TEMPORAL DYNAMICS OF EMOTION REGULATION STRATEGIES: AN ERP STUDY

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Abstract

Distraction and cognitive reappraisal are two widely used types of emotional regulation strategies that are thought to be reliable when down-regulating our emotions to negative or unpleasant stimuli. Gross’s process model of emotion generation (Gross, 1998) holds that they differ in the time they intervene in the emotion-generative process and also how they impact emotional responses when they are used to regulate negative emotions. Distraction which involves attentional deployment is expected to operate earlier than reappraisal that entails meaning evaluation and reevaluation. Cognitive reappraisal encompasses various strategies that are used to regulate our emotions through reinterpretation. Self-focused and situation-focused reappraisal are two of them. The former is considered more efficient and thus would lead to a greater attenuation of the LPP than the latter. To test this prediction, electrocortical responses to angry faces when using these strategies were measured using the late positive potential (LPP). Twenty four healthy participants were recruited for the study and were cued to down-regulate their emotions using these strategies while angry and neutral facial stimuli were seen on a computer screen. Contrary to prediction, distraction did not modulate the LPP earlier than reappraisal. However, supporting our hypothesis self-focused strategies largely modulated the LPP than situation-focused strategy. The pattern of result suggests that reappraisal might have an influence on the early neural processes of emotion generation and that the subcategories of cognitive reappraisal have a differential effect on emotional regulation.

Keywords: LPP, Emotion Regulation (ER), Reappraisal, Distraction, Angry face
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Temporal Dynamics of Emotion Regulation Strategies: an ERP study

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1. Introduction

James Gross in his statement ‘we are at once governed by—and governors of—our emotions’ (Gross, 2014, pg ix) put forward, in a nutshell, the concept of emotion regulation. This implies that we are in charge of our emotions and the way we appraise, interpret or evaluate emotionally salient stimuli shapes the way we respond to them. Emotions are biologically-based and help individuals meet challenges, opportunities and involve changes in subjective experience, behaviour and physiology (Levenson, 1994). Emotions can be helpful or hurtful depending on the situation. Emotions facilitate behavioural responses, fosters decision making and even enhance our social interactions. On the other hand, when an emotion is of the wrong intensity, time, or duration it can be hurtful. To avoid this, it is paramount to regulate our emotions.

Thompson (1994) describes Emotion regulation (ER) as an ‘extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features to accomplish one’s goals’ (pp. 27-28). ER occurs when a person attempts to modify one or several aspects of an emotional response (what we experience, how we experience them and when) and this modulation or changes is what bring about our final response to an emotional event (Gross, 1998). ER serves as an avenue in which a person can navigate complex or difficult social situations, choose where to focus one’s energies and helps reduce distress.

The field of ER is one of the fastest growing in psychology. This might be because of various psychopathologies that have been linked to emotional dysregulation (Hajcak, Macnamara, & Olvet, 2010), for example, depression (Gross & Munoz, 1995), anxiety disorders, schizophrenic spectrum disorder (Meyer & Shean, 2006), borderline personality disorder (Meyer, Pilkonis, & Beevers, 2004) and bipolar disorder (Phillips, Ladouceur, & Drevets, 2008) among others. Effective emotion regulation has been revealed to be highly crucial for mental and physical health (Davidson, Putnam, & Larson, 2000; Gross, 1998). Outside psychopathology, the ability to regulate one's emotions effectively has a huge impact on cognitive and social well-being (Gross, 2002; Tamir & Mauss, 2011). One of the key focus of emotion regulation as a field of
study is examining, assessing and organizing the different ER strategies people use in their day to day activities in different situations and examining the various outcomes associated with them.

Gross (2015) proposed five types of emotion regulation strategies in his process model of emotion regulation, these include; situation selection, situation modification, attenional deployment, cognitive change and response modulation. The focus of this study is distraction and cognitive reappraisal which are sub-types of attentional deployment and cognitive change respectively. These strategies have been shown to be effective in downregulating our emotions to unpleasant stimuli (Paul, Simon, Kniesche, Kathmann, & Endrass, 2013; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011).

Distraction involves directing our attention away from an emotionally salient stimulus while cognitive reappraisal refers to strategies that are used to modulate (increase or decrease) our emotional response to an emotion-evoking stimulus. Reappraisal can also be categorized into self-focused or distancing strategies and situation focused strategies (Koenigsberg, et al., 2010). The former involves detaching or distancing one’s self from an emotion-eliciting event by reappraising the personal relevance of such stimuli. The latter entails focusing on the situational context of the event or stimuli and not the personal relevance.

Researchers have begun to examine the neurophysiological correlates, time course and efficiency of these strategies using the modulation of an event-related potential (ERP) known as the late positive potential (LPP). The LPP is a positive going ERP component that is maximal between 300-800ms after stimulus onset and is sustained for several seconds post stimulus presentation (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp, et al., 2000). The LPP across various studies has been shown to be highly sensitive to emotionally salient visual stimuli (Paul, et al., 2013; Foti & Hajcak, 2008; Hajcak & Nieuwenhuis, 2006) and is largest for both extremely arousing unpleasant stimuli and pleasant stimuli. However, the LPP has been shown to be reduced in amplitude when our emotion is downregulated. In several studies, when participants were instructed to downregulate their emotions by decreasing their emotional response to either pleasant or unpleasant pictures, there was a decrease in the LPP modulation.
Majority of studies examining the LPP modulation towards various types of emotion regulation strategies have done so using emotion evocative scenes gotten from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005) (Weinberg & Hajcak, 2010; Ochsner, et al., 2004; Moser, Krompinger, Dietz, & Simons, 2009). The IAPS is a database for standardized pictures used in the study of emotions and attention. The images used are often taken from a variety of picture categories of people, animals, landscape e.t.c. However, some of the pictures presented in these studies are pictures of situations that are hardly encountered in our day to day activities. No known studies have examined the regulation of emotional responses using facial stimuli. Facial expressions like angry or threatening faces are socially important stimuli that are easily and frequently encountered. Facial threatening expressions have been linked to an enhanced LPP modulation (Moser, Huppert, Duval, & Simons, 2008; Schupp, et al., 2004). Specifically, Dimberg & Ohman (1983) revealed that threatening faces are at a more threatening advantage when such faces are directed towards the subjects. The study aims to examine the LPP modulation to angry facial expressions and also when distraction and reappraisal strategies emotion regulation strategies are employed.

Distraction and reappraisal have been revealed to have a distinct influence on our emotional responses and reliably modulate the LPP when negative or unpleasant emotional stimuli are down-regulated. Only a few studies have examined their temporal dynamics, temporal dynamics here means the time course that indicates when each strategy begin to take effect and when they are at their peak. The importance of time course analysis in emotion regulation research has been shown to reveal important information about the processes involved in ER strategies (Thiruchselvam, et al., 2011; Qi, et al., 2017). Distraction operates primarily through the use of attentional deployment, whereas reappraisal operates through meaning-evaluation mechanisms which involve computing a meaning to an emotional event and reevaluating it to alter the affective significance of such event. According to the process model (Gross, 2015), when an emotional stimulus is encountered deployment of attention comes first before evaluation of its meaning and
reevaluation. Since distraction does not involve meaning processing, it is predicted that it would attenuate the LPP earlier than cognitive reappraisal which involves elaborative meaning processing and re-processing (Thiruchsalvem, et al., 2011; Paul, et al., 2010).

The second prediction is regarding self-focused reappraisal (also known as distancing or detached reappraisal) and situation focused reappraisals which are subtypes of cognitive reappraisal. These strategies have been shown to differ in their effectiveness and involve distinct neural networks. Self-focused reappraisal strategies are considered more efficient and operate earlier than situation focused reappraisal. Thus, it is predicted that former would elicit a greater attenuation of the LPP compared to the latter. Overall, the study sets out to provide an elaborate effect comparison of the temporal dynamics of the LPP modulation between cognitive reappraisal and distraction and also between the types of cognitive reappraisal. The third aim will be more exploratory in nature and will focus on the associated sex differences in the LPP attenuation in response to the emotional regulation strategies and this is based on the findings of (Canli, Desmond, Zhao, & Gabrieli, 2002; Cahill et al., 2001) that have suggested that men and women process emotional stimuli differently.

