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THINKING THINGS OVER

The Electrophysiology and Temporal Dynamics of Self- and Situation-Focused Reappraisal

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Abstract

Cognitive reappraisal is an emotion regulation strategy that has been shown effective in down-regulating negative emotions in both psychological and electrophysiological measures. Although there are many studies on cognitive reappraisal, only recently have there been studies differentiating between various ways of employing the strategy. This event-related potential (ERP) study sets out to compare the efficiency and temporal dynamics of three cognitive reappraisal techniques – situation-focused reappraisal, social distancing, and temporal distancing – by measuring their effects on emotional responses to aversive pictures, as indexed by the affective ERP component the late positive potential (LPP). EEG data was recorded from 17 participants. The results revealed no significant differences between emotion regulation strategies and baseline for the total ERP epoch (3,000 ms). When differentiating between early (400-800 ms), mid (800-1,500 ms), and late (1,500-3,000) periods of the epoch, significance was found in some conditions, but since no significant overall LPP activity was found, these numbers are difficult to interpret.

Keywords: cognitive reappraisal, emotion regulation, late-positive potential, temporal distancing, social distancing, situation-focused reappraisal

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1. Introduction

From introspection, we know that emotions are powerful and sometimes hard to ignore. It is difficult to imagine pursuing any goal without the emotional component motivating us to do so. While it is hard to even picture what a life without emotions would be like, a life where our emotions control everything may not be desirable either. Our ability to regulate our emotions is a crucial factor of where we will end up in life: discipline could be a vehicle for success, while impulsivity may land you in prison. Dysregulation of emotion is a common denominator of mood disorders (e.g. major depressive disorder and bipolar disorder), anxiety disorders, schizophrenia, and personality disorders (Kanske, Heissler, Schönfelder, & Wessa, 2012; Koenigsberg et al., 2009; Zilverstand, Parvaz, & Goldstein, 2017).

Judging from the number of publications, the interest in emotion regulation (ER) has grown extensively over the past decades. When searching Web of Science for ER, the publication number has grown from 4 in 1990, reaching 2,012 in 2017.

The *process model of emotion regulation* (Gross & Thompson, 2007), suggests there are five families of ER strategies. The division of families is made based on the fundamental notion that they intervene with the emotion generation at different times in the process. Some strategies are considered antecedent-focused, while others are considered response-focused. The most studied strategy is *cognitive reappraisal*, an antecedent-focused strategy which refers to consciously re-evaluating situational elements with the goal to regulate emotion. It involves cognitive functions such as working memory, semantic memory, language, and attention. Cognitive reappraisal has been correlated with activity in regions of the prefrontal cortex (PFC) including dorsomedial, dorsolateral, and ventrolateral prefrontal parts that along with parietal and temporal cortex exert control over subcortical areas that are involved in generating emotion (Buhle et al., 2014; Kalisch, 2009; Kohn et al., 2014).

Although cognitive reappraisal is most studied out of the ER strategies, the diverse ways of employing this strategy is a less explored area. Ochsner et al. (2004) proposed a differentiation between situation- and self-focused reappraisal, where s*ituation-focused reappraisal* refers to re-evaluating the situational aspects, while *self-focused reappraisal* refers to re-evaluating the self-relevance of a situation, either by taking a socially detached, third-person perspective referred to as *social distancing*, or by *temporal distancing*, i.e. picturing the situation to have happened some time ago or in the distant future. While a fundamental aspect of the process model of ER is the temporal difference between strategies that enable their division, research using event-related potentials to study ER is still rather limited. ERP studies on ER typically use ERP component the late positive potential (LPP) for measure, since it is a strong marker of emotional reactivity (Moser, Krompinger, Dietz, & Simons, 2009).

Only a few studies have directly compared the temporal dynamics and effects of situation-focused reappraisal and self-focused reappraisal, and the few existing studies have made the comparison only using the self-focused technique social distancing. One study (Willroth & Hilimire, 2016) found situation-focused reappraisal to be more effective than self-focused reappraisal in down-regulating the LPP. Although the difference was significant, it was only apparent in the PO8 electrode. Another study observed effective down-regulation of the LPP in central-parietal electrodes with the use of social distancing, while situation-focused reappraisal did not show significant effect in this regard. These different results may be caused by the different methods used for analysis: while the first study (Willroth & Hilimire, 2016) chose an early and relatively short time window for analysis (300-1000 ms), the second study (Qi et al., 2017) analyzed the time window of 300-5000 ms. Furthermore, Moser et al. (2017) analyzed the LPP at different time windows. Participants were asked to use social distancing to down-regulate the emotional response to unpleasant pictures. Analysis showed a reduction of the LPP in the 1000-6000 ms time window, while a time window of 400-1000 ms showed no significant reduction. These results may indicate that reappraisal techniques take time to reach their full effects.

Although temporal distancing has been shown to be effective in the down-regulation of negative emotions (Bruehlman-Senecal & Ayduk, 2015), there is little research on this topic. Furthermore, no studies to date have directly compared temporal distancing to social distancing, though one study (Yanagisawa et al., 2011) suggested temporal distancing to be closely linked to the impact of social exclusion.

The aim of this essay is to (1) examine and compare the temporal dynamics of situation-focused reappraisal and the self-focused reappraisal techniques social and temporal distancing by looking at what time they begin to exert their effects, and (2) compare the performance of these three reappraisal techniques when they are used to down-regulate the emotional reactions to unpleasant pictures. This will be done by conducting an experiment in where participants are asked to apply the different techniques of social distancing, temporal distancing, and situation-focused reappraisal separately while viewing images of angry and neutral faces. The control measurement will be the LPP amplitude. The hypothesis about aim (1) is that self-focused reappraisal techniques will show an earlier effect onset than situation-focused reappraisal (with respect to the findings of Qi et al., 2017). Regarding aim (2), temporal distancing should be as efficient as social distancing in the down-regulation of negative emotions in response to unpleasant pictures considering their seemingly close relationship (see Yanagisawa et al., 2011). Due to narrow work on the topic, there are no strong predictions about how temporal distancing compares to situation-focused reappraisal.

A comprehensive review of the research on cognitive reappraisal will be provided for context. The first part of the review will look at what brain areas are implemented in cognitive reappraisal by presenting fMRI findings, merely to give a wider understanding of the phenomena. The second part aims to give specific background information for the present study by presenting research on the electrophysiological activity underlying cognitive reappraisal, covering some important ERP findings, specifically focusing on the relationship between reappraisal and the LPP.

2. Background

2.1 Emotion

The concept of emotion is used for a broad range of responses and its definition differs depending on the context in which it is being used. For example, Carver and Scheier (1990) view emotions as the information of a system that monitors the difference between a goal and reality, and the speed at which it is being reduced. Another example is the view of emotions as response-tendencies (i.e. that they are only one aspect of what determines behavior) (James, 1894), which is still drawn upon by some emotion theorists (e.g. Frijda, 1986; Scherer, 1984). Because of these differences, Gross (2015) has identified three major criteria for emotions shared by most approaches of emotion research. First, emotions involve “loosely coupled changes in the domains of subjective experience, behavior and peripheral physiology” (Gross, 2015). For example, they alter our subjective experience, our action-tendencies, our body language (e.g. facial expressions) and cause physiological changes contributing to the metabolism needed for other relevant processes (Etkin, Büchel, & Gross, 2015). Second, emotions “unfold over time” (Gross, 2015). That is, they are thought to last from seconds to minutes. The unfolding of emotions is captured in the *modal model of emotion* (Gross & Thompson, 2007), which will be discussed in more detail later. Finally, emotions can be "either helpful or harmful, depending on the context" (Gross, 2015). Emotions help guide our behavior in ways that profit us. However, when dysfunctional, emotions can be harmful. This is when ER may be beneficial.

2.1.1 Emotion Generation

In their modal model of emotion, Gross & Thompson (2007) try to unite what is shared between different views on emotion. This model views the generative process of emotion as a transaction between a person and a situation, one that is meaningful for and requires attention from the person, and that causes a coordinated but flexible response involving multiple systems. The modal model of emotion describes the unfolding of emotion over time by describing it as an order of events, namely situation-attention-appraisal-response. The model is predicated on the notion that the strength of emotions increases over the time course of emotion generation. The beginning of the sequence i.e. the *situation*, has psychological importance to the person and can be an internal (i.e. a mental representation) or an external (physical) event. The situation draws *attention*, causing *appraisals* that create an overall valuation. The appraisals also trigger emotional *responses*.

Emotion generation is a highly complex process. Sometimes the responses that are generated in the process interact with the environment and creates a new situation, different from the one causing the initial response. Thus, this feedback loop creates new sequences of situation-attention-appraisal-response (Gross & Thompson, 2007).

