



The effect of arousal on regulation of negative emotions using cognitive reappraisal: An ERP study



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ABSTRACT

Because the effectiveness of the emotion regulation strategy cognitive reappraisal may vary with emotion intensity, we investigated how stimulus arousal affects reappraisal success. Participants up- and down-regulated emotional responses using cognitive reappraisal to low and high arousing unpleasant pictures while the electroencephalogram (EEG) was recorded. Up-regulation resulted in more negative self-reported valence, while down-regulation resulted in less negative self-reported valence regardless of stimulus arousal, suggesting that subjective reappraisal success does not vary with emotional intensity. Participants felt that down-regulation of emotional responses to low arousing unpleasant pictures was easiest, which is in line with previous findings that participants showed a greater preference for reappraisal in low than high arousing situations. The late positive potential (LPP) amplitude was enhanced by down-regulation of high arousing unpleasant pictures. Even though this effect was unexpected and is opposite to the typical effect of down-regulation on the LPP, it is in line with several previous studies. Potential explanations for LPP regulation effects in the unexpected direction, such as strategy selection and task design, are evaluated. Suggestions and recommendations for future research are discussed, including using trial-by-trial manipulation of regulation instructions and studying the effect of stimulus arousal on up- and down-regulation of positive emotions.

1. Introduction

Fortunately, we can control our emotions to some extent. Emotion regulation is the use of behavioral or cognitive strategies to generate new emotions or to increase or decrease the intensity of current emotions (Ochsner and Gross, 2005). There are multiple regulation strategies, including distraction and cognitive reappraisal. Distraction involves thinking about something unrelated and reappraisal entails changing the meaning of a situation by reinterpreting it (Gross, 2002; Ochsner and Gross, 2005). Reinterpreting the situation can, for example, be done by changing the personal relevance, which has been called self-focused reappraisal, or by imagining better or worse outcomes, which has been called situation-focused reappraisal (Ochsner et al., 2004). It has been proposed that the effectiveness of reappraisal to up- and down-regulate emotions may vary depending on the intensity of the emotion, but this has not been systematically tested yet.

Emotions are characterized by valence and arousal. Valence is the pleasantness of an emotion, and arousal indicates its intensity (Bradley and Lang, 1994; Russell, 2003). Emotion regulation has been studied using event-related potentials (ERPs). The late positive potential (LPP)

reflects multiple and overlapping positivities over the centro-parietal scalp beginning in the time window of the P3, i.e., around 300 ms after stimulus onset (Hajcak et al., 2010). Because this LPP is typically enhanced for negative and positive compared to neutral stimuli, the LPP amplitude is assumed to reflect arousal rather than valence (Schupp et al., 2006). The amplitude of the LPP is modulated by emotion regulation instructions according to the regulatory goal. Because reappraisal is thought to have favorable cognitive and social consequences (Gross, 2002), most studies have focused on reappraisal. Furthermore, most emotion regulation studies have focused on down-regulation of negative emotions because that has obvious clinical relevance (e.g., Blechert et al., 2012; Hajcak and Nieuwenhuis, 2006; Moser et al., 2014; Zhang et al., 2012). Some studies, however, have also focused on up-regulation of negative emotions (Moser et al., 2009; Moser et al., 2010) and on up- and down-regulation of positive emotions (e.g., Baur et al., 2015; Kropfing et al., 2008; Langeslag and Van Strien, 2010, 2013; Moser et al., 2009; Moser et al., 2010), which play an important role in daily life as well (Gross, 2013). It is widely acknowledged that up-regulation of emotions enhances the LPP amplitude, while down-regulation of emotions reduces the LPP amplitude

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and that the LPP can be used as an index of regulation success (Hajcak et al., 2010).

In some previous studies, however, no LPP reduction by down-regulation was observed (Baur et al., 2015; Langeslag and Van Strien, 2010, 2013). We have previously explained such absence of the typical down-regulation effect using the notion of floor and ceiling effects (Langeslag and Van Strien, 2010, 2013). That is, it may be hard to up-regulate emotions that are already intense (i.e., ceiling effect) and to down-regulate emotions that are weak to begin with (i.e., floor effect). In a previous study, down-regulation decreased the LPP amplitude more for high than for low arousing stimuli (Shafir et al., 2016), which could be interpreted as a floor effect. Because the emotional stimuli in our previous studies were relatively low arousing, the absence of the typical LPP down-regulation effect could be a floor effect as well (Langeslag and Van Strien, 2010, 2013). Conversely, because the stimuli in Krompinger et al.'s study (2008) were relatively high arousing, the absence of the typical LPP enhancement by up-regulation in that study could have been the result of a ceiling effect. Of course, the occurrence of floor and ceiling effects is a post hoc explanation that requires experimental testing.

In contrast to the notion of floor and ceiling effects, it has been suggested that reappraisal may not be effective for down-regulating emotions that are intense. In one study, acute stress induced by the cold pressure task reduced the effectiveness of reappraisal in down-regulating conditioned fear of a mild electric shock (Raio et al., 2013). Because the arousal and the to-be-regulated emotions were elicited by different stimuli, this study suggests that high background arousal reduces the effectiveness of reappraisal. In two other studies (Shafir et al., 2015; Shafir et al., 2016; Sheppes et al., 2011), participants were confronted with low and high arousing negative stimuli and had to express their preference for using reappraisal or distraction to down-regulate their emotions. Participants showed a clear preference for distraction in high arousing situations and for reappraisal in low arousing situations. Although these results are informative about strategy preferences, they are not informative of regulation success. In the ERP part of one of those studies (Shafir et al., 2015), participants saw a cue that informed them of whether the upcoming unpleasant picture would be low or high in arousal and instructed them to passively view or to use distraction or situation-focused reappraisal to down-regulate the emotions elicited by the picture. When the pictures were low arousing, both strategies were equally effective in reducing subjective negative experience, and distraction reduced the LPP amplitude but reappraisal did not. When the pictures were high arousing, both strategies were effective but reappraisal was less effective than distraction, and reappraisal reduced the LPP amplitude later than distraction did. These results suggest that distraction is more effective than reappraisal to down-regulate emotions that are intense. In another ERP study (Shafir et al., 2016), however, distraction reduced the LPP amplitude more than reappraisal did regardless of the arousal level of the stimuli. Either way, it is unclear how arousal affects regulation success when participants are not provided with information about the intensity level of the upcoming stimulus, as in the studies described above that did not find the expected reduced LPP for down-regulation (Baur et al., 2015; Langeslag and Van Strien, 2010, 2013). Moreover, it remains unclear how stimulus arousal would modulate up-regulation success.