The next chapter focuses on the key features of emotion and emotion regulation, models of emotion generation and regulation. The third chapter examines the biological and electrophysiological basis of ER strategies of interest, the neural correlates of the late positive potential and the empirical findings of the LPP, distraction and reappraisal. The last section of chapter three briefly examined the empirical findings of the LPP, ER and the associated sex differences.
2. Emotions and emotion regulation

2.1 Key features of emotion

There are some key elements of emotions as identified by Gross (2014) in his *Handbook of Emotional Regulation*. The first is ‘when it occurs’, in accordance with the appraisal theory, emotions occur when a person attends to and evaluate a situation that is of relevance to his or her current goal (Lazarus, 1991). Such goal might be wanting to go to a party or staying back at home. These goals can be serious or unserious, conscious or not, simple or complicated, they may be shared by all or on a personal note. As the goal evolves or changes our emotional responses to them also changes (Gross, 2014). The second core feature of emotion is that it is multifaceted in nature and involves various changes in our subjective experiences, body physiology and our behaviours (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Emotion is not just about what we feel or about our subjective experiences, it also influences how we act and behave, some of these behaviours include, a shift in our gaze, changes in our posture, among others (Frijda, 1986). The third feature of emotion is its malleability, this means our emotions are capable of being changed, influenced or modulated in a large number of ways (Gross, 2008). It is the malleable feature of emotions that give rise to the possibility of it capable of being regulated.

2.1.1. The modal model of emotion generation.

The modal model of emotion generation unites the common features of emotion that have been described by various approaches to emotion study. That is; a goal that is meaningful to a person and attracts attention and appraisal, multifaceted response system and malleability of emotions. This model holds that emotion generation occurs in a sequence of steps over time; this happens in few seconds or minutes and can take a shorter or longer time. The emotion generation is often a dynamic ongoing process that occurs recursively (Gross, 2015).
The sequence starts with a real or imagined psychologically relevant situation or event. Real event describes features of the external environment e.g. getting fired at work. Imagined events are internal representations e.g. thinking about getting fired. This is followed by directing attention to the emotional situation. The situation is then assessed, evaluated and interpreted in the light of relevant goals (Appraisal) before a response is generated. The emotional responses generated after this sequential process, are thought to give rise to changes in experiential, behavioural, and physiological response systems that characterize emotion. (Gross, 2015).

2.2. Emotion regulation (ER)

Emotional regulation involves the activation of a goal to influence our emotions. According to Gross (2015), ER can be regarded as a means to an end (goal). For instance, I might reinterpret getting fired from a job as a stepping stone to getting a better job in other not to feel sad (goal). The most common goal of emotion regulation is to decrease negative emotion. However, emotion regulation can also involve an increase in negative emotions (such as when trying to increase one's anger to collect a debt) and an increase or decrease in positive emotions, For instance, trying to look less happy after winning a lottery. It is also
worth noting that ER might be an *intrinsic* or *extrinsic* process. When the goal is to regulate one's emotions which occur often time, this is referred to as an intrinsic ER, and when another person's emotion is being regulated it is an extrinsic form of ER. An action can also serve both an intrinsic and extrinsic regulatory functions. For instance, a mother trying to soothe her crying child (extrinsic), in other to calm herself down (intrinsic).

Depending on the goal to be achieved, people sometimes change the intensity, duration, magnitude of their emotions and these results to a changed emotional response in terms of the experiential, behavioural or physiological domain (Smith & Kleinman, 1989; Samson, Huber, & Gross, 2012). It should be noted that ER might not necessarily be a conscious process, it can happen outside one's conscious awareness, for instance, the presence of a briefcase in a room might lead people to behave more competitively or more seriously than an ordinary backpack (Kay, Wheeler, Bargh, & Ross, 2004) or hiding the affection one feels for someone for the fear of rejection. (Gross, 2014)

### 2.2.1 The process model of emotion regulation (ER)

One of the most widely used frameworks in the study of ER is the process model of emotion regulation by Gross (2014). This model was derived by identifying each of the major points in the modal model at which the emotion-generation process can be altered. The process model of emotion regulation postulates that each of this four point in the modal model of emotion can be subject to regulation
This model yields five emotion regulation strategies: situation selection, situation modification, attentional deployment, cognitive change and response modulation. Each of these strategies can be used in combination with the other. According to the process model, each of these strategies and how they are used have a specific and different consequences as regards how a person thinks, behave, feels and act both immediately and at a long run (Gross, 2015) and this might be because emotions occur over time and each point of the emotion regulation process reflects differences in patterns of emotional experience, expression and physiology. These differences might also be linked to the different cognitive demands each of these strategies create. The rest of this section explains the five types of ER strategies and relevant literature findings.

Situation selection refers to taking actions that make it more (or less) likely being in a situation that one will like to have that would give rise to desirable (or undesirable) emotions. Such situation can be, deciding to go to a party a former lover would be present or staying at home. This is the first of the emotion
regulation strategies as it shapes the emotion generation process at the earliest possible point. It is also one of the most forward-looking approaches to emotion regulation (Aspinwal & Taylor, 1997). This strategy increases the chances of a person’s exposure to helpful and positive situations that would enhance a positive state of mind (Jacobson, Martell, & Dimidjian, 2001). On the other hand, other types of strategies focus on decreasing a person’s exposure or reaction to harmful situations (Kober & Bolling, 2014).

Situation modification; after a situation as being selected, it is also possible to directly alter the situation in order to change or modify its emotional impact (Gross, 2015). This strategy is well suited for unavoidable situations. An example is hiding a questionable artwork from one's parent when they come for an unexpected school visit. Sometimes, drawing the line between situation selection and modification can be difficult because situation modification leads to a ‘new situation’. A Situation as it has been earlier stated might be an external or internal event but in this context, according to Gross (2014) situation modification as to do with modifying an external or physical situation. Clark (2001) suggests that since situation modification leads to a short-term relief, it reduces the chances of the long-term benefit of full exposure to feared situations.

Attentional deployment entails influencing emotional responding by redirecting attention away or within a given situation. This can be done by selectively deploying or focusing one's attention on a particular situation that brings about more or less emotional impact with the goal of influencing one's emotional response. Gross (2008) refers to attentional deployment as an internal version of situation selection. The most commonly used attentional deployment strategy is distraction, which would be discussed in detail in the next section.

Cognitive change involves modifying or altering one's appraisal of a situation in order to change its emotional impact. The most studied form of cognitive change is cognitive reappraisal. Cognitive reappraisal entails attending and automatically judging a particular situation (appraisal) then reevaluating or rejudging in a neutral or positive way in order to lead to a more or less emotional impact.
Response modulation as to do with influencing one's emotion after it has been developed. Gross (2015) refers it as directly influencing experiential, behavioural or physiological component of an emotional response after it has been well developed. For instance, drugs or alcohol can be used to alter a person's cognitive experiences or physiological response. Expressive suppression is one of the most studied forms of response modulation and it involves playing down the behavioural manifestation of an emotion (Gross, 1998).

These strategies can also be categorized into antecedent-focused strategies and response-focused strategies (Gross, 1998). The former (the first four) manipulates the input system by altering emotional response before they are activated or generated, the latter manipulates the output i.e. occurs after an emotional response is fully generated; they alter emotional responses once initiated. Response focused strategies are not as effective because of it's associated cognitive and physiological costs (Gross, 1998, 2002; Gross & Levenson, 1997; Richards & Gross, 2000) and its negatively related to measures of well-being and positive emotions (Gross & John, 2003).

The next section focuses on the two types of emotion regulation strategies that are of interest to this study, that is, distraction and cognitive reappraisal strategies.

2.3. Distraction and cognitive reappraisal strategies

Distraction is one of the most studied forms of attentional deployment and it involves redirecting ones attention from a current situation to another or redirecting one's attention within a given situation. E.g. thinking about lunch break in a boring class. Distraction can be an internal or external shift in focus e.g when someone begins to bring up pleasurable memories that make one lose focus on a current situation (internal) or simply shifting one's eye gaze away from an emotional situation (external). Similar to distraction is spatial attention involves deploying ones attention to irrelevant or non-emotional parts of a stimulus. Distraction has been shown to be an efficient ER strategy as it reduces the unpleasantness of
stressful or negative situation. It has been shown to decrease the activation of pain-related brain regions such as the insula (Bantick, et al., 2002; Seminowicz & Davis, 2007) and also reduce subjective emotional intensity (Urry, 2010).

Cognitive reappraisal targets the meaning or the relevance of a potential emotion-eliciting event. In our daily activities when one is faced with situations that are meant to be distressing, we often try to find the good in the bad or take an alternative interpretation of the seemingly bad situations by thinking about it in a positive light or in a less emotional way. An example is viewing a fatal accident scene as one that doesn’t directly affect one or a loved one. According to Lazarus (1991), a person’s response to an emotional event is not dependent on the objective properties of the situation but on how the event is appraised. This strategy is most commonly used for decreasing the impact of a negative emotion but it can also be used to decrease or increase both positive and negative emotions (Ochsner & Gross, 2002). Apart from reducing emotional responses, reappraisal can also be used to change the quality of emotional responses (Shiota & Levenson, 2012). Compared to other forms of strategies, cognitive reappraisal influences emotional experiences and expressions successfully with no known physiological cost like high blood pressure (Gross & Levenson, 1993; Gross, 1998) or mental cost (memory impairment) (Richards & Gross, 2000) that has been linked with other strategies like suppression. It has also been found to be consistently more beneficial than other strategies (Webb, Miles, & Sheeran, 2012). Reappraisal provides one of the most flexible and effective means of reducing the negative impact of an aversive event (Gross, 2002; Gross and Levenson, 1993; Richards & Gross, 2000). As mentioned, reappraisal is not just be used to better a bad situation that might elicit a negative response (i.e downregulating our emotions) it can also be used to mentally make a bad situation worse, or a neutral situation bad (up-regulation). Sometimes up-regulating our emotion is required in some situations even if it’s a negative emotion.

