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The temporal dynamics of emotion regulation: An EEG study of distraction and reappraisal

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ABSTRACT

Distraction and reappraisal are two widely used forms of emotion regulation. The process model of emotion regulation (Gross, 1998) holds that they differ (1) in when they act on the emotion-generative process, and (2) in their impact on subsequent responses to regulated stimuli. We tested these two predictions by measuring electrocortical responses to neutral and emotional images during two phases. In the regulation phase, images were watched or regulated using distraction or reappraisal. During the re-exposure phase, the same images were passively watched. As predicted, during regulation, distraction reduced the late positive potential (LPP) earlier than reappraisal. Upon re-exposure, images with a distraction (but not reappraisal) history elicited a larger LPP than images with an attend history. This pattern of results suggests that distraction and reappraisal intervene at separate stages during emotion generation, a feature which may have distinct consequences that extend beyond the regulatory episode.

1. Introduction

The ability to regulate emotions when they are maladaptive is among the most critical of human capacities (Gross, 2007). A growing body of research has begun to examine the cognitive processes which support this vital ability (Ochsner and Gross, 2008), identifying distinct forms of cognitive control which enable us to dynamically alter the type and intensity of our emotional responses. In particular, two widely used strategies – termed distraction and reappraisal – have garnered widespread interest as indispensable tools in the cognitive regulation of emotion.

Distraction – which involves deploying attention away from the emotionally salient aspects of an emotion-eliciting event – has been shown to successfully reduce various indices of emotional responding, including subjective emotional intensity and corrugator muscle activity (Urry, 2010). It has also been shown to decrease the unpleasantness of painful stimulation, and to diminish activation in pain-related brain regions such as the insula (Bantick et al., 2002; Seminowicz and Davis, 2007). Furthermore, in clinically oriented research, a number of studies attest to distraction's efficacy in attenuating dysphoric mood (Lyubomirsky and Nolen-Hoeksema, 1993; Nolen-Hoeksema, 1991; Nolen-Hoeksema and Morrow, 1993). In contrast to distraction, reappraisal involves re-evaluating an emotional event's underlying meaning. It too can successfully attenuate subjective (Gross, 1998), peripheral physiological (Jackson et al., 2000), and neural (Goldin et al., 2008; Ochsner et al., 2002, 2004; Phan et al., 2005) indices of emotional responding such as amygdala and insula activity.

Although outcome-based research suggests that both distraction and reappraisal are capable of diminishing emotional responding across many different affective contexts, it is not yet clear precisely how the mechanisms underlying these two major emotion regulation strategies differ. The goal of the present study was to test theoretically derived predictions regarding the temporal dynamics of these two forms of cognitive emotion regulation. To achieve this goal, we employed a temporally sensitive electroencephalogram (EEG)-derived index of emotional stimulus processing in order to probe the temporal dynamics of these two forms of regulation.

1.1. Temporal dynamics of distraction and reappraisal: theoretical predictions

According to the process model of emotion regulation (Gross, 1998), the key distinction between these two forms of cognitive emotion regulation is that the two strategies engage separable underlying processes: distraction operates primarily through the use of attentional deployment, whereas reappraisal operates primarily through meaning-evaluation mechanisms which serve to compute and alter the affective significance of an emotional stimulus.

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More specifically, the process model holds that the cognitive processes underlying the generation of emotion occur through a temporally extended sequence of stages: upon encountering an emotional stimulus, the deployment of attention towards the stimulus occurs prior to the evaluation of its meaning. Cognitive regulation strategies can be distinguished by which stage in this emotion-generative process they have their primary impact. As distraction operates through the deployment of attention, it should intervene early in the emotion-generative trajectory, before elaborative meaning-processing of the stimulus can occur. By contrast, reappraisal should involve first constructing a default evaluation of the emotional stimulus before a re-construal can be implemented, and should therefore impact the emotion-generative process relatively later (also see Sheppes and Gross, in press, for a new theoretical framework that further elaborates the underlying operations and consequences of attentional distraction and cognitive reappraisal).

This yields the basic prediction that distraction should modulate the unfolding of emotion generation *prior to* the evaluative processing of an emotional stimulus' meaning. By contrast, reappraisal should modulate emotion generation *during* the processing of the stimulus' meaning. While this "timing hypothesis" is central to the process model's conception of distraction and reappraisal, it has not yet been directly tested.