In this study, we set out to test how arousal affects reappraisal success. Participants up- and down-regulated their emotional responses to low and high arousing unpleasant pictures. We focused on negative emotions for two reasons. First, studying both negative and positive emotions would have made the design of the study too complex and the task too long. Second, focusing on negative instead of positive emotions makes this study comparable to most previous studies on emotion regulation, as the large majority of those have studied the regulation of negative emotions only (e.g., Hajcak and Nieuwenhuis, 2006; Moran et al., 2013; Moser et al., 2006; Moser et al., 2014; Moser et al., 2009;

Moser et al., 2010; Murata et al., 2013). Valence, arousal, and difficulty ratings were collected to test whether subjective feelings are differentially affected by reappraisal of low and high arousing stimuli, whereas the LPP amplitude will serve as an objective measure of regulation success (Hajcak et al., 2010). Clarifying how arousal influences the effectiveness of reappraisal is relevant for the use of emotion regulation in daily life and in clinical settings.

There are two sets of competing hypotheses, the first of which is derived from the notion of floor and ceiling effects. This notion predicts that up-regulation will be effective for low arousing unpleasant stimuli (resulting in more negative self-reported valence, higher self-reported arousal, a larger LPP amplitude, and low perceived difficulty), but not for high arousing stimuli (resulting in no effects on self-reported valence and arousal or the LPP amplitude, and high perceived difficulty). Down-regulation, in contrast, will be effective for high arousing unpleasant stimuli (resulting in less negative self-reported valence, lower self-reported arousal, a smaller LPP amplitude, and low perceived difficulty), but not for low arousing stimuli (resulting in no effects on self-reported valence and arousal or the LPP amplitude, and high perceived difficulty). The second set of hypotheses is derived from the view that reappraisal is not effective for down-regulating intense negative emotions. This view predicts that down-regulation will be effective for low arousing unpleasant stimuli (resulting in less negative self-reported valence, lower self-reported arousal, a smaller LPP amplitude, and low perceived difficulty), but not for down-regulation of high arousing unpleasant stimuli (resulting in no effect on self-reported valence and arousal or the LPP amplitude, and high perceived difficulty). This view does not make any predictions about the effectiveness of up-regulation.

2. Methods

2.1. Participants

Thirty-three students of the University of Missouri – St. Louis volunteered to participate. This sample size was based on the previous ERP study that tested the effect of arousal on the preference for reappraisal or distraction. That study had 30 participants, 27 of which were included in the data analysis (Shafir et al., 2015). Inclusion criteria of the current study were normal or corrected-to-normal vision, no mental disorders or use of medication affecting the central nervous system. All participants were right-handed as determined by a hand preference questionnaire (Bryden, 1982). One participant withdrew from the study because he found the high arousing unpleasant stimuli too intense and one other participant was excluded because of excessive EEG artifacts (see below). The final sample consisted of 31 participants (mean age = 24.8 years, range = 19–39 years, 19 women). The study was approved by the local institutional review board. Participants provided informed consent according to the Declaration of Helsinki and were remunerated with course credit or \$20.

2.2. Stimuli

The stimuli were 30 neutral, 90 low arousing, and 90 high arousing unpleasant pictures¹ from the International Affective Picture System

¹ Numbers of the IAPS pictures used: neutral: 1390, 2102, 2191, 2383, 2394, 2410, 2445, 2487, 2575, 2635, 2840, 2870, 2890, 5395, 5471, 7036, 7038, 7041, 7044, 7050, 7057, 7058, 7100, 7130, 7140, 7242, 7550, 7590, 7710, 9210; low arousing unpleasant - set 1: 1270, 2053, 2278, 2375.1, 2399, 2694, 2715, 2750, 2799, 2800, 3230, 6010, 6241, 9001, 9041, 9046, 9102, 9110, 9181, 9265, 9270, 9301, 9342, 9390, 9421, 9432, 9440, 9584, 9830, 9926; set 2: 2141, 2276, 2455, 2590, 2682, 2692, 2710, 2716, 2900, 3220, 3280, 3300, 4621, 6311, 6800, 6940, 9005, 9045, 9101, 9182, 9220, 9280, 9290, 9320, 9331, 9341, 9417, 9530, 9561, 9594; set 3: 2095, 2205, 2312, 2490, 2700, 2718, 2722, 2745.2, 2753, 3181, 3190, 3215, 3301, 4635, 6561, 6610, 9000, 9008, 9010, 9090, 9140, 9190, 9340, 9404, 9430, 9471, 9520, 9560, 9582, 9592, high arousing unpleasant - set 1: 1120, 1200, 1301, 1932, 2683, 2691, 3015, 3069, 3080, 3100, 3130, 3170, 3400, 3530, 4664.2, 5971, 6230, 6315, 6415, 6550, 6570, 6830, 6834, 8230, 8480, 9250, 9254, 9600,

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