2.1.2 The Neural Bases of Emotion Generation

The multifaceted nature of emotion generates activity in multiple brain regions. Emotion generation is correlated with activity in subcortical structures such as the amygdala, the ventral striatum (Etkin et al., 2015; Ochsner, Silvers, & Buhle, 2012) and the periaqueductal grey (PAG; Etkin et al., 2015) along with cortical structures including the dorsal anterior cingulate cortex (dACC; Etkin et al., 2015) and the insula (Etkin et al., 2015; Ochsner et al., 2012). The complexity of the information being processed varies between the areas. The subcortical areas process basic motivational features while higher-order areas process and integrate information from multiple regions. The amygdala is inclined to spotting possible threats and may process information related to affective goals. The ventral striatum is involved in determining what cues may anticipate rewarding and reinforcing events (Ochsner et al., 2012). The hippocampus may contribute memory-related features enabling temporal and spatial context for the stimulus (Etkin et al., 2015). The cortical areas integrate information from several structures, including subcortical areas. Insula may add information facilitating our perception and interpretation of bodily state and needs (Etkin et al., 2015), and the ventromedial PFC (vmPFC), specifically the dACC, can put the stimulus in context by integrating information containing valuations formed by the amygdala and ventral striatum with information in other areas and thus relating the stimulus to other motivations and goals (Etkin et al., 2015; Ochsner et al., 2012).

2.2 Emotion Regulation (ER)

Emotions can be our best friend or our worst enemy, so the regulation of emotions is vital for both our mental and physical well-being. ER, more specifically, is the employment of a goal to control the course of an emotion (Gross, 2015), and happens when the emotional reaction itself becomes the target of valuation (Etkin et al., 2015). ER, in this context, refers to the regulation *of* emotion rather than regulation *by* emotion, and is the process through which emotion is adjusted with respect to the goals of the individual. ER entails a goal to either up- or down-regulate an emotional response. *Intrinsic ER* is when the emotions regulated are one’s own, for example when Jane’s emotions are regulated by Jane herself. *Extrinsic ER* is when the goal is in another person, where e.g. Jane’s emotions are regulated by Joe (Gross, 2013). Most research done on ER focuses on the topic of intrinsic ER, as will be the topic of this thesis. ER can also be divided into the categories of *explicit* and *implicit*, where the former refers to a conscious and cognitively effortful process, (e.g. trying to keep a neutral facial expression when sad) and the latter refers to nonconscious, automatic processes (Ochsner & Gross, 2008). The focus of this study will be intrinsic, explicit ER.

2.2.1 The Process Model of Emotion Regulation

More often than not, people try to decrease negative emotions and increase positive emotions. Regardless of what the goal may be, *the process model of emotion regulation* proposes that there are five potential points in the emotion generation process where emotion can be regulated: (1) situation selection, (2) situation modification, (3) attentional deployment (4) cognitive change, and (5) response modulation (Gross, 1998). This distinction constitutes the five families of ER strategies. The strategies vary in target (whether they intervene with the situation, attention, appraisal or response-stage represented in the modal model of emotion), effect, and their neural bases. The strategies also differ in whether it is their main goal to change the emotion (“I don’t want to feel sad anymore”), or if ER is a by-product of the pursuit of another goal (e.g. feeling better as a by-product of graduating school) (Ochsner, & Gross, 2005). ER strategies can be divided into *antecedent-focused* or *response-focused*, dependent on what part of the situation-attention-appraisal-response sequence they target, where antecedent-focused strategies target the first three stages and response-focused strategies (as the name implies) targets the response (Gross & Thompson, 2007).

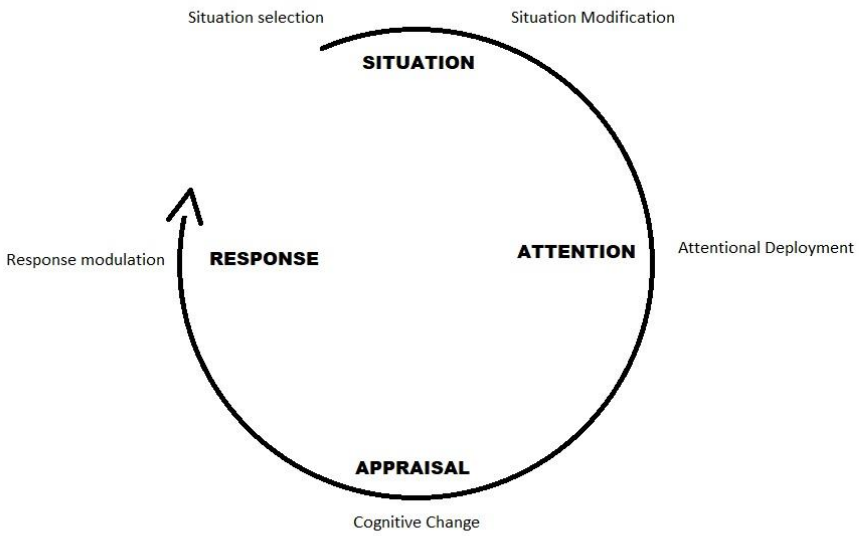

Figure 1. The process model of emotion regulation: five families of ER strategies target different stages of the modal model of emotion (situation-attention-appraisal-response). The response gives rise to a new situation and the cycle starts over. (Revised from Gross & Thompson, 2007).

Situation selection means taking measures to control the likeliness that a situation will occur, which in turn regulates the likeliness of an emotion to arise. The situation can be either desired or undesired, depending on which emotions we assume it to cause. An understanding of hypothetical situations is needed to make situation selection possible, and we use our previous experiences to gain that understanding. This may seem easy, but there are a few problems to consider. First, when looking back in time, there seems to be a large gap between the "experiencing self" and the "remembering self" making it harder for us to make these kinds of judgments (Kahneman & Tversky, 2003). The experiencing self knows only the now, while the remembering self is the narrator, whose stories can be colored by our current emotions. The same goes for planning ahead: we are quite poor judges when it comes to estimating what our future experience of situations will be like, and our anticipations are colored by what we feel in the moment of imagining a future event (Gross & Thompson, 2007).

Situation modification takes place when the situation (of the situation-attention-appraisal-response sequence) is an external event (as opposed to modification of an internal event, referred to as “cognitive change”, which will be covered in a couple of paragraphs), and lies in the future. For example, cleaning your house before your family comes over to avoid complaints from your parents. There is an overlap between situation selection and situation modification, since modifying a situation can lead to a completely new (presumably more desirable) situation (Gross, 1998).

When it is not possible or appropriate to modify a situation, our emotions can be regulated by controlling our attention, also called *attentional deployment*. Ways to do this include distraction, concentration, or rumination. Distraction refers to leading one’s attention to non-emotional elements of the situation or to direct the attention from the situation elsewhere. On the contrary, concentration refers to paying attention to emotional elements in the situation. This strategy is used in acting for example, with the goal to trigger an emotional response. Distraction and concentration are both internal processes, attentional deployment can be carried out by e.g. covering the eyes. Rumination is when attention is repeatedly focused on feelings and their consequences, a strategy often practiced by people suffering from depression that comes with very negative costs, such as an increased risk for depression (Gross, 1998).

Cognitive change means to change one’s appraisal of a situation: how you view its significance or your ability to cope with it; with the goal being to change the emotional outcome. One form of cognitive change is *cognitive reappraisal* which refers to altering the meaning of a situation in a way that also changes the impact it has on our emotions. Cognitive reappraisal is the focus of the present study and thus will be thoroughly covered later (Gross, 1998).

Response modulation is the direct altering of the emotional response and can be of behavioral, physiological or experiential nature. A behavioral response, or to what extent you express your emotions, can affect your emotions by either enhancing or reducing them. Techniques targeting the physiological and experiential aspect include relaxation, exercise, or the use of drugs or food (Gross, 1998). A widely studied form of response modulation is expressive suppression, in which one suppresses the behavioral response.

To provide a solid review of the neural underpinnings of ER and specifically cognitive reappraisal, the following sections will cover fMRI research. Understanding what specific brain areas and networks are implemented in the processes will offer a broader understanding for the present study.

