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Using distraction to regulate emotion: Insights from EEG theta dynamics

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ABSTRACT

Distraction is a powerful and widely-used emotion regulation strategy. Although distraction regulates emotion sooner than other cognitive strategies (Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011), it is not yet clear whether it is capable of blocking the earliest stages of emotion generation. To address this issue, we capitalized on the excellent temporal resolution of EEG by focusing on occipital theta dynamics which were associated with distinct stages of visual processing of emotional stimuli. Individually defined theta band dynamics were extracted from a previously published EEG dataset (Thiruchselvam et al., 2011) in which participants attended to unpleasant (and neutral) images or regulated emotion using distraction and reappraisal. Results revealed two peaks within early theta power increase, both of which were increased by emotional stimuli. Distraction did not affect theta power during an early peak (150–350 ms), but did successfully decrease activity in a second peak (350–550 ms). These results suggest that although distraction acts relatively early in the emotion-generative trajectory, it does not block fast detection of emotional significance. Given that theta dynamics were uncorrelated with Late Positive Potential activity, the present results also encourage researchers to add the occipital theta to the growing toolkit of EEG-based measures of emotion regulation.

1. Introduction

Emotion regulation refers to efforts to influence the magnitude or duration of one or more aspects of the emotional response (Gross, 1998, 2013; Koole, 2009). One major emotion regulation strategy is distraction, which involves diverting attention away from the emotional stimulus (Sheppes and Gross, 2011). While a key feature of distraction is relatively fast interference with emotion generation (Thiruchselvam et al., 2011), the precise stimulus processing stage at which this occurs is unclear. In the present study, we ask whether distraction is capable of precluding rapid selection of emotional significance at an initial attentional stage, or whether it becomes effective only later (Schupp et al., 2006). To this end, we capitalized on the excellent temporal precision of EEG, focusing in particular on occipital theta correlates of emotional processing (Knyazev et al., 2009; Knyazev, 2007; Lewis, 2005; Womelsdorf et al., 2010; Zhang et al., 2013).

2. Mechanisms of emotion regulation by distraction

The emotion regulation literature provides ample evidence that regulatory strategies such as distraction can be effective in reducing the neural, behavioral, and experiential correlates of emotion (Diekhof et al., 2011; McRae et al., 2010; Webb et al., 2012). Moreover, recent research shows that distraction affects emotion generation relatively faster than other cognitive strategies such as reappraisal which involves altering the meaning of an emotional situation (Thiruchselvam et al., 2011). However, the existing evidence does not specify the particular phase of emotional processing that is targeted by distraction. Two stages can be distinguished in visual attention in general (Chun and Potter, 1995; Itti and Koch, 2001; Marois and Ivanoff, 2005) and emotional attention in particular (Öhman, 1986; Schupp et al., 2006). During an initial large-capacity stage, crude stimulus features are rapidly evaluated for various cues of significance. A subset of information is then given access to further consolidation and elaboration in working memory (WM). If the first stage is truly characterized by large capacity, then consuming attentional resources via distraction should not heavily affect early prioritized processing of emotional stimuli. This leads to the prediction that distraction may not preclude early detection of emotional significance, although it may very well block later stages of processing characterized by capacity limits on attention.

More broadly, it is still unclear to which extent rapid evaluation of emotional stimulus features proceeds automatically (i.e., does not require attentional resources). On the one hand, some research suggests that emotional stimulus features can be appraised even when attention is consumed by other tasks (Vuilleumier, 2005). However, other studies indicate that the prioritized processing of emotional information can be effectively blocked when participants need to engage in tasks that exhaust their attentional resources (Pessoa, 2005). However, as the relevant studies have mainly relied on fMRI, a lack of temporal resolution might have limited the ability to conclusively resolve this question (Pessoa, 2010). In the present study, we use a more temporally precise EEG-based measure of emotional appraisal to ask whether early stages

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of the evaluation of emotional stimuli require top-down attention resources.

3. Theta dynamics and stages of motivated attention to affective content

Dynamics in EEG theta frequency (around 3–8 Hz) are particularly sensitive to the processing of emotional stimuli (for reviews see Bekkedal et al., 2011; Knyazev, 2007; Lewis, 2005). Theta power at various scalp locations can be enhanced by affective content that is characterized by arousal (Aftanas et al., 2002, 2004; Balconi and Lucchiari, 2006; Balconi and Pozzoli, 2009; Krause et al., 2000) and negative valence (Aftanas et al., 2001). Of particular relevance for the present investigation, posterior theta has been linked to the consequences of affective attention on perceptual processing (Aftanas et al., 2001; Basar et al., 2006; Zhang et al., 2013). In particular, during the perception of emotional stimuli, activity in sensory cortices is enhanced by inputs from frontoparietal attention areas as well as subcortical emotional regions such as the amygdala (Pourtois et al., 2013). It is possible that these modulatory inputs are synchronized in the theta frequency band, which is sufficiently slow for the long distance between sensory brain areas and origins of the modulatory signals (von Stein and Sarnthein, 2000; Varela et al., 2001). Theta has also been explicitly implicated in emotional brain networks (Lewis, 2005; Womelsdorf et al., 2010). In line with this view, posterior theta was recently found to be both increased by emotional stimuli and selectively attenuated by distraction (Zhang et al., 2013).

