Master Degree Project

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Facial expressions and Electrophysiological impressions – An LPP study of emotional regulation

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Abstract

The conceptual model of emotion regulation (ER) of Gross and Thompson (2007) introduces families of ER strategies ordered on a temporal scale. This scale has been attributed implications both for the grouping strategies but also for the neurocognitive processing. The two event-related potential (ERP) studies of emotional regulation presented here focus on emotional regulation at different temporal distances, as well as, different stages of cognitive processing. Trying to discern if various neural processes could be disentangled by looking at different stages of the late positive potential (LPP). The theoretical background begins with the neurocognitive science of emotionality and visits cognitive processing at both early and late stages before summating results of the contemporary research of emotional regulation. 39 participants were enrolled within the two experiments aiming to compare the efficiency of different strategies in reducing negative social emotion induced by photographs of angry faces. Technical difficulties discourage conclusions about how temporal distancing is most effectively adapted. Results suggest self-focused distancing strategies are more effective than situation-focused reappraisal and could be preferred for therapeutic purposes based on greater observed LPP effect.

Keywords: LPP, emotional regulation, distraction, cognitive reappraisal, distancing, late- and early selection processing, social emotion, self-referential processing.

Acknowledgment

This project happened while I was recovering from traumatic events that left deep imprints in my personal emotional responses to the event around me. It has been a journey of great learning and understanding that aided me in my healing process. I would like to thank the University of Skövde and all staff relevant to the cognitive neuroscience programs there for always offering creative and inspiring learning experiences. Especially, of course, to my supervisor Oskar Macgregor and my examiner Sakari Kallio. I would also like to thank my family. My parents, for always pushing me a little further, and my kids for giving me the courage and strength to never give up.

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1. Introduction

At certain points in life, it can seem like ordeal is stacked upon ordeal and you are living something of a tribulation. In these situations, the ability to successfully regulate emotion can make or break a person. Those of us who have suffered emotional instability know from the inside what havoc emotions run wild can cause. Most can see just how essential proper emotional regulation is in order to reach success in the modern world of achievements, both in a personal as well as material perspective. The scientific study of emotional regulation is a field that has grown substantially during the last decade. Publications found in a Web of Science search have increased from a few in the early nineties to a total over 2000 last year. A number of these studies suggest that it even might be the case that emotional dysregulation lies in the very heart of various arduous psychiatric disorders (Hajcak, MacNamara, & Olvet, 2010; Koenigsberg et al., 2010; Kudinova et al., 2016; Zilverstand, Parvaz, & Goldstein, 2017), such as bipolar disorder (Phillips, Ladouceur, & Drevets, 2008), borderline personality disorder (Meyer, Pilkonis, & Beevers, 2004), or even schizophrenic spectrum disorders (Meyer & Shean, 2006). Whatever reason that lies behind, or at what level our individual challenge in managing our emotions surface, the experience of struggling with emotions is something that most of us will experience at times in our lives. For this reason, emotion regulation (ER) is crucial to us all.

Within the field of ER, the conceptual model of Gross and Thompson (2007) is the most influential and as well foundational for the studies of this thesis. The model characterizes five families of ER strategies and orders them on a temporal scale. For the sake of contextual clarity, these will be described shortly beginning with the first, *situation selection.* This family of strategies regulates emotion before they even arise by making the choice of whether to even involve oneself in a particular situation. Situation modification is the second family, an example of a modification to a situation to access ER is bringing a good friend to sit in the audience to an otherwise terrifying presentation. The remaining three families involve very different mechanisms but this point involves a shift from modifying external features to employing internal resources. All types of attentional deployment e.g. distraction, rumination, thought suppression, rumination, and mindfulness belongs to the third family. Cognitive change or cognitive reappraisal involves a psychological effort to change the interpretation of the situation as such which can be accomplished in different manners. The last family of the model response modulation refers to the suppression of emotion-expressive behavior.

The scope of the thesis centers on two of the families, attentional deployment and cognitive reappraisal. Within these well-studied sorts of strategies (Paul, Simon, Kniesche, Kathmann, & Endrass, 2013) *distraction* is the most prominent type of attentional deployment, therefore featured also in the current work. Within the reappraisal family, there are three types relevant to the included studies. *Situation-* vs. *self- focused reappraisal* constitutes the first distinction among these, followed by the two different types of self-focused: *temporal-* and *social- distancing.* The literature review will aim to provide an understanding of the theoretical grounding of the differences between these strategies.

Empirically, the strategies are commonly studied by exposing the participants to pictures with a content chosen to evoke an emotional response. The participants are asked to use a previously described strategy, or just neutrally observe during the presentation of the pictures. The effects are measured either through EEG (electroencephalogram), a brain imaging technique such as e.g. fMRI (functional magnetic resonance imaging), affective self-reports, or a conjunction of these. There is a majority of studies utilizing pictures from the international affective picture system (IAPS) (Kanske, Heissler, Schönfelder, Bongers, & Wessa, 2011; McRae et al., 2010; Paul et al., 2013; Qi et al., 2017; Schönfelder, Kanske, Heissler, & Wessa, 2013; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011; Willroth & Hilimire, 2016). Although effective in producing desirable brain effects, the IAPS-pictures depict scenes that most of us will never encounter such as war-crimes and human mutilation. Another option of pictures is emotion expressing faces, these are sometimes used together with the IAPS-pictures and can be categorized as *social* stimuli. Many of the existing studies of ER combines social and non-social stimuli, (Koenigsberg et al., 2010) which might contribute to the conceptual confusion surrounding the current science of emotionality and emotions (Gross, 2015). With this background, it is probable that the current studies utilizing exclusively social-emotional stimuli will prove useful.

The thesis theoretical background aims to describe the current scientific context surrounding the study of ER, its theoretical origins as well as its empirical results. The empirical part of the thesis is built upon data from previous projects focusing on ER strategies and the ‘late positive potential' (LPP), an event-related potential (ERP) in the EEG. It brings together two related but separate studies, including a new data processing and analysis and gathers the results eventually aiming for both an elaborate analysis of the LPP in relation to ER and an investigation of the temporal dynamics between various strategies. The aim of the empirical part of the thesis is to compare and analyze the effectivity between the different temporal distances as well as between different strategies providing potential therapeutic relevance.

As a starting point, there is a brief insight into the scientific study of emotionality and its cognitive control because it is relevant to the topic to understand the basics of the goal of the regulation. Chapter three describes the main subject of the thesis, ER, and its temporal dynamics. The fourth chapter describes and differentiates the various strategies of the studies, and the fifth describes its measure, the ERP in relation to ER.

2. The Science of Emotionality

The concept of emotion has been viewed from different perspectives through scientific history. In early psychological history, James (1890) introspected upon the connection between bodily feelings and emotions and adopted the view of physical changes as the origin of subjective experiences. As he concluded that "a certain amount of brain-physiology must be presupposed or included in Psychology" (James, 2009, p. 5) he was certainly ahead of his time in pairing emotions with 'physical effects on the nerves'. The contemporary view of physiological and neural emotionality has its origins in research focusing on a 'limbic system concept' (MacLean, 1949, 1952) generating emotion. The theory as such has been refuted, but the importance of subcortical structures such as the amygdala remains. LeDoux has contributed to contemporary cognitive neuroscience models of the amygdala in fear-processing and the interactivity of the amygdala and hippocampus in emotional memory (LeDoux, 1993, 1995).

The basic emotion theory of Ekman and Davidson (1994) put forth the idea that emotions evolved "for their adaptive value in dealing with *fundamental life tasks* " (Ekman, 1992 p.171) and described universal facial expressions connected to a set of emotions. This elucidates a link between the inner subjective state and action tendencies that is intimately relevant to the effect of emotion in human social life.

What James termed as physical effects on the nerves is now understood as autonomic and neuroendocrine changes that anticipate and support emotion-related behavior. Instances of such are: changes in facial expression, posture, withdrawing or striking (Ekman, 1972; Frijda, 1986; Kreibig, 2010; Lang & Bradley, 2010; Levenson, 1992). Despite the obvious advancements made towards understanding emotions both in the physiological context as well as their possible evolutionary origin, the scientific view of emotions can be perceived as shattered. To solve the challenge to define emotion and unite the diverse co-existing conceptualizations Gross and Thompson (2007) have proposed a conceptual model that will be presented further on. Attempting a definition Gross (2015) also highlights key features of emotion, the first being that *emotions unfold over time*. This feature has proven its relevance also to ER which is the specific scope of this thesis. Another key feature of emotion according to Gross (2015) is that *emotions can be either helpful or harmful* depending on the context. Helpful emotions appropriately guide sensory perception, enhance decision making, provide information regarding the best course of action, inform us about others behavioral intentions, and motivate socially appropriate behaviors. When emotions are of wrong intensity, duration, frequency, or type for any given situation they are harmful and can maladaptively bias cognition and behavior. Thus, it is not hard to see just how important effective and appropriate ER is and which potentially destructive effects a lack of ER can have, both individually and on a wider societal scale.

2.1. The modal model of emotion

The modal model of emotion (Gross, 2015) takes into consideration and includes the interactive nature of emotion into the situation originating it thereby explaining it in a wider context than mere information-processing computations. Presupposing that emotion is important to human social life, and emotion expression serves this link (e.g. Ekman & Davidson, 1994), this wider context can be considered highly relevant to interpersonal emotion and social interactions.

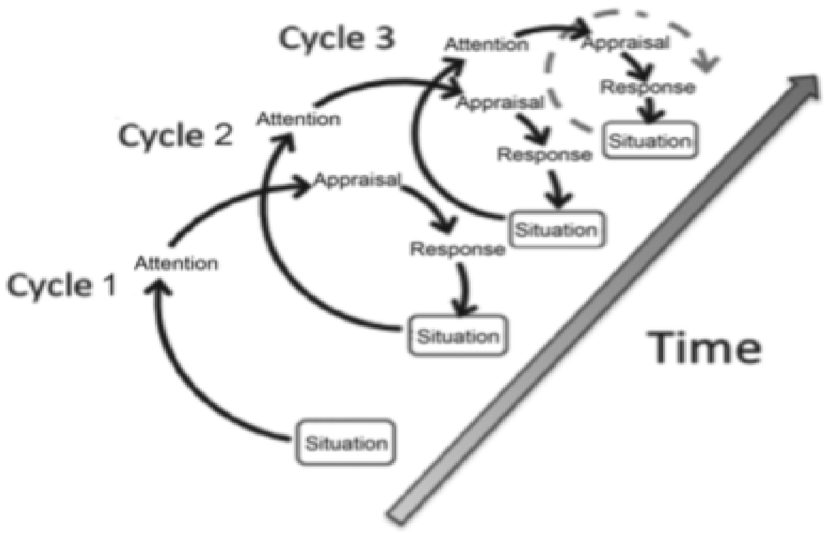

Figure 1: The modal model of emotion extending in time. From: *Emotion regulation: Current status and future prospects* (p. 4), by J. J. Gross, 2015, Psychological Inquiry, *26*(1), 1–26. Copyright 2015 by Taylor & Francis Group, LLC. Used with permission.