2.2.2 Neural Bases of Emotion Regulation

The activation patterns of ER naturally overlap some with the activity of the emotion generation process. Most studies of ER assume a modulating part and a part that is being modulated. Part of the neural activity employed in the ER process seems to overlap with non-emotional regulatory processes, i.e. “cold” processing (Botvinick, Cohen, & Carter, 2004; D’Esposito, Postle, & Rypma, 2000). ER processing has been correlated with activations in the lateral prefrontal cortex (lPFC) and anterior cingulate cortex (ACC) – areas that are also recruited in “cold” processes such as conflict monitoring, attentional deployment and working memory (Frank et al., 2014). Amygdala and orbitofrontal cortex (OFC) are also activated in both emotional and non-emotional conditions (Ochsner et al., 2004; Ochsner & Gross, 2005). A meta-analysis of 23 neuroimaging studies looking at activation patterns of the ER process showed that the dorsal part of the lateral PFC (dlPFC), although it may primarily control “cold” regulatory processes, may have an initiative role in ER (Kohn et al., 2014). The meta-analysis also suggested a part of the anterior midcingulate cortex (aMCC) to integrate information, enabling emotion reactive behavior due to its ideal location for regulating behavior as well as activity in subcortical areas linked to affect generation. The results suggest the ER process look like this: when ER has been initiated by the dlPFC, the superior temporal gyrus, the angular gyrus, and the pre-supplementary motor area carry out the regulation while aMCC integrates these processing steps (Kohn et al., 2014). Another considerable influence on ER (which may not necessarily be a part of the ER process as such) is the evaluation of emotion, which specifies the need for ER. This type of information may be processed by the vmPFC (Kohn et al., 2014).

2.3 Cognitive Reappraisal and its Neural Bases

Cognitive reappraisal an ER strategy that is recurrent in our everyday lives, and you have probably practiced it today without even reflecting on it. It is when you are faced with obstacles, big or small, and make something good out of the situation; when you miss the bus and your initial reaction is to curse out the bus driver, but then instead you decide that this is a wonderful opportunity to get your morning coffee. It involves seeing alternative interpretations and choosing the better one. It may sound like mere positive thinking but being able to reappraise is crucial for our well-being, and people who instead suppress emotion expressive behaviors are likely to suffer from long-term issues including reduced emotional control, poor interpersonal functioning, and depressive symptoms. Regular use of reappraisal, on the other hand, yields increased emotional control, better interpersonal functioning, and overall well-being (Gross, & John, 2003). Cognitive reappraisal is, in other words, the conscious re-evaluation of an emotion-triggering stimulus, inducing a clear change (from the initial appraisal) in the self-relevant meaning of the stimulus (Etkin et al., 2015). Thinking about alternative evaluations of the situation that challenge the initial appraisal has been shown effective to minimize the magnitude of the emotion (Ochsner & Gross, 2008). Although reappraisal is generally used to decrease negative emotion, it can be used to increase them, or to up- or down-regulate positive emotions as well (Ochsner & Gross, 2005).

In one of the first imaging studies that investigated the process of reappraisal, a parallel was drawn to the cognitive control of “cold” processes such as attention, working memory, and other thought processes. The notion was that the PFC and cingulate cortex controlled activity in subcortical regions that are involved in the processing of emotion (Ochsner & Gross, 2005). Since this study was carried out, the hypothesis has been supported by over 50 imaging studies (Ochsner et al., 2012).

Based on these findings, Ochsner & Gross (2005, 2008; Ochsner et al., 2012) propose the reappraisal process to involve three distinct neural systems. The first one includes dlPFC, posterior portions of PFC and inferior parietal cortex generally involved with selective attention and working memory. This network is assumed to guide attention toward relevant features of the stimulus as well as holding the reappraisal content and goal in awareness. The second system consists of dACC/dorsomedial PFC (dmPFC) which processes information related to monitoring performance, specifically tracking congruity between emotional responses and new appraisals with respect to goals. The third neural network is constituted by ventrolateral PFC (vlPFC), which helps select responses with respect to goals while inhibiting alternative responses. Thus, the vlPFC can help select proper reappraisals for the circumstances. Then, by retrieving semantic information about self-relevance and context, the vlPFC enables the reappraisal to override the initial appraisal. Dorsomedial regions of the

PFC may also be used to interpret and reinterpret one's own and other's mental states, which can be relevant to the ER process (Ochsner & Gross, 2005).

But how do these processes exert control over activity in areas linked to emotional responding? There are two main hypotheses about how this is carried out. The first view is that areas involved in cognitive control (in PFC) initiate activity in the vmPFC structure, which then regulates activity in regions linked to emotional responding, e.g. amygdala. That is, vmPFC has an intermediary role between controlling regions and emotional regions. Support for this notion is found in our anatomy, which shows weaker links between regions in PFC linked to cognitive control and amygdala, compared to connections between vmPFC and amygdala (Ghashghaei, Hilgetag, & Barbas, 2007). The vmPFC has also been found to be crucial for fear extinction, which is a form of down-regulation of negative emotions (e.g. Milad et al., 2007). The second view, brought forward by Ochsner et al. (2012), holds that PFC and cingulate cortex control activity in semantic, perceptual, and subcortical systems, and that semantic and perceptual systems make the connection between control and affect systems and thus play the mediating part in the reappraisal process. In anatomical terms, prefrontal- and parietal structures employ their effects on subcortical areas through changes in the lateral temporal cortex. This view received major support from the most thorough meta-analysis on reappraisal-focused neuroimaging studies to date (Buhle et al., 2014).

Following this notion, Silvers, Buhle, & Ochsner (2013) suggest a dichotomy of brain areas consisting of *source-regions* and *target-regions*, where (as the names imply) source-regions are the controlling, modulating part of the process and the target-regions are the ones being regulated. Source-regions are found in PFC and cingulate cortex while target-regions include the amygdala, ventral striatum, and insula. In accordance with this dichotomy, the following paragraphs will go over source- and target-regions presenting the results of Silvers et al. (2013) along with other fMRI findings.

2.3.1 Prefrontal and Cingulate Cortex

The reappraisal process involves both the initial appraisal as well as the new, competing appraisal. This implies activation in areas important for emotional conflict detection. Following this idea, a meta-analysis (Kalisch, 2009) found consistent activation in the areas dACC and mPFC, known to be central to emotional conflict detection. However, they did not find the same for ventral parts of ACC (vACC) and mPFC, suggesting that suppression of emotional stimulus is not a main part of the reappraisal process. On the other hand, other studies (e.g. Urry et al., 2006) linked activation in vACC and mPFC to downregulation of activity in the amygdala. Furthermore, ventral ACC and mPFC regions are involved in tasks of affect-labeling of emotional faces (Lieberman et al., 2007), distracting oneself from fear-conditioned stimuli (Delgado, Nearing, LeDoux, & Phelps, 2008), and strategies used to decrease activity in the amygdala. Taken together, it seems that vACC and mPFC may be part of the top-down regulation process controlling amygdala activity, as well as a more general inhibitory process (also involving areas such as dACC and lPFC) that exerts control over limbic regions resulting in decreased negative affect (Etkin, Egner, & Kalisch, 2011).

So far, there is no general agreement on the role of vmPFC in reappraisal. Some (e.g. Ochsner, Bunge, Gross, & Gabrieli, 2002) propose it integrate semantic and memory information (of the medial temporal lobes), affective appraisals of individual stimuli (originating in ventral striatum and amygdala) with current goals (residing in PFC and the brainstem), while others (Kohn et al., 2014) have suggested it may evaluate our emotions, thereby determining the need for regulation. Buhle et al. (2014) reported neural activity in vmPFC during reappraisal. Yet, in studies comparing reappraisal to responding naturally, there was no increased activity vmPFC during reappraisal. Some studies have even shown a decrease in vmPFC activity, implying that this area may, in fact, be a target-region for reappraisal (Silvers et al., 2013). Nevertheless, strong interconnectivity between vmPFC and appraisal structures is linked to higher control over the amygdala and insula (Urry et al., 2006), and both between-subject (e.g. Ochsner et al., 2002) and within-subject (Banks, Eddy, Angstadt, Nathan, & Phan, 2007) studies reveal vmPFC-amygdala interactions to constitute an important mechanism underlying successful reappraisal.

2.3.2 Amygdala

The amygdala is well-known to be involved in affective processes, especially negative emotions such as fear and anxiety (Davis, 1992). However, the amygdala is also involved in the processing of positive emotions, e.g. reward (Haber & Knutson, 2010). Imaging studies of the implementation of reappraisal have consistently shown changes in amygdala activity. Activity changes depending on whether the reappraisal goal is to up-regulate or down-regulate positive or negative affects. Because most studies of reappraisal involve down-regulation of negative affects, amygdala activity is typically decreased.

Nevertheless, the studies that focus on increasing positive affects also show increased amygdala activity (Silvers et al., 2013).

2.3.3 Ventral Striatum

Activity in ventral striatum is linked to craving (Robinson & Berridge, 1993), reward (Haber & Knutson, 2010), and romantic love (Bartels & Zeki, 2000). Drevets et al. (2001) found drug-induced euphoria to be positively correlated with ventral striatum activity, suggesting that dopamine activity in this area be of importance for creating associations between cues (i.e. learning stimuli-reward relationships). Reappraisal of both positive and negative emotions induces changes in the ventral striatum (Silvers et al., 2013). As compared to amygdala activity, ventral striatum shows increased activation in the modulation of positive emotions more than it does when regulating negative emotions (Ochsner et al., 2012).