Cognitive reappraisal is not a homogeneous strategy, it encompasses series of strategies which varies depending on how a person interprets the situation in question. Two of those strategies are based on the relevance of an emotional event to self (self-focused or distancing strategies) or the situation (situation-
focused strategy). The distinction is derived from the theories that revealed there is unique role self-relevant information plays on memory (Baumeister, 1998). Situation-focused strategy involved reinterpreting the nature of the events themselves, reevaluating others’ actions, dispositions, and outcomes. There is no form of personalization and whatever reinterpretation is made is based on the situation. For example ‘‘the accident doesn’t look so bad, some of the victims would survive.’’ “This does not impact me,”, or “The person was not really hurt” ‘‘the horror movie is fiction’’

Self-focused reappraisal strategies alter the personal relevance of a situation, it makes one feel very much or less actively involved or connected to the event that is going on. Self-focused reappraisal also known as distancing strategy (Koenigsberg, et al., 2010) can be done through temporal distancing and social distancing or detachment.

Self-focused strategies (social and temporal distancing) involve distancing or detaching one’s self from an emotional situation. Particularly, temporal distancing involves shifting one's thought pattern about immediate experiences or situations into a broader or a distant perspective or viewing an emotional event in past or futuristic term. Temporal distancing like other forms of psychological distancing (social and spatial) produces a state of detachment from one's immediate experiences (Yanagisawa, et al., 2011). Just like when we encounter stressful events in our day to day activities that often leads to distress, the effects, however, fade off with the passage of time (Gilbert, Kiul, & Pelham, 1988).

Distancing has been revealed to buffer people against future negative affects and reoccurring negative thoughts (Ayduk & Kross, 2008; Kross & Ayduk, 2008). As humans, we have the ability for mental time travel, by envisaging the future or remembering the past. Research suggests that people are more positive, optimistic and see the distant future as brighter than the near future. They tend to imagine distant future event in an abstract manner compared to near future events, this way they de-emphasize the concreteness or the situation-specific features of the event that might lead to negative emotions, this tendency has an influence on the way they process information (Trope & Liberman, 2003, 2010) and also how they react to unpleasant emotionally stimuli (Bruehlman-Senecal & Ayduk, 2015). Taking a temporally
distant perspective on a situation especially an emotion-eliciting one helps people to better cope with the situation (Ayduk & Kross, 2008). An example is imagining that in the next couple of weeks, month or years that the exam failed wouldn’t matter anymore. Or “my poor grades won’t stop me from getting the job in few years”.

Social distancing, on the other hand, involves viewing a situation from a detached, third-person perspective. It involves reinterpreting emotional stimuli in an unemotional way or disengaging from the emotional implications of the target situation. An example is “I do not know any of the car crash victims”. Research suggests that detaching oneself from a negative situation or viewing the situation from a detached perspective reduces the intensity of such situation (Qi, et al., 2017). In general, distancing strategies or self-focused reappraisal strategies are thought to be more disengaging and more efficient than situation focused strategies (Sheppes, et al., 2014; Qi et al., 2017).

Distraction and cognitive reappraisal are distinguished by their separable underlying process. The former operates primarily through the use of attentional deployment while the latter operates through the meaning-evaluation mechanism which first involves constructing a meaning to the emotional situation at hand and reevaluating the meaning. Deployment of attention away from or towards (a part of) an emotional situation occurs prior to evaluative-processing of such situation hence reducing the extent to which the emotional significance of such stimuli would be appraised. When one is faced with an emotionally salient situation, the decision to evaluate and reevaluate comes after paying some attention to such stimulus (Gross, 2015). By this, distraction intervenes in the emotion-generation trajectory earlier than reappraisal which involves meaning processing.
3. Biological and electrophysiological bases of emotion regulation

3.1 Neural correlates of distraction and cognitive reappraisal

A number of studies have shown that these strategies engage and activate the neural regions associated with working memory, attention and cognitive control in different ways (e.g. McRae, et al., 2010; Mayer, et al., 2007). Both strategies recruit areas associated with down-regulation of emotions, like the amygdala, insula and the prefrontal cortex, parietal regions and the cognitive control areas like the anterior cingulate cortex (ACC) (Schonfelder, et al., 2014; McRae, et al., 2010; Kanske, Heissler, Schonfelder, Bongers & Wessa, 2011; Ochsner & Gross, 2005). Ochsner, et al’s., (2004) study revealed that both strategies decreased the activation of the amygdala, increased the activation of the prefrontal cortex and the ACC.

These regions have been linked with the control of cognition, attention to an emotional stimulus, verbal working memory and response selection. Specifically, the dorsal lateral PFC is involved in generating and maintaining alternative ways of thinking about an emotional stimulus. The ACC engages in monitoring alternative interpretations to this stimulus. The amygdala plays a role in goal appraisal and modulation of an emotional activity and has been implicated in determining whether a stimulus is affectively relevant or not, whether to attend to such stimuli and generate physiological and behavioural responses to them if relevant (Phelps 2006; Whalen, et al., 2004). Distraction and cognitive reappraisal were also shown to activate the left inferior parietal cortex which is associated with the perception of emotion and interpretation of sensory stimuli.

However, distraction has been shown to lead to greater activation in the right prefrontal cortex and parietal regions (Mayer, et al., 2007). Additionally, McRae, et al., (2010) found out that there is a greater increase in the prefrontal cortex activation and the parietal region and a stronger decrease in amygdala activation for distraction compared to reappraisal. Since distraction is not attending to or encoding all emotionally salient part of a stimulus there will be a greater reduction in amygdala activity. On the other
hand, because reappraisal involves attendance to and reevaluation of the meaning of an emotional stimulus, amygdala activity might not decrease as much.

Reappraisal involved a greater activation in regions involved in appraising an emotional stimulus like the medial prefrontal cortex (mPFC) which has also been linked with emotional awareness and mental state attribution and suggested to play a role in evaluating an affective stimulus in the light of current goals (Teasdale, et al., 1999). Reappraisal was also associated with an increased activity in the dorsal mPMC which is implicated in semantic and self-reflective processes that are relevant to elaborating the affective meaning of a stimuli (Olsson & Ochsner, 2008; Gilbert et al., 2006) also the ventrolateral prefrontal cortex(vlPFC) which reflects the affective value of a stimulus (Bender, Hellwig, Resch, & Weisbrod, 2007).

Specifically, as regards reappraisal strategies, studies have shown that the effects, as well as the neural mechanisms employed in both strategies, are different (e.g Ochsner et al., 2004; Willroth & Hillmire, 2016). A study by Ochsner et al., (2004) revealed that self-focused reappraisal recruits the medial prefrontal cortex (mPFC) which has been linked with self-referential judgments (Kelley, et al., 2002) and also reflects the processes that are involved in monitoring how emotional cues affects self, such information is important in keeping emotionally salient event towards or distant from one’s self (Gusnard, Akbudak, Shulman, & Raichle, 2001). On the other hand, situation focused reappraisal recruited the lateral PFC (IPFC). The IPFC has been associated with manipulation and maintenance of information about stimuli in the external world (D’Esposito, Postle, & Rypma, 2000). These pattern of differences in the IPFC and mPFC were also observed when participants judged the valence of their own emotional response to a photo (self) and the valence of the emotion expressed by the figures depicted in the photo(situation). The amygdala was however modulated similarly in both strategies (Ochsner, et al. 2004). The findings of Koenigsberg, et al., (2010) is also similar to this, they found a modulation in the mPFC and amygdala in response to distancing from a negative emotional event.
3.2. The late positive potential (LPP)

The LPP is a sustained positive deflection of a stimulus-locked ERP, which amplitude is modulated by the emotional content of a stimulus. An ERP is a measure of neural activities which reflects positive and negative changes in voltage when an electroencephalogram (EEG) is time locked to a specific event. The ERP reflects activities of a population of neurons, particularly, summated post-synaptic potentials (Luck, 2005). ERP waveforms depict rapid and early changes in these scalp-recorded voltages overtime which reflects sensory, cognitive, motor and affective processes elicited by a stimulus, in order of milliseconds. Hence, it is suitable for detecting the effects of experimental manipulations as they occur on different processing stages. Thus, well suited for measuring near instantaneous activities underlying affective and cognitive processes associated with ER.

The LPP occurs from about 300ms post-stimulus presentation and is larger following the presentation of both pleasant and unpleasant stimuli) compared to a neutral stimulus (Foti, Hajcak, & Dien, 2009; Hajcak & Olvet, 2008).