As Figure 1 illustrates, the starting point of the cycle described in the modal model of emotion is a *situation* drawing *attention,* giving rise to an *appraisal* which then generates a *response* in its turn feeding into (a new) *situation* completing and repeating the cycle (Gross & Thompson, 2007). The situation can be of physical nature as well as an internally represented of any psychological importance to the subject and are evaluated in light of how it affects current active individual goals (Gross, 2015). Within this event-based description, the temporal dimension of emotional unfolding is nicely fitted and the model also offers a resolution-point for the distinction between helpful and harmful emotional outcomes, i.e. at the point of regeneration of the loop. Of course, helpful emotions generate favorable results in changing the situation generating the emotion (thereby creating a new) yielding constructive results for the individual.

2.2. Emotion processing in the brain

The multimodal experience of emotion involves complex processing in different parts of the brain. The higher order integrative functions are correlated to activity in the cortical layer with contribution from various areas of specific roles. Subcortical neural processing involves; amygdala, the ventral striatum, and periaqueductal grey (PAG) (Etkin, Büchel, & Gross, 2015; Ochsner, Silvers, & Buhle, 2012). The amygdala as usually implied in fear-processing, spot possible threats and generally arousing stimuli. The processing of information related to affective goals is also managed by this structure. Relating to ER, amygdala and a network centered around it is commonly described as the target of the regulative effort (Zilverstand et al., 2017). The ventral striatum is involved in reward or reinforcing outcome-prediction from e.g. social cues (Ochsner et al., 2012). The insula may contribute interoceptive aspects, and the hippocampus provides memory stored temporal or spatial information (Etkin et al., 2015). The ventromedial prefrontal cortex (vmPFC) integrates affective valuations aided by information passed by the amygdala and ventral striatum originated in different areas. These areas include a temporal lobe system storing information about prior encounters with the stimuli and prefrontal control centers responsible for information about current behavioral goals (Ochsner et al., 2012). These current goals are put in context to other individual motivational demands by the dACC (Etkin et al., 2015).

2.2.1. Cognitive control of emotion

The contemporary science of ER has three major antecedents within psychology beginning with Freud's psychodynamic study of psychological defenses. The study of the regulation of anxiety and other negative emotions, defenses such as defenses of processing and alike originated in this line of work. As second, the stress and coping tradition (e.g., Carver & Scheier, 1994; Lazarus & Folkman, 1984) have contributed with concepts like reappraisal and detachment and produced the first evidence that subjective experience and physiological responses can be altered by in which terms stimuli is perceived (Speisman, Lazarus, Mordkoff, & Davison, 1964). The developmental study of self-regulation is the third antecedent manipulating kids impulses to eat treats by instructing them to think about them in abstract ways. Upon this foundation ER studies, today uses both behavioral and neuroscience methods to understand and describe how emotional regulation is instantiated (Ochsner & Gross, 2005).

In cognitive neuroscientific models cognitive control is thought to involve areas in lateral (l) and medial (m) prefrontal cortex (PFC) implementing control processes in interaction with subcortical and posterior cortical regions responsible for encoding and representing specific, e.g. emotional, information (Ochsner, Bunge, Gross, & Gabrieli, 2002). The context of functional connectivity is interesting in relation to emotional regulation, it describes correlations between activations in various neural areas during task performance. Studies of this kind looking at ER have indicated interactive activity between the amygdala, anterior cingulate gyrus (ACG), and the cingulate cortex, subsequently looping back to the amygdala. Paths of processing with links between the orbitofrontal cortex (OFC) and dorsolateral PFC, as well as between the amygdala and OFC was observed. This collaborated with anatomical findings that indicate OFC could have a mediating role between higher-order dorsolateral prefrontal regions and the amygdala relevant to emotional regulation (Phillips et al., 2008)

3. Emotion Regulation

As pictured in the modal model of emotion described in the previous section a human, or for that matter a brain, and its internal processes are favorably described within a larger context. That is, at least if the object of study and its description is interacting with the context. As scientists, we strive for ecological validity and for this criterion to be represented within the theoretical realm theoretical explanations also need to be framed in a larger context. The conceptual foundation of ER offered by Gross and Thompson (2007) and further elaborated by Gross (2015) and collaborating colleagues builds on the modal model of emotion and treats each event of it as a possible point of a regulatory process to intervene with the emotion generation trajectory.

The modal model of emotion extended in time (Figure 1) portraits how the emotion-generative and emotion regulative processes co-occur fluently in our minds. Thus, the emotion trajectory that we subjectively experience or scientifically observe is resulting from a complex interplay between emotion generation and emotion regulation (Gross, Sheppes, & Urry, 2011). To discern ER from emotion generation Gross et al. (2011) identify three core features of ER, the first is *the activation of a goal* to modify the emotion-generative process. The goal can be either within oneself or your goal might be to regulate someone else's emotion. The second core feature of ER is *the engagement of a process* that is responsible for altering the emotion trajectory. The process can be either conscious or non-conscious, referring to automatic processes (Ochsner & Gross, 2008). The third core feature is the resulting *impact on emotion dynamics,* meaning that it increases or decreases latency, rise time, magnitude, duration or offset of the emotional response.

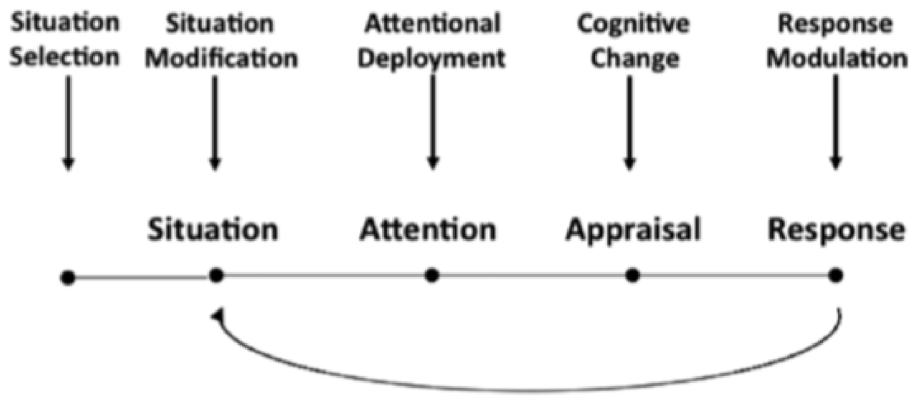

Figure 2: The modal model of emotion, strategy-families and processing stages on the temporal scale. From: *Emotion regulation: Current status and future prospects* (p. 4), by J. J. Gross, 2015, Psychological Inquiry, 26(1), 1–26. Copyright 2015 by Taylor & Francis Group, LLC. Used with permission

3.1. Temporal dynamics of ER

The conceptual model of ER Gross and Thompson (2007) orders the five families of ER described in the introduction on a temporal scale (Figure 2). Beyond the processing steps in the model further elaboration of the various qualities of the strategies is possible. The broadest distinction within the group of strategies is that of *antecedent-focused* and *response-focused.* Strategies adhering to the former start operating early on, before response tendencies are fully activated, while the latter operates later on in the process. A prediction of the process model at this stage is that the antecedent-focused strategies are thought to be generally more effective. This is because more time has lapsed when the response-focused strategies operate and they must overcome a well-developed suite of inter-related emotion processes (Sheppes & Gross, 2012). This assumption has been stated as *the generic timing hypothesis* and has been tested by comparing the effects of reappraisal (cognitive change) to the effects of active suppression (response modulation). A large number of studies have demonstrated the relative costs of suppression compared to reappraisal in affective, cognitive and social domains. The generic timing hypothesis suggests ER strategies of any kind will always be more effective when initiated at a low level of emotional intensity. Another possibility is that time matters significantly for some ER strategies while for others it matters little or not at all. This is an assumption derived from the *process-specific timing hypothesis* (Sheppes & Gross, 2011).

3.1.1. Early and late selection strategies.

The distinction between early and late selection strategies is built upon information processing theories arguing that people have limited cognitive capacity to execute mental operations. The limited capacity and cognitive resources pose constraints that result in continuous competition for dominance and determines the response or output from the cognitive system. At the *early stage* perceptual information competes to capture attention, a filtering mechanism then determines what passes through to the next stage of more elaborated semantic analysis. At the *late stage* various representations compete at the semantic level to affect the final response. Across the two stages, conflict resolution requires more mental effort at the late stage since there is more information within the representation of the stimuli (Sheppes & Gross, 2011). It is from this theoretical account that the distinction of 'early selection'- and 'late selection'- strategies are burrowed. Relevant to the current study, distraction (attentional deployment) is a strategy belonging to the early selection while reappraisals (cognitive change) belong to the late selection (see Figure 2).

4. Regulation strategies

Since theory now has led to the point of the first distinction between ER strategies involved in the current study, the following sections will elaborate on these. The first one will be distraction followed by reappraisals, in plural since reappraisal can be achieved in different ways which research have found some potentially important differences between. Subsequently, these will be outlined and described.

4.1. Distraction

Most of us experience distraction on a daily basis but we might not think of it as a strategy to regulate emotion, and even though it might serve the purpose it seems to be to a certain cost. In the ER context, distraction actually refers to a broad range of regulation possibilities involving an explicit or implicit shift of attentional focus. This is can be implemented in a number of different ways which is also evident looking at various study designs. Distraction can be achieved by focusing on non-emotional parts of pictorial stimuli (Hajcak, Dunning, & Foti, 2009) or by inserting an intellectually demanding tasks (Schönfelder et al., 2013; Seminowicz & Davis, 2006), or otherwise absorb or lead the participants focus during the condition (McRae, Ciesielski, & Gross, 2012; Thiruchselvam et al., 2011). As an early selection ER strategy distraction operates through the mechanism of attentional deployment and should intervene early on in the emotion-generative process. Thus, before the meaning of relevant stimuli occur in the semantic stage, and actually block this kind of processing of the stimuli from occurring (Sheppes & Gross, 2011). With a glance at the empirical support, distraction does undoubtedly seem to have an effect on the perception and experience of emotion. There is, unfortunately, also some evidence that emotional information left without semantic processing might have a higher arousing impact upon re-exposure (Thiruchselvam et al., 2011).