Furthermore, theta dynamics can distinguish different stages of emotional stimulus processing. In a pair of studies, Knyazev and colleagues discovered two early theta power peaks (occurring before and after 250 ms) that were both enhanced by emotional (compared to neutral) stimuli (Knyazev et al., 2009, 2010). However, intentionally attending to emotional aspects of the stimuli modulated power only in the second peak, suggesting that the emotional amplification of the first peak occurred automatically. This finding is particularly interesting because it suggests that these peaks may be related to the two processing stages envisaged in dual-stage models of visual attention. First, capacity differences between the stages fit with the finding that the first theta peak, but not the second, was enhanced automatically regardless of the allocation of attention. Second, the timing of the peaks overlaps with the proposed durations of the dual stages (Schupp et al., 2006). In summary, different lines of research converge on the idea that posterior theta power may reflect the prioritized processing of affective stimuli during distinct phases of attention to emotional stimuli.

4. The present study

The association between theta dynamics and affective processing stages suggests that theta can be used to investigate the stage at which distraction intervenes in emotion generation. To address this goal, we re-analyzed data from a previously published EEG study on the effects of emotion regulation on the Late Positive Potential (LPP; Thiruchselvam et al., 2011). EEG was recorded while participants viewed affective images in four conditions defined by regulation instruction and stimulus valence: unregulated viewing of neutral (neutral-attend) and unpleasant images (negative-attend), as well as regulating emotion from unpleasant images with distraction (negative-distract) and reappraisal (negative-reappraise). For this paper, the occipital event-related spectral perturbations (ERSP) induced in different conditions were compared in individually-defined theta bands.Consistent with prior research, we expected affective stimuli to modulate theta power at two consecutive peaks. We predicted that distraction would effectively dampen activity in the second peak, but not in the first peak, suggesting that this strategy does not intervene at early stages of emotion generation. We also expected the modulation of the second peak to be exclusive to distraction, with possible effects of reappraisal on theta power emerging only later.

5. Methods

5.1. Participants, procedure and stimuli

The sample consisted of 18 healthy students (9 women, mean age = 19.3) with normal or corrected to normal vision. Prior to EEG measurement, participants were trained in the use of emotion regulation strategies using practice trials with dynamic feedback and shaping by the experimenter. For the distraction condition, they were instructed to feel neutral in response to the unpleasant image by generating unrelated mental content, such as imagery of complex geometric designs or scenes around their neighborhood. For reappraisal, subjects were asked to feel neutral by altering their construal of the image, for instance by imagining that the depicted scenario would improve over time or by adopting the perspective of a detached observer. For unregulated viewing trials, participants were instructed to attend to the image and respond naturally. During practice trials, participants reported their thought processes and received feedback from the experimenter.

The experiment consisted of a regulation task and a re-exposure task, only the first of which is analyzed in this paper. Each regulation trial began with a white fixation cross on black screen (2 s) followed by an instruction cue (2 s), followed in turn by a neutral or unpleasant image covering 85% of the screen shown for 5 s. Stimuli were presented on a computer screen at a viewing distance of approximately 50 cm. The instruction cue and image backgrounds were color-coded according to the conditions: gray for neutral-attend, black for negative-attend, blue for negative-distract, and green for negative-reappraise. Participants had been trained to initiate regulation attempts only after picture onset on each trial. Upon image offset, participants saw two consecutive Self-Assessment Manikin scales prompting them for emotional valence and arousal ratings.

112 trials were presented in four blocks of 28, each containing 14 unregulated trials (7 neutral-attend and 7 negative-attend) together with 14 trials with one regulation instruction. Trials within each block were presented in randomized order. The order of blocks as well as block and picture set pairings were counterbalanced across participants. One neutral and three unpleasant sets of 28 unpleasant photographs each were selected from the International Affective Picture System (Lang et al., 2005). The unpleasant stimulus sets were balanced in terms of normative valence and arousal ratings, as well as the presence of humans in images. Further details of the methods are available in a previous report (Thiruchselvam et al., 2011).

5.2. EEG recording and processing

Continuous data were recorded from 42 scalp and 2 ocular electrodes at 500 Hz sampling rate and 0.05–100 Hz band-bass online filter. New offline processing was conducted for the present paper using EEGLAB (Delorme and Makeig, 2004) and Matlab software. Data were first down sampled to 250 Hz and re-referenced to linked mastoids. Remaining preprocessing included a) ocular artifact correction using Independent Components Analysis (ICA) and b) automatic segment removal. In order to obtain optimal ICA solutions for ocular artifact correction, a separate copy of the data was used to ICA for each participant (Debener et al., 2010). The ICA training data sets were high-pass filtered at 1 Hz; segmented from fixation onset to picture offset; cleaned of channels with improbable data distribution (EEGLAB pop_rejchan algorithm, threshold 5 SD); and of segments with excessive power in the muscular range (pop_rejspec, 15–30 Hz). Infomax ICA algorithm was applied to each of these data sets with EEGLAB default settings. Independent components with known features of eye-blinks as well as horizontal and vertical eye-movements were identified visually for each participant. Then, the contributions of these components (i.e., ocular