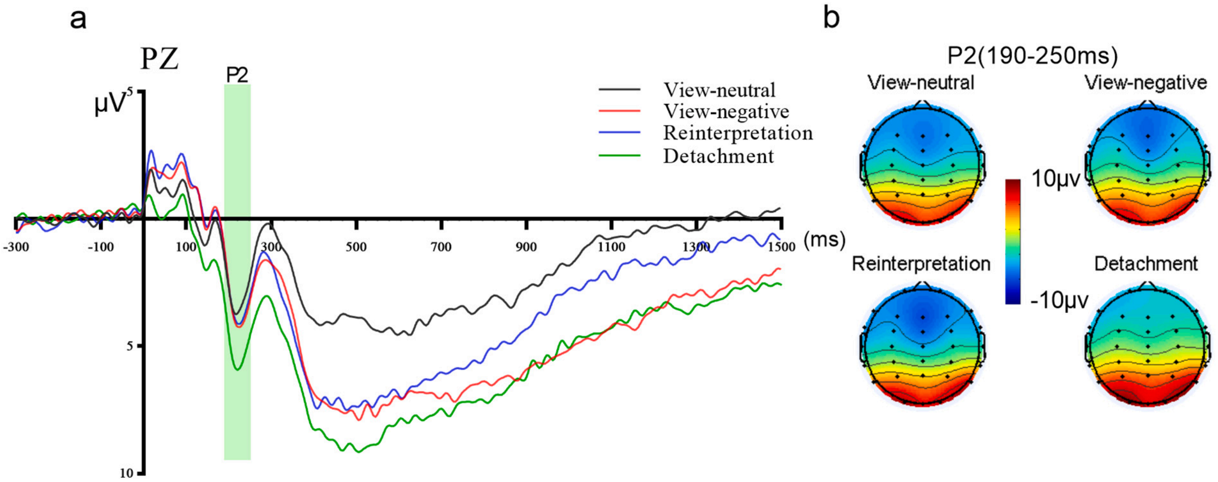

Fig. 4. Grand-average P2 (a) and the topographical distribution of wave P2 (b) for the four task types in the regulation task at posterior sites (P3, Pz, and P4).

amplitude between Reinterpretation and View-neutral ($P = 0.534$, $d = 0.16$) as well as View-negative ($P = 0.806$, $d = -0.05$) were observed.

3.3. Late positive potential

Fig. 6 depicts the centroparietal LPP waveforms elicited by images in the emotion regulation task. The descriptive statistics of LPP were shown in sTable 1. In the early LPP time window, a significant main effect of task type was observed (F (3, 87) =15.43, $P < 0.001$, $\eta_p^2 = 0.35$). Post-hoc tests (Fig. 7) revealed that View-negative ($M = 6.07$, SD = 4.89, $P < 0.001$, $d = 1.11$), Reinterpretation ($M = 5.15$, SD = 4.92, $P < 0.001$, $d = 0.76$), and Detachment ($M = 6.74$, SD = 5.03, $P < 0.001$, $d = 1.37$) exhibited a higher LPP amplitude than View-neutral ($M = 3.17$, SD = 3.65). Moreover, relative to View-negative, neither Reinterpretation ($P = 0.105$, $d = -0.35$) nor Detachment ($P = 0.232$, $d = 0.26$) modulated the LPP amplitude during the early time window. However, Reinterpretation showed a lower LPP amplitude than Detachment ($P = 0.006$, $d = -0.61$). For the late time window, a significant main effect of task type was also observed (F (3, 87) = 8.50, $P < 0.001$, $\eta_p^2 = 0.23$). View-negative ($M = 4.25$, SD = 4.91, $P < 0.001$, $d = 0.88$) and Detachment ($M = 4.06$, SD = 4.70, $P < 0.001$, $d = 0.82$) exhibited a larger LPP amplitude than View-neutral ($M = 1.47$, SD = 4.49). Reinterpretation attenuated the centroparietal LPP ($M = 2.08$, SD = 5.21, $P = 0.002$, $d = -0.68$) when compared with View-negative, reaching the same level as View-neutral ($P = 0.37$, $d = 0.19$), while Detachment did not decrease the centroparietal LPP in the late time window ($P = 0.79$, d = -0.06). In addition, Reinterpretation showed a lower LPP amplitude than Detachment ($P = 0.004$, $d = -0.63$).