4.1.1. Neural modules operating distraction.

A functional MRI (fMRI) study utilizing blood oxygenation level dependence (BOLD) examined neural activations during ER. When closing down on distraction they found the dorsal ACC (dACC), parietal cortex, and insula activations to be specific for distraction compared to reappraisal. A more extended and strong reduction in amygdala activity was also found (Kanske et al., 2011). These results corroborate those of McRae et al. (2010) who found distraction to preferentially activate areas associated with the allocation of attention as well as decreased processing in areas associated with affective meaning. The latter lends support to the view of distraction as an early selection strategy.

4.2. Reappraisals

This type of ER is actually very mundane and something we do probably every day without even thinking about it. It also happens to be one of the most studied types of regulation. Within the model of Gross and Thompson (2007), it belongs to the family called cognitive change.

What is meant by reappraising is to mentally re-evaluate a situation in some way to change its emotional impact. For example, you can choose to believe that someone who looked at you in anger really was not but rather had a terrible tooth-ache. Although, reappraisal can aim to either up- or down-regulate either positive or negative emotions. Effectiveness of reappraisal have been demonstrated in various subjective and physiological measures of emotion processing such as self-reported emotional intensity, facial expressivity (Kim & Hamann, 2012; Ray, McRae, Ochsner, & Gross, 2010), skin conductance level (McRae et al., 2012), and heart-rate (Hofmann, Heering, Sawyer, & Asnaani, 2009). The concept has had the time to get established since it took off from the stress and coping tradition already in the 60s. (see previous section).

4.2.1. Neural modules operating reappraisal.

The primary region found selectively activated for reappraisal compared to distraction in the fMRI study by Kanske et al. (2011) was bilateral OFC. The process thought to be relevant is *the recognition of the stimulus as momentary relevant and semantic change of it* inherent to reappraisal. In the study of McRae et al. (2010) a network including medial PFC previously associated with emotional awareness and mental state attribution was preferentially activated during reappraisal. Accompanied by activation in ventrolateral PFC possibly reflecting the affective value of stimuli, and with inferotemporal regions important for recognizing social cues. Spatial proximity of clusters activated for reappraisal and distraction distinctively is discussed favoring the explanation that the two strategies might recruit similar processes but to different degrees (McRae et al., 2010).

In virtue of reappraisals being such a broad and common mental operation, it is also flexible in the sense that there is a number of ways in which a situation can be re-evaluated. One of the studies of this thesis will test different types of reappraisals, these will, therefore, be elaborated upon in subsequent sections. Estimations about locus relating to specific mental operations are gathered from imaging studies while some of the operation specific information comes from EEG studies.

4.3. Self- and situation- focused reappraisals

The first useful distinction to make within the reappraisal type of ER is between reappraisals focusing on the situation versus reappraisals focusing on the self. Situation-focused appraisal changes how the situation as such is appraised, reinterpreting actions, dispositions, and outcomes, e.g. that the man with the knife perhaps does not plan to stab you but to help that bird stuck in a string. Self -focused appraisal re-evaluates stimuli as less personally relevant. This is a dimension building on psychological theories and neuroscientific literature demonstrating that self-referential processing seems to have a specific role. Faculties where this have been demonstrated includes memory, emotion, and motivation. Distinct medial prefrontal systems for this kind of processing has also been identified (Gusnard, Akbudak, Shulman, & Raichle, 2001; Kelley et al., 2002; Northoff et al., 2006).

In the emotion regulation choice framework (Sheppes, 2014) a factor related to the late- and early selection distinction applicable to the different reappraisals is presented, namely the engagement-disengagement factor. On this scale, self-focused reappraisal is considered more disengaging from the stimuli than situation-focused. Within self-focused reappraisal there are further divisions of methods to decrease self-relevance, these will be presented further on.

Ochsner et al. (2004) found similar success for both self- and situation-focused reappraisals in modulating emotion and commonalities in activations of many neural systems replicated more recently such as regions of the PFC (left, and dorsal medial), cingulate cortex, and amygdala modulations. The direct comparison between self- and situation-conditions found one key difference but only during the condition to down-regulate emotion, decreasing emotion by self-focused appraisal differently recruited medial PFC. The relevant area corresponds to BA 32 and has been associated with self-referential judgments and with processes thought to reflect a default self-monitoring state of brain activation (Gusnard et al., 2001; Kelley et al., 2002).

An area of lateral PFC was activated differently during situation-focused reappraisal, this area is generally implicated in the maintenance and manipulation of information about stimuli in the external world. From these results stems the hypothesis that *self- and situation-focused reappraisals depend on neural systems involved in general internally focused as compared to externally focused processing* beyond their commonalities within reappraisal-networks (Ochsner et al., 2004).

Another aspect of self-reference is surfacing through a study examining the LPP elicited through mentally referring to oneself by name (third-person self-talk) compared to a first-person perspective, i.e. 'I'. The effects are also examined through fMRI and the two joint results show that as the LPP is reduced by referring to oneself by name, activity in medial PFC - a marker of self-referential processing was also reduced. Interestingly, the activity in areas corresponding to cognitive control was not increased coupled to this down-regulation of emotion (Moser et al., 2017).

4.4. Social and temporal distancing

Self-focused reappraisal was in the past section explained as the process of making stimuli less personally relevant, it makes one feel more or less involved with the ongoing event. Another name for self-focused reappraisal is *distancing strategies.* How this distance is achieved is the basis of yet another distinction. *Social distancing* is the process of taking a detached third-person perspective (Ochsner & Gross, 2008) instead of experiencing it as personal.

Koenigsberg et al. (2010) examined the neural correlates of using social distancing to regulate negative emotion elicited by pictures of social situations via fMRI. Over both aversive and neutral social scenes, distancing activated the precuneus and posterior cingulate cortex (PCC); intraparietal (IPS), and middle/superior temporal gyrus (M/STG). Their findings include a demonstration that distancing from aversive social scenes modulates amygdala activity through engaging networks implicated in social perception, perspective-taking, and attentional allocation.

Temporal distancing is a separate process related to 'mental time travel' which can be achieved by imagining the current situation from either a past or future perspective. In relation to imagining the future, the main division is either imagining the near-future (e.g. visualizing events tomorrow or in some days ahead) or imagining the distant future (e.g. envisioning events in years ahead) (Bruehlman-Senecal & Ayduk, 2015).

Yanagisawa et al. (2011) examined the use of temporal distancing against the experience of pain elicited by social exclusion aided by near-infrared spectrography (NIRS). They found that imagining events in the distant future perspective (next year and beyond) induced less experienced social pain than imagining it in the close future (tonight and tomorrow). Distant future and less social pain were correlated with increased activity in right ventrolateral PFC.

Unfortunately, direct comparison of the different distancing techniques seems to be lacking in the overall literature of ER and in almost all cases studying perspective-broadening regulation the instructions how to regulate have been a mixture of both social and temporal distancing. Although sufficient in proving the efficacy in emotion regulation, this approach is not helpful in assessing the stand-alone benefits of either one of the distancing techniques (Bruehlman-Senecal & Ayduk, 2015).

5. Emotion regulation measured by EEG and ERPs

The most prominent benefit of EEG and its event-related aspects as a tool of cognitive neuroscience is its temporal resolution, which as pointed out by Luck (2014), is especially profitable due to being a continuous measure of processes in the brain. In the EEG it is possible to see changes in neuronal activity as a process; from before stimulus onset until the actual ERP component of interest arise and subsequently, post-stimulus processing. To understand emotional processing and how it differs between individuals; the temporal unfolding of emotional reactivity, peak amplitude of response, rise time to peak, as well as recovery time are important factors (Foti, Hajcak, & Dien, 2009). This makes EEG and ERPs a perfect match in the search for answers relating to emotional processing which is reflected in the substantial amount of published studies putting the two together.

5.1. The affective ERP

The current studies utilize the LPP as a measure of the cognitive process of study, as such, it is important to understand the background and some technical aspects of this ERP component. The positive, long latency deflection of the EEG occurring at approximately 300 ms in response to affective pictures is usually referred to as the LPP. The onset is, thus, shared with another well established ERP, the P300, or P3. The classical P3 component usually studied in the oddball-paradigm reflects the allocation of attention following salient stimuli and has been divided into the subcomponents P3a and P3b. The P3b is sensitive to both valence and arousal variation whereas the P3a seems to index more pure attentional processes (Olofsson, Nordin, Sequeira, & Polich, 2008). Principal component analysis suggests that the scalp-recorded P3-LPP complex is a composite by an increased positivity in the time range of P300 as well as slower, later peaking positivities (Dien, Spencer, & Donchin, 2004). When and where the P300 seizes and the LPP starts is not completely evident but the LPP can be considered as the sustained positive complex beginning in but extending well beyond the P300 time-range (Hajcak et al., 2010). LPP amplitude sensitivity to both valence and arousal is established (Schupp, Flaisch, Stockburger, & Junghöfer, 2006) and it has been shown that the emotion-related increases can be moderated by top-down regulatory processes. Put in other words: emotionally elicited processes can be modulated by cognitive control. LPP reflects automatic attention to emotional stimuli, but can also be manipulated through selective attention (Hajcak et al., 2009). Hajcak & Nieuwenhuis, (2006) have shown the LPP to be reduced in response to reinterpreting pictures in a less negative way. Foti and Hajcak (2008) showed attenuated LPPs as unpleasant pictures were preceded by more neutral than negative descriptions, indicating semantic responsivity. Thus, it seems that all necessary components for studying both distraction and reappraisal are present within the LPP. The remaining question is how results could be analyzed and interpreted? The subsequent section will cover previous ERP research of ER which probably will help answer that question.

5.2. Time sequences of the LPP -Temporal dynamics revisited

By studying the surroundings of the LPP and the components time course in its full duration, the unfolding of different processes across time can be investigated. Different reappraisal instructions might not just alter the size of the LPP but also its duration (Hajcak et al., 2010). This relates to a model proposed by Dien et al. (2004) applying stages of information processing progression of the P300 component, from simpler to more complex. In relation to emotional stimuli then, the model ascribes the LPP to signify the degree to which attentional resources are engaged and the strength of the memory trace to be stored (Olofsson et al., 2008). The early portion of the LPP (400-600ms) has been suggested to indicate and reflect the point in time a stimulus is attended to while the following, sustained peak of positivity reflects semantic elaboration (Schupp et al., 2006). Looking at LPP studies of emotion regulation and relating to the early- and late- selection hypothesis, there is some evidence in favor of the idea.

Comparison between distraction and reappraisal has found distraction induced LPP modulations 300 ms post picture onset whereas reappraisal modulated the LPP time course only later, at 700 ms (Paul et al., 2013). This is in line with a preceding study with respect to distraction whereas reappraisal modified the LPP only at 1500 ms (Thiruchselvam et al., 2011). These results confirm conceptualization that distraction targets early attentional stages and reappraisal requires time-consuming semantic processing.

