Temporal Distancing and
Emotion Regulation: An ERP study

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Abstract

Reappraisal is a cognitive emotion regulation strategy that induces a reduction in the arousal response elicited by both unpleasant and pleasant stimuli. One form of reappraisal is that of temporal distancing. Temporal distancing is the cognitive tool that allows the individual to perceive the stimuli in a broader temporal perspective. Reappraisal’s impact on the arousal response can be measured by assessing the amplitude of the event-related potential (ERP) component the late positive potential (LPP), a centro-parietal slow-wave ERP beginning around 350 ms post-stimulus and sustaining for up to several seconds. The aim of this study was to test various temporal-related perspectives in order to see their effect on the LPP. The analysis of the data suggests that a decrease in the amplitude of the LPP in response to emotionally unpleasant facial stimuli corresponds to adopting a temporal distancing strategy, regardless of the exact temporal distance chosen.

Keywords: Event-related potential, emotion regulation, reappraisal, late positive potential, temporal distancing
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“Time heals all wounds.” 

_English proverb_
Introduction

On February 1, 2011, Alissa Kent’s brother, with his soul torn to pieces, testified at the trial against Ron J. Richard in Salk Lake City, Utah (USA). He accused Ron of killing his sister because Ron could not accept that Alissa had rebuilt her shattered life with Tom Dennis – a companion at her place of employment – after divorcing Ron two years prior. Driven by his desire for revenge, Ron jealously committed a criminal act by shooting both Alissa and Tom.

People usually make the wrong choice when they have been seized by emotions such as hate, revenge, or fear. Since a happy situation might elicit an exaggerated response, and a dreadful event might interrupt the normal processing of the information (Gross & Muñoz, 1995), several mechanisms have been proposed by which we have been able to control these emotions that disturb our well-being whilst aiding mental health (Gross & John, 2003). One of these proposed mechanisms is that of reappraising emotional stimuli, which involves cognitive changes. In this study, unpleasant portraits have been used in order to assess the emotional arousal. This emotional arousal has been modified by the participants applying a specific cognitive strategy. This cognitive strategy has allowed the subject to envision the stressing portrait in a broader temporal perspective.

To my knowledge, this is the first study to date that has explicitly connected the effects of the reappraisal in the context of a temporal perspective with the neural cortical changes.

Late Positive Potential, Temporal Distancing, and Reappraisal

The late positive potential (LPP) is a slow-wave, event-related potential (ERP) component that is related to emotional processing (Keil et al., 2002). In ERP experiments, the LPP amplitude displayed is higher when a subject passively views both unpleasant and pleasant pictures rather than neutral one (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). Since one is able to downregulate the emotional response, the LPP is also subject
to modification by different cognitive approaches (Moser, Hajcak, Bukay, & Simons, 2006). Hence, LPP is an index of emotional arousal. The LPP elicited either by passively viewing pictures or by reappraising pleasant as well as unpleasant images has been divided into three periods: early, middle, and late LPP (Qi et al., 2017).

*Temporal distancing* (TD) is a mental strategy that engages *chronesthesia* which, is the ability to remember the past and imagine the future, a cognitive tool suggested to be exclusive to humans (Nyberg, Kim, Habib, Levine, & Tulving, 2010). The TD strategy acts by placing the stressor in the context of the ‘bigger picture’, envisioning the stressing stimulus in a broader temporal perspective, so that the unpleasant event is reappraised by the subject (Schartau, Dalgleish, & Dunn, 2009; Yanagisawa et al., 2011).

The LPP and TD are connected by the cognitive mechanism that regulates the response elicited by emotional events: the *reappraisal* (Bruehlman-Senecal & Ayduk, 2015; Hajcak, MacNamara, & Olvet, 2010). Reappraisal is a cognitive change, an *emotion regulation* (ER) strategy, whereby a stimulus is reinterpreted ‘before the emotion response tendencies have been fully generated’ (Gross & John, 2003, p. 349). In general, the more effective the emotion regulation is, the lower the level of emotional arousal is. Furthermore, a reappraisal strategy very commonly encountered in studies because of its effectiveness is the self-focused strategy (Gross, 2001). By adopting this strategy, the subject is able to self-regulate emotions (Bruehlman-Senecal, Ayduk & John, 2016). For instance, envisioning how a current stressor will affect us in the distant future is a self-focused strategy that aids in overcoming the unpleasant event (Yanagisawa et al., 2011).

**Research Questions**

Reappraisal and emotion regulation have been addressed in many different ways (see Gross, 1998; Ochsner et al., 2004). In this study, different TD approaches were adopted by the participants in order to reveal differences in the LPP elicited by the same stimulus.
The first question addressed was: does TD have an impact on emotional arousal (e.g. LPP) when the subject is shown unpleasant pictures? Although there is evidence based on questionnaires (Bruehlman-Senecal, Ayduk, & John, 2016; Yanagisawa et al., 2011) and reports (Schartau et al., 2009) of mental health–related benefits occurring when a subject applies a broader temporal perspective on a stressor, nothing has been reported regarding the TD impact on the LPP after viewing unpleasant pictures in an ERP experiment.

The second question is closely related to the first because it follows the natural progression of the study. In the event that TD does have an impact on LPP, do the different TD perspectives have varying impacts on LPP when the subject is shown unpleasant pictures? In other words, does a distant-future perspective have a stronger impact on LPP than a near-future perspective?