3.4. Correlation results

To test whether the early ERP components (N1, N2, and P2) predicted the decrease of LPP amplitude when using cognitive reappraisal, correlations were performed. Fig. 8 presents the correlations between

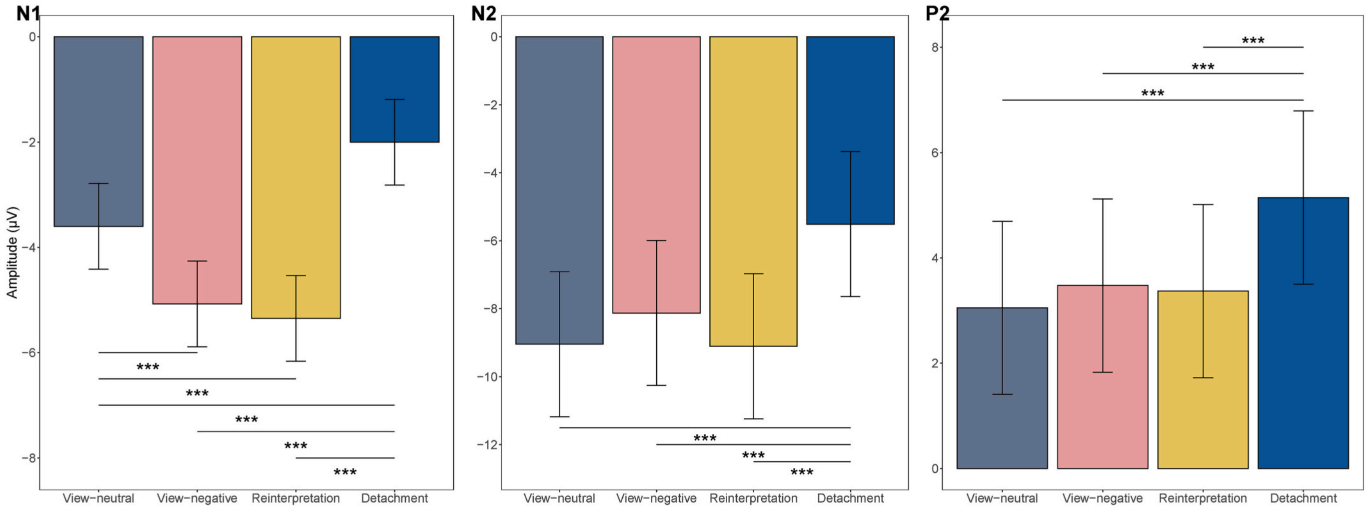

Fig. 5. The estimated mean amplitude of N1, N2, and P2 across the four task types in linear mixed models after controlling gender, age, anxiety, and depression scores. Error bars represent 95 % confidence intervals of means. ***$P < 0.001$.