The perspective that self- and situation- focused reappraisal constitutes heterogenous regulation strategies is consolidated in recent research finding LPP differences between the different reappraisals. However, looking at the existing studies comparing the two, there seem to be some discrepancies. Willroth & Hilimire (2016) found situation- focused reappraisal to have a better effect on emotion experiences and also to modulate LPP, an effect the self-focused variant did not achieve. These results are contradicted by another study comparing the two same strategies although referring to them slightly differently (detached vs. positive reappraisal). Qi et al. (2017) found LPP modification by both variants but the detached reappraisal (i.e. social distancing) resulted in earlier and stronger attenuation than the positive reappraisal (i.e. situation focused distancing). Thus, two studies in direct contradiction to each other. Potential explanations centers around the timing aspect, the first study examined LPP during the time span between 300-1000 ms post-stimulus while the latter found the effects no earlier than 900 ms post-stimulus for detached reappraisal and even later (1700 ms) for positive reappraisal. This empirical foundation gives the impression that reliable appraisal modulations of the LPP are to be expected only in the later time span which is also in line with the theoretical view of it as a late selection strategy.

6. Methods

6.1. Objectives and study designs

The empirical studies aim to study ER in a context relevant to the common contemporary human and thus produce results of ecological validity. To serve this goal, stimuli are restricted to human angry facial expressions and neutral expressions in comparison. Faces convey information of the attentional focus and motivational, and emotional state. Facial expressions are important to non-verbal social exchange, marks internal states and signals intentions. In the perspective of the signaling function, the expression can be referred to as threatening (Schupp et al., 2004). In an evolutionary perspective threatening faces are likely to activate the human fear system and demonstrate superior fear conditioning compared to friendly faces (Öhman, 1986; Öhman & Mineka, 2001). Angry faces have previously been studied in relation to LPP and are reflected as augmented amplitudes over centero-parietal sensors compared to neutral faces (Schupp et al., 2004). There are indications that the LPP is sensitive enough to even reflect the *level* of facial affect expression (Duval, Moser, Huppert, & Simons, 2013). However, the present studies are to our knowledge unique in applying these various ER strategies to facial stimuli.

Facial expressions and electrophysiological impressions

In order to asses and compare the efficiency of the different strategies two separate studies were performed. The first study set out to asses the efficiency of the self-focused appraisal strategy of temporal distancing. Conditions were set up to compare the effects of close- compared to distant- future perspectives. The length of each temporal distance was varied in the span of 1 day / 1 week /1 month / 1 year and as comparison trials were conducted where the participants neurally observed the pictures. The paradigm of making comparisons across instances of the same task has been promoted in previous literature since it apart from measuring the relative success of each condition, offers the possibility of comparing process-pure mental processes (Berkman & Lieberman, 2009). The benefit of isolating a specific process is particularly relevant for imaging studies relating to the reverse inference problem. However, in the context of ERPs, we are desiring to use the presence of a specific component as an indicator that the process we are studying is present which is inviting related difficulties (Kappenman & Luck, 2012). Thus, by using this design we allow for a more elaborate analysis of the timing and magnitude of the LPP in relation to ER.

The aims of the temporal distancing study (study 1) are to examine the temporal dynamics of temporal distancing. To asses whether temporal distancing can reliably down-regulate emotion in response to angry facial expressions, and to examine whether the LPP decreases gradually with increasing temporal distance, or which distance is most effective in modulating the LPP.

The strategy comparing study (study 2) compares the emotion regulatory effects of different strategies i.e. distraction, situation- focused distancing, social distancing, and temporal distancing in the distant future perspective of 1 year. The three distancing strategies adhere to the reappraisal type of ER and thus late selection strategies while distraction is an early selection strategy. For comparison, a condition of neutrally observing the pictures was included. The aims of the strategy comparing study are to compare the temporal dynamics of the different ER strategies, i.e. timing of effect onset and maximum effect. A further aim of study 2 includes assessing whether certain strategies are more effective than others in regulating the response to angry facial expressions.

Hypotheses:

The temporal distancing study:

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Temporal distancing should become most effective in later time windows as literature has shown for social distancing.

The further away in the future, the larger the effect on the LPP, i.e. the instruction to reflect upon one's emotions how one would feel about the situation in one year should result in a larger attenuation of the LPP than in one week.

The strategy comparative study:

Distraction should modulate the LPP earlier than the various reappraisals

Self-focused strategies should be characterized by earlier offset than situation-focused reappraisals.

6.2. Experimental and procedural specifics

The two studies were conducted concurrently by two separate teams of students at HIS lab in Skövde during the spring of 2018.

6.2.1. Participants.

Participants of both studies were between 18-40 years old, right-handed and with normal or corrected vision. Dyslexia, current neurological or psychiatric disorders, epilepsy, as well as color blindness all served as exclusion criteria. Study 1 admitted 27 participants and study 2 had 32 participants. Participants were exclusive to their study, meaning none of them took part in both studies.

6.2.2. Measures.

EEG-data was recorded with 34 Ag/Cl electrodes positioned according to the 10/20 placement system, placement was ensured by the positioning by a stretchable electrode cap (g.GAMMAcap). Electrodes positioned on the mastoid positions (right, RM and left, LM) as well as the 4 electrooculogram-electrodes (EOG) utilized adhesive tape made for the specific purpose. EOG electrodes recording blinks and eye-movements were placed approximately 1cm below and above the right eye and at the external canthi of each eye. Cap- electrode sites were: Fz, F1, F2, F7, F8, FCz, FC2, FC1, T7, T8, C3, C4, CP1, CP2, Cpz, Cz, O1, O2, O9, O10, P8, P7, Pz, PO, and Oz. The ground electrode was placed at AFz. During recording, all electrodes were referenced to Cpz, but offline re-referenced to RM and LM.

6.3. Procedure and stimuli

Common to both studies, upon arrival in the lab the participants were presented with a questionnaire (on paper) including the portraits within the study. The purpose of this was to validate the impact of the faces by a rating of valence and arousal on two 9 point manikin Likert scales.

Photographs of adult human faces were also selected from Umeå University Database of Facial Expressions (Samuelsson, Jarnvik, Henningsson, Andersson, & Carlbring, 2012). The included faces (36) showed both an angry and a neutral variant, thus made a total of 72 pictures used as stimuli. Selected faces were evenly distributed across gender and were between 21-55 years of age. The faces were presented pseudo-randomly and each participant performed a total of 432 picture-trials. After study specific ER- instructions a fixation dot appeared on the screen (250 ms) followed by picture presentation conducted in stages (see Figure 3 on the next page). Each photograph was presented during 3,000 ms followed by a jittered postmask with a latency of 700-900 ms. Approximately twice per presentation block but randomly a question relating to the gender of last shown face were shown. The answer was given aided by a gamepad. The purpose of this procedure was to keep participants alert and engaged in the experiment.

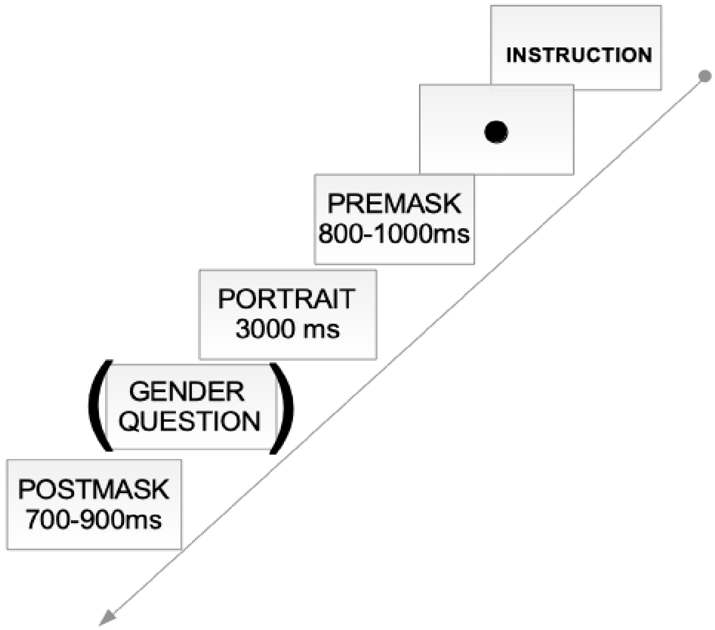

Figure 3: Schematic demonstration of the experiment presentation.

Both studies included practice trials prior to the actual experiment designed to train the participants in applying the strategies and to engage the participants' attention by asking questions to be answered. During the practice, the participants were told that they would use different mental strategies to reduce the emotional impact of the angry faces they were going to see, and the specific regulation instructions were introduced. The portraits used in the training trials were different from those otherwise used in the experiment. The variations in time and ER strategy were presented in a block design, between each block there was a break for relaxation, the participants then used the gamepad to continue when they were ready for next round. The experiment utilized a block design consisting of 12 blocks with 36 pictures per block, the blocks were in randomized order between participants. The reason behind the block-design was the perceived difficulty of rapid recurring shifts that otherwise would have been necessary.

6.3.1. The temporal distancing study.

All in all the study encompassed six conditions of which two represented baseline i.e. passive observation of neutral and angry faces. The instruction presented before each block was identical and as follows: ‘Imagine that you are seeing each person in front of you right now on a public train. Just observe their face.' Subsequent four conditions and eight blocks were preceded by the temporal distancing instruction: ‘Imaging that you are seeing each person in front of you right now on a public train. Their angry face might make you uncomfortable, so imagine that you think to yourself how little their anger will mean to you in 1 Day/ 1 Week/ 1 Month/ 1 Year.' Please apply this strategy after each face is shown, not before.' The conditions were presented twice, pseudo-randomly and the same strategy was never directly repeated.

6.3.2. The strategy comparative study.

The four strategies distraction, situation focused reappraisal, social distancing, and temporal distancing was presented along with the passive observation blocks of both neutral and angry faces. The baseline instruction was identical to the temporal distancing study presented above, for specific phrasing of the different instructions see appendix. For distraction purpose, an image was presented before the instruction. After each block of ER strategy, the participants were asked how successful they were in utilizing the current strategy with the options ‘yes', ‘no', or ‘somewhat'.