2.3.4 Insula

Insula is involved in various cognitive, affective and regulatory processes. Activity in anterior insula is liked to cognitive control as well as attention and acts as an information integration hub for these types of processes. Insula is classically considered a limbic region, because of its involvement in emotional responding and empathy, and is believed to serve as a viscerotopic map of bodily information (e.g. sensations, affective states) (Menon & Uddin, 2010), information that is by some (e.g. Craig, 2009) considered crucial for experiencing negative emotions. Anterior and posterior portions of insula differ in reappraisal-related activity, posterior regions being dominant. The low activation patterns in anterior portions may be a result of its anatomical closeness to vlPFC, which plays a significant role in reappraisal, however, this is so far only speculation (Silvers et al., 2013).

2.4 Different Areas of Studying Cognitive Reappraisal

Although there is a general agreement across brain-imaging studies concerning the neural correlates of cognitive reappraisal, some studies differ. As with any new field of research, the lack of terminology used to describe different phenomena, along with an inconsistency with the use of terms, can cause some issues. For example, while one study may ask the participants to reappraise by reinterpreting the situation with the goal to up-regulate positive emotions, another study may require participants to adopt a third-person perspective with the goal to down-regulate negative emotions (Ochsner, & Gross, 2008).

The following sections will go over the diverse ways of studying the phenomenon of reappraisal and the results that follow. Starting with examining the effects of reappraisal goals, then going on to introduce different ways of applying the strategy of cognitive reappraisal specifically comparing two such techniques, and finishing with investigating some fMRI studies on temporal dynamics to show the importance of time-aspects in ER.

2.4.1 Up- Versus Down-Regulation of Emotion

There are differences in brain activity when attempting to up-regulate versus when trying to down-regulate emotions. Frank et al. (2014) found that parahippocampal gyrus and bilateral amygdala activations increased with up-regulation and decreased when emotion was down-regulated, consistent with the notion that amygdala activity is positively correlated with experienced emotional intensity. The same study found consistent activation in higher areas (incl. cingulate cortex, superior frontal gyrus and premotor cortex) in both up- and down-regulation of emotion (regardless of regulation strategy) congruent with the notion of target and source-regions. Lieberman et al. (2007) found differences in PFC activations during up-regulation versus down-regulation of emotion. Although both up- and down-regulation of emotion activated PFC bilaterally, down-regulation showed stronger activity in right PFC. A possible explanation is that down-regulation, as opposed to up-regulation, involves inhibition of initial appraisals and is, therefore, more demanding. Earlier findings suggest that response inhibition processes activate right dorsal PFC and particularly vlPFC (Lieberman et al., 2007).

There is an inconsistency across studies when it comes to dmPFC activity during up-regulation of emotions. Buhle et al. (2014) analyzed 12 studies comparing up-regulation goals to a control condition and found that half of the studies showed activation in anterior parts of the dmPFC, while the other half showed activation in its surrounding structures. The researchers postulate that this may be because the stimuli used in most reappraisal research are photographs of people, and since dmPFC contributes to judgments about mental states, the region may play a supportive role in the processing of this type of stimuli.

Although both up- and down-regulating emotions activate subcortical regions such as caudate and putamen, they seem to differ primarily in their respective activation of the amygdala. Goals to up-regulate emotion activate dorsal parts of the amygdala and sublenticular extended amygdala (a region positioned between striatum and amygdala), whereas down-regulation goals (in addition to the dorsal amygdala regions) activate ventral amygdala regions too. While the basolateral complex of the amygdala is reciprocally connected with vlPFC, along with parietal and temporal areas (processing visuospatial and semantic information), the central amygdala nucleus draws on information from mPFC and feed forward to automatic processing regions integrating emotional information. One possible explanation to this is that while increase goals modulate amygdala outputs (extending from the central nucleus), decrease goals use a pathway to amygdala via semantic/perceptual regions – a notion supported by anatomical data showing that the basolateral complex is reciprocally linked to areas involved in semantical representation (including vlPFC, temporal and parietal regions) (Ochsner et al., 2004). This gives support to the semantic/perceptual hypothesis (Ochsner et al., 2012) presented earlier, namely, that semantic and perceptual systems play the mediating part in the reappraisal process by making the connection between control and affect systems. Thus far these are speculations, as there is not enough research focusing on goals to up-regulate emotion (Ochsner et al., 2012).

Morawetz, Bode, Baudewig, & Heekeren (2016) found some differences between up- and down-regulation of emotion during reappraisal, observing strong connectivity between inferior frontal gyrus (IFG) and dlPFC, dmPFC, and vlPFC during successful down-regulation. Up-regulation revealed increased activity in a network consisting of IFG and dmPFC, vmPFC, ACC, and amygdala. Activity in amygdala covaried with lPFC and mPFC activity.

2.4.2 Different Reappraisal Techniques

So far, we have covered the five families of ER strategies. When it comes to cognitive reappraisal, it can be sub-divided into reappraisal techniques. Techniques in this context refer to the different ways a strategy can be applied in a given situation. Since the field of ER research in cognitive neuroscience is still relatively new, the terminology used to describe the different techniques of cognitive reappraisal may differ between studies. Here, the most commonly referred techniques are covered.

A widely used distinction of reappraisal techniques is the differentiation between *self-focused* and *situation-focused* reappraisal techniques. Self-focused reappraisal works by decreasing the personal significance to, or psychological distance from, the emotional stimulus: either by mentally taking the perspective of an uninvolved observer (i.e. a detached, third-person perspective) referred to as *social distancing* (or *detachment*) (e.g. Beauregard, Levesque, & Bourgouin, 2001; Ochsner et al., 2004); or by using *temporal distancing*, which means to imagine the emotional stimulus to have taken place some time ago (e.g. Bruehlman-Senecal & Ayduk, 2015). Situation-focused reappraisal entails changing the significance of the stimulus (i.e. situation) by re-evaluating the situational elements (Ochsner et al., 2004).

Comparing situation-focused reappraisal (e.g. Ochsner et al., 2002) and social distancing (e.g. Beauregard et al., 2001; Ochsner et al., 2004), differences are found in neural activity. Situation-focused reappraisal shows a higher increase in activation in the left hemisphere, particularly in PFC and temporal cortex, while structures supporting distancing may be more lateralized to the right in PFC. These activity patterns may reflect differences in reliance on some specific brain areas: semantic and linguistic information in situation-focused reappraisal, and spatial information in distancing. Situation-focused reappraisal, as opposed to distancing, requires looking for and choosing alternative meanings – a process that may require semantic information. Distancing, however, shows higher activation than reinterpretation in parietal parts that are implemented in spatial processes. One interpretation of this data is that distancing implies switching perspectives (both conceptual and spatiotemporal) and observing the stimulus from a different viewpoint (Ochsner et al., 2012).

2.4.3 Temporal Dynamics

There are differences in brain activity between early and late stages of the reappraisal episode, which may reflect different cognitive processes (Goldin, McRae, Ramel, & Gross, 2008; Kalisch, 2009). Because emotional stimulus is often extended over time, the automatic emotional response may be stimulated repeatedly requiring attention and continuous regulation of appraisals to fine-tune one’s response. Additionally, our reactions to the initial stimulus affect us, and thus form further stimuli which influence our appraisals. Evaluation of a situation is also affected by our motivations, which may change over the period of the emotional event. The complexity of the appraisal process naturally impacts the process of cognitive reappraisal, having us make a continuous effort adjusting our reappraisals (Kalisch, 2009). Accordingly, reappraisal-related activity grows throughout the reappraisal episode (Kalisch et al., 2005). This dynamic view of reappraisal is recognized by ER theorists such as Gross & Thompson (2007) and its temporal component is a fundamental part of the process model of emotion regulation.

Sheppes & Gross (2011) wanted to have a closer look at the *generic timing hypothesis*, which is a universal assumption across ER theories, and which holds that the intensity of emotions grows over time. Thus, when down-regulating emotion, early intervention will always require less effort and resources compared to late intervention. The hypothesis rests on the notion (originating from information processing theories e.g., Pashler & Sutherland, 1998), that we have a limited capacity for cognitive operations and therefore information will compete to become part of the output. The requirement for more resources posed by higher emotional intensity leads to fewer resources for the processing of ER strategies. In this manner, the antecedent-focused strategies differ from response-focused strategies in their consequences on cognitive, affective, and social domains. Most studies on ER strategies have participants implement the strategies in the first cycle of the emotion generation process (Kalisch, 2009), so, Sheppes & Gross (2011) tested the generic timing hypothesis by proposing the *process-specific timing hypothesis* expecting that when the different strategies were applied in a late cycle instead of implementing the strategies in the first cycle, the results should be different compared to implementing them in the first cycle. They found the underlying operational processes of ER strategies and the strength of the ER process to be predictors of how much influence emotional intensity/timing would have. Their results highlight the crucial role of emotional intensity (i.e. timing) for the effectiveness of various ER strategies. Sheppes et al. (2014) developed this framework further by differentiating between strategies by their level of engagement with the emotional processing. Cognitive reappraisal is generally considered to be an engaging strategy, while distraction disengages with the emotional processing early on. It is proposed that disengaging strategies are more efficient and show their effects earlier than engaging strategies. Supporting this idea, there is a larger preference for reappraisal, as compared to distraction, when the emotional intensity is low, while high-emotional intensity results in a preference for distraction over reappraisal (Sheppes, Scheibe, Suri, & Gross, 2011). Conceivably, this is so because reappraisal is less effective during high-emotional intensity.