Overview of the Thesis

The aim of this thesis is to record, via an ERP technique, the impact of different TD perspectives on the LPP elicited by angry faces. In the first part of the introduction, a brief explanation of the study was given in order to outline the basic context of LPP, TD, and reappraisal. However, a deeper context of these three topics is provided in the Background section. In order to answer the research questions, an ERP study was developed using 20 students as participants at the University of Skövde, Sweden. This study was split into three parts in order of occurrence: the questionnaire, practice, and the experiment. A questionnaire containing images of angry and neutral portraits was given to all the participants. Next, the participants practised the cognitive strategy they had been asked to apply during the portrait presentation. Finally, the experiment was run, during which the participants reappraised angry faces using the TD strategy (see Methods). The results collected showed that: (1) the LPP amplitudes elicited by angry faces were lower than the angry-face baseline when the subject carried out the TD strategies; (2) the TD
LPP amplitude was similar to the LPP amplitude elicited by neutral portraits; and (3) although there was an LPP reduction when TD was applied, there were no differences regarding the LPP amplitude among the different TD strategies (see Results). In short, TD may be an effective strategy for downregulating emotional response. The causes of all the TD strategies eliciting a similar LPP amplitude during the portrait presentation as well as future perspectives are discussed at the end of this thesis (see Discussion).

Limitations

Although there are other models that may explain emotion regulation (Gross & Muñoz, 1995), this study is rooted in the work of emotion regulation carried out by Gross (Gross, 1998, 2002; Gross & Muñoz, 1995; Gross & Thompson, 2007). Furthermore, TD strategy is a psychological construct considered as a self-focused strategy that engages reappraisal (Bruehlman-Senecal, Ayduk, & Jhon, 2016). It means that TD effects have been tested solely by self-reports. Little is known about the cognitive changes elicited by this specific, reappraisal strategy (see Background and Discussion sections) and no previous studies have been conducted around TD and ERP experiments. Following this concept, TD was applied by the participants as another self-focused reappraisal strategy.

Finally, technical limitations concerning the electroencephalogram (EEG) equipment (defective cables), the analysis of the channels (signal interpolated from defective cables), and the artefacts rejection (a rejection that may have also involved a good signal) necessitated a reduction in the number of subjects from 27 to 20 in the final analysis.
**Background**

*Chronesthesia*, the ability to remember the past and imagine the future, is a cognitive human tool as Nyberg, Kim, Habib, Levine, and Tulving (2010) suggested. The human being can both review past experiences and imagine the future. In the case of imagine the future, humans usually perceive the future from two perspectives: the near future (e.g. visualising events coming up tomorrow or in the forthcoming days) and the distant future (e.g. envisioning their lives in the coming years, as stated in Bruehlman-Senecal & Ayduk, 2015). The differences between near- and distant-future events have been addressed by Trope and Liberman (2003). In the abstract of their review, they state that ‘the greater the temporal distance, the more likely are events to be represented in terms of a few abstract features that convey the perceived essence of the events (high-level construals) rather than in terms of more concrete and incidental details of the events (low-level construals)’. In other words, both near- and distant-future predictions, preferences, and information processes are governed by how people construe their near- and distant-future events, and the latter is likely to present more abstract and schematic objects than the former. Nonetheless, the impact of temporal perspective on the emotions is still unknown.

**The Core of Emotion and Its Regulation**

Gross and Thompson (2007) suggested that emotions have three features.

First, emotions occur due to an interaction between an individual, an event, and the relevance of that event to the aims of the individual. These aims create different emotions by virtue of the nature of the aims. The aims can be either long-lasting (e.g. staying alive) or transitory (e.g. taking the last train to university). They can be either conscious and complex (delivering the annual report in front of the finance department) or unconscious and simple (e.g. typing a message). Additionally, they can be generally shared (e.g. the aim of a couple to have children) or entirely personal (e.g. buying a specific book for the summer holidays). Emotions result any time an individual is in a situation that is relevant
to their aims. Since human beings change their goals throughout their lifespan, their emotions change as well.

Secondly, emotions modulate central and peripheral physiology by recruiting behavioural changes (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). When a highly powerful emotion arises, we are forced to act in specific ways. These acts involve motor activity and behavioural changes (*multisystem changes*) which, in turn, lead to energy demand. The regulation of emotions is crucial not only for our mental health but also to save energy due to emotional responses incurring a high energy cost. As Gross and Thompson (2007, p. 5) said, ‘Maturational changes in the physiological and behavioural response systems involved in emotion play a fundamental role in the development of emotion, particularly in infancy and early childhood’. The first steps in life are essential for the child in order to understand the physical consequences of emotions and to improve emotion regulation (Mills & McCarrol, 2012).

Thirdly, emotions can be modulated (Gross & Thompson, 2007). In the paragraph above, emotions have been defined as triggers that force *multisystem changes*; that is, emotions have the ability to suspend what we are doing and force themselves into our awareness – this imperative quality has been termed ‘control precedence’ by Frijda (1986, p.78). However, as Gross and Thompson (2007, p. 5) said, ‘the multisystem changes associated with emotions are rarely obligatory’. Until now, nothing has been reported about how an emotion is formed; because an emotion is fed by the same social matrix that feeds other responses, this competition makes emotions malleable in many different ways. In other words, although emotions can change physiological and behavioural responses, they are vulnerable to being changed before they are fully formed. This last feature is the kernel of *emotion regulation*.

Once what constitutes the emotions have been established, other affective processes can be misunderstood as emotions. This is the case with stress, moods, and impulses. The first refers solely to unpleasant affective processes (Lazarus, 1993). Moods often last longer and are more diffuse than emotions (Lang, 1995). Impulses has less flexibility in
application than emotions and a much narrower range of potential objectives (Ferguson, 2000). Finally, following this line, Gross and Thompson (2007, p. 5) coined the concept of the *modal model of emotions* defined as ‘a person-situation transaction that compels attention, has particular meaning to an individual, and gives rise to a coordinated yet flexible multisystem response to the ongoing person-situation transaction’. According to this model and the emotion’s features, emotions can be regulated when they do not respond accurately to our life events (Tooby & Cosmides, 1990). Therefore, the regulation of emotions in response to unsympathetic events is important in order to keep up our physical (Greer & Watson, 1985; Mauss & Gross, 2004) and mental health (Hajcak, MacNamara, & Olvet, 2010) as well as our memory (Richards & Gross, 2000).