6.4. Data processing and analysis

Offline analysis of data was performed by MATLAB v8.5.1.281278 (MathWorks, 2019) using the EEGLAB v13.6.5b (Delorme, & Makeig, 2004) toolbox and ERPs were handled by the ERPLAB v7.0 plugin (Lopez-Calderon, & Luck, 2014). The raw data was downsampled from 512Hz to 256Hz and re-referenced to the average of mastoids. Next, channels containing noise disturbing the remaining set (previously identified by eye) was rejected. A 180th-order stopband notch filter with a cutoff at 50 Hz for line noise was applied to the continuous EEG. As a preprocessing step for removing artifacts with Independent Component Analysis (ICA) the EEG was filtered with a second order Butterworth low-pass filter with a half-power (-3dB) cutoff at 1 and 30 Hz (the higher highpass filter settings are recommended for ICA analysis). Data were segmented into epochs starting 500 ms prior to picture onset and continuing until 3,000 ms post-stimulus. Epochs exceeding three standard deviations above the joint electrode probability activity limits were rejected, after which ICA was run. Multiple Artifact Rejection Algorithm (MARA) was used to automatically identify

ICA components reflecting artifacts (Winkler, Haufe, & Tangermann, 2011). The ICA weights were then transferred back onto the pre-processed, unepoched data (that had only been subjected to the notch filter), and the relevant MARA-detected components were removed from this data. Subsequently, this data was filtered with a second-order Butterworth highpass filter with a half-power (-3dB) cutoff at 0.1 Hz, and was, as before, segmented into epochs of 3500 ms, with 500 ms pre-stimulus baseline and 3000 ms post-stimulus.

LPP was quantified across a cluster of central-parietal electrodes (Cz, CP1, CP2, Cpz, & Pz) and analyzed as mean amplitude between 400-3000 ms as full duration as well as in time windows of 400-800 ms (early), 800-1500 ms (mid), and 1500-3000 ms (late). The P300 component was analyzed as mean amplitude between 250-400 ms. Statistical analysis was performed by IBM SPSS Statistics v. 25. All ANOVAS used is the ‘repeated measures' version and in virtue of using within-subject design, across all ANOVAS of more than two levels of factors the ‘Greenhouse-Geisser' adjustment was used to correct for heterogeneity of covariance among factors (Luck, 2014).

7. Results

7.1. Face ratings

For both studies the rated difference between angry and neutral faces reached statistical significance: In study 1 (N=27) high scores of valence and arousal corresponded to negative valence and high arousal. Angry faces rated higher on arousal (M= 6.8, SD=1.9) than neutral (M=3.6, SD=1.8), and lower on valence (M=2.5, SD=1.2) than neutral (M=5.1, SD=.9). Significance was tested with a t-test = p < .01.

Results of study 2 (N=32) corroborated those of study 1: Angry faces were rated higher for arousal (M=6.2, SD=.8) than neutral (M=3.1, SD=.4) and lower for valence (M=2.4, SD=.5) than neutral (M=4.9, SD=.3) t-test revealed p=<.001. Thus, for both studies, the angry faces were rated more arousing and aversive than their neutral counterparts.

7.2. ERP-data

7.2.1. The temporal distancing study.

The original data from this study was heavily weighted by artifacts resulting in a substantially decimated pool of data (N=16). Eight of the initially inherent EEG-sets were for different reasons excluded prior to preprocessing and three additional were excluded in the process due to the high percentage of rejected trials. Between 0.5-15.4% of trials were rejected from the remaining sets. Despite the careful re-preprocessing of the original raw-data that was carried out, it was obvious at first visual inspection of the LPP that some noise had passed through the filters leaving unwanted residual oscillations in the late section of the LPP. Inspection of individual ERP sets revealed abnormal values in the set that was then excluded post-hoc (N=15).

The P3 wave was quantified finding a slightly higher value for angry faces (M=4.82 SD= 4.90) than neutral (M=4.57 SD=4.38), the t-test verified that there was no significant difference (t=-.61 P=.55) between the two conditions.

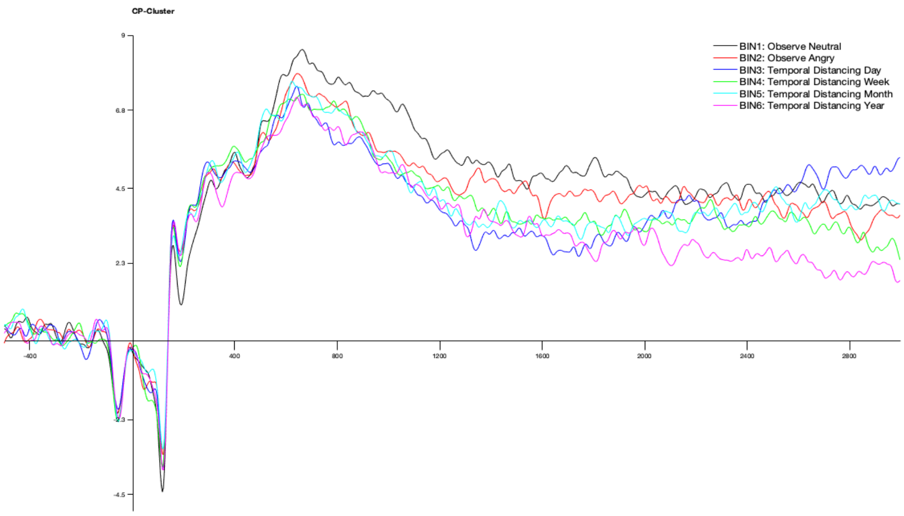

Figure 4: LPP of the different conditions in study 1.

Initially, an ANOVA was run to comparing the LPPs for the entire length indicating no significance (F=1.24 P=.31). Next, the LPP was segmented into the early, mid and late part and a 3 (LPP-stage) x4 (TD-condition) level ANOVA was performed indicating no significant interaction (F=1.47 P=.24) and no significant main effect for condition (F=.28 P=.77).

7.2.2. The strategy comparative study.

The data from this study survived the processing steps to a higher degree (N=24) than prior study, the remaining set suffered between 1.2-49.1% rejected trials. By early visual inspection of the plotted LPP, it was evident that something unexpected had interfered with t

the intended control condition of observe-neutral. Because of this aberration, an analysis of the P3 was calculated between the conditions of passive observation of neutral (M=4.12 SD=4.56) and angry faces (M=4.00 SD=4.44). Analysis performed by a paired sample t-test, the results showed no significant difference (t=.251 P=.80).

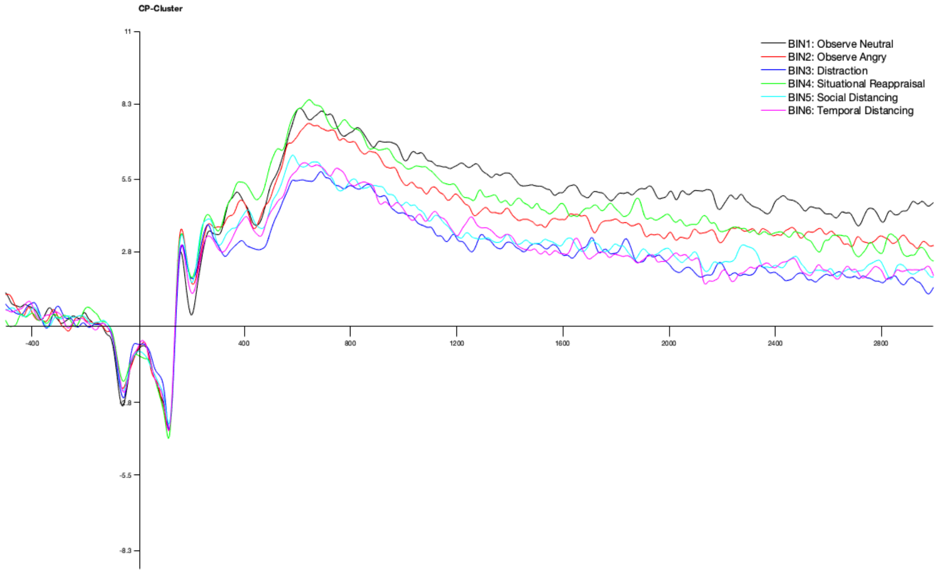

Figure 5: LPP of the different conditions in study 2.

Initial analysis of the LPP focused on the full duration (400-3000ms), it was compared across the conditions by a repeated measures ANOVA with instruction-type as within-subject factor revealing a significant main effect of instruction type: F =5.93 P= <.001 (Fischer's LSD). Pairwise comparisons depicted in table 1 (continued on next page).

Table 1: Significant (LSD) pairwise comparisons of mean amplitude 400-3000 ms LPP**.**

Pair:	P =Fischer's LSD (std err.)	P=Bonferroni (std err.)
Observe neutral - Distraction	P = .001 (.612)	P= .011 (.612)
Observe neutral – Social distancing	P = .003 (.598)	P= 1.00 (.519)
Observe neutral – Temporal distancing	P = <.001 (.446)	P = .039 (.598)
Observe angry - Distraction	P = .037 (.446)	P = .548 (.614)
Observe angry – Social distancing	P = .044 (.473)	P = .658 (.678)
Observe angry – Temporal distancing	P = .006 (.381)	P = .096 (.473)

Pair:	P =Fischer's LSD (std err.)	P=Bonferroni (std err.)
Distraction – Situational reappraisal	P = .022 (.612)	P = .327 (.612)

The early time-window of the LPP significantly differed between distraction and situational reappraisal, situational reappraisal and social distancing, and situational reappraisal and temporal distancing. Results of pairwise t-test within table 2.

Table 2: Significant (LSD) pairwise comparisons of the early-time window of the LPP.

Pair:	P =Fischer's LSD (std err.)	P=Bonferroni (std err.)
Distraction – Situational reappraisal	P = .001 (.512)	P = .003 (.512)
Situational reappraisal – Social distancing	P = .014 (.546)	P = .82 (.546)
Situational reappraisal - Temporal distancing	P = .002 (.454)	P = .013 (.454)

In order to further compare the LPP it was quantified and measured in the same manner as in study 1: 3 x 4 level ANOVA indicated no significant interaction (P=.620) but a significant main effect for instruction F= 4.595 P= .012.

8. Discussion

8.1. The temporal distancing study

Based on the current data it is hard to answer any of the hypotheses of the first study. It is not just that the obtained LPPs are almost identical between the various temporal distances and the control conditions, reflected both in the visual wave of the LPP and in the statistics comparing its measurements. The small subset of participants left due to inherited problems of the online EEG-setting is problematic. We are, unfortunately in the situation where it is hard to say whether existing differences just happen to be invisible due to a very small sample, leaving us with a high risk of making a type II-error. Measurements of the obtained LPP do show that it is attenuated with time but this is expected as the voltage of the electrical activity wear out, and the corresponding slope is seen in both the passive observe conditions. Due to the lack of pronounced difference among any of the conditions, it is impossible to say how the ER strategy has affected the LPP. In the situation of having more data in a better state remaining after processing it would have been interesting to compare the LPPs of varying the temporal distance to the other types from the strategy comparative study in order to analyze the LPP resulting from different emotional regulation processes. The interesting thing about the design of the temporal distancing study is that the various conditions utilize the same cognitive, and probably neural, process. From what is possible to see in the LPPs (regardless of small sample issues) the effects are almost identical in the first 2000 ms poststimulus. Interestingly, and perhaps vaguely supporting both hypotheses, the 'year' condition is more strongly attenuated in the 2000-3000 ms phase than remaining conditions.