![Figure 3: ERP waveforms at electrode CPz. ERP waveforms at electrode CPz associated with pleasant, neutral, and unpleasant stimuli in the passive viewing block. Note that positive voltage changes are plotted as upward deflections. Adapted from Hajcak and Nieuwenhuis (2006, p. 295).](image)

The LPP reflects the sustained attention to emotionally salient visual stimuli and is highly sensitive to such stimuli. Within this context, an emotionally salient stimulus refers to the content and the
motivational relevance of the stimulus. It has been shown that the LPP is much more enhanced by biologically relevant stimuli like images of mutilations, erotic scenes e.t.c (Weinberg & Hajcak, 2010) and stimuli that are of personal relevance. There would be a more enhanced LPP to images of close friends than images of familiar, random or even famous faces (Grasso & Simons, 2011).

Research has revealed that the modulation of the LPP can be sustained throughout stimulus presentation and even for about 1000ms after the stimulus offset. This means the LPP indexes continuous processing of emotional stimuli following it offset (Cuthbert, et al., 2000; Gross, 2015). This means that aside from capturing, emotional stimuli also holds attention (Vuilleumier, 2005). Studies have shown that the LPP is generally modulated by a pleasant or unpleasant stimuli but early modulation (300-600ms) reflects obligatory focus and processing of the stimulus while the late portion (600ms and above) reflects sustained and more mental engagement with the stimulus (Olofsson, Nordin, Sequeira, & Polich, 2008; Weinberg & Hajcak, 2010).

The study of (Nummenmaa, Hyona, & Calvo, 2006) revealed that when participants were presented with emotional and non-emotional or neutral stimuli individuals were faster able to detect emotional stimuli even when they were asked to look only at the neutral ones, the fact that emotional stimuli are detected earlier than neutral ones might be because emotional situation captures attention faster. The amplitude of the LPP is revealed to be commensurate with the arousal level of a person in response to an affective stimulus. This means that the emotional effects of the LPP vary in accordance with the experienced emotional intensity of the affective content (Schupp, et al., 2000; Keil, et al., 2002). However, the LPP is independent and insensitive to the stimulus size, perceptual characteristics or its complexity, making it a reliable index for measuring an emotional aspect of a stimulus (Bradley, Hamby, Low, & Lang, 2007). Also, Schupp, et al., (2004a) found out that the presence of human characteristics (e.g. faces) affects the modulation of the LPP.

Research suggests that the emotional salience of a stimulus can be manipulated whether intrinsically or extrinsically to modulate the LPP magnitude (Hajcak, Dunning, Foti, & Weinberg, 2014). It
has been revealed that when one's emotion is downregulated there is a decrease in the amplitude of the LPP, this is evident in research employing cognitive reappraisal, distraction, suppression and the other types of ER strategies that are used in everyday life.

The first LPP study to demonstrate that our emotions can be down-regulated by reinterpreting emotional stimuli i.e. cognitive reappraisal was carried out by Hajcak & Nieuwenhuis (2006). They had participants view series of images extracted from the IAPS (International Affective Picture System; Lang, et al., 2005). The participants viewed unpleasant stimuli for one second followed by an instruction to reinterpret (reappraise in other to downplay the effect of the negative stimulus and reduce negative response) or ‘‘attend’’ (i.e focus on their natural feelings about the stimulus). The study found out that the unpleasant stimulus presented after the reappraisal instruction was associated with reduced LPP amplitude beginning at 200ms post-stimulus presentation and lasted till stimulus offset compared to those presented after the attend instructions. Greater LPP reduction was also associated with greater reduction in self-reported emotional experience following reappraisal.

Hajcak, Moser, & Simons (2006) also found out that interpreting a stimulus as non-affective or affective can modulate the LPP. They had participants view pleasant and unpleasant pictures and categorize them as affective (indicating whether the picture is pleasant or unpleasant) or non-affectively (indicating the number of people present in the picture), the result showed that when participants viewed either a pleasant or non-pleasant stimuli in a non-affective manner there was a reduction in the LPP modulation as compared to when it was interpreted in an affective manner. Individual differences in preference to emotional stimuli also play a role in LPP modulation variation. A person who has a phobia for spider would elicit a larger LPP towards a spider or something similar to spiders (Leutgeb, Schafer, & Schienle, 2009). This implies that individual differences in response to picture contents that elicits desire or unpleasantness to a person would have a larger LPP (Hajcak, MacNamara, & Olvet, 2010)
Most LPP studies have used complex emotional scenes from the IAPS (Thiruchsalvem, et al., 2011; Moser, et al., 2006, 2009; Hajcak, et al., 2010, Foti, et al., 2009) that a person might unlikely encounter in their day to day activities, but the LPP can also be modulated by other types of stimuli, such as (threatening faces, provocative words or even hand gestures (Flaisch, Hacker, Renner, & Schupp, 2011)). Particularly, facial expressive stimuli like angry faces are basic human social-emotional stimuli (Ohman, 2009) that are often encountered. Threatening/angry faces reflect a single category of stimuli with different affective degree (Wessing, Rehbein, Postert, Fünniss, & Junghöfer, 2013) and have been shown to capture attentional resources (Mogg, Millar, & Bradley, 2000) and activate the human fear system (Whalen, et al., 2004). Typically, angry expressions are characterized by frowning brows, staring eyes, a shut mouth with tensed lips (Ekman & Friesen, 1975), these expressions signal a readiness for an attack for the observer of the face especially if the face is directed towards a subject (Dimberg & Ohman, 1983). ERP studies have revealed that threatening faces reliably modulate the LPP (Eimer & Holmes, 2002). Though, it has been shown that emotional faces evoke mild emotional responses compared to emotional scenes as they are less intense (Wessing, et al., 2014). Britton, Taylor, Sudheimer, & Liberzon (2006) also found out that there is reduced arousal ratings of emotional faces compared to emotional scenes. Surprisingly, no study has examined the effect of ER strategies on angry or threatening faces.

### 3.3 Neural correlates of the LPP.

The LPP involves an expansive brain region that includes both the cortical and subcortical regions and its modulation is determined by emotional valence (Liu, Huang, McGinnis, Keil, & Ding, 2012). Studies combining ERP and fMRI methods revealed that the modulation of the LPP elicited in response to emotional stimuli is correlated with an increased blood flow in the occipital, parietal, and inferotemporal regions in the brain (Keil, et al., 2002; Sabatinelli, Lang, Keil, & Bradley, 2007). The visual cortex has also been shown to be increased in activation in response to the processing of visual emotional stimulus compared to neutral ones. (Bradley, et al., 2003; Lane, et al., 1997, 1999; Lang, et al., 1998). Inclusively, several studies have
shown that the LPP is pronounced at centroparietal electrodes (e.g. Hajcak, et al., 2010; Moser, et al., 2009). Also, various neuroimaging studies have found that there is an enhanced LPP and heightened BOLD activities in the emotional processing structure such as the amygdala and the prefrontal cortex in response to an emotional visual stimulus.

The amygdala has also been found to play a role in raising visual information so that emotional stimuli are preferentially processed (Bradley, et al., 2003; Lane, et al., 1997, 1999). The amygdala projects to the occipital cortex and this might be the reason for increased occipital activation during the processing of emotional stimuli (Bradley, et al., 2003). Hajcak, et al, (2009) in an ERP study showed that the amygdala becomes active within 200msec following the presentation of threatening stimuli. In response to pleasant pictures, Liu, et al, (2014) in an ERP and fMRI study found a significant correlation between the occipitotemporal junction, medial prefrontal cortex, amygdala, and also LPP-BOLD correlation in the ventrolateral prefrontal cortex, insula, and posterior cingulate cortex in response to unpleasant pictures.

The physical stimulation (Hajcak, et al., 2010) and activation (MacNamara, Ferri & Hajcak, 2011) of the dorsolateral prefrontal cortex has been suggested to reduce the amplitude of the LPP. Foti & Hajcak (2008) revealed that the LPP modulation for the passive viewing of pictures becomes evident at the central and even frontal recording sites at about 1000ms. Similarly, when using the reappraisal strategy, apart from the LPP central-parietal recording site, (Hajcak & Nieuwenhuis, 2006; Hajcak, et al., 2014; Moratti, Saugar, & Strange, 2011) found out that emotional modulation of the LPP indexes the coordination of frontoparietal networks. Similarly, Wessing, et al., (2014) in an LPP-MEG study also found a correlation between the frontoparietal networks and the downregulation our emotions.
3.4 The LPP and emotion regulation strategies: empirical findings

3.4.1. LPP, distraction and reappraisal

Distraction and reappraisal are both very effective forms of ER strategies and have been shown to differ in when they intervene in the generative process (Gross, 2015). Studies have revealed that attention manipulation strategies like distraction have a large effect on the amplitude of the LPP (Hajcak, et al., 2010). Distraction has been shown to occur earlier in the emotion generation trajectory as a result, an earlier modulation in the LPP. For instance, (Thiruchselvam, et al., 2011; Hajcak, et al., 2009) studies indicated a sustained, stronger and earlier (as early as 300ms), reduction in LPP modulation while reappraisal yielded a late reduction in the LPP amplitude occurring around 1500ms to 1700ms.