According to Gross (1998, p. 275) emotion regulation refers to the process whereby ‘individuals influence which emotions they have, when we have them, and how we experience and express them’. Emotion regulation involves all conscious and nonconscious strategies that we use in order to increase, maintain, or decrease one or more factors of an emotional response (Gross, 2001). Thompson (1994, p. 27) defines emotion regulation as ‘the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one’s goals’. There are four aspects of the core of emotion regulation that are important to explain (see Gross & Thompson, 2007, pp. 8–9). Firstly, emotion regulation involves not only negative emotions but also positive ones (Brans, Koval, Verduyn, Lim, & Kuppens, 2013; Parrott, 1993). Secondly, emotion regulation can be applied in either conscious (Dennis & Hajcak, 2009; Foti & Hajcak, 2008) or unconscious states (Boden & Baumeister, 1997; Cole, 1986). Thirdly, emotion regulation is neither essentially good nor bad (Gross, 2002). Fourthly, since the *multimodal model* of emotions regulates the whole body of emotions over time, the regulation of emotions is *dynamic* with respect to numerous factors such as latency, onset time, magnitude, length of action, and offset of responses in the behavioural, experiential, and physiological domain (Gross, 1998; Thompson, 1990). In the onset time period, emotions can be regulated at different points. The
same emotion is subject to different emotion regulation strategies according to the timeline in which these strategies act. In other words, there is a chronological order of five different response strategies that unfold sequentially to modify the emotions.

**Emotion Regulation Strategies**

The study of emotion regulation and emotion regulation strategies has been largely addressed by Thompson (1990, 1994), and Gross (1998, 2001, 2002, 2015; Gross & Thompson, 2007). According to these authors, there are broadly two families of emotion regulation strategies called *antecedent-focused emotion regulation* and *response-focused emotion regulation* (see Figure 1). The former concerns all the strategies involved in how the individual modifies their behaviour or physiological responses prior to emotions becoming fully activated (e.g. deciding to attend a friend’s party rather than study for college exams). The latter is related to how the individual reacts when the emotion — i.e. the behaviour or physiological response — has already been generated (e.g. realising people have not been wounded following a terrible car accident). The first family comprises four emotion regulation strategies: *situation selection, situation modification, attentional deployment, and cognitive change*.

*Situation selection* is the initial strategy applied and indicates those conscious selections that an individual makes at the expense of others (e.g. having a party with your friends instead of spending time on your assignments). Once the selection is made, the emotions prompted by the situation can be mitigated — applying the *situation modification* strategy — in order to adjust its emotional impact; e.g. one of your friends ask you whether you have checked the university e-mail account and you respond that you do not want to talk about the university (Lazarus & Folkman, 1986). After this, the situation offers numerous aspects to focus on.

The *attentional deployment* strategy is used to select which situation is best to employ (e.g. talking with your friends about your favourite music instead of having a conversation with acquaintances about Korean filmmakers; see Nix, Watson, Pyszczynski, &
Greenberg, 1995). Once an individual has focused on a certain aspect of the situation, the different meanings of that aspect are evaluated. The interpretation of these different meanings prevents the emotions to trigger behaviour and physiological responses (e.g. reappraising that ridiculous, unreasonable comment made by an acquaintance over your favourite band music; see MacNamara, Foti, & Hajcak, 2009).

On the other hand, the second family of the emotion regulation strategies has *response modulation* as its only member and this takes place when the emotion has already been formed. The response modulation strategy engages all attempts to restrict behavioural responses (e.g. inhibiting all the potential gestures or facial expressions that might be displayed after listening to the same acquaintance this time supporting your favourite band or concealing your embarrassment the next day after disastrously failing the assignments; see Cutuli, 2014; Goldin, McRae, Ramel, & Gross, 2008).

Due to the research being focused on cognitive changes (i.e. reappraisal) elicited by portraits with accompanying descriptions, this emotion regulation strategy will be explored in detail.

**Reappraisal and the Impact on the ERP**

Reappraisal, rooted in the work of Lazarus (1991), is a strategy used to mitigate emotional response elicited when a certain stimulus is displayed (e.g. when we know that the dreadful monster exists only within the context of the movie); in other words, when an individual reappraises or cognitively re-evaluates a potentially emotion-evoking situation in terms that diminish its emotional impact (Gross, 2001). With regard to effectiveness and flexibility, reappraisal seems to better reduce the negative emotions evoked by an adverse event compared to the emotion suppression strategy (Gross, 2002; Richards & Gross, 2000). Since reappraisal is evoked early in the time span of emotion generation, this strategy is not subject to continuous self-regulation during the emotional process and therefore has no impact on memory (Richards & Gross, 2000). However, other studies associate reappraisal with enhanced memory performance (Willroth & Hilimire, 2016).
With regard to the nature of reappraisal, Ochsner et al. (2004) as well as Willroth and Hilimire (2016) differentiate two types of reappraisal: *self-focused* and *situation-focused*. The former involves an individual-made reinterpretation of the event’s relevance – changing the bridges between the event and the subject, and the latter reinterprets the nature of the event itself – reassessing its features, outcomes, and dispositions.

**Schematic classification of the Gross-based emotion regulation strategies**

*Figure 1.* According to the process model of emotion regulation, two emotion-regulation-involved families are represented in five sequential strategies. Antecedent-focused emotion regulation is represented by four different strategies: (1) situation selection, (2) situation modification, (3) attentional deployment, and (4) cognitive change; whilst response-focused emotion regulation is represented by (5) a response modulation. The original illustration can be observed in Gross (2001, p. 215).