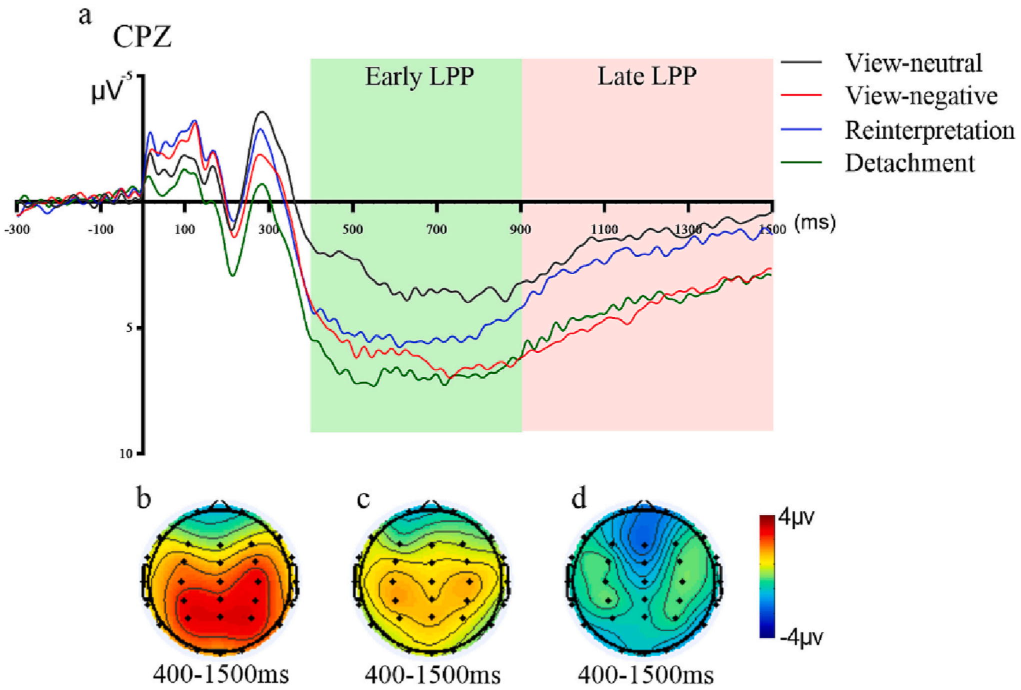

Fig. 6. Image-locked late positive potentials pooled at centroparietal sites (CP3, CPz, and CP4) in the regulation task (a). Topographical distribution of the difference wave of View-negative minus View-neutral (b), View-negative minus Reinterpretation (c), and View-negative minus Detachment (d).

the difference of N1, N2, and P2 and the differences of reducing the LPP when compared reinterpretation with detachment. The decrease of the LPP was positively associated with increase of N1 amplitude (Early LPP: $r(30) = 0.74$, $P < 0.001$; Late LPP: $r(30) = 0.55$, $P = 0.002$), the increase of N2 amplitude (Early LPP: $r(30) = 0.73$, $P < 0.001$; Late LPP: $r(30) = 0.56$, $P = 0.001$), and decrease of P2 amplitude (Early LPP: $r(30) = 0.69$, $P < 0.001$; Late LPP: $r(30) = 0.55$, $P = 0.002$).

4. Discussion

To uncover further nuances in the differences between reinterpretation and detachment, the ERP technique was applied in the present study to compare the psychophysiological mechanisms underlying these two tactics. In terms of self-reported emotional ratings, reinterpretation was more effective in increasing the valence ratings than detachment, whereas detachment was more effective in reducing the arousal ratings than reinterpretation. In addition, reinterpretation reduced the centroparietal LPP during the late time window, while detachment did not. Specially, the differences of early ERP component (N1, N2, and P2) between detachment and reinterpretation were observed, which predicted the reduction of LPP amplitude. These results revealed that these two tactics from the cognitive reappraisal family differed in controlling emotion as indicated by altered subjective and electrophysiological responses.

Consistent with other studies, successful reinterpretation and detachment could modulate personal emotional experiences during emotion regulation (Paul et al., 2013; Schönfelder et al., 2014; Thiruchselvam et al., 2011; Willroth and Hilimire, 2016). In addition, we observed the differential effects of these tactics in modulating arousal and valence ratings. Specifically, reinterpretation was associated with a