However, there have been several inconsistencies in the temporal dynamics of both strategies across several studies. In Schonfelder, Kanske, Heissler, & Wessa’s (2014) study, though both strategies were found to reduce the LPP when employed, the LPP reduction was seen to take effect from 1000-2000ms with stronger attenuation when distraction was employed than when reappraisal was employed (2000-3000ms). Paul, et al., 2014 also found this form of differences but across varying time window. They have not been a unified stand on when distraction begin to take effect amongst studies, but Gross’s model suggests that it occurs earlier than every other ER strategies (Gross, 2014)

3.4.2. LPP, self-focused appraisal and situation focused appraisal

A lot of studies have compared reappraisal with the various forms of strategies like suppression, distraction, amongst others, that are used in the day to day regulation of our emotions. However, little is known about the differences between reappraisal strategies i.e. the self-focused reappraisal and situation focused reappraisal and their electrocortical responses. In fact, few studies that have made this comparison have somewhat been inconsistent. Qi, et al., (2017) found out that there are not just differences in the neural
processing of these strategies as shown by Ochsner, et al., (2004) but there are also differences in their emotional outcomes and LPP modulation. They revealed that detached reappraisal (similar to self-focused, sometimes used interchangeably) elicited earlier (700-900ms) and greater attenuation at the central-parietal site and across subsequent time windows. Positive reappraisal (similar to situation focused) began to attenuate the LPP from 1100ms at the central parietal LPP. Also, detached reappraisal reduced self-reported arousal to a greater degree than positive reappraisal did. Studies have shown that detached reappraisal is more disengaging than positive reappraisal because it involves disengagement from stimulus emotional implication (McRae, et al., 2012; Sheppes, et al., 2014). Disengagement strategies are suggested to operate earlier and more efficient than engagement strategies (Sheppes, 2014).

However, Willroth & Hillmire (2016) found out that situation focused reappraisal is effective for reducing both negative responses and upregulating our negative and positive emotions and also has an impact on memory. Also, situation focused reappraisal is associated with a reduction in both subjective report and LPP amplitude in the right hemisphere hence more effective way of reducing the impact of a negative stimulus compared to self-focused reappraisal or passive viewing. Though this difference was found only at the PO8 electrode between a time range of 300-1000ms post-stimulus. They found no difference in LPP modulation using self-focused strategies (Willroth & Hillmire, 2016).

A meta-analysis by Webb et al., (2012) revealed that reappraisal strategies had reliable positive effects on emotional outcomes. They revealed that self-focused strategies had a greater effect size on emotional outcomes than situation-focused strategies, though the difference was not found to be significant.

3.5. LPP and sex difference

Research has shown that emotionally salient stimuli are processed differently in men and women because they recruit different part of the brain during processing (Canli, 2002). Hall, Witelson, Szechtman, & Nahmias (2004) showed that women had a similar pattern of activation during emotional processing as
men but to a greater degree, Women showed greater activations in regions correlated with both emotional intensity ratings and better recognition memory for most emotionally salient pictures. They found out that females are more reactive to unpleasant emotional stimuli (both in terms of subjective arousal and enhanced limbic and prefrontal brain activities) and less efficient in regulating their emotions to unpleasant pictures and this might be due to them recruiting fewer cognitive control resources during processing of emotionally salient stimuli. McRae, et al., (2008) in an fMRI study discovered that there are more significant reductions in limbic and prefrontal regions when downregulating responses towards negative emotional stimuli in men compared to women. Also, Gardener, Carr, Macgregor, & Felmingham (2013) in an ERP study found a greater increase in the LPP amplitude when women were told to increase their emotional response towards a negative stimulus, this suggests that females may reflect a greater emotional appraisal towards unpleasant emotional stimuli.

3.6. Aim of study

The aim of the study was to examine two theoretically derived predictions about the temporal dynamics of distraction and reappraisal strategies.

1. Examine the temporal dynamics of emotional regulation strategies i.e cognitive reappraisal strategies (self-focused (social and temporal distancing)), situation-focused strategies and distraction using angry facial expressions. Since distraction intervenes earlier than reappraisal in emotion generation process, it is hypothesized that distraction will lead to an earlier attenuation of the LPP than reappraisal strategies.

2. As regards to cognitive reappraisal strategies, it is hypothesized that self-focused strategies will attenuate the LPP greater than situation focused strategy.

3. A secondary aim of the study is to assess whether there would be significant gender differences associated with LPP modulations among these strategies in response to angry facial expression. It is
hypothesized that males will elicit a lesser LPP modulation in response to angry faces and greater attenuation in the LPP amplitude compared to females across strategies.

4. Methods

4.1 Participants

32 students of the University of Skövde participated in the study (15 males, 17 females). Eight of which were excluded, six because of the data corruption, and two did not complete the experiment. Therefore, twenty-four subject’s data were analyzed. Participants were between 18 to 40 years old, right-handed, had normal or corrected to normal vision, were not colour blind, dyslexic, had no current or ongoing psychiatric or neurological disorders and fluent English speakers.

4.2 Procedure and stimuli

On arrival at the lab, participants were made to settle and received both verbal and written description of the experiment. They were then given an opportunity to ask questions about the study before going ahead to sign the informed consent. They were also told they could withdraw at any point during the experiment if they felt the need to.

The participants were presented the set of faces that would be seen on the computer screen, printed on a paper and asked to rate the faces on the dimensions of valence (1 [Negative] to 9 [positive]) and arousal (intensity) (1 [low] to 9 [high]) using a pen.
Figure 3: Self-assessment manikins (Bradley & Lang, 1994). a) Represents the valence scale going from negative to positive. b) Represents the arousal scale going from low to high arousal.

After the self-ratings, participants were taken into the experiment room and were seated in front of a computer monitor. Their skull was measured to find the vertex, which was marked on top of the scalp. The EOG electrodes that have been attached to an adhesive tape were placed and the electrode cap was fitted (details of electrode placement in subsequent section) A game-pad was also handed to them to navigate during the experiment.

Thirty-six Photographs of adult human faces selected from Umeå University database of facial expressions (Samuelsson, Jarnvik, Henningsson, Andersson, & Carlbring, 2012), displaying both angry and neutral expression making a total of 72 faces were used.

Figure 4: Sample faces from the Umeå University database of facial expressions depicting both angry and neutral expression (Reference above)

The faces selected were evenly distributed between gender and their ages ranged from 21 to 55. These faces were presented pseudo-randomly on a 24” screen with 1920 x 10800 screen resolution.
Participants performed a total of 432 picture trials presented using the E.prime software (https://www.pstnet.com/eprime.cfm) to control the presentation and timing of the stimuli. Participants were cued to respond to pictures either by passively viewing them without employing any strategy or by implementing emotion regulation strategies.

Four types of strategies were to be employed to downregulate the emotional impact of the angry faces: distraction, situation-focused reappraisal, social distancing and temporal distancing. Each of these strategies was presented randomly in blocks including the blocks for the neutral-view and angry-view. In total, twelve blocks of trials were presented each consisting of 36 pictures trials. Two blocks for each strategy and also 2blocks each for passive view of the neutral faces and angry faces. The blocks were presented randomly across subjects.

Prior to each block presentation, a text description of the strategy to apply was displayed and participants read the instructions for as long as they wanted to. Before each face was presented, a fixation cross was presented for about 500ms to orient their gaze to the centre of the screen. Each face was presented for 3000ms and pictures of male and female faces were counterbalanced across trails.

Prior to the experimental blocks, to ensure that the participants understood what they had to do and familiarize themselves with the task and emotional regulation instructions, participants performed some practice blocks. During the practice, they were given detailed instructions about the task they were about to embark on. They 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 emotional regulation instruction strategies were given during the practice.

For attention check purpose, participants were randomly asked the gender of the last face seen. After each block, they were also asked how successfully they were able to utilize each of the strategies where they could press ‘no’, ‘yes’ or ‘somewhat’ using the gamepad provided.

### 4.3 Emotion regulation instructions.

The instructions given are presented verbatim below.
Distraction task, ‘’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’’.

Figure 5: The neutral image used as the distracting stimuli (Presented before the instruction)

Situation focused reappraisal task, ‘’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 imagine that you think that they will realize that they overreacted, and will get over it soon and be happy instead’’

Social distancing task ‘’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 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 task, '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 imagine that you would think to yourself how little their anger will mean to you in 1 year’’
Finally, Participants were asked to view the faces passively, that is without employing any strategy ‘imagine that you are seeing each person in front of you right now on a public train. Just observe their face’” Same instruction was given for the neutral faces. Participants were explicitly told to only start imagining after the picture is been displayed and not before

4.4 EEG recording, data reduction and analysis

The EEG data was recorded using 33 active Ag/AgCl electrodes positioned according to the international 10/20 placement system. Electrodes were placed using a stretchable electrode cap (g.GAMMAcap) and water-soluble gel (g.GAMMAgel) was applied to ensure conductivity.