The impact of reappraisal strategies on the brain’s activity has been summarised by Hajcak, MacNamara and Olvet (2010). In general, reappraisal inhibits the amygdala’s activity whereas brain areas that may facilitate cognitive control, such as the lateral prefrontal cortices (LPFCs) and medial prefrontal cortices (MPFCs), show an increased activity (Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner & Gross, 2008; Phan, Wager, Taylor, & Liberzon, 2004; Schaefer et al., 2002; Tabert et al., 2001). Therefore, reappraising an emotional stimulus engages a level of high self-control by reducing emotional processing and increasing cognitive control (Miller & Cohen, 2001).
Nonetheless, in the context of temporal resolution, functional magnetic resonance imaging (fMRI) is not appropriate for unravelling the electrophysiological features of reappraisal. For the purpose of augmenting the insight of the reappraisal, numerous ERP studies have been carried out in order to monitor in real time the neocortical waveform changes when a participant has been instructed to reappraise visual stimuli (Foti & Hajcak, 2008; Hajcak & Nieuwenhuis, 2006; Orozco & Ehlers, 1998; Schupp et al., 2004; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). Furthermore, Cacioppo, Crites, Berntson and Coles (1993) reported, for the first time, changes in a component close to P3 prompted by sequences of unpleasant and pleasant words. In other words, Cacioppo et al. (1993) identified a *late positive ERP component* as the marker for differentiating participants’ attitudes produced by words.

**Late Positive Potential: The ERP Signature for Emotion Regulation**

The late positive component identified by Cacioppo et al. (1993) is named the Late Positive Potential (LPP). Before exploring the studies of LPP in detail, it is important to describe the main features of this ERP component. LPP is a midline positive-going slow-wave ERP component that begins around 350 ms after picture onset. The maximal amplitude is located at 800–1,500 ms upon the picture’s presentation and is observable until the picture offset (up to 6 s) (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Hajcak, MacNamara, & Olvet, 2010; Thiruchselvam et al., 2011). The scalp-activity distribution panels made by the LPP reported initial activity around the occipital electrodes before moving toward more central sites (Foti & Hajcak, 2008; Hajcak et al., 2010; Hajcak & Nieuwenhuis, 2006). Similarly, Sabatinelli, Lang, Keil and Bradley (2006) reported fMRI-based findings on the LPP. In their study, they state that the blood-oxygen-level dependent (BOLD) signal correlated significantly with the LPP amplitude in the lateral occipital, inferiortemporal, and parietal visual areas. The reason why numerous emotion regulation studies have been conducted to understand this component using many different ERP approaches is that its amplitude varies with respect to the type of stimulus: a
higher amplitude corresponds to the presentation of pleasant as well as unpleasant pictures. Threatening faces or facial expressions showing a range of emotions (i.e. happiness or anger, sadness or joy) elicited a higher LPP amplitude in contrast to the amplitude elicited after presenting neutral pictures (Hajcak et al., 2010; Hajcak & Nieuwenhuis, 2006). Furthermore, LPP is shown to be independent of stimulus size (De Cesarei & Codispoti, 2006), and stimulus repetition (Codispoti, Ferrari, & Bradley, 2006). As stated above, multiple studies have been conducted on LPP; here, the most noticeable ones are summarised.

In 2000, two separate studies carried out by Cuthbert’s and Schupp’s teams and followed by in-depth validation two years later by Keil et al. (2002) found that emotional pictures from the International Affective Picture System (IAPS) elicited a larger LPP in amplitude than neutral pictures when viewed passively by the subjects (see Figure 2). These studies were the first to report variations in ERP components based on affective pictures and formed a new field of study in emotion regulation. In the case of Cuthbert’s study, it is important to mention that an increase in skin conductance was recorded when the participants were looking at both pleasant and unpleasant pictures in contrast to neutral pictures.

Four years later, in 2004, Schupp and colleagues again reported the same pattern in the LPP when threatening, friendly, or neutral faces were used as unpleasant, pleasant, and neutral pictures respectively. This finding was corroborated using different types of gestures by Flaisch, Häcker, Renner, and Schupp (2010), and in the case of Duval, Moser, Huppert, and Simons (2013), by using a face database. All these studies deserve a careful and thorough analysis because they are sceptical of the ecological validity of highly emotional pictures, such as mutilated corpses, murder attempts, raids, and aggression showed in IAPS. On the other hand, sad, happy, angry, disgusted, nervous, or fearful portraits show a higher ecological validity (Goeleven, De Raedt, Leyman, & Verschuere, 2008).
In 2006, Moser et al. described a reduction in the LPP after participants were required to mitigate the impact of unpleasant pictures (IAPS) on themselves through reappraising the picture or focusing their attention on specific details that might aid them in decreasing their emotional response. The participants subsequently applied two different emotion regulation strategies indistinctly: attentional deployment and reappraisal. Nonetheless, the instructions given to the participants prior to the pictures’ presentation helped them to perform both effectively, avoiding the unfolding of other strategies.

**An illustration of the LPP variations elicited by passively viewing of emotional pictures**

![Waveform](image)

*Figure 2.* The waveform approximately represents the grand average during the viewing of affective pictures, measured separately for each valence category (pleasant, neutral, and unpleasant). The left panel represents the potential variations from the picture onset (0 s) to 1 s. The right panel shows the subsequent 5 s of slow potential variation. Adapted from Cuthbert et al. (2000, p. 101).

Two striking studies summarise the impact of reappraisal on LPP: the first one by Hajcak and Nieuwenhuis (2006) was conducted according to specific instructions given
prior to the presentation of IAPS pictures in order to assess the amplitude of the LPP generated by unpleasant stimuli. Those instructions were designed either to reappraise an unpleasant image or to simply attend to those unpleasant images. LPP was diminished due to the reappraisal instructions (see Figure 3). Furthermore, the effect of reappraisal on unpleasant images produced a less intense emotional response. In a second study, Foti and Hajcak (2008) introduced the concept of intrinsic and extrinsic factors by inserting descriptions before the IAPS pictures. These descriptions were displayed prior to the viewing of the same picture. Surprisingly, a more negative description for an unpleasant picture had a bigger impact on LPP than a neutral description for the same picture. The extrinsic factor, the description of the picture, modulated the LPP via the assessment of the stimulus, meaning that negative descriptions increase the LPP, while neutral descriptions decrease it. Therefore, one can use different descriptions in order to attenuate the impact of a picture on the participant’s emotions.