A second prediction regarding the temporal dynamics of distraction and reappraisal is more subtle. In particular, we postulate that the differential impact of distraction and reappraisal on the emotion-generative trajectory during regulation may have consequences that extend to the processing of the stimulus when it is later encountered. This prediction is grounded in a body of research showing that emotional stimuli that have been previously attended to – and whose affective significance has already been evaluated – result in weaker emotional responses than novel emotional stimuli (Wilson and Gilbert, 2008). Insofar as distraction intervenes in the emotion-generative process early – thereby preventing the processing of the stimulus' underlying meaning – it should lead individuals to evaluate the stimulus as more novel upon subsequent re-exposures, compared to a stimulus that was previously attended to and evaluated. This should lead stimuli with a distraction-history (versus a history of simple viewing) to elicit greater emotional responses upon re-exposure. By contrast, to the extent that reappraisal intervenes later in the emotion-generative trajectory – enabling one to construct an evaluation of the stimulus' affective significance – stimuli with a reappraisal-history should not have this detrimental effect.

In fact, insofar as reappraisal involves changing the appraisal of an emotional stimulus, reappraisal could modify the default appraisal for that stimulus. Upon re-exposure, this modified appraisal can become activated. Thus, stimuli with a reappraisal-history might elicit weaker emotional responses upon re-exposure compared to those with a history of simple viewing, a prediction which is supported by recent findings (MacNamara et al., in press).

1.2. Temporal dynamics of distraction and reappraisal: empirical findings

Prior research in which distraction and reappraisal have been directly contrasted has lent support to the idea that there are important differences in their underlying processes. A recent functional magnetic resonance imaging (fMRI) study (McRae et al., 2010) found that although both strategies commonly recruited prefrontal and cingulate neural regions implicated in cognitive control, they differentially activated specific regions as well. Relative to reappraisal, distraction led to greater activation in right prefrontal and parietal regions that have been linked to the control of attention (Mayer et al., 2007). On the other hand, relative to distraction, reappraisal elicited greater activation in specific prefrontal areas (i.e. ventral lateral pFC) involved in tracking a stimulus' current affective value (Van Overwalle, 2008; Teasdale et al., 1999).

While McCrae et al.'s (2010) investigation supports the notion that distraction operates through attentional deployment whereas reappraisal acts through evaluative processes that compute the affective significance of the emotional stimulus, the relative temporal insensitivity of fMRI has made it difficult to resolve questions about the time–course of distraction and reappraisal. What is needed is a temporally sensitive measure of the unfolding emotion-generative process, and for this, previous investigations have benefited from the excellent temporal resolution offered by EEG/ERP methods (see Schupp et al., 2006 for a review).

Of particular interest has been a well-known ERP component known as the late positive potential (LPP). The LPP is a positive-going slow-wave that is maximal at central–parietal sites, beginning approximately 300 ms after stimulus onset and often lasting for the entire stimulus duration (up to 6 s). A large number of studies have found the LPP to be robustly enhanced for emotionally arousing compared to neutral stimuli (Cuthbert et al., 2000; Hajcak and Olvet, 2008; Keil et al., 2002; Schupp et al., 2000, 2003, 2004). Importantly, the LPP does not appear to be sensitive to low-level perceptual characteristics of a stimulus, such as image size (De Cesarei and Codispoti, 2006) and figure-ground complexity (Bradley et al., 2007), rendering it a reliable index of the processing of emotionally arousing features of the stimulus (see Hajcak et al., 2010 for a review).

Importantly, several recent studies have shown the LPP to be highly sensitive to appraisal manipulations which alter the meaning attributed to an emotional stimulus. Specifically, the LPP is reliably smaller when an unpleasant stimulus is cognitively evaluated in a neutral compared to a negative manner (Foti and Hajcak, 2008; Hajcak and Nieuwenhuis, 2006). The LPP is also amplified when a neutral stimulus is appraised in aversive terms (MacNamara et al., 2009). Thus, the LPP is sensitive to the evaluative processing of an emotional stimulus' meaning throughout the course of emotion generation. As such, it would seem to be a useful electrocortical index in comparing the hypothesized difference between distraction and reappraisal with respect to when they intervene in the emotion-generative trajectory. More specifically, a reduction of the LPP from its earliest stages (approximately 300 ms) would reflect restricted evaluative processing of the affective significance of the stimulus. By contrast, an attenuation of the LPP beginning at later stages would signify that some elaborative meaning-processing of the stimulus' affective significance has occurred.

Recent studies have shown that directing one's gaze to non-arousing aspects of an emotional stimulus can also modulate the LPP (Dunning and Hajcak, 2009; Hajcak et al., 2009), likely by limiting the processing of affectively significant information. While these studies suggest that distraction may influence the course of the LPP, they do not enable strong inferences about the precise temporal dynamics of attentional deployment as compared to reappraisal since the two strategies were not directly compared within the same paradigm.

1.3. The present study

The goal of this study was to examine two theoretically derived predictions about the temporal dynamics of distraction and reappraisal:

(1) *Distraction should intervene in the emotion-generative trajectory earlier than reappraisal.* Insofar as the LPP tracks the evaluation of a stimulus' affective meaning, we predicted that distraction would reduce the LPP from its very beginning, since attentional redeployment should prevent such meaning-processing. By