Two electrodes were attached on the left and right mastoids (LM, RM) using adhesive tapes made for electrodes placement. The electrooculogram (EOG) generated from blinks and eye movements were recorded using electrodes placed approximately 1cm below and above the right eye and at the external canthi of each eye. The electrode sites used were the following Fz, F1, F2, F7, F8, FCz, FC2 FC1, T7, T8, C3, C4, CP1, CP2, CPz, Cz, O1, O2, O9, O10, P8, P7, Pz, POz, and Oz. The ground electrode was placed at AFZ. During recording, all electrodes were referenced to CPz. Offline, during data processing the EEG for each trial, were re-referenced to the average activities of the left and right mastoids. The EEG and EOG were amplified by g.USBamp amplifier (g.tec). Signals were recorded with a sampling rate of 512 Hz and a bandpass filter of .01 to 0.30 Hz.

Independent component analysis (ICA) was subsequently performed to remove components associated with eye movements, eye blink activity, line noise and other components that do not reflect brain activities. EEG data were segmented into epochs that began 500ms prior to the picture onset and continued for 3,000ms. Separate averages were computed for each participant in each of the six task types (neutral-view, angry-view, Distraction situation focused reappraisal, social distancing and temporal distancing) and the grand average amongst all subject was computed.
4.4.1. Data analysis

The analysis was conducted using ERP lab toolbox (version 5) (www.erpinfo.org) within EEGLab (http://sccn.ucsd.edu/eeglab/) inside the Matlab environment (version R2015a, http://www.mathworks.com/). The practice blocks were excluded from the analysis and averaged ERPs were calculated for all the trials within the remaining blocks. Central-parietal LPPs were quantified as the average activity collapsed across five electrodes (Cz, CPz, Pz, CP1 and CP2) between 400ms and 3000ms after picture onset. The time window was divided into three: early 400-800, mid 800-1500 and late 1500 to 3000.

Paired sample t-test was conducted to examine if there was a significant difference between the angry-view and all strategies across the three-time windows. A 4 x 3 repeated-measures analysis of variance (ANOVA) was used to analyse the main effect across all strategy types and time windows. An independent t-test was conducted to examine sex difference. All ANOVA results were Greenhouse–Geisser corrected if the sphericity assumption was violated; post-hoc multiple comparisons were performed using planned t-test. Effect sizes are presented as partial eta-squared ($\eta^2_P$) for F tests and as Cohen’s d for t-tests.
5. Results

In presenting the result, the validity of the stimuli used was examined through t.test analysis of the self-reported face ratings. Following this, I examined whether all 4 strategies modulated the central-parietal LPPs and examined the time courses for respective strategies and examination of the two major predictions about distraction and reappraisal strategies.

5.1 Face ratings

The self-reported valence and arousal ratings were analyzed using an independent sample t.test. As expected, angry faces were rated higher for arousal (m=6.20, SD=.77) than neutral (M=3.13, SD=.39) and lower for valence (M=2.4, SD=.53) than neutral (M=4.9, SD=.31). The t.test result indicated a statistically significant difference between angry and neutral faces based on valence (t(70) = -24.5, p < .001 and arousal (t(70) = 21.2, p < .00

5.2 ERP data

I first examined whether the ER strategies modulated the LPP in the expected direction and subsequently examined their time course. Based on growing body of research, it is expected that the LPP will be enhanced in response to angry view compared to the neutral view, thereby depicting the response of LPP to emotionally salient stimuli. Also, It is expected that distraction and reappraisal strategies would attenuate the LPP in relation to angry view (Hajcak and Nieuwenhuis, 2006; Thiruchselvam et al., 2011, Schönfelder et al., 2014).

To test these predictions, the mean of the LPP for the total picture duration (400-3000ms) was analysed using a repeated measure ANOVA, with instruction type (neutral-view, angry-view, distraction, situation-focused, social distancing and temporal distancing) as a within-subject factor. A significant main effect of instruction types was found, F(4,499.2) = 15.6, P = < 0.01, ηP 2 = .12
<table>
<thead>
<tr>
<th>Total time window</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t.value</th>
<th>p.value</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 Angry</td>
<td>14.02</td>
<td>8.12</td>
<td>2.16</td>
<td>0.41</td>
<td>0.44</td>
</tr>
<tr>
<td>Neutral</td>
<td>10.5</td>
<td>8.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 2 Angry</td>
<td>14.02</td>
<td>8.12</td>
<td>4.22</td>
<td>.000</td>
<td>0.86</td>
</tr>
<tr>
<td>Distraction</td>
<td>7.25</td>
<td>6.65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 3 Angry</td>
<td>14.02</td>
<td>8.13</td>
<td>1.61</td>
<td>.122</td>
<td>0.33</td>
</tr>
<tr>
<td>Situation focused</td>
<td>10.5</td>
<td>9.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 4 Angry</td>
<td>14.0</td>
<td>8.13</td>
<td>3.61</td>
<td>.001</td>
<td>0.74</td>
</tr>
<tr>
<td>Social distancing</td>
<td>7.28</td>
<td>6.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 5 Angry</td>
<td>14.02</td>
<td>8.13</td>
<td>4.2</td>
<td>.000</td>
<td>0.85</td>
</tr>
<tr>
<td>Temporal distancing</td>
<td>7.78</td>
<td>7.12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Means (standard deviations) for pair-wise comparisons between angry-view and neutral view angry view and distraction, situation-focused reappraisal, social distancing and temporal distancing for the total picture duration at the central parietal LPP.

Planned t.test as expected showed that, angry view (M=14,SD=8.13) elicited a larger LPP than neutral view (M=10.5,SD=8.55), t(23)=2.16, P = .041, d= 0.44. Also, there was also a significant difference in angry view and distraction (M=7.25,SD=6.65),t(24)=4.22, P<0.01, d=0.8; social distancing (M=7.78, SD=6.40), t(24)=3.61, P=.001, d= 0.74 and temporal distancing (M=7.78, SD=7.12), t(23)=4.20, P=<.000,
d=0.86. However there was an insignificant difference between angry view and situation focused reappraisal (M=10.5, SD=9.14), t(23)=1.60, P=0.12, d=0.32. This result depicts that all strategies apart from situation-focused reappraisal reliably modulated the amplitude of the LPP at the total time window. Post hoc comparison also revealed that there was no significant difference in the overall magnitude of the LPP amongst all strategy types. Meaning all strategies are not different from each other. The LPP for strategy types for the entire picture duration is presented in figure 6.

![Figure 6: Grand average of the Stimulus-locked LPPs pooled at central-parietal sites (CP1, CPz, CP2, P1, Pz, P2) during the regulation task across all total time window(400, 3000)](image)

**5.2.1 Is there an earlier attenuation of the LPP for distraction than reappraisal strategies?**

To examine the time point each strategy began modulating the LPP, the time window was divided into, early time window (400-800ms), mid time window (800-1500ms) and late time window (1500-3000ms), a 4(strategy type) x 3(time window) repeated measure ANOVA was performed. This revealed
there was a significant interaction between time window and strategy types, $F(3.35, 231.2) = 8.09$, $P < .001$, $\eta^2_{p} = .105$.

Finally, to examine the time period when the LPP for each strategy type began to differ from angry view and to examine whether each ER strategies exhibited a different time course, a planned t-test was performed comparing each strategy to angry view across the 3-time windows. The paired sample t-test between angry view and all strategies across the 3-time windows are presented in table 2.

<table>
<thead>
<tr>
<th>Time window</th>
<th>Angry (standard deviation)</th>
<th>Distraction (standard deviation)</th>
<th>T. value</th>
<th>P. value</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early(400-800ms)</td>
<td>7.19(1.1)</td>
<td>3.86(53)</td>
<td>9.44</td>
<td>.004</td>
<td>1.9</td>
</tr>
<tr>
<td>Mid(800-1500)</td>
<td>7.19(1.1)</td>
<td>3.86(53)</td>
<td>9.44</td>
<td>.004</td>
<td>1.9</td>
</tr>
<tr>
<td>Late(1500-3000)</td>
<td>7.19(1.1)</td>
<td>3.86(53)</td>
<td>9.44</td>
<td>.004</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 2: Means (standard deviations) for pair-wise comparisons between angry-view and distraction, situation-focused reappraisal, social distancing and temporal distancing at each time window of the central parietal LPP.