Because different descriptions can affect the arousal of the subject in distinct grades, the reader would expect a list of studies detailing how the adoption of a broader temporal distancing can reduce the LPP when a subject reappraises an unpleasant picture in contrast to the LPP elicited by the observation of the same unpleasant picture. However, the lack of studies focused on both LPP and TD suggests that there is a gap in the literature reviewed. Although the studies on LPP itself are rather numerous, one can barely find even a few studies on the TD effects on arousal. For instance, in 2011, Yanagisawa’s team applied a TD approach to reduce the stress generated by an environment of social exclusion. The description of the event was changed to a greater degree in order to diminish the effects of social pain: thinking in a ‘distant-’ as opposed to a ‘near-’ future condition is less painful in a social exclusion context. By contrast, Ahmed, Somerville, and Sebastian (2017) used negative scenarios to assess the TD. The greatest regulation of stress was linked to those participants who projected further ahead. Hence, taking into account that these two studies are one focused on the effects of the TD on the emotion regulation, the reader may wonder about the TD effects on the LPP: can an ERP experiment be conducted
with varied TD so that the LPP will be modulated by the different TD conditions? In other words, does TD facilitate the reappraisal of a distressing event and will this process be recorded in an ERP experiment?

Therefore, the objective of this master's thesis is to fill the gap in this field of cognitive neuroscience. The thesis used an ERP approach to record the variations in the LPP amplitude elicited by angry faces before the subject applied four different TD strategies. The experiments were designed to corroborate the hypothesis that TD modulates the LPP and different TD perspectives modulate the LPP at different level.

An illustration whereby reappraisal decreases the LPP elicited by unpleasant IAPS pictures

Figure 3. ERP waveforms at electrode CPz. Unpleasant IAPS pictures were both simply observed (red dashed lines) and reappraised in a less negative way (grey line). Note that negative voltage changes are plotted as upward deflections. Adapted from Hajcak and Nieuwenhuis (2006, p. 295).
Methods and Materials

The Participants

Prior to the experiment, each participant had to sign the informed consent paper after reading the document in which all technical equipment was explained in order to avoid misunderstandings. The experiment was performed by twenty students from the university of Skövde who were right-handed with no neural disorders and with normal or corrected vision. The students were seated in a well illuminated and ventilated room built specifically for hosting the participants, the EEG equipment, and the monitor in which the portraits would be displayed.

The Questionnaire, the Practice, and the Experiment

Since the experimental focus was on the impact of portraits on the participants, a questionnaire including the portraits was given to the participants in order to validate the desired impact of the faces. The questionnaire was retrieved from the Umeå Database of Facial Expressions (Samuelsson, Jarnvik, Henningsson, Andersson, & Carlbring, 2012) and encompassed 18 angry female portraits, 18 angry male portraits, 18 neutral female portraits, and 18 neutral male portraits. The age range of the portraits was 18–67, many of them students and thus a good representation of the Swedish population. The participants had to rate each portrait based on their valence and arousal. For that reason, two 9-point Likert scales were included. The higher score on the valence scale corresponded to a negative rating of the portrait, and the higher score on the arousal scale corresponded to a high-intensity rating of the portrait.

After the questionnaires were filled in, the participants had a practice immediately before the experiment. The practice was designed to train the participants in the mental strategy required as well as to engage their attention by posing questions that they had to answer. The portraits displayed in the training were different from those in the experiment. Moreover, the participants had the opportunity to communicate with the experimenter at any time during the training. Afterward, the participants were left alone in the
room, and the experimenter moved in an adjoining room to control the progress of the experiment and the EEG signal.

When the participants were ready, the experiment designed to measure the impact of TD on LPP using angry portraits took place as follows (see Figure 4). First, a specific instruction – given at the beginning of the experiment – classified the experiment into six conditions. Each condition encompassed a specific instruction and 36 portraits (either angry or neutral, depending on the instruction). The first two conditions represented the baseline: to observe angry and neutral faces. Both conditions were accompanied by the same instruction: ‘Imagine that you are seeing each person in front of you right now on a public train. Just observe their face’. The other conditions were each accompanied by an instruction designed to drive the participant to reappraise – in the context of different temporal distancing strategies – angry faces after they had been presented. The instruction was as follows: ‘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 to yourself how little their anger will mean to you in 1 Day /1 Week /1 Month /1 Year. Please only apply this strategy after each face is shown, not before.’ The conditions were presented twice pseudo-randomly and the first condition never was repeated in the same position in the second round. Secondly, after the instruction, there was a premask stage (800–1,000 ms of duration) before the portrait presentation in order to avoid potential heart beat interference with the ERP signal. In order to keep the participants paying attention to the picture, and thus, to the experiment, a fixation dot appeared in the middle of the screen (250 ms of duration) immediately before the presentation. A question relating to the gender of the last face shown (‘What gender did the last person have?’) was also presented approximately twice per condition and randomly between the portraits with the same objective as the fixation dot. Thirdly, the same portraits displayed in the questionnaire were used in the experiment and the presentation lasted for 3,000 ms. After the portrait presentation, there was a 900-ms postmask stage. Finally, there was a brief pause
between conditions whereby participants were allowed to relax until they were ready to continue.