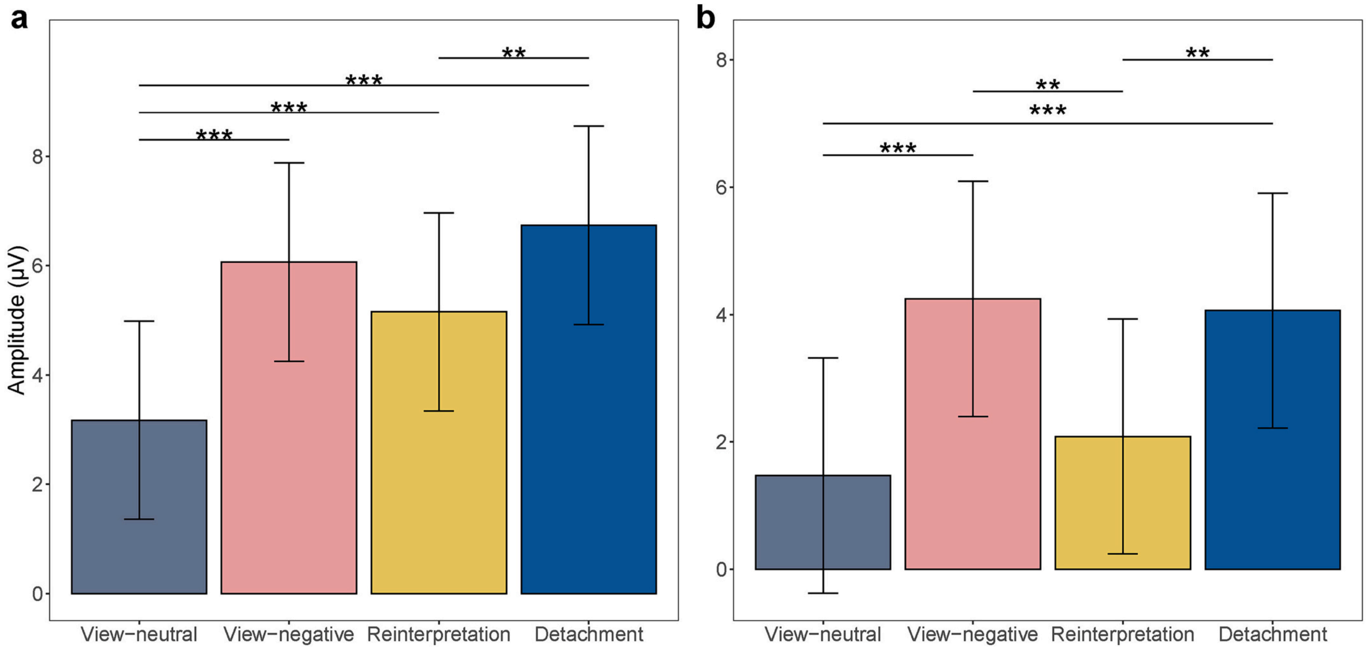

Fig. 7. *The estimated* mean amplitude of late positive potentials at early (a) and late (b) time windows across the four task types in linear mixed models after controlling gender, age, anxiety, and depression scores. Error bars represent 95 % confidence intervals of means. * $P < 0.05$, ** $P < 0.01$, ***$P < 0.001$.

higher valence rating than detachment, whereas detachment was associated with a lower emotional arousal than reinterpretation, which is consistent with the findings of Qi et al. (2017). Conceptual differences may account for the differential effects of these tactics. Reinterpretation is focused on transforming the meaning of stimulus in a positive way rather than on transforming the viewpoint from which the stimulus is considered (Ochsner et al., 2012; Powers and LaBar, 2019).

According to the EEG results, in the early time window, negative images elicited higher LPP compared with neutral images, which is consistent with studies indicating that LPP increased when negative stimuli were viewed (Foti and Hajcak, 2008; Hajcak et al., 2010). However, the reduction of LPP was not observed when reinterpreting, or detaching the negative stimulus. This might be the reason that attention was oriented to the negative pictures at stimulus onset, while in the late time window, attention was transferred to the emotional content of images (MacNamara et al., 2022; Weinberg and Hajcak, 2011). In the late time window, reinterpretation, but not detachment, was associated with a reduction in LPP amplitude, demonstrating that reinterpretation may be more effective than detachment at reducing LPP. This finding is in line with the notion proposed by Willroth and Hilimire (2016) and an fMRI study (Hermann et al., 2021); however, it is inconsistent with the findings of Qi et al. (2017). We were unable to observe whether detachment decreased LPP, possibly because participants focused more on the goal of reducing their negative emotional experiences and tended to report lower ratings for emotional experiences. Thus, emotional stimuli remained in the participants' working memory when applying detachment. This is a difference between detachment and distraction (Powers and LaBar, 2019). Notably, the results for detachment in the study by Qi et al. (2017) are similar to those for distraction in that an earlier modulation in LPP was identified (Sheppes, 2014; Thiruchselvam et al., 2011). In fact, the theoretical framework in that study was referred to as disengagement distraction (Sheppes, 2014). In addition, stimulus intensity may also influence the results. The stimulus intensity in the present study was similar to that in the study by Willroth and Hilimire (2016) and a little higher than that in the study by Qi et al. (2017). Studies have demonstrated that detachment is likely to be effective for emotional responses of low-to-moderate intensity but not high-intensity responses (Wisco et al., 2015). We also observed higher activation at the left lateral PFC during reinterpretation based on source localization analyses, while no notable activation for detachment was identified. This result may further explain why detachment was less effective at reducing LPP than reinterpretation.