It could be that the design of the temporal distancing study would have profited from using stimuli of higher aversion rate such as IAPS-pictures to obtain a more robust LPP in response to salience. In the current situation, there is a possibility that the emotional response of the stimuli is to discrete to give the hypothetical, probably very small, differences among the TD conditions a chance to diverge, even if the sample would have been appropriate. Perhaps the differences are too small to be measured by EEG in the first place or perhaps the necessity of filtering the data due to noise cancel out interesting changes. Any of these options are possibilities, however impossible to make any hard conclusions about looking at the results from the current data.

8.2. The strategy comparative study

In relation to the first hypothesis, that distraction should modulate the LPP earlier than the various reappraisals, the analysis of the early time window resulted in significance only between distraction and situational reappraisal. By close visual inspection of the LPP, it does appear that the distract condition is earlier than the self-focused reappraisals as well in attenuating the waveform in the approximately 300-800 ms phase. This is, however, a very small difference. The findings of this study thus suggest that distraction modulates the LPP earlier than situational reappraisal and on a trend level this seems to apply also to the two self-focused distancing techniques. Previous findings (McRae et al., 2010; Paul et al., 2013; Schönfelder et al., 2013; Thiruchselvam et al., 2011) show more robust early LPP modulations for distraction compared to self-focused appraisal strategies lending support to the dichotomy of early-late selection strategies, so how come our results are not corroborating? The main factor differing between the current study and the preceding ones is the category of pictures used as stimuli. Though providing ecological validity and the framing of social emotionality, it is probably also true that the IAPS pictures offer a stronger emotional response than pictures demonstrating an angry face. The more pronounced LPP effects of emotional scenes compared to faces has been demonstrated in a previous study (Thom et al., 2014). The results of their comparison of LPPs elicited from emotional scenes versus faces demonstrate significantly less LPP-difference in the responses to facial stimuli than in response to emotional scenes, such as IAPS-pictures. The low LPP response to facial stimuli in Thom et al. (2014) might be affected by the fact that both faces and scenes were mixed within the study reflecting the arousal systems use of context-specific cues to determine the range of arousal. LPP effects in response to facial expressions and emotional scenes need to be further examined in order to fully understand contextual sensitivity and interactions of different types of stimuli.

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Since many ER-studies have used IAPS-pictures, and these probably also are more arousing and have a more pronounced valence, these studies might have evoked a stronger emotional response. It could be that the more pronounced effects obtained by distraction compared to self-focused distancing in previous studies are explained by the stronger emotional reaction to the stimuli. Within this context though, the results of two studies into the ERPs of emotional face processing reviewed by Eimer and Holmes (2007) is relevant. The results of these two studies demonstrate that emotional faces trigger an increased positivity compared to neutral but much earlier than the traditionally measured LPP. This effect of emotional faces had onset as early as 120 to 180 ms post-stimulus and was measured at frontocentral sites. The origin of this positivity is discussed to probably arise from a neocortical system where representations of emotional content are task-dependently generated for control of behavior. The system is suggested to be activated in parallel with the ongoing evaluation of emotional content in subcortical circuits related to the amygdala. Thus, literature can somewhat support the conclusion that emotional faces have an emotional impact but that this impact, maybe varying on some arousal threshold, may or may not activate the more general emotion generation circuitry commonly measured by the LPP.

The second hypothesis of the strategy comparing study concerned the probably earlier onset of self-focused strategies compared to situation-focused. By visual inspection and fairly generous use of statistics both of the self-focused strategies have an earlier effect onset than the situation-focused. Strictly interpreted, it is only compared to temporal distancing that the test reaches statistical significance but in regard to the fairly small sample size (<30) the results could be offered some charitability. However, compared to previously conducted comparisons between self- and situation- focused reappraisals the current results show an unaffected LPP effect in response to situational reappraisal. Qi et al. (2017) also found greater, and earlier attenuation in response to self-focused than situation-focused reappraisal though their situation-effect was more robust than ours.

The study by Willroth and Hilimire (2016) had the direct opposite results compared to our study since LPP was modified by situation-focused appraisal but not self-focused. They analyzed a time window of the LPP between 300-1000 ms and used IAPS-pictures as stimuli. The stimuli are, thus, common to the study of Qi et al. (2017), the time-window though, is not. The small effect of situation-focused reappraisal in down-regulating negative emotion was found only in 1700 ms poststimulus in the latter study, while self-focused modified the LPP at 900 ms. Because the stimuli used in both these studies differ contentwise from what was used in our study, direct comparison suffers from inadequacy. From the faint effect we can see in the LPP of situational reappraisal in our study though, the attenuating effect takes time. At the end of our late time-window, the LPP in response to situational reappraisal has a slightly lower amplitude than passive observation of angry faces.

It is possible that the explanation behind differences between our and previous studied could be due to the stimulus material, or it could be due to the specific task relevant to the condition. Situation-focused reappraisal, or as it is referred to by Qi et al. (2017), positive reappraisal is a fairly broad term in the respect that a situation can be reinterpreted in many different ways, probably inferring different cognitive, and possibly neural, processes. The engagement-factor, emphasized by Sheppes (2014), is a good candidate to explain differences between self- and situation- focus, and also a hint that there might very well be differing neural processes involved within different reappraising techniques. Engagement level with the stimuli material can, of course, also serve as a possible confounding variable. If situation-focusing reappraisal induces a higher rate of engagement with the stimuli, it could explain both an earlier offset as well as a more robust LPP modulation of the self-focused distancing strategies. It is possible that the situation-focused instruction in our study prompted a high level of engagement with the angry face, especially since the instruction emphasized the emotional experience of that person (see appendix). Unfortunately, there is no general habit of in detail describe what instructions participants have been given for each condition within the ER research, why it is impossible to know what kind of specific operations that have occupied the participants' mind during the various reappraisal studies.

8.2.1. The amplitude of the observe neutral condition.

It was expected based on prior research that the LPP would be attenuated in response to the observe-neutral condition as compared to the observe-angry condition, depicting the LPP response to emotionally salient stimuli. This effect, though, seems absent in our data. What we see instead is that the LPP in response to neutral faces actually has a higher amplitude than the LPP in response to the passive view of angry faces. The reason behind looking at the P3 wave of the two passive watch conditions was that the number of neutral faces was less than the angry ones. It was thus suspected that there could be a sort of ‘oddball' effect with respect to the neutral stimuli. If this was the case it would have been expected that the P3 should have had a higher amplitude in response to the neutral faces than the angry, but this was not the case. The difference between the two conditions in the P3 time window is negligible but grows with the lapse of the LPP.

Further on in the process of data analysis, the discovery of the results of the study of Thom et al. (2014) offered some release to our puzzling results of higher LPP amplitudes in response to neutral than angry faces. This particular effect is present also in their ERP comparison of emotional stimuli. The higher amplitude of neutral compared to angry faces was observed both for the LPP, and for another component often analyzed in affective neuroscience studies, the early posterior negativity (EPN). The only component with the opposite pattern (higher amplitude for angry) was the early visual face-sensitive N170. In contrast, the expected effect, higher amplitude for pictures of emotional valence, was present for the LPP in response to emotional scenes. Even though not explaining why, this indicates that our results could reflect an actual phenomenon rather than something funky in our recording. It also implicate that the condition of passive view of neutral faces might not serve a very good comparison in our studies.

Another aspect is that it is probable that face perception is guided by affective and contextual variables. Neutral faces are processed differently neurally depending on the context in which they were first presented (Wieser et al., 2014). The fact that our study was based on pairs of faces, the same person but one picture of each expression, could possibly have affected the processing of the neutral faces. In a magnetoencephalography (MEG) study, it was shown that faces paired only once with positive or negative contextual information are processed differently by the brain (Morel, Beaucousin, Perrin, & George, 2012). Stimuli processing could also have been influenced by the fact that the angry, but not the neutral, faces were repeatedly presented together with an instruction to down-regulate the emotional response. This pairing could perhaps result in an unintentional down-regulation of the response to angry faces even in the passive watch conditions.

8.3. The self-referential aspect of neural processing

A growing body of cognitive neuroscience of self-referentiality, the level of which stimuli are experienced as strongly related to one's own body, suggests that this type of information might be distinctly processed by the brain. Northoff et al. (2006) suggest a cortical-subcortical midline system integrating bodily and sensory information important to oneself relative to others. Through dense reciprocal connections via e.g. the periaqueductal grey and the stria terminalis this system could reach through various cortical areas. If there is such a system it could be responsible for facilitated processing and emotional regulation by engaging functional networks through established routes. It is feasible especially with the focus on social emotion that regulation is easier to achieve using cognitive models of related processing rather than shifting to cognitions about external factors. In comparison to the engagement-factor of stimuli, self-referentiality is relevant in the sense that stimuli with high self-referentiality should be considered as more engaging than stimuli of low self-referentiality.

There is a connection between TD and what is referred to as ‘mental time-travel', much research has been going on related to this, imagination, and episodic memory (see for example Addis, Wong, & Schacter, 2007; Schacter, Addis, & Buckner, 2007). It was found that the neural system active in the mental time-travel (medial PFC, medial temporal lobe, lateral temporal lobe and cortex, lateral parietal cortex, and precuneus) also corresponded to ‘the default mode network', a functional unit discovered through and active in relaxed non-task states (Raichle, 2015). Beyond discussing neural modules, when it comes to complex psychological concepts and constructs, the paradigm of functional connectivity is indeed interesting. Moser et al. (2017) enabled ER through a linguistic route (third-person self-talk), by-passing the classical cognitive control areas in frontoparietal sections and without observing amygdala modulation in the fMRI-part of the study. So it seems that it is possible to access ER through multiple mechanisms, and probably, neural processing routes. Perhaps by further exploration of self-referential processing as a cohesive mechanism of subjective experiences, new contexture could be found in the messy biology of human emotional life.

8.4. Strategy-choice implications pertaining to interpersonal emotion

In completely speculative terms, it could be that in order to regulate social emotion it is more efficient to use strategies drawing on closely related processing. Following the raw implications of the current data, these results indicate that situation-focused reappraisal isn't the best choice of ER strategy to down-regulate negative interpersonal emotion. In a wider context, it has been indicated that distraction could lead to an emotional rebound upon re-exposure in contrast to reappraisal strategies (Thiruchselvam et al., 2011). Qi et al. (2017) found attenuation of the LPP in response to self-focused distancing in their re-exposure task, an effect absent for the situation-focused variant. Thus, overall, if any type of strategy should be recommended to handle negative emotion in a social context, the self-

focused reappraisals, also referred to as distancing would be preferred. Both due to a higher effectivity but also due to seemingly higher adaptability.