**Equipment, Data Acquisition, and Data Analyses**

The portraits were presented centrally on a monitor that was connected to a computer outside the room and observed by the experimenter. The participants were seated in a chair 1.5 metres in front of the monitor inside a well-illuminated and ventilated room. EEG signals at electrode locations AFz, F1, F2, F7, F8, Fz, FC1, FC2, FCz, C3, C4, Cz, CP1, CP2, CP3, CP4, CPz, P7, P8, Pz, POz, O1, O2, O9, O10, Oz, T8, T7, LM, RM and four electrooculography electrodes (EOGs) were measured with an active EEG electrode system – g.GAMMAsys (g.tec medical engineering GmbH, Austria). All EEG recording sites were carefully prepared by being injected with conductive electrode gel. Electrode impedances were transformed by the system to output impedances of about 1 kΩ. The amplifiers were connected to a second computer where the signals were recorded using MATLAB (version R2015a) (Adimulam & Srinivas, 2016). The ground electrode was placed at AFz and during the data acquisition CPz acted as a reference. Later, the mastoid electrodes (LM and RM) replaced CPz as the reference during the data analysis. The four EOGs were placed around the eyes proximal to the orbicularis oculi muscles; two of them were placed laterally relative to both the left and right eye towards the temples, with the remaining two placed on the dorsal and ventral edges around the right eye. These recorded any eye-blinks and strong activity produced by the eye’s rectus muscles. All other electrodes were attached to a cap designed to fit 95% of adult individuals using the international 10–20 placement system (Jasper, 1958).
**Schematic sequence of the presentation**

![Diagram of presentation sequence]

**Figure 4.** The presentation was constructed along different stages: the premask (800–1,000 ms) took place immediately before any portrait was displayed, then the portrait presentation (3,000 ms) was followed immediately by a postmask (1,000 ms). Approximately twice per condition, a gender-related question was presented (UPR, until the participant’s response).

For the data analysis, EGGLAB (version v13.6.5b) for MATLAB (version R2015a) was used (Delorme & Makeig, 2004). The data was analysed according to Independent Component Analyses (ICA; Makeig, Bell, Jung, & Sejnowski, 1996) as follows: first, the signal was reassembled from 512 Hz to 256 Hz and the reference from CPz was replaced by the average of the mastoids including the CPz signal. Then, the data was filtered for ICA to 1 Hz and an automatic rejection of bad (non-EOGs) ICA channels was run. Finally, the ICA data was epoched, the bad ICA epochs (except for the four EOGS) were marked, and the ICA was run. Subsequently, the bad ICA components were manually rejected with a tool included in EEGLAB (Sarma, 2009).

The next steps were performed to create five grand averages. Each grand average corresponded to the ERP signals of each condition from the 20 participants. The missing channels were interpolated (see Limitations) in order to gain a signal from the electrodes.
surrounding the bad electrode. The main steps were regarding the automatic detection of artefacts, the average only for the good signal plus standard deviation, and the grand average plus grand average filter. Finally, the grand averages were plotted as a cluster of five electrodes: Cz, CP1, CP2, CPz, and Pz. Furthermore, four different files were created so that the essential information from the cluster of each condition could be retrieved for analytical purposes. All the data in these files included the ERP signal from 400 to 3,000 ms and the area for negative waveforms was zeroed. In this respect, IBM SPSS Software (version 24) was selected to analyse the results collected by the experiment and the questionnaire.
Results

Questionnaire: Validation of the Portraits

27 fully-completed questionnaires were collected from the participants. As described above, the main objective of the questionnaire in this study was to validate the impact of the portraits on the subjects in order to generate different LPP amplitudes (e.g. angry portraits elicit higher LPP amplitudes than neutral portraits). The average score ± the standard deviation (SD) of the valence was computed separately from angry portraits and neutral portraits. The average score ± SD of arousal was computed in the same manner. Since higher scores of valence and arousal correspond to negative valence and high intensity of arousal, the mean score of angry portraits for valence and arousal was expected to be higher on both scales than neutral portraits. According to the analysis (see Table 1 and Figure 5), participants rated the portraits in two different ways depending on the face type. Angry faces were rated as more negative (7.5 ± 1.2) and more intense (6.8 ± 1.9) than neutral faces (5 ± 0.9 and 3 ± 1.8, respectively). Kurtosis’ and skewness’ tests were run in order to assess the distribution of the four conditions (see Table 1). Both of them corroborated the normal distribution of the data. Finally, an independent t-test demonstrated that the mean difference between the angry and neutral portraits was statistically significant (p < 0.01). Overall, validation of the portraits gave access to measuring the LPP elicited by the portraits at the six dissimilar conditions.

Scalp Map Distribution

The scalp maps (see Figure 6) represent the neural activity recorded by the electrodes from the 20 participants (see Limitations). The distribution of the LPP activity was polarised. It started at the occipital zone (400–800 ms) and then moved to more central sites (1,500–3,000 ms). These results validated that the ERP component measured was the LPP (Hajcak, MacNamara, & Olvet, 2010; Schupp et al., 2004).
Table 1. Angry faces were rated as more negative and intense than neutral faces. Skewness and Kurtosis tests corroborated the histogram’s distribution

<table>
<thead>
<tr>
<th></th>
<th>Valence Angry Face</th>
<th>Valence Neutral Face</th>
<th>Intensity Neutral Face</th>
<th>Intensity Angry Face</th>
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<td>972</td>
<td>972</td>
<td>972</td>
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<td>Skewness</td>
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<tr>
<td>Std. Error of Skewness</td>
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<td>.08</td>
<td>.08</td>
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<tr>
<td>Kurtosis</td>
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<td>-.11</td>
<td>.32</td>
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<tr>
<td>Std. Error of Kurtosis</td>
<td>.16</td>
<td>.16</td>
<td>.16</td>
<td>.16</td>
</tr>
</tbody>
</table>

The Grand Averages: LPP Patterns

The six-condition grand averages were computed from the 20 subjects. Data from seven subjects was rejected due to either technical issues or artefact detection. The waveform of the cluster was, in accordance with Foti and Hajcak (2008), split into three periods: early LPP (400–800 ms), middle LPP (800–1,500 ms), and late LPP (1,500–3,000 ms). In this way, analysis of the LPP pattern was facilitated as comparisons of the mean variation of the waveform regarding the LPP were accorded to the three main steps: the raising of LPP (early LPP), the peak of LPP (middle LPP), and the tail of LPP (late LPP) (see Figures 7 and 8).