On a neural level, high- and low-intensity emotions seem to recruit the same neural systems (including dmPFC, dlPFC, and vlPFC) during reappraisal. High-intensity emotions showed increased activity in left dlPFC and recruited right lPFC as well as dmPFC – areas that were not active of low-intensity emotions during reappraisal. Reappraisal during low-intensity emotions did not recruit any additional areas as compared to the reappraisal of high-intensity emotions. The results are congruent with the hypothesis that reappraisal during high-intensity emotions requires more cognitive resources than the reappraisal during low-intensity emotion (Silvers, Weber, Wager, & Ochsner, 2014).

2.5 ERP Studies on Cognitive Reappraisal

The bulk of research on cognitive reappraisal consists of fMRI studies investigating what brain areas and networks are involved and in what ways, which provides an adequate insight into the workings of reappraisal. However, fMRI provides a relatively poor temporal resolution which renders it inept to answer important questions. There is a growing body of ERP research in the field. ERP studies on cognitive reappraisal commonly use picture-viewing paradigms to investigate stimulus-specific activity, in where participants (in the experimental condition) are shown pictures with emotional contents and are then asked to up- or down-regulate their emotional response by reappraising the contents. The control condition typically involves simply viewing pictures that lack a strong emotional component, i.e. neutral pictures.

2.5.1 The Late Positive Potential (LPP)

Because the goal of reappraisal techniques is to regulate emotions, the ERP component of interest is typically the late positive potential (LPP). The LPP is a strong marker of emotional reactivity and has been shown to attenuate when using various ER strategies including cognitive reappraisal, and its amplitude has been associated with subjective ratings of emotional arousal for the stimuli (Hajcak & Nieuwenhuis, 2006; Moser, Hajcak, Bukay, & Simons, 2006; Moser et al., 2009; Weinberg & Hajcak, 2010). In ERP studies using cognitive reappraisal to down-regulate emotion, attenuation of the LPP is typically viewed as an indicator of successful reappraisal. The LPP generally shows up as a midline centroparietal ERP 300 ms after stimulus onset, but has been observed as early as 200 ms after stimulus onset (Schupp et al., 2000), and its amplitude is larger following pleasant or unpleasant stimuli compared to neutral stimuli (MacNamara & Hajcak, 2010; Moser et al., 2006).

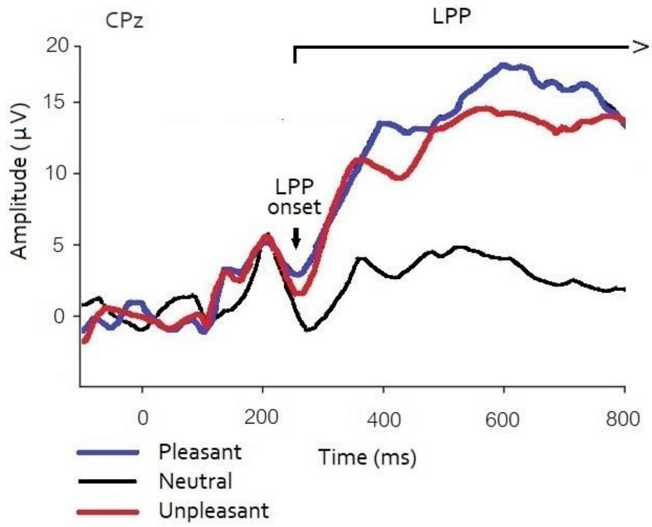

Figure 2. Example of the LPP in a passive viewing condition, here beginning at approximately 250 ms after stimulus onset. Note that the waveform is plotted positive voltage deflections upward (Image is adapted from Hajcak & Nieuwenhuis, 2006).

The LPP moves from parietal (400-800 ms) towards more central and frontal regions (1000 ms+) over the progression of the emotion episode (Foti, Hajcak, & Dien, 2009; Gross & Thompson, 2007). This spatial shift may indicate that there are distinguishable ERP components embedded in the LPP and implies that there may also be functional differences throughout: early stages (300-600 ms) processing essential and general features of ER; while later stages process (600 ms+) more complex and specific features of engagement with the stimuli (e.g. anticipation of behavioral interference) (Weinberg & Hajcak, 2011).

According to research combining EEG and fMRI, the LPP reflects extensive, parallel activity across the visual system including the visual cortex (Sabatinelli, Keil, Frank, & Lang, 2013) as well as temporal, occipital and parietal brain areas (Sabatinelli, Lang, Keil, & Bradley, 2006). A study using magnetoencephalography (MEG) demonstrated that mLPP – the magnetic equivalent of the LPP – resides in occipitoparietal and prefrontal cortical regions (Moratti, Saugar, & Strange, 2011).

Parvaz, MacNamara, Goldstein & Hajcak (2012) had participants reappraise or passively view images while measuring the LPP and alpha bandwidth power (which is inversely linked to brain activity). Their results showed that reappraisal, congruent with previous findings, attenuated the LPP amplitude. More importantly, however, reappraisal was also linked to decreased alpha bandwidth power in left PFC implying increased activity in the region. Their results match the fMRI findings that show reappraisal to increase activity in vmPFC and lPFC (e.g. Ochsner et al., 2004).

The ERP literature comparing self- and situation-focused reappraisal is today quite inadequate. The large portion of existing research focuses on contrasting cognitive reappraisal with other ER strategies such as distraction (e.g. Kanske, Heissler, Schönfelder, & Wessa, 2012; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). Despite the fact that fMRI studies have revealed differences in brain activation between self-focused reappraisal and situation-focused reappraisal (the former showing increased activity in mPFC linked to introspection, and the latter in lPFC which is linked to externally focused processing) (Ochsner et al., 2004), most ERP studies on cognitive reappraisal use methods that do not allow for comparison between different reappraisal techniques. Only recently, there have been publications of ERP studies directly comparing self-focused reappraisal and situation-focused reappraisal techniques.

One such article (Willroth & Hilimire, 2016), examined the effects of self- and situation-focused reappraisal on emotional experience and the LPP in two separate studies using the picture-viewing paradigm. There were three strategy conditions – two reappraisal conditions and one (passive) viewing condition – to which the stimuli were randomly assigned. The reappraisal conditions had an instruction including three examples of the strategy. Examples and definitions were based on the ones by Ochsner et al. (2004), meaning that the self-focused reappraisal technique used was social distancing while the situation-focused reappraisal condition required participants reinterpret the depicted situation as more positive. Each trial started with a fixation cross, followed by displaying one instructing word: “view”, “change”, or “distance”. The stimulus was then displayed, followed by a blank screen after which participants were asked to rate their experience in valence. For stimuli, study 1, 30 participants viewed 36 negative and 36 neutral images, while study 2 had 30 different participants view 120 negative and 120 neutral images distributed across 5 blocks. All images were selected from IAPS based on valance ratings. Results showed that while both reappraisal techniques lead to decreased self-reported negative emotion, situation-focused reappraisal produced the largest reductions. Situation-focused reappraisal also resulted in attenuated LPP, while self-focused reappraisal showed no such effects. Nevertheless, the decrease of the LPP amplitude was evident in only one electrode (PO8).

Contrasting to these results (of Willroth & Hilimire, 2016) are the results of another, otherwise very similar, study (Qi et al., 2017) also comparing social distancing to situation-focused reappraisal. Reappraisal instructions in this study were very much alike to the ones of the previous one (of Willroth & Hilimire, 2016), and IAPS images were used as stimuli and trial sequences were arranged in a similar manner (fixation cross, instruction cue word, stimulus, blank screen). This experiment was comprised of 4 blocks, with a total of 112 images, and included a passive viewing condition. The results were, however, very different. In this study, social distancing started operating earlier and situation-focused resulted in greater attenuation of the centroparietal LPP (collapsing across multiple electrode sites) along with larger reductions of arousal in self-reports. Although both techniques successfully modulated the LPP, social distancing displayed an earlier onset time and lasted longer (Qi et al., 2017).