8.5. Methodological concerns derived from the current work

The modulation of the sustained LPP by motivational demands of affective content have been established and serves a foundation for the present studies. However, it has also been demonstrated that the extended duration of the LPP (1000-2000 ms) can be modulated by task-relevant means. Thus, provided that the task requires persistent motivated attentional processing, task-relevant stimuli of non-emotional nature might give similar LPP results (Gable & Adams, 2013). This suggests that non-emotional motivational processes could underlie the LPP modulations seen in our studies since we did not control for this factor. The fact that we used instructions employing a significant dose of imagination might highlight this possibility in comparison to a situation where participants just had the pictures displayed to them. It is interesting though, even within this context, that our ER strategies had such diverse effects. It is possible to argue that the strategies might have effects, by different means, to any kind of motivational processing whether emotional or not. A lingering question, however, would be if it really matters then, how the processing is framed - emotional or not - as long as the strategies employed to impact what goes on in the mind actually does.

8.5.1. Angry faces as stimuli.

Two studies of the neural processing of facial emotion (Eimer & Holmes, 2002; Eimer, Holmes, & McGlone, 2003) also begs the question if the LPP as measured both in time and space really captures the processing of emotional faces. It does, in fact, seem that processing of emotion expressing faces is relevant to social emotion. Though, whether these evoke enough emotional valence to impact the LPP as traditionally measured might be in question. There also seems to be an ongoing dispute whether facial expressions really are objects of facilitated processing, i.e.that they are processed automatically by the brain outside of attentional control (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Shupp et al., 2004). If, as some argue, attention is a necessity for neural processing of facial expressions, angry faces might serve a bad candidate as stimuli in ER studies. This is because attention, at least partially, is focused somewhere else than directly and fully to the stimuli. Implications for future studies is twofold, first, in relation to studying emotion as traditionally measured by the LPP, emotional faces might not be the best stimuli material. Additionally, controlling for task-relevance related modulation of the LPP no matter what stimuli are used is important in any ER study. Perhaps even more so if and when relative low-level valence stimuli are used. Second, if the aim is to study social emotion, or more specific, the neural processing of emotion conveyed by facial expression, other ERP signatures than the LPP could be of great importance. Further, exploration of the effect of a possible facial emotion processing network located in neocortex described by Eimer and Holmes (2007) and its interconnections with the subcortical emotion processing structures would be very interesting.

9. Lasting impressions and direction of future research

Emotional regulation is indeed a promising avenue of research within cognitive neuroscience. There are numerous interesting processes and phenomena to examine and describe in neuro-cognitive terms. The various emotional regulation- and appraisal- strategies tap into several broadly relevant topics such as self-referentiality, conscious awareness, subjective experience, and engagement with emotional stimuli. Beyond the philosophical and scientific inquiry of how the brain enables these faculties of the mind, there are actual hands-on gains of studying these psychological processes in order to understand functions and dysfunctions of emotional -experience and -regulation and how these are related to the brain.

Besides the LPP there are other ERP signatures of interest to ER such as the EPN. However, primary to exploring more measures of ER, the need to specify explanandum and instrumentation is obvious. Specification of in which context emotionality is studied needs to be provided in order to bring conceptual clarification to this branch of science. As the neuro-affective science still seem to be in its infancy; so seem the ER strategies, still in lack clarity of definition and conceptual consensus. In order to further distinguish neural processes and examine mechanisms of emotion generation and regulation, the concepts need specification and elaboration of definitions.

Based on the results, or perhaps more correctly put, lack of results it would be interesting to replicate the temporal distancing study, perhaps with some adjustments to the stimuli in order to find a more robust emotional LPP effect. It would surely gain insight to study LPP, and perhaps other emotionally sensitive ERPs, in response to scenes and faces in an experimental design both allowing and not allowing interactional effects. The difference between situation-focused reappraisal and distancing techniques we found would also be immensely interesting to look further into. Careful experimental design and consideration of the information and instructions given to participants could result in expanded knowledge of the affective ERPs in response to social-emotional stimuli. These ERPs might make important contributions to the fundamental knowledge of neural mechanisms underlying various cognitive operations aiming to process, and regulate emotion.

References:

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, *45*(7), 1363–1377.

Berkman, E. T., & Lieberman, M. D. (2009). Using Neuroscience to Broaden Emotion Regulation: Theoretical and Methodological Considerations. *Social and Personality Psychology Compass*, *3*(4), 475–493. https://doi.org/10.1111/j.1751-9004.2009.00186.x

Bruehlman-Senecal, E., & Ayduk, O. (2015). This too shall pass: Temporal distance and the regulation of emotional distress. *Journal of Personality and Social Psychology*, *108*(2), 356–375. https://doi.org/10.1037/a0038324

Carver, C. S., & Scheier, M. F. (1994). Situational coping and coping dispositions in a stressful transaction. *Journal of Personality and Social Psychology*, *66*(1), 184–195. https://doi.org/10.1037/0022-3514.66.1.184

Dien, J., Spencer, K. M., & Donchin, E. (2004). Parsing the late positive complex: mental chronometry and the ERP components that inhabit the neighborhood of the P300. *Psychophysiology*, *41*(5), 665–678.

Duval, E. R., Moser, J. S., Huppert, J. D., & Simons, R. F. (2013). What's in a Face?. *Journal of Psychophysiology*.

Eimer, M., & Holmes, A. (2002). An ERP study on the time course of emotional face processing. *Neuroreport*, *13*(4), 427-431

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia*, *45*(1), 15-31.

Eimer, M., Holmes, A., & McGlone, F. P. (2003). The role of spatial attention in the processing of facial expression: an ERP study of rapid brain responses to six basic emotions. *Cognitive, Affective, & Behavioral Neuroscience*, *3*(2), 97-110.

Ekman, P. (1972). Universal and cultural differences in facial expression of emotion. *Nebraska Symposium on Motivation*, *19*, 207–284.

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion*, *6*(3–4), 169–200.

Ekman, P. E., & Davidson, R. J. (1994). *The nature of emotion: Fundamental questions.* Oxford University Press.

Etkin, A., Büchel, C., & Gross, J. J. (2015). The neural bases of emotion regulation. *Nature Reviews Neuroscience*, *16*(11), 693–700. https://doi.org/10.1038/nrn4044

Foti, D., & Hajcak, G. (2008). Deconstructing reappraisal: descriptions preceding arousing pictures modulate the subsequent neural response. *Journal of Cognitive Neuroscience*, *20*(6), 977–988.

Foti, D., Hajcak, G., & Dien, J. (2009). Differentiating neural responses to emotional pictures: evidence from temporal-spatial PCA. *Psychophysiology*, *46*(3), 521–530.

Frijda, N. H. (1986). *The emotions*. Cambridge University Press.

Gable, P. A., & Adams, D. L. (2013). Nonaffective motivation modulates the sustained LPP (1,000–2,000 ms). *Psychophysiology*, *50*(12), 1251-1254.

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, *26*(1), 1–26.

Gross, J. J., Sheppes, G., & Urry, H. L. (2011). Cognition and Emotion Lecture at the 2010 SPSP Emotion Preconference: Emotion generation and emotion regulation: A distinction we should make (carefully). *Cognition & Emotion*, *25*(5), 765–781. https://doi.org/10.1080/02699931.2011.555753

Gross, J. J., & Thompson, R. A. (2007). Emotion Regulation: Conceptual Foundations. In *Handbook of emotion regulation* (pp. 3–24). New York, NY, US: The Guilford Press.

Gusnard, D. A., Akbudak, E., Shulman, G. L., & Raichle, M. E. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. *Proceedings of the National Academy of Sciences*, *98*(7), 4259–4264. https://doi.org/10.1073/pnas.071043098

Hajcak, G., Dunning, J. P., & Foti, D. (2009). Motivated and controlled attention to emotion: Time-course of the late positive potential. *Clinical Neurophysiology*, *120*(3), 505–510. https://doi.org/10.1016/j.clinph.2008.11.028

Hajcak, G., MacNamara, A., & Olvet, D. M. (2010). Event-related potentials, emotion, and emotion regulation: an integrative review. *Developmental Neuropsychology*, *35*(2), 129–155. https://doi.org/10.1080/87565640903526504

Hajcak, G., & Nieuwenhuis, S. (2006). Reappraisal modulates the electrocortical response to unpleasant pictures. *Cognitive, Affective, & Behavioral Neuroscience*, *6*(4), 291–297.

Hofmann, S. G., Heering, S., Sawyer, A. T., & Asnaani, A. (2009). How to Handle Anxiety: The Effects of Reappraisal, Acceptance, and Suppression Strategies on Anxious Arousal. *Behaviour Research and Therapy*, *47*(5), 389–394. https://doi.org/10.1016/j.brat.2009.02.010

James, W. (1890). The principles of. *Psychology*, *2*, 94.

James, W. (2009, March 13). The Principles of Psychology [Text]. Retrieved April 26, 2019, from http://ebooks.adelaide.edu.au/j/james/william/principles/

Kanske, P., Heissler, J., Schönfelder, S., Bongers, A., & Wessa, M. (2011). How to Regulate Emotion? Neural Networks for Reappraisal and Distraction. *Cerebral Cortex*, *21*(6), 1379–1388. https://doi.org/10.1093/cercor/bhq216

Kappenman, E. S., & Luck, S. J. (2012). ERP components: The ups and downs of brainwave recordings. *The Oxford Handbook of Event-Related Potential Components*, 3–30.

Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding the Self? An Event-Related fMRI Study. *Journal of Cognitive Neuroscience*, *14*(5), 785–794. https://doi.org/10.1162/08989290260138672

Kim, S. H., & Hamann, S. (2012). The effect of cognitive reappraisal on physiological reactivity and emotional memory. *International Journal of Psychophysiology*, *83*(3), 348–356. https://doi.org/10.1016/j.ijpsycho.2011.12.001

Koenigsberg, H. W., Fan, J., Ochsner, K. N., Liu, X., Guise, K., Pizzarello, S., … Siever, L. J. (2010). Neural Correlates of Using Distancing to Regulate Emotional Responses to Social Situations. *Neuropsychologia*, *48*(6), 1813–1822. https://doi.org/10.1016/j.neuropsychologia.2010.03.002

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology*, *84*(3), 394–421. https://doi.org/10.1016/j.biopsycho.2010.03.010

Kudinova, A. Y., Owens, M., Burkhouse, K. L., Barretto, K. M., Bonanno, G. A., & Gibb, B. E. (2016). Differences in emotion modulation using cognitive reappraisal in individuals with and without suicidal ideation: An ERP study. *Cognition and Emotion*, *30*(5), 999–1007. https://doi.org/10.1080/02699931.2015.1036841

Lang, P. J., & Bradley, M. M. (2010). Emotion and the motivational brain. *Biological Psychology*, *84*(3), 437–450. https://doi.org/10.1016/j.biopsycho.2009.10.007

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer publishing company.