Firstly, the early LPP means were compared between the observe-angry-face (OAF 2.23 ± 1.32) to the observe-neutral-face (1.84 ± 1.23) conditions (dependent t-test; p < 0.01) as well as between the observe-angry-face to all other TD (1 Day: 1.85 ± 1.24; 1 Week: 1.79 ± 1.29; 1 Month: 1.89 ± 1.02; 1 Year: 1.79 ± 1.09) conditions (dependent t-test; p < 0.01). Then, the same results were obtained, using the same comparison, for the middle (observe angry face: 6.37 ± 3.59; observe neutral face: 4.68 ± 4.12; TD 1 Day: 4.82 ± 3.98;
TD 1 Week: 4.64 ± 3.51; TD 1 Month: 4.29 ± 3.18; TD 1 Year: 4.39 ± 3.59) and late LPP (observe angry face: 3.66 ± 1.72; observe neutral face: 2.57 ± 1.74; TD 1 Day: 2.58 ± 2.03; TD 1 Week: 2.57 ± 1.83; TD 1 Month: 2.60 ± 1.33; TD 1 Year: 2.70 ± 1.86; dependent t-test; \( p < 0.01 \); see figure 7) periods. Secondly, the observe-neutral-face condition was compared to each TD condition (dependent t-test; \( p > 0.05 \), see Figure 7) for the three LPP periods.

**Histograms of the 9-point Likert scales: Valence and Arousal**

*Figure 5.* The histograms show the normal distribution of valence and arousal. Point 9 on the valence scale corresponds to the most negative score (angry faces: 7.5 ± 1.2) and point 1 corresponds to a neutral score (neutral faces: 5 ± 0.9). Points 6 to 9 on the arousal scale represent the most intense scores (angry faces: 6.8 ± 1.9) whilst points 1 to 5 represent the least intense scores (angry faces: 3 ± 1.8).
In view of the results, the six means ± SD (observe angry face: 9.12 ± 6.57; observe neutral face: 12.36 ± 6.13; TD 1 Day: 9.25 ± 6.79; TD 1 Week: 9.00 ± 6.07; TD 1 Month: 8.77 ± 5.10; TD 1 Year: 8.88 ± 6) from 400 to approximately 3,000 ms (the entire LPP duration, see Figures 7 and 8) were analysed: the observe-angry-face condition was compared to each TD condition (dependent t-test; \( p < 0.01 \)) and the observe-neutral-face to each TD condition (dependent t-test; \( p > 0.05 \)).

**Scalp map distribution along the six conditions**

![Scalp map distribution](image)

*Figure 6.* Three time periods and their voltage scales according to the LPP time frames: early (400–800 ms), middle (800–1,500 ms), and late (1,500–3,000 ms). Neural activity starts at the occipital sites and then moves toward the central sites. This scalp map sequence confirms that the study was focused around the LPP component.

In short, the observe-angry-face mean differed statistically from the rest of the conditions at any LPP period including the entire LPP period.
Tables with the mean and standard error (SE, error bars ±) of the three LPP periods plus the entire LPP period

**p < .01

Figure 7. Observe-angry-face condition is the only one that has a mean difference (dependent t-test, p value < .01) among the rest of the conditions at any time measured. Mean ± SE during Early LPP: observe neutral 1.87 ± 1.23; observe angry 2.33 ± 1.32; TD 1 Day 1.85 ± 1.24; TD 1 Week 1.79 ± 1.19; TD 1 Month 1.89 ± 1.02; TD 1 Year 1.79 ± 1.07; Middle LPP: observe neutral 4.68 ± 4.12; observe angry 6.37 ± 3.59; TD 1 Day 4.82 ± 3.98; TD 1 Week 4.64 ± 3.51; TD 1 Month 4.69 ± 3.18; TD 1 Year 4.39 ± 3.59; Late LPP: observe neutral 2.57 ± 1.74; observe angry 3.66 ± 1.72; TD 1 Day 2.58 ± 2.03; TD 1 Week 2.57 ± 1.83; TD 1 Month 2.60 ± 1.33; TD 1 Year 2.70 ± 1.86; Entire LPP period: Observe neutral 12.36 ± 6.13; observe angry 9.12 ± 6.57; TD 1 Day 9.25 ± 6.79; TD 1 Week 9 ± 6.07; TD 1 Month 8.77 ± 5.10; TD 1 Year 8.88 ± 6.
The Grand Averages of the six conditions

Figure 8. Portrait onset starts at 0 ms and lasts for 3,000 ms. The green dashed lines represent the demarcations between the LPP time frames (early, middle, and late). CP-cluster corresponds to Pz, CPz, Cz, CP1, and CP2. The comparisons of the means between the observe-angry-face and observe-neutral-face conditions as well as the observe-angry-face versus all the TD conditions during the LPP period (400–3,000 ms) were statistically significant (dependent t-test, \( p < 0.01 \)). The same result was obtained during the early, middle, and late LPP stages. Legend: ‘Observe Neutral’ refers to the observe-neutral-face condition; ‘Observe Angry’ refers to the observe-angry-face condition; Temp Dist: ‘1 Day’ denotes the temporal distancing of one day whilst ‘1 Week’ denotes the temporal distancing of one week, with ‘1 Month’ and ‘1 Year’ referring to one month and one year respectively.
Discussion

According to the results, the subjects elicited a lower LPP amplitude when they completed any TD condition than when they completed the angry-face baseline condition (Figure 8). This finding was in concordance with the previous studies on TD using stressors (Bruehlman-Senecal & Ayduk, 2015; Bruehlman-Senecal, Ayduk, & John, 2016; Yanagisawa et al., 2011) since the arousal index during the TD strategies was mitigated when a subject visualised negative stimuli. Furthermore, the ERP experiment was design to force cognitive changes (a reappraisal) instead of other strategies, such as attentional manipulation. Distraction is an emotion regulation strategy whereby a distractor suppresses the attention of the subject on a given aspect. Therefore, it is crucial to point out the differences between these two strategies, as the results show the arousal elicited by angry portraits was lower during TD conditions than the angry-face baseline condition due to the reappraisal. In Figure 8, the reader can observe the main difference: the LPP elicited by cognitive changes lasted for 3,000 ms while the LPP elicited by a distractor lasted for 1,000-2,000 ms (Schonfelder, Kanske, Heissler, & Wessa; 2014) or even less than 300 ms (Hajcak, Dunning, & Foti, 2009; Thiruchselvam et al. 2011) after the stimulus onset.