In addition to the changes in LPP, differences in early components of ERP were also identified. The N1 and N2 amplitude was smaller in the frontocentral region for detachment than reinterpretation, whereas P2 amplitude was larger for detachment than reinterpretation. The differences in early processes between reinterpretation and detachment may further explain the different effects of these tactics. The N1 component is usually considered an indicator of processing bias for threatening stimuli (Sun et al., 2012). We observed a greater negative N1 amplitude for View-negative than for View-neutral, which is consistent with other reports (Foti and Hajcak, 2008). The lower amplitude of N1 for detachment compared with that for reinterpretation suggested that detachment may focus less on emotional images and more on cognitive determinants than reinterpretation. Studies have also revealed that detachment requires high cognitive effort to regulate high-intensity negative images (Scheffel et al., 2021). We noticed that frontal LPP, indicating cognitive effort or attentional control, was higher for detachment than for reinterpretation (Fig. 3), supporting evidence that higher cognitive effort is associated with being less effective at regulating negative emotion (Moser et al., 2014; Qi et al., 2017).

A lower frontocentral N2 was observed in detachment than in reinterpretation. Research has associated N2 with conflict monitoring (Carter and Van Veen, 2007; Folstein and Van Petten, 2008). The lower N2 revealed for detachment suggested that less conflict was detected during emotional regulation, which is consistent with the results for N1 indicating less focus on stimuli when applying detachment. A recent ERP study using face–word Stroop tasks demonstrated that the N2 component might be associated with emotional attention (Xue et al., 2016). Therefore, detachment might entail less top-down attention paid to emotional images than reinterpretation, indicating that individuals engaging in reinterpretation must monitor the conflict between top-down positive reinterpretation and bottom-up emotional evaluations before attenuating their emotional response (Ochsner et al., 2002). Self-related neural processes may also explain the differences between these two tactics. Detachment also refers to self-focused tactics, corroborating