The result of the t-test revealed that distraction from its very beginning at 400ms began attenuating the LPP and consistently remained lower for the remaining time windows especially at the late time window. However, inconsistent with previous studies, the result also shows that self-focused reappraisal strategies also began attenuating the LPP amplitude at the early time window (social distancing $t(23)=9.91$, $P=.001$, $d=0.79$, temporal distancing $t(23)=5.17$, $P=.001$, $d= 0.81$). To ascertain whether there was a significant difference in the LPP attenuation between the two self-focused strategies and distraction at the early time window, a paired sample t-test was also carried out, the result showed no significant effect, social distancing $t(23)= -.43$, $P =.67$, $d=-.09$, temporal distancing $t(23) = -1.65$, $P =.11$, $d = -.34$). On the basis of
this result, our main prediction that distraction will elicit a smaller LPP at the early time window was rejected.

Across the mid and late time windows, there was also a significant reduction in the LPP modulation in response to distraction and self-focused reappraisal strategies. Unlike the early and late time window, situation focused reappraisal also elicited a significantly reliable reduction in the LPP amplitude at the mid time window $t(23)=5.34, P=.03, d=1.1$.

### 5.2.2 Self-focused reappraisal strategies will elicit a greater reduction in LPP amplitude compared to situation focused strategies?

As regards the second prediction, it can be concluded that there was a greater modulation of the LPP, the paired sample t.test comparing each strategy with angry view (table1) showed that there was a greater attenuation of the LPP when self-focused reappraisal strategies: social distancing ($t(23) =3.61, p = .001$) and temporal distancing ($t(23) = 4.2, p = <.001$) were used than when situation focused reappraisal was used $t(23) =1.61, p = .122$. This result lends support to our hypothesis that there would be a greater reduction in the LPP amplitude using self-focused strategies.

Interestingly, when the time courses were divided into 3-time windows, a significant reduction in the LPP was also noticed at the mid time window for situation focused strategy $t(23) = 5.34, p = .029$). The result of the paired t.test between strategies and angry view revealed in table 2 also shows that there was an earlier attenuation in the LPP amplitude when self-focused strategies were employed: early time window (400-800ms): social distancing ($t(23) =9.91, p = .001$) and temporal distancing ($t(23) = 5.17, p = .007$) compared to when situation focused strategy was applied ($t(23) =1.61, p = .017$). The modulation of the LPP in response to situation-focused reappraisal began noticeable only at the mid time window ($t(23) = 5.34, p = .029$).

Therefore, the findings suggest that self-focused reappraisal were not only greater in attenuating the LPP but they also did so earlier than situation-focused reappraisal.
5.2.3. Sex differences and the LPP

The emotion regulation strategies were collapsed as a single strategy to examine if there was a significant sex difference in the emotion regulation strategies at the total time window. An independent sample t-test was conducted to examine this, the result revealed that there was no significant difference in the LPP between male and female when employing the strategies (male; \( M=8.01, SD=4.41, n=13 \), (female; \( M=8.43, SD=6, n=11 \) \( t(22, 18.1) = -.2, p = .85 \)), Angry view (male; \( M=15.7, SD=7.76, n=13 \), (female \( M=11.2, SD=7.76, n=11 \); \( t(22, 21.3)=1.43, p = .17 \)) and neutral view (male \( M=10.6, SD=8.49, n=13 \), (female \( M=10.9, SD=9.70, n=11 \); \( t(22, 20.1)=-.085, p = .933 \)). The presented result does not lend support to the hypothesis that was raised
6. Discussion

6.1. Emotion regulation strategies will reliably modulate the LPP?

The current research is built on previous empirical findings and theories of ER by using the LPP elicited during an unpleasant picture view (angry faces) and the LPP that is elicited when different emotion strategies are applied.

Consistent with numerous research that has found out that unpleasant facial expression successfully induced negative emotion, which is indicated by an increase in the LPP modulation in response to these faces than neutral faces (Wessing, et al, 2014; Eimer & Holmes, 2002; Eimer, Holmes, & McGlone, 2003), the present study found a significant increase in the LPP in response to angry faces and more importantly a reduced LPP was found when emotion regulation strategies (distraction and self-focused reappraisal) were employed, which depicts a successful emotional regulation or modulation.

However, contrary to expectation, there was no significant reduction in the overall LPP amplitude when situation focused reappraisal was employed. This might be due to the way the regulatory instruction was presented. Foti & Hajcak, (2008) suggests that during regulatory task when interpreting an emotionally salient event, the mere presence of a description is not enough to effectively down-regulate one’s emotion, rather, it is the nature of the description that determines the potential of the emotion regulation strategy. Hence, it is possible that the situation-focused reappraisal instruction used in this study was not specific enough to lead to a decrease in LPP.

Nonetheless, a study carried out by Urry (2009) also did not find a decrease reappraisal effects in terms of expressive behaviour and physiological responses when situation-focused reappraisal was used. Their findings are similar to the present study and according to the researcher the lack of situation-focused reappraisal effect on the negative emotions could be likened to different demanding regulatory goals presented on a randomized trial by trial basis and the goals were delivered at different points in time when the unpleasant faces were presented. The present study also manipulated six experimental goals within one
experiment. This is so far the only known study that has had participants mentally manipulate their emotional response to six varying strategies all in a single experiment. This might be the reason participants may have been unable to devote sufficient resources to generating situation-focused reappraisal that would effectively decrease negative emotions to the angry faces (Urry, 2009).

6.2 Is there an earlier attenuation of the LPP for distraction than reappraisal strategies?

Distraction and reappraisal are two strategies that have been shown to reliably attenuate the LPP and they are thought to differ in their timing characteristics. Distraction is said to operate earlier in the ER process because it involves attentional deployment and little or no meaning evaluation since an individual is not attending to the emotional aspect of the stimuli. Thus, it is expected to modify the LPP amplitude earlier than reappraisal which involves first appraising a situation and reinterpreting it. However, contrary to previous studies (Thiruchselvam, et al., 2011; Schönfelder, et al., 2014; Paul, et al., 2013; McRae, et al., 2010) distraction did not modulate the LPP earlier than cognitive reappraisal (self-focused). Both strategies were found to robustly reduce the LPP from it very beginning all through stimulus presentation. When the time courses were examined, no difference was found in the early time window between reappraisal and distraction. The reason for this might be associated with many things some of which are described below.

Firstly, one of the most important causes of differences worth noting is that the present study design differs from the previous emotion regulation paradigms with respect to the use of facial stimuli, the past studies have used emotional scenes, which are usually taken from a variety of picture categories (people, animals, mutilations, landscapes, etc.) gotten from the IAPS (Lang, et al., 2005) database and these images are of different affective gradient compared to facial stimuli that produce a single affective gradient. Therefore, this difference limits their comparability.

Second dissimilarities that might have led to inconsistent findings is the experimental designs. Some researchers have employed a modified oddball paradigm or a randomized trial by trial presentation where each picture trial is preceded by the strategy instruction to be employed.
In the present study, however, participants were only given the strategy instruction once and that was before they implemented the strategy, that is, before the block presentation.

Still on experimental design, a number of emotion regulation studies design have had the ‘distractor’ as an arithmetic printed on the emotional stimuli (Schonfelder, et al., 2014, Li et al 2017). The studies employing this design have found an earlier and largely significant difference in distraction and other strategies and its LPP modulation to unpleasant stimuli. Many other studies have also asked participants to mentally generate a distractor that is, a geometric or a neutral image that was not in any way associated with the emotional stimuli presented or generate their own alternative interpretation to the presented emotional stimulus after viewing it, with this design it is possible that the interpretations generated are the ones responsible for the changes in brain activities and not any ongoing task-related activities or cognitive processes. For instance, ‘think of a neutral thing when the picture is being displayed’ or view this picture from a third person perspective (Thiruchselvam, et al., 2011, Strauss, Kathryn, & Whearty, 2016).

The present study, however, presented a specific distractor (neutral image) before the onset of the instruction and picture trial and asked the subjects to mentally focus on the neutral image seen while the 36 faces are being displayed in each block. With this design, there are not any observable differences in the stimuli across all regulation strategies (compared to studies that had arithmetic presented on the emotional stimulus face for distraction strategy, thereby making it visually different from the other strategies) which therefore aids comparison. This study’s design allows for a direct comparison of emotion regulation strategies under almost equal circumstances as it presents images in the same experimental conditions. However, since participants were explicitly cued to mentally imagine the specific image presented prior to the picture trials, it is possible that they forgot what the neutral image looked like even at the early onset of the block trial because it’s easier to generate a neutral thought or image of one’s choice than trying to mentally remember a specific one that has most likely not been seen before. There have been numerous inconsistencies with the experimental designs of previous studies and it is not clear whether or how these experimental designs or task-related differences mentioned above can impact the LPP.
On the other hand, the equal attenuation of reappraisal strategies together with distraction at the early time window is not entirely surprising, Moser, et al’s., (2009) study revealed that the effect of reappraisal on the LPP started as early as 400ms and lasted up 3000ms, thereby consistent with our result. Some studies have even found an earlier modulation of the LPP in response to reappraisal instructions, as early as 200ms (Hajcak & Nieuwenhuis, 2006; Moser, et al, 2006), this difference according to these researchers has been linked to the experimental design manipulation, few of which have been mentioned above. It could also be that the Gross model of emotional generation and regulation simply doesn’t cover for the explanation of early modulation of the LPP by reappraisal. Gross’s model suggests that the early portion (400ms-600ms) of the LPP after an emotionally salient stimulus has been encountered reflects the point in time a stimulus is attended to, and the sustained positivity reflects a semantic elaboration. So by this, reappraisal requires a time-consuming attention and appraisal before reevaluation.