A possible explanation for these incongruent findings may be the length of the time windows used for analysis. As previously mentioned, Kalisch et al. (2005) found activity linked to reappraisal to grow over the course of the reappraisal episode. Willroth and Hilimire (2016) analyzed activity occurring 300 to 1000 ms, while Qi et al. (2017) looked at activity between 300 and 5000 ms. A recent study by Moser et al. (2017), investigating social distancing in the form of third-person self-talk and its impact on the LPP, divided the ERP into two separate epochs: early (400-1000 ms) and late (1000-6000 ms). While they did not find any significance in the early time window, the late time window showed third-person self-talk to significantly reduce the LPP. Taken together, these studies indicate reappraisal to take full effect with time.

These studies are focused on one self-focused technique namely social distancing, leaving the question open of how temporal distancing relates to social distancing as well as to situation-focused reappraisal. A series of studies by Bruehlman-Senecal and Ayduk (2015) investigated the dynamics of temporal distancing by asking participants to imagine a stressful situation as if it recently happened, or to think about a stressful situation from a distant-future perspective. They found that when participants took the distant-future perspective, stress was significantly reduced as compared to the near-future perspective, indicating that temporal distancing has the capacity to down-regulate the emotional impact of stressors.

One study used near-infrared spectroscopy to examine how social exclusion relates to temporal distancing by observing vlPFC activity (an area that, as mentioned, has been proposed to play a key role in the regulation of emotions) (Yanagisawa et al., 2011). Participants that adopted a temporally distant perspective successfully down-regulated the feeling of social pain – a process that was correlated with increased activity in right vlPFC. The authors propose temporal distancing to influence the process of regulating the impact of social exclusion. On these bases, it can be hypothesized that that temporal distancing should be as effective as social distancing in the down-regulation of negative emotions.

3. Methods

The data used in this experiment was collected for a larger study with the goal to explore the dynamics of different ER strategies. The data processed in the current study concerns the LPP amplitude and how it is modulated using situation-focused and two different types of self-focused cognitive reappraisal techniques, namely social and temporal distancing. Since several studies (e.g. Foti et al., 2009; Hajcak & Olvet, 2008) have linked the LPP to emotional arousal, modulation of the LPP indicates regulation of emotion and thus provides a good dependent variable for the present study.

3.1 Objective, Aims & Hypotheses

The aim of this study is to (1) compare the temporal dynamics of situation-focused reappraisal and the self-focused reappraisal techniques social and temporal distancing, by comparing the times at which the techniques show most effect on the LPP, and (2) compare the efficiency of situation-focused reappraisal and social and temporal distancing on controlling emotional responses to emotionally arousing pictures of angry faces.

According to the conceptual framework of ER strategies (Sheppes et al., 2014), disengaging strategies start operating earlier and are more efficient than engaging strategies. Because self-focused reappraisal is considered more disengaging than situation-focused reappraisal (Qi et al., 2017), the hypothesis about aim (1) is that self-focused reappraisal will show an earlier effect onset than situation-focused reappraisal as indexed by an earlier attenuation of the LPP (considering the findings of Qi et al., 2017). Regarding aim (2), temporal distancing should be as efficient as social distancing in the down-regulation of negative emotions in response to unpleasant pictures (see Yanagisawa et al., 2011). There are no strong predictions about how temporal distancing compares to situation-focused reappraisal since the literature so far is insufficient.

Because the LPP has been shown to be a good indicator of emotional arousal, effectively dampening its amplitude suggests effectiveness of the ER strategy used. Ergo, the present study will provide a comprehensive comparison between three emotional reappraisal techniques commonly used in everyday life. The findings of this study may be of interest for therapeutic treatments such as cognitive behavioral therapy.

3.2 Participants

Participants were recruited by e-mailing students and by posting on social media, where general information about the study was provided. There was a total of 17 participants in the study (11 females), within the age range 18-40 years old (M=24.5, SD=3.669). Participants reported being healthy, with normal or corrected-to-normal vision, and right-handed. Exclusion criteria were dyslexia, ongoing neurological or psychiatric disorders, epilepsy, or color-blindness.

3.3 EEG-recording

Using a stretchable electrode cap (g.GAMMAcap), recordings were made using 33 active Ag/AgCl electrodes placed according to the International 10/20 System on the following sites: Fz, F1, F2, F7, F8, FCz, FC1, FC2, Cz, C3, C4, CP1, CP2, CP3, CP4, Pz, P7, P8, POz, OZ, O1, O2, O9, O10, T7, and T8. Recordings were online referenced to CPz and re-referenced offline to the average of the left and right mastoid (attached with adhesive tape). The ground electrode was placed at AFz, and an electrooculogram (EOG) was recorded from the external canthi of the eyes (for horizontal movements), and supra- and suborbit of the right eye (for vertical movements).

EEG and EOG data were recorded at a sampling rate of 512Hz using g.GAMMAsys electrode interfaces and relayed through two g.USBamp amplifiers (g.tec medical engineering GmbH, Austria) with an impedance of 1kOhm. The amplifiers were connected to a computer that recorded the signal using the Simulink toolbox in MATLAB R2015a (MATLAB and Statistics Toolbox Release 2R015a, The MathWorks, Inc., Natick, Massachusetts, United States.) Due to excessive line noise in the recorded data, a relatively strong online low-pass filter 30Hz was used, in combination with a more standard high-pass 0.01Hz filter.

3.4 Stimuli

The stimuli consisted of 72 photographs of human faces. 36 of the faces showed a neutral, non-emotional, expression and the other 36 expressed anger. The 36 neutral and 36 angry faces were of the same 36 individuals, so two emotional expressions each. 18 of the individuals were females. The photographs were taken from the *Umeå University Database of Facial Expressions*. The stimulus presentation was created using E-Prime 2.0 (http://www.pstnet.com/about.cfm?ID=173), and was pseudo-randomized, with all 36 angry or neutral faces being shown within one block. In total, there were 12 blocks for each experimental participant.

3.5 Procedure

Upon arrival, participants were given a spoken description of the study, as well as an instruction sheet including a short general written description of the study. They were then given an informed consent form (in accordance with the Declaration of Helsinki). If they agreed, they did so by giving their signature. Participants were then asked to fill out a questionnaire in which they were required to rate images of faces (the same images that were subsequently used as experimental stimuli on a computer screen) in valence (ranging from positive-negative) and intensity (ranging from high-low). Each questionnaire contained the faces in a pseudo-randomized order to avoid confounding factors.

After completing the questionnaire, participants were seated on a chair in front of a computer screen, approximately 115 cm from the display. Once seated, their head was measured to locate the electrode cap at the center. EOG and mastoid electrodes were put in place, and water-soluble gel (g.GAMMAgel) was applied on all electrodes for conductivity.

The participants were given a Playstation hand controller to communicate their answers during the experiment. They were first put through a practice block (with the same general structure as the experimental blocks) and were told to ask any questions they may have afterward. The practice block also allowed the EEG signal to stabilize before the experimental recordings were made.

The experiment was conducted with a within-subject design and consisted of 12 separate blocks with short breaks in between, each block consisting of 36 trials. Since each condition was run twice (in two separate blocks), there was a total of 72 trials per conditions. Prior to each stimulus, there was a fixation dot on the display for 250 ms, indicating the location of the upcoming stimulus. The stimulus was then displayed for 3,000 ms. Following each stimulus, a blank screen was shown, with a jittered duration (800 ms – 1,000 ms) for trial-to-trial latency variability. Approximately twice per block, a control question (asking the participant to indicate, by hand controller button press, the gender of the last face seen) was randomly displayed on the screen to make sure the participant was staying alert throughout the experiment. Thus, each sequence included, in order, blank screen, fixation dot, stimulus, intermediary (blank) screen. The blocks were presented in a randomized order. One experimental session took approximately 60 minutes.

At the beginning of each block, an instruction was shown on the display. There was a total of six different types of instructions comprising the six conditions used in this experiment. Each instruction was presented twice (across the total of 12 blocks). Out of the six instructions, four included descriptions of ER strategies, and two were instructions to passively observe the stimuli. In all blocks, the participants were asked to imagine that they were seeing the person (i.e. stimulus) with the angry or neutral face in front of them right now on a public train. For the blocks using ER strategies, the participants were instructed how to apply the specific strategy, with the goal to down-regulate the emotional impact of the stimulus. The four ER strategies used were: situation-focused reappraisal, social distancing (self-focused reappraisal), temporal distancing (self-focused reappraisal), and distraction. Distraction was included to be a part of a larger study and is not further discussed in this thesis. For the two remaining blocks, the participants were instructed to passively observe the stimulus (not using any ER strategy).