LeDoux, J. E. (1993). Emotional memory systems in the brain. *Behavioural Brain Research*, *58*(1), 69–79. https://doi.org/10.1016/0166-4328(93)90091-4

LeDoux, J. E. (1995). Emotion: Clues from the brain. *Annual Review of Psychology*, *46*(1), 209. https://doi.org/10.1146/annurev.ps.46.020195.001233

Levenson, R. W. (1992). Autonomic Nervous System Differences among Emotions. *Psychological Science*, *3*(1), 23–27. https://doi.org/10.1111/j.1467-9280.1992.tb00251.x

Luck, S. J. (2014). *An introduction to the event-related potential technique*. MIT press.

MacLean, P. D. (1949). Psychosomatic disease and the" visceral brain"; recent developments bearing on the Papez theory of emotion. *Psychosomatic Medicine*.

MacLean, P. D. (1952). Some psychiatric implications of physiological studies on frontotemporal portion of limbic system (visceral brain). *Electroencephalography & Clinical Neurophysiology*.

McRae, K., Ciesielski, B. G., & Gross, J. J. (2012). Unpacking cognitive reappraisal: goals, tactics, and outcomes. *Emotion*, *12*(2), 250–255. https://doi.org/10.1037/a0026351

McRae, K., Hughes, B., Chopra, S., Gabrieli, J. D. E., Gross, J. J., & Ochsner, K. N. (2010). The Neural Bases of Distraction and Reappraisal. *Journal of Cognitive Neuroscience*, *22*(2), 248–262. https://doi.org/10.1162/jocn.2009.21243

Meyer, B., Pilkonis, P. A., & Beevers, C. G. (2004). What's in a (Neutral) Face? Personality Disorders, Attachment Styles, and the Appraisal of Ambiguous Social Cues. *Journal of Personality Disorders*, *18*(4), 320–336. https://doi.org/10.1521/pedi.2004.18.4.320

Meyer, J., & Shean, G. (2006). Social-Cognitive Functioning and Schizotypal Characteristics. *The Journal of Psychology*, *140*(3), 199–207. https://doi.org/10.3200/JRLP.140.3.199-207

Morel, S., Beaucousin, V., Perrin, M., & George, N. (2012). Very early modulation of brain responses to neutral faces by a single prior association with an emotional context: evidence from MEG. *Neuroimage*, *61*(4), 1461-1470.

Moser, J. S., Dougherty, A., Mattson, W. I., Katz, B., Moran, T. P., Guevarra, D., … Kross, E. (2017). Third-person self-talk facilitates emotion regulation without engaging cognitive control: Converging evidence from ERP and fMRI. *Scientific Reports*, *7*(1), 4519. https://doi.org/10.1038/s41598-017-04047-3

Moser, J. S., Krompinger, J. W., Dietz, J., & Simons, R. F. (2009). Electrophysiological correlates of decreasing and increasing emotional responses to unpleasant pictures. *Psychophysiology*, *46*(1), 17–27.

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain—A meta-analysis of imaging studies on the self. *NeuroImage*, *31*(1), 440–457. https://doi.org/10.1016/j.neuroimage.2005.12.002

Ochsner, K., & Gross, J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*(5), 242–249. https://doi.org/10.1016/j.tics.2005.03.010

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking Feelings: An fMRI Study of the Cognitive Regulation of Emotion. *Journal of Cognitive Neuroscience*, *14*(8), 1215–1229. https://doi.org/10.1162/089892902760807212

Ochsner, K. N., & Gross, J. J. (2008). Cognitive Emotion Regulation: Insights from Social Cognitive and Affective Neuroscience. *Current Directions in Psychological Science*, *17*(2), 153–158. https://doi.org/10.1111/j.1467-8721.2008.00566.x

Ochsner, K. N., Ray, R. D., Cooper, J. C., Robertson, E. R., Chopra, S., Gabrieli, J. D. E., & Gross, J. J. (2004). For better or for worse: neural systems supporting the cognitive down- and up-regulation of negative emotion. *NeuroImage*, *23*(2), 483–499. https://doi.org/10.1016/j.neuroimage.2004.06.030

Ochsner, K. N., Silvers, J. A., & Buhle, J. T. (2012). Functional imaging studies of emotion regulation: A synthetic review and evolving model of the cognitive control of emotion. *Annals of the New York Academy of Sciences*, *1251*, E1-24. https://doi.org/10.1111/j.1749-6632.2012.06751.x

Öhman, A. (1986). Face the beast and fear the face: Animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology*, *23*(2), 123–145.

Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychological Review*, *108*(3), 483.

Olofsson, J. K., Nordin, S., Sequeira, H., & Polich, J. (2008). Affective picture processing: an integrative review of ERP findings. *Biological Psychology*, *77*(3), 247–265.

Paul, S., Simon, D., Kniesche, R., Kathmann, N., & Endrass, T. (2013). Timing effects of antecedent- and response-focused emotion regulation strategies. *Biological Psychology*, *94*(1), 136–142. https://doi.org/10.1016/j.biopsycho.2013.05.019

Pessoa, L., McKenna, M., Gutierrez, E., & Ungerleider, L. G. (2002). Neural processing of emotional faces requires attention. *Proceedings of the National Academy of Sciences*, *99*(17), 11458-11463.

Phillips, M., Ladouceur, C., & Drevets, W. (2008). A neural model of voluntary and automatic emotion regulation: implications for understanding the pathophysiology and neurodevelopment of bipolar disorder. *Molecular Psychiatry*, *13*(9), 829–857. https://doi.org/10.1038/mp.2008.65

Qi, S., Li, Y., Tang, X., Zeng, Q., Diao, L., Li, X., … Hu, W. (2017). The temporal dynamics of detached versus positive reappraisal: An ERP study. *Cognitive, Affective, & Behavioral Neuroscience*, *17*(3), 516–527. https://doi.org/10.3758/s13415-016-0494-4

Raichle, M. E. (2015). The Brain's Default Mode Network. *Annual Review of Neuroscience*, *38*(1), 433–447. https://doi.org/10.1146/annurev-neuro-071013-014030

Ray, R. D., McRae, K., Ochsner, K. N., & Gross, J. J. (2010). Cognitive Reappraisal of Negative Affect: Converging Evidence From EMG and Self-Report. *Emotion (Washington, D.C.)*, *10*(4), 587–592. https://doi.org/10.1037/a0019015

Samuelsson, H., Jarnvik, K., Henningsson, H., Andersson, J., & Carlbring, P. (2012). The Ume\a a university database of facial expressions: a validation study. *Journal of Medical Internet Research*, *14*(5), e136.

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience*, *8*(9), 657.

Schönfelder, S., Kanske, P., Heissler, J., & Wessa, M. (2013). Time course of emotion-related responding during distraction and reappraisal. *Social Cognitive and Affective Neuroscience*, *9*(9), 1310–1319.

Schupp, H. T., Flaisch, T., Stockburger, J., & Junghöfer, M. (2006). Emotion and attention: event-related brain potential studies. *Progress in Brain Research*, *156*, 31–51.

Schupp, H. T., Öhman, A., Junghöfer, M., Weike, A. I., Stockburger, J., & Hamm, A. O. (2004). The facilitated processing of threatening faces: an ERP analysis. *Emotion*, *4*(2), 189.

Seminowicz, D. A., & Davis, K. D. (2006). Interactions of pain intensity and cognitive load: the brain stays on task. *Cerebral Cortex*, *17*(6), 1412–1422.

Sheppes, G. (2014). Emotion regulation choice: theory and findings. *Handbook of Emotion Regulation*, *2*, 126–139.

Sheppes, G., & Gross, J. J. (2011). Is timing everything? Temporal considerations in emotion regulation. *Personality and Social Psychology Review*, *15*(4), 319–331.

Sheppes, G., & Gross, J. J. (2012). Emotion regulation effectiveness: what works when. *Handbook of Psychology, Second Edition*, *5*.

Speisman, J. C., Lazarus, R. S., Mordkoff, A., & Davison, L. (1964). Experimental reduction of stress based on ego-defense theory. *The Journal of Abnormal and Social Psychology*, *68*(4), 367.

Thiruchselvam, R., Blechert, J., Sheppes, G., Rydstrom, A., & Gross, J. J. (2011). The temporal dynamics of emotion regulation: An EEG study of distraction and reappraisal. *Biological Psychology*, *87*(1), 84–92.

Thom, N., Knight, J., Dishman, R., Sabatinelli, D., Johnson, D. C., & Clementz, B. (2014). Emotional scenes elicit more pronounced self-reported emotional experience and greater EPN and LPP modulation when compared to emotional faces. *Cognitive, Affective, & Behavioral Neuroscience*, *14*(2), 849–860. https://doi.org/10.3758/s13415-013-0225-z

Willroth, E. C., & Hilimire, M. R. (2016). Differential effects of self- and situation-focused reappraisal. *Emotion*, *16*(4), 468–474. https://doi.org/10.1037/emo0000139

Yanagisawa, K., Masui, K., Furutani, K., Nomura, M., Yoshida, H., & Ura, M. (2011). Temporal distance insulates against immediate social pain: An NIRS study of social exclusion. *Social Neuroscience*, *6*(4), 377–387. https://doi.org/10.1080/17470919.2011.559127

Zilverstand, A., Parvaz, M. A., & Goldstein, R. Z. (2017). Neuroimaging cognitive reappraisal in clinical populations to define neural targets for enhancing emotion regulation. A systematic review. *NeuroImage*, *151*, 105. https://doi.org/10.1016/j.neuroimage.2016.06.009

Appendix

The experimental instructions of the strategy comparative study (study 2) are stated here. First the general instruction and then the condition-specific instructions.

‘Imagine that you are seeing each person in front of you right now on a public train. Their angry face might make you uncomfortable, so instead of focusing on their face, try to mentally focus on remembering the image you just saw instead, without looking away from their face'. The first sentence about imagining the train was repeated for every condition but the second sentence varied.

The situation focused reappraisal instruction: ‘Their angry face might make you uncomfortable, so imagine that you think that they will realize that they overreacted, and will get over it soon and be happy instead.'

Social distancing instructions: ‘Their angry face might make you uncomfortable, so imagine that 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.'

Temporal distancing instruction: ‘Their angry face might make you uncomfortable, so imagine that you would think to yourself how little their anger will mean to you in 1 year.’

All ER instructions ended with: ‘Please apply this strategy after each face is shown, not before.’