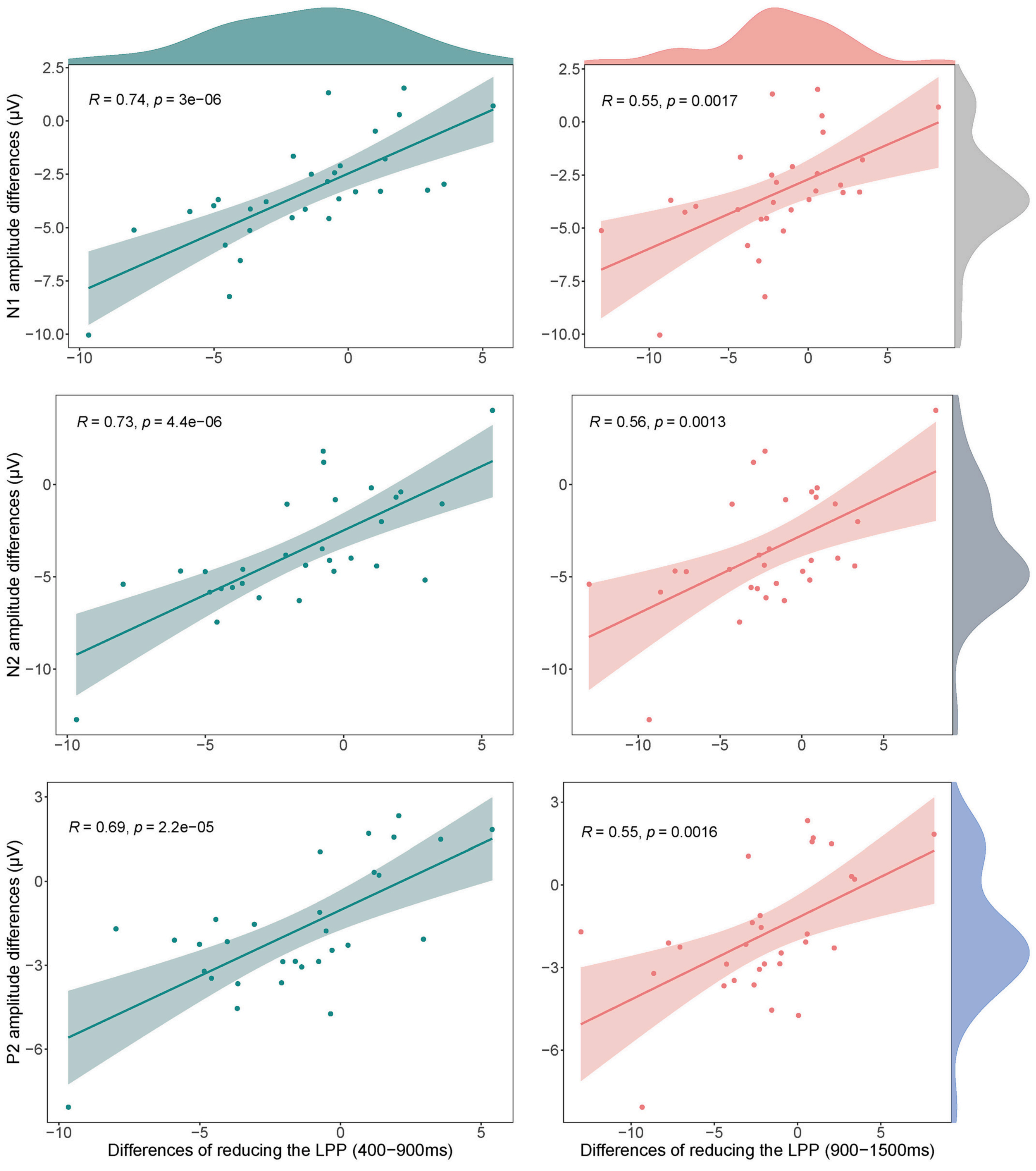

Fig. 8. Correlations between the difference of N1 (up), N2 (middle), and P2 (down) and the differences of reducing the LPP when compared reinterpretation with detachment in early (left panel) and late (right panel) time window.

the finding that self-related stimuli can elicit smaller N2 amplitudes than neutral stimuli (Zhu et al., 2016).

Another key finding was that detachment exhibited a higher amplitude of P2 in the parietal region than reinterpretation. This result corroborates findings that spatial attention is associated with detachment rather than interpretation (Ochsner et al., 2012). An ERP study demonstrated that attention can be oriented towards spatial locations, amplifying the posterior P2 amplitude (Kanske et al., 2011b). Furthermore, fMRI studies have revealed the reorientation of attention to alternative perspectives during detachment associated with the parietal regions (Ochsner et al., 2012), indicating greater spatial and attentional processing in detachment (Dörfel et al., 2014). According to the recent taxonomy by Powers and LaBar (2019), some forms of detachment involve spatial processes. Future studies can further explore the differences in neural mechanisms among different forms of detachment, including spatial, temporal, and objective distancing. Another related explanation could be that the P2 component reflects a motivated perception process, with effects on top-down goal (Amodio, 2010; Zougkou et al., 2017). According to Willroth and Hilimire (2016), research participants were motivated to achieve the goal of detachment during emotion regulation. In addition, the P2 component was associated with a failure in cognitive reappraisal (Cao et al., 2020), which might indicate that detachment is less effective at decreasing LPP than reinterpretation. The correlation results of the present study also revealed that P2 was positively correlated with LPP in the late time window.

The results of the correlation analyses in the present study reveal that early cognitive processing is associated with LPP in the late time window. In detail, a larger increase of N1 and N2 amplitude and a larger decrease of P2 amplitude may lead to a larger reduction of LPP in both time windows when conducting cognitive reappraisal, which explains the contradictory results of prior studies (Qi et al., 2017; Willroth and Hilimire, 2016). The causal relationship between early cognitive processing and emotional response should be assessed in future studies based on a novel paradigm.

This study has several limitations. First, the valence and arousal ratings were recorded retrospectively at the end of each trial. We cannot exclude the possibility that affect labeling in earlier trials influenced the emotional response in later trials. Second, although a block design was used, we cannot exclude the possibility that mixed strategies were used in one block. Furthermore, individual differences may exist when applying the two tactics. In addition, subgroups of reinterpretation and detachment were not explored in the present study. Thus, future studies could assess the effect of detachment from a spatial, temporal, and objective perspective. Third, we provided evidence that reinterpretation and detachment exhibited different psychophysiological mechanisms. Which tactic is more effective in clinical practice should be explored further through interventional or longitudinal studies.

5. Conclusions

The present study demonstrates that detachment and reinterpretation tactics differ in their ERP temporal course and neural mechanisms. The results for early ERP components expand on the findings of other studies on cognitive reappraisal (Qi et al., 2017; Willroth and Hilimire, 2016), providing a more nuanced understanding of the differences between reinterpretation and detachment. Future studies should focus on the lasting effects and neural correlates of these two tactics using a longitudinal design to verify whether reinterpretation is more effective than detachment in clinical practice.

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Ethics approval

The experiment procedures were approved by the Ethics Committee of the Department of Psychology in Nanjing university.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2023.03.004.

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