As stated earlier, each instruction included a description of the imaginary situation: “Imagine that you are seeing each person in front of you right now on a public train.” For the condition with the neutral faces, participants were asked to just observe their face. For the ER conditions, the text continued with: “Their angry face might make you uncomfortable, so imagine that…”, followed by the specific ER instruction:

1. Situation-focused reappraisal: “…you think that they will realize that they have overreacted, and will get over it soon and be happy instead.”
2. Social distancing: “… you take a detached, third-person perspective, reminding yourself that you don’t know them and therefore it makes no difference to you how they feel.”

3. Temporal distancing: “you think to yourself how little their anger will mean to you in 1 year.”

All ER instructions were followed by: “Please only apply this strategy after each face is shown, not before.”

At the end of each block, participants were asked if they thought they did well in applying the strategy, to which they answered by pressing the relevant hand controller button.

3.6 Data Processing and Analysis

For ERP analysis, the ERPLAB plugin (Lopez-Calderon, & Luck, 2014) for the EEGLAB toolbox (Delorme & Makeig, 2004) was used in MATLAB R2015a (The MathWorks, Inc., Natick, Massachusetts, United States.). Data from the practice block was discarded from the analysis. The experimental data was resampled from 512Hz to 256Hz and was re-referenced to the average of left and right mastoids. Next, the raw data was high-pass filtered from 0.1 Hz. Epochs of 3500 ms were then extracted from the continuous EEG-recording, starting 500 ms before stimulus onset. Baseline correction was set for the period -500 ms to 0. Channels that contained extremely noisy data were automatically rejected. Using independent component analysis (ICA; an algorithmic means for subtracting typical artifacts, such as eye blinks, from EEG data; Delorme & Makeig, 2004) on the 1Hz-filtered data set resulted in a set of data weightings that was then manually inspected for typical artefactual components, which were rejected and excluded from the analysis. Subsequently, all rejected channels were interpolated, and a process of artifact detection was run. Thereafter, the ERPs for each participant were calculated and averaged, before calculating the grand average ERPs.

When the averaged participant ERP data had been processed using ICA, the resulting datasets were analyzed using paired t-tests in IBM SPSS Statistics 23.

4. Results

Questionnaire ratings for angry and neutral faces in valence 1-9 (1 being negative and 9 positive) showed a mean score of 4.850579 (SD=0.329994) for neutral faces, whereas the angry faces had a mean score of 2.445255 (SD=0.526194), showing a significant difference (p=<0.0001). Ratings for intensity also had a set range between 1-9 (1 being low intensity, and 9 high), neutral faces had a mean score at 2.871181 (SD=0.292457), while angry faces had a mean score of 6,128241 (SD=0.939665547), also showing a significant difference (p=<0.0001).

The total time epoch of 3000 ms showed no significant effect between any of the conditions. When comparing the conditions of observing neutral faces with observing angry faces, the result was insignificant (p=0.255). When comparing the condition of observing angry faces with situation-focused reappraisal (p=0.163), social distancing (p=0.096), and temporal distancing (p=0.31) individually, no significance was found.

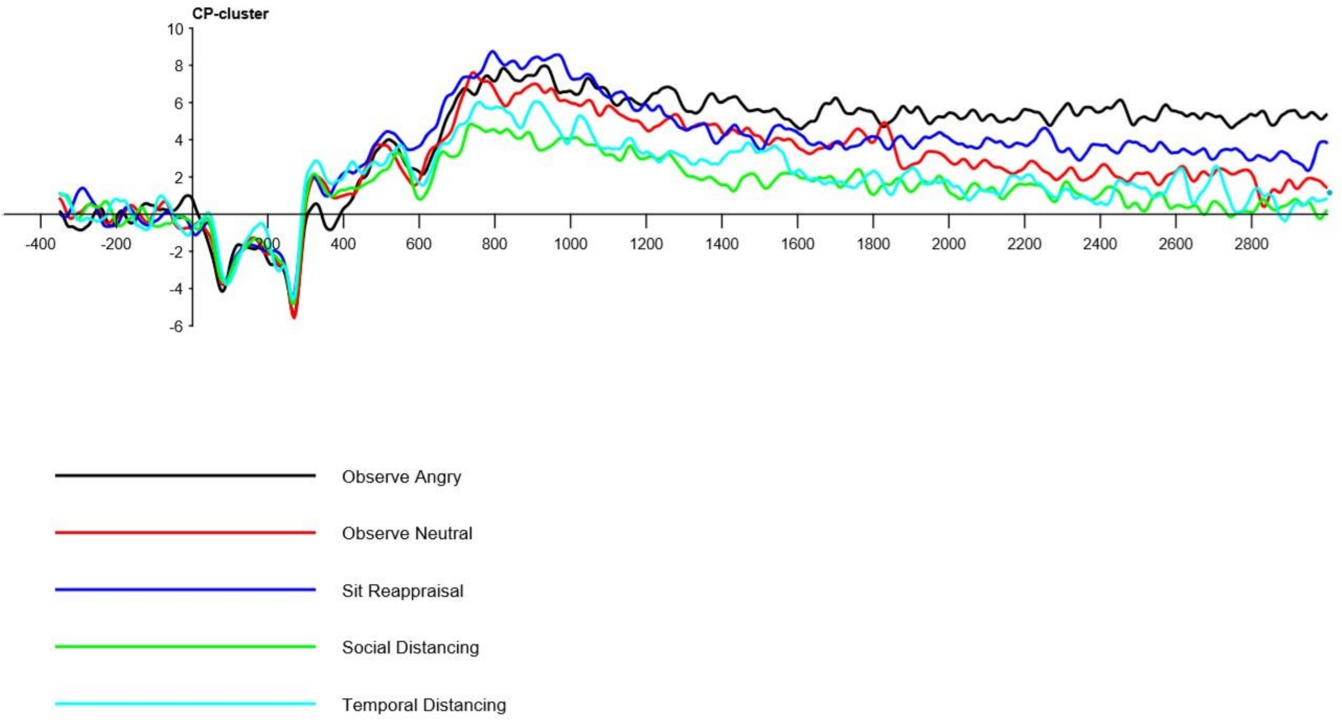

Figure 3. Grand average of the LPP amplitude.

Dividing the data into three separate time periods, early (400-800 ms), mid (800-1500 ms), and late (1500-3000 ms), p-values were obtained for the conditions separately for each sub-epoch. In the early time period, no significance was found contrasting observing neutral faces to observing angry faces (p=0.832). No significance was found comparing observance of angry faces to situation-focused reappraisal (p=0.553), nor when comparing observing angry faces and social distancing (p=0.067). However, comparing observing angry faces to temporal distancing did show a significant value (p=0.049).

The middle time period (800-1500 ms) gave significant results when comparing observing angry faces to social distancing (p=0.044) and temporal distancing (p=0.029) separately. Comparisons between all other conditions, however, showed no significance (Observe neutral - observe angry, p=0.244; observe angry - situation-focused reappraisal, p=0.155).

The late time period (1500-3000 ms) did not result in any significant values (observe neutral – observe angry, p=0.2; observe angry – situation-focused reappraisal, p=0.14; observe angry – social distancing, p=0.19; observe angry – temporal distancing, p=0.589).

	Observe neutral - Observe angry	Observe angry - Situation-focused reappraisal	Observe angry - Social distancing	Observe angry - Temporal distancing
Total	0.255	0.163	0.096	0.31
Early	0.832	0.553	0.067	**0.049**
Mid	0.244	0.155	**0.044**	**0.029**
Late	0.200	0.140	0.190	0.589

5. Discussion and Conclusion

This study set out to examine the temporal dynamics and the effects of situation-focused reappraisal, social distancing, and temporal distancing. The results did not reveal any significant differences when comparing the conditions of observing neutral faces versus observing angry faces across all time periods. Since the goal of the strategies is to dampen the emotional response to the angry faces, this poses a major issue for the validity of all strategy comparisons. So, although the results showed a significant difference of the temporal distancing strategy during both the early (p=0.049) and mid-time epoch (p=0.029), as well as for social distancing during the mid-time period (p=0.044), the non-significance between the observe neutral and the observe angry condition makes these numbers difficult to interpret. However, visual inspection of the grand average indicates that the reappraisal techniques did have the down-regulating effect anticipated, and thus the non-significant numbers are likely due to high variance, noisy data, or something in the experimental design, rather than the reappraisal techniques not working.

Concerning the first hypothesis, that self-focused reappraisal techniques would start operating earlier than situation-focused reappraisal, it is difficult to draw any conclusions due to the non-significant numbers obtained for situation-focused reappraisal. As is the case for the comparison between temporal distancing and situation-focused reappraisal. However, looking at the grand average it seems that the self-focused reappraisal techniques can be more efficient than situation-focused reappraisal.