While the reason for this study and some others (Hajcak & Nieuwenhuis, 2006; Moser, et al., 2006, 2009) that have found an early reappraisal effect could be easily linked to differences in experimental manipulation, it could also be that reappraisal alter early neural responses to unpleasant stimuli as suggested by McRae, Ochsner, Gross, & Gabrieli (2002). They also suggested that reappraisal might be a form of distraction that disrupts emotion processing in similar ways a secondary task disrupts a primary task. This could imply that down-regulation of an emotion via cognitive reappraisal occurs not just because the meaning of an emotional event has been reinterpreted but because of engagement in cognitive processes that draws attentional resources from it. To this end, cognitive reappraisal might intervene early, mid or late in the emotion generation trajectory, depending on the circumstances and this might be applied to any other strategy also.

Finally, the early modulation of reappraisal could also mean that since block by block design was used, participants might have changed expectations about the upcoming pictures, Schonfelder and colleagues suggested that conscious adjustment of expectations about a stimulus might be an effective strategy for the cognitive control of emotions. So it is not impossible that this study and others that found an
early attenuation of the LPP in response to reappraisal might have studied the controlled generation of emotional responses which tends to occur earlier and not controlled regulation (Schonfelder, et al., 2014).

6.3 Self-focused strategy will lead to a greater attenuation of the LPP compared to situation focused strategies.

The present study found out that self-focused reappraisal strategies, also known as detached or distancing strategies resulted in a stronger attenuation of the LPP than situation-focused reappraisal. These findings support previous studies (Qi, et al., 2017; Sheppes et al., 2014) that suggested that the more disengaging and distant perspective taken on an emotion-eliciting event, the earlier and greater the LPP modulation. Particularly, Sheppes, et al. (2014) suggests that detached reappraisal strategies are not as emotionally engaging as positive reappraisal which is often used interchangeably with situation-focused reappraisal. Self-focused strategies tend to push thought content in a socially or temporally irrelevant or neutral direction. In this experiment, situation-focused involves first imagining seeing the angry faces in the public train and imagining that the angry faces will feel they overreacted and become happy afterwards, this means trying to interpret a negative emotion in a positive light. This strategy has been shown to be more emotionally engaging than just simply taking a detached or distant perspective by imagining the person as nothing to do with the experimenter or the angry face might mean nothing to them in a year from the experiment time.

A study by Shiota & Levenson (2012) also revealed that detached reappraisal tends to be more effective in overall emotional responding while positive reappraisal reduced emotional responding to negative emotion to a lesser degree. The present study also corroborates the findings of (Yanagisawa, et al., 2011; Trope & Liberman, 2003, 2010), these researchers suggested that psychological distancing like temporal distancing or social distancing produces a state of detachment from one's immediate emotional experiences and this is evident in the reduced LPP following the both self-reappraisal strategies.
Apart from a stronger modulation, the present study also found an earlier modulation of the LPP when self-focused strategies were employed. This is consistent with Qi et al., 2017, who found an earlier modulation of the LPP when detached reappraisal was used but such effect was not found for positive reappraisal until around the 1100-1700ms. This implies that both self and situation focused reappraisal are characterized by different time points. On the other hand, Willroth & Hilimire (2016) found a contrary result to this, they found out that situation-focused strategies elicited a greater reduction in the LPP and no effect was found with self-focused reappraisal, though this particular study needs to be interpreted with caution, as the time window examined was (300ms-1000ms) and only the electrode PO8 was accessed.

Very few studies have examined the differential effect and temporal dynamics of various form of self-focused and situation-focused reappraisal, the findings of this study add to be body of knowledge on reappraisal but more replications need to be done especially because of facial stimuli that were used and haven’t been used by any known study to compare the differential effects of these strategies.

6.4 Sex differences and the LPP

A lot of ERP studies have not been carried out to explore the differential effect of gender and the LPP when ER strategies are applied. Studies have shown that emotionally salient stimuli are processed differently in men compared to women and that there are sex differences in response to negative visual stimulus (Canli, et al., 2002; Cahill, et al., 2001). Particularly, Hall et al. (2004) found out that females are more reactive to unpleasant emotional stimuli (both in terms of subjective arousal and enhanced limbic and prefrontal brain activities) and less efficient in regulating their emotions to unpleasant pictures. This might be due to them recruiting fewer cognitive control resources during processing of emotionally salient images. It was expected that there would be a larger LPP in response to emotional stimuli and also a lesser reduction in women compared to men when emotion is being down-regulated.

Nonetheless, the result revealed that there was an insignificant difference between male and female in the processing of facial stimuli with or without emotion regulation strategies. This finding is partly
consistent with a study that has found no difference in the LPP modulation between male and female when they were asked to ‘decrease’ their emotional responses (Gardener et al., 2013). Gardener and colleagues study result revealed that neither females nor males showed a significant reduction in the LPP amplitude when asked to down-regulate their emotion. The present studies result is however inconsistent with previous fMRI studies that have found significant reductions in limbic and prefrontal regions when one is consciously down-regulating emotional responses towards a negative emotional stimulus particularly for men and, to a significantly lesser extent in women.

Based on this result, it would be hasty to draw conclusions about sex differences in response to unpleasant facial stimuli and emotional regulation strategies majorly because of the small sample size (13 males, 11 females), also, all strategies were collapsed as one strategy, in future work larger sample size should be used and gender response to each of the emotion regulation strategies should be accessed.

6.5 Limitations, recommendations for future study

It is important to note some limitations of the current research. First, a fairly small sample was used. In addition to studying a larger sample, future studies should measure affective reaction through subjective self-reports of emotional response before and after emotional regulation strategies have applied. By this, one is able to tell if there is a difference between the neural response and subjective ratings when the strategies are employed and how they relate to individual differences in emotional reactivity and regulation. Also, this study manipulated six experimental conditions, which is so far the largest known experimental manipulation in an emotion regulation study. Whether combining several strategies in a single study has an effect on the emotional responses, in the long run, is not known but might be worth taking note of.

The present study also focused only on the emotional modulation of unpleasant stimuli, future studies should examine how modulation of responses to other stimuli (e.g. pleasant) affects the ERPs and more importantly how different experimental design, manipulations and instructions might be best used to down-
regulate electrophysiological responses to emotionally salient stimuli and also how other different forms of attentional deployment like selective or spatial attention might modulate the LPP in comparison with reappraisal strategies. Since the presented distracting stimuli leads to an increased cognitive load (trying to mentally imagine and focus on the object) future studies could employ spatial attention which involves directing ones attention to a non-emotional part of stimuli like the hair, the shape of face or any other part that could keep them distracted from the ongoing or presented unpleasant stimuli. As regards the unexpected insignificance difference that was found when situation focused was used at the total time window, subsequent studies might benefit from systematically controlling the way in which the reappraisal instructions are presented. These instructions should be presented in a more straightforward and relatable context. For example imagining that the angry faces looks like one in a movie or the person was angry for some other personal reasons.

In addition, very few studies have examined the effects of ER strategies on the LPP using facial threatening stimuli, more studies need to replicate the findings of this study to ascertain whether the differential and non-differential results were based on the experimental manipulation and design or based on the facial stimuli that were used.

6.6 Conclusion

In summary, the present study has explored the LPP modulation to angry faces when different emotion regulation strategies are employed. Twenty four healthy participants were recruited for the study. Two major hypotheses were raised; first, distraction will modulate the LPP earlier than cognitive reappraisal strategies. Second, self-focused reappraisal strategies will lead to a stronger attenuation of the LPP than situation focused reappraisal and a secondary exploratory aim that states that there would be a greater increase in the LPP modulation in females when angry faces are viewed and also a lesser reduction in the LPP when ER strategies are employed compared to males.

The general findings of this experiment partly corroborate previous studies. No significant earlier attenuation of the LPP was found when distraction was used compared to when reappraisal was used. The
potential reasons for this have been elaborated above. Previous studies on reappraisal strategies support our findings of greater attenuation of the LPP when self-focused strategies were used compared to when situation focused reappraisal was used. Inclusively, the study did not find significant gender differences in LPP modulation both when emotion regulation strategies were applied and when the pictures were viewed passively.

This study highlights the importance and the influence of the late positive potential in the study of emotion and emotion regulation. The LPP continues to be a valuable tool in the study of the time course of attention to emotional stimuli and emotion regulation through the use of different strategies. This study, though with few limitations, provide significant directions for future studies.
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