Although the varied TD strategies have been reported to affect the stimuli in different degrees (Ahmed et al., 2017), we did not find any statistical difference in the means amongst any of the four TD means even when the greatest TD perspective (TD 1 year) was compared to the lowest TD perspective (TD 1 day). This might be due to three main reasons.

The first one concerns the technical issues. Because the signal was not only interpolated in some electrodes but the artefact detection and the posterior rejection of these artefacts might also involve a good signal, the mean values of the LPP amplitude of the four TD strategies might be statistically different among them if a deeper and careful analysis were run (see Limitations).

The second reason is related to the Type II Error (Akobeng, 2016). The Type II Error means that the null hypothesis is not rejected even though the hypothesis is false. The
probability of committing a Type II Error happens when the sample size is too small. In this study, the null hypothesis is that the means of the different TD strategies do not statistically differ from each other. Taking into account that the sample size was 20 participants, the risk of committing a Type II Error is high (at least 30 participants are required to avoid the Type II Error). Therefore, the null hypothesis should be tested again with a higher number of participants. On the other hand, the means that were statistically different (angry face vs. neutral and TD strategies) are valid as the p-value was set under 0.05 (Akobeng, 2016, see Type I Error).

The third one is about the instruction itself. All the TD strategies were conducted by this instruction: ‘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 to yourself how little their anger will mean to you in 1 Day /1 Week /1 Month /1 Year. Please only apply this strategy after each face is shown, not before.’ The baselines, in turn, were conducted by this instruction: ‘Imagine that you are seeing each person in front of you right now on a public train. Just observe their face’. The reader can note that both instructions differ not only in the content but also in how the information is given. The TD instructions provide much more content unrelated to the temporal strategy that it is required to apply than the baseline instruction – the baseline instruction is much shorter. This difference is clearly in opposition to the common Latin expression *ceteris paribus* which means ‘other things held constant’. This expression is widely used to state the effect of the variable *a* over the variable *b* when the rest of the variables remain constant. For example, in the context of social-economic status, Hackman and colleagues argued that the better the financial empowerment of parents, the better neurocognitive the development of their children, *ceteris paribus* (Hackman, & Farah, 2009; Hackman et al., 2010). Hence, according to this old expression and our hypothesis, the broader the TD perspective applied, the lower the LPP amplitude elicited, *ceteris paribus*. However, the instructions, as mentioned above, differ not only in the TD variable but also in the text. For this reason, the instructions should be unified with slight differences corresponding to the
condition presented. For instance, the instruction that directs the subject to observe the portraits might be worded as: ‘Imagine that you are seeing each person in front of you right now on a public train. Their angry/neutral face might make you uncomfortable’; whilst the instruction that conducts the subject to reappraise the portraits in a broader temporal context might be: ‘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 to yourself how little their anger will mean to you in 1 Day /1 Week /1 Month /1 Year. Please only apply this strategy after each face is shown, not before’. Please note that the final sentence in the reappraisal instruction has been extended with the part that force the subject to reappraise the portraits. In the same line, it may be interesting to compare, within a reappraisal environment, a present perspective with future perspectives. For that purpose, the inclusion of a present-time-related component in the reappraisal instruction may allow the comparison between a present perspective and a future perspective. This present perspective may be used as a control to test the efficiency of any TD strategy employed.

Regardless of these issues, these results should not be taken as strong evidence to support the assumption that LPP have been modulated by TD, but the beginning of a new scope of cognitive neuroscience in which further studies (based on the same hypothesis that have prompted these experiments) asses the LPP amplitudes elicited by different TD. This study also pointed out the need for more research on the emotion regulation. For instance, there is no study regarding the TD effects on subjects that utilises fMRI measurement. The closest study to fMRI was developed by Yanagisawa et al. (2011). However, this study was performed via near-infrared spectroscopy (NIRS) and, as Mehagnoul-Schipper et al. (2002, p. 15) said: “Disadvantages of NIRS are the relatively low spatial resolution and low cerebral penetration depth”.

Another important aspect is the neurobiological correlates of LPP. As noted in the Background section, there is evidence pointing to the amygdala as the region implicated in processing emotional visual stimuli (Ochsner & Gross, 2008). However, as Hajcak,
MacNamara, and Olvet (2010, p. 137) said: “To our knowledge, no studies to date have explicitly linked the LPP to the activity of specific neurotransmitter systems”. However, Nieuwenhuis, Aston-Jones, and Cohen (2005) undertook a great, in-depth review in which they suggest that the P300 is the reflection of the phasic activity of the locus coerulerus-neuroepinephrine system. Insofar as P3 and LPP may be connected by the same neuromodulatory activity, the hypothesis whereby the locus coerulerus-neuroepinephrine system also generates the LPP is feasible and attractive. Altogether, these studies reveal that further research on this topic should be addressed.

In short, we have demonstrated that the LPP amplitude elicited by angry portraits decreased when participants employed a TD strategy without the need of using IAPS pictures. Nonetheless, there are many more aspects to be explored, especially in the context of TD.
References