Regarding hypothesis two, stating that temporal distancing should be as efficient as social distancing in the down-regulation of negative emotions, temporal distancing results were significant in the early and mid time window, which may indicate that it starts operating earlier than social distancing. In the mid time window, temporal distancing (p=0.029) also suggests a larger reduction of the LPP as compared to social distancing (p=0.044). Nevertheless, these numbers differ so slightly that they may not reveal anything of significance.

There were some issues regarding the equipment. During the pilot for the experiment, it was noted that some electrodes were causing noise in the recorded data. Even after extensive problem shooting, and although the electrodes were replaced, these issues persisted throughout the experiment resulting in a large rejection of channels. Along with the relatively low participant number, this may have contributed to the non-significant results. Other similar studies (Hajcak, Dunning, & Foti, 2009; Willroth & Hilimire, 2016; Moser et al., 2017; Qi et al., 2017) have used anywhere between 21-29 participants. Taken together with the noisy data recordings, the circumstances were not optimal.

The variables did not show a normal distribution, which typically warrants non-parametrical t-tests. However, the t-test is considered a robust method for analysis, even when the data does not have a normal distribution (Borg & Westerlund, 2007). With this being said, this does not guarantee that the chosen method did not contribute a confounding factor given the low number of participants and trials.

The selection of stimuli was made the bases of existing valence and intensity scores for each image based on subjective ratings. Although this can be considered standard procedure in studies like this one, using scores based on self-reports could also be problematic in this context. While some have found a link between self-reports of arousal and the LPP (Hajcak & Nieuwenhuis, 2006), others (Foti & Hajcak, 2008; MacNamara, Foti, & Hajcak, 2009) have not been able to find such a relationship. It may be so that the will to meet the expectations in such a task as well as one’s ability to introspect (or lack thereof) is influencing the self-reports.

International Affective Picture System (IAPS) is a widely used database for stimuli across ERP studies exploring and comparing the different ER strategies. Although

IAPS stimuli have been shown to reliably influence the LPP (Britton, Taylor, Sudheimer, & Liberzon, 2006), it could be argued that its contents (e.g. war crimes) provide low ecological validity as they are not often encountered in everyday life. Social situations (including inter-personal stress) on the other hand, is something most people experience on a daily basis. Social stress has been found to trigger intense emotional responses (Koenigsberg et al., 2010), and threatening face stimuli reliably trigger the LPP (Schupp et al., 2004) and recruits additional brain regions as compared to complex emotional images (Britton et al., 2006). On these bases, the database of choice for the present study was the Umeå University Database of Facial Expressions, providing a higher ecological validity than standardized IAPS images do. The selection of the specific face images used was made based on preexisting ratings of how accurately each face depicted the emotion it was supposed to represent (emotion expression accuracy ratings), choosing the angry (and neutral) faces with the highest accuracy scores. Also, the obtained questionnaire scores for this study suggest that the chosen stimuli were emotionally arousing and thus would trigger the LPP.

However, IAPS images of complex emotional scenes have been rated higher in arousal than emotional facial expressions (Britton et al., 2006) which seems to suggest a more robust modulation of the LPP. Thus, it could be argued that using face stimuli is more suitable for studies focusing on the up-regulation of emotions (e.g. rumination in social anxiety).

Although using IAPS images of complex emotional scenes perhaps could have resulted in a larger effect size, images of aversive scenes would have posed a different challenge: it would be problematic (ethically and practically) to compose instructions for the social distancing strategy and apply them on aversive scenes (e.g. an image of an injured person), since asking participants to distance themselves emotionally would potentially feel intuitively wrong and consequently might trigger strong emotional responses.

One issue that is fundamentally present in the experimental design is the costs of ecological validity, which come with increased control over the conditions studied. In the present study, one such limitation was that the participants were not able to freely choose ER strategy. This may seem trivial, and the use of predefined instructions for the different strategies was an essential part of the experimental design considering the need to isolate various reappraisal techniques for comparison. However, congruent with the process specific timing hypothesis (Sheppes & Gross, 2011) which highlights the importance of emotional intensity for strategy selection, people seem to choose ER strategy based on how intense the emotion is. Cognitive reappraisal, as one strategy, has been shown less effective during high-emotional intensity levels (Sheppes et al., 2011). Following this notion, it is not implausible that the efficiency of situation-focused reappraisal as well as social and temporal distancing to be influenced by how arousing the stimuli are. Although the present study did not set out to answer these questions, it might be an interesting topic for future research.

The LPP shares some characteristics with the P300, an ERP component that is linked to stimulus salience, and shows up as a wide positivity along the parietal midline about 300 ms to 500 ms post-stimulus. It has been suggested that the LPP is linked to some of the same underlying processes as the P300, and studies of the LPP sometimes mention the P300 due to their morphological and topographical resemblance (Hajcak & Olvet, 2008). Accordingly, the LPP may be like the P300 in that it, too, could be sensitive to infrequent stimuli. Given the design of this study, where the angry face stimuli are shown repeatedly throughout and the neutral faces being more infrequent, it could cause an increased LPP amplitude for the observe neutral condition, and thus reduce the difference between the observe neutral and the observe angry conditions.

Attenuation of the LPP is typically understood as a reflection of a reduced emotional response following ER instructions (e.g. Hajcak & Nieuwenhuis, 2006; Moser et al., 2006). This interpretation is based on the observed correlation between the LPP amplitude and self-reported scores of emotional arousal (Hajcak & Nieuwenhuis, 2006). However, studies have reported reappraisal (following instructions to cognitively reduce negative emotions) to operate as early as 400 ms after stimulus onset (Moser et al., 2009) which leads to the question what reductions of LPP amplitude in this early time windows (400-800 ms) reflect. Given that cognitive reappraisal is a voluntary (non-automatic), conscious process that requires effort, it seems unlikely that the early modulation of the LPP reflects this complex process of narrative change (i.e. reinterpretation). Granted that the LPP is sensitive to cognitive load (MacNamara, Ferri, & Hajcak, 2011) it is not implausible that attentional deployment (due to task difficulty), rather than reinterpretation, is responsible for these early reductions of the LPP amplitude. One study (Foti & Hajcak, 2008) dealt with this question by reducing task difficulty by providing participants with appraisal narratives prior to stimulus presentation. Their results indicate that narrative does play a role in the regulation of the LPP. Nevertheless, it can be argued that this study focuses on modulating the initial appraisal (which is part of the emotion generation rather than the emotion regulation process) and that these results may not be representable for the process of reappraisal.

The time window used for analysis of cognitive reappraisal techniques is crucial for the results concerning attenuation of the LPP since it seems that reappraisal takes full effect with time (see Moser et al., 2017; Willroth & Hilimire, 2016; Qi et al., 2017). Nevertheless, there are no studies to date directly investigating how long it takes to reappraise, which raises two questions: (1) whether the time frame used to apply reappraisal techniques is sufficient, and (2) whether the time window used for analysis captures the entire reappraisal process. ERP experiments generally give participants between 3000-6000 ms to reappraise (e.g. Willroth & Hilimire, 2016; Qi et al., 2017). While it would be interesting to look at later time windows, analyzing ERPs that stretch beyond a few seconds is problematic because of slow voltage drifts unrelated to neural activity (Luck, 2005). Thus, limiting the analysis to 3000 ms after stimulus onset grants less noise in the data. Furthermore, extending the trials would have resulted in longer experimental sessions, which could have caused other issues such as participants having difficulties sustaining their attention.

Two studies (MacNamara, Ochsner, & Hajcak, 2010; Thiruchselvam et al., 2011), looking at the LPP in relation to re-exposure to stimuli that has previously been reappraised, found similar results as the present study, i.e. significance in the mid, but not the early and late time windows. These experiments were comprised of two stages. First, participants were required to reappraise, distract, or to passively view stimuli. In the second stage, participants were asked to passively view the same images used for stimuli in the first stage. Analysis of the LPP of the second phase suggests that reappraisal, including social distancing, may have enduring effects on neural responses to image stimuli. In the present study participants were only provided instructions at the beginning of each block, which constitutes a slight chance that they forgot to use the strategies on each stimulus. Hence, there is a possibility that instead of applying the strategy of social distancing, participants were only (passively) viewing previously reappraised stimuli. This could explain the results only being significant in the mid-time window. Although these similarities are noteworthy, it is yet to be determined whether these results are coincidental or reflect something of value, given that these studies are not identical in their experimental setup.

To summarize, although significance was not found between the observe neutral and observe angry conditions making it difficult to interpret the rest of the results, visual inspection of the grand average implies that the strategies did down-regulate the LPP to some degree. It is reasonable to assume that the insignificant results can be a reflection of high variance in the data due to the low number of participants. Given the strong background to the hypotheses, the questions that this study set out to explore are still valid, intriguing and deserve to be